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Construction Management *JumpStart*

Third Edition

**The Best First Step
Toward a Career in
Construction Management**



WILEY

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Construction Management JumpStart

The Best First Step Toward a Career in Construction Management

Third Edition

Barbara J. Jackson

WILEY

This edition first published 2020
© 2020 John Wiley & Sons, Inc.

Edition History:

John Wiley & Sons 2004 (1e), John Wiley & Sons 2010 (2e)

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Registered Office

John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA

Editorial Office

John Wiley & Sons, Inc., 111 River Street, Hoboken, NJ 07030, USA

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Library of Congress Cataloging-in-Publication Data

Names: Jackson, Barbara J., author.

Title: Construction management jumpstart : the best firststep toward a career in construction management / Barbara Jackson.

Description: Third Edition. | Hoboken : Wiley, 2020. | Revised edition of the author's Construction management jumpstart, c2010.

Identifiers: LCCN 2019045368 (print) | LCCN 2019045369 (ebook) | ISBN 9781119451013 (paperback) | ISBN 9781119451068 (adobe pdf) | ISBN 9781119451082 (epub)

Subjects: LCSH: Construction industry—Management.

Classification: LCC HD9715.A2 J32 2020 (print) | LCC HD9715.A2 (ebook) | DDC 624.068—dc23

LC record available at <https://lcn.loc.gov/2019045368>

LC ebook record available at <https://lcn.loc.gov/2019045369>

Cover design: Wiley

Cover image: © Steve Debenport/[iStock.com](https://www.iStock.com)

To the many people who have purchased this book and used it to launch their career in construction, transition into management from the field, or used it to begin their studies as they prepare for a career in construction—one of the most rewarding and impactful paths a person can follow.

Acknowledgments

No great accomplishment ever happens in a vacuum. There are always a lot of people behind the scenes who deserve much of the credit for any good thing that makes it to the light of day. I believe this book is one of those good things, and it would never have happened without the hard work and dedication of several people.

I want to start by thanking Sybex for launching the JumpStart series. I believe that it serves a unique purpose by introducing the public to a number of career paths that they may otherwise never encounter. I am especially grateful to Elizabeth Peterson for discovering my web page and making the phone call asking whether I would be interested in writing this book. I want to acknowledge her for recognizing construction management as the untapped career opportunity that it is. Elizabeth, by initiating this book on construction management, you have provided a great service to the construction industry and the clients it serves. Thank you.

I also want to thank the many other talented members of the Sybex team who helped put this book together. I'll start by thanking my developmental editors, Brianne Agatep and Maureen Adams, for walking me through the writing process and taking care of all of my formatting errors. Next I want to give a special thanks to Suzanne Goraj, who cleaned up all of my grammatical gaffes and helped my message ring loud and clear. And to Mae Lum, the production editor, a special thank-you for keeping everything on track while I traveled around the country teaching seminars and doing consulting work for the construction and design-build industry. I'd also like to thank Agatha Kim, Kelly Talbot, and Angela Smith for all of their contributions to making the second edition of this book even stronger.

Of course, I would be remiss without thanking the rest of the Sybex team responsible for tying up the loose ends and putting the whole thing together: compositor Kate Kaminski of Happenstance Type-O-Rama, illustrator Jeff Wilson of Happenstance Type-O-Rama, proofreader Nancy Riddiough, and indexer Nancy Guenther. For the Second Edition, copyeditor Kim Wimpsett, compositor James Kramer of Happenstance Type-O-Rama, illustrator Richard

Sheppard of Happenstance Type-O-Rama, proofreaders Publication Services, Inc., and indexer Jack Lewis. For the Third Edition, thanks to copy editor Mike Isralewitz and production editor Jayalakshmi Erkathil Thevarkandi.

In addition to the fine folks at Sybex, a number of other supporters must be mentioned. Let me start by acknowledging several authors, most of them good friends and fellow faculty, who have written really good texts used as general references in the writing of this book.

Managing the Construction Process: Estimating, Scheduling, and Project Control by Frederick E. Gould (2004)

Construction Jobsite Management by William R. Mincks and Hal Johnston (2004)

Management of Construction Projects: A Constructor's Perspective by John E. Schaufelberger and Len Holm (2002)

Construction Management Fundamentals by Clifford J. Schexnayder and Richard E. Mayo (2004)

BIM and Construction Management: Proven Tools, Methods, and Workflows by Brad Hardin (2009)

I extend a very special thank-you to my dear friend, colleague, and technical editor Paul Weber for his diligent review of every word in the manuscript for technical accuracy and application. Paul, I greatly appreciate your support and assistance in helping me achieve this goal. And as always, your abilities to communicate graphically were put to good use in several instances throughout the book. I would also like to thank Jes Frazier for her steadfast help and support in helping me review every page and every word.

And finally, as always and forever, I thank my husband, Wayne, for his continued support, love, and understanding year after year while I continue to pursue the passions of my heart.

About the Author

Barbara J. Jackson is Director of the Franklin L. Burns School of Real Estate and Construction Management, in the Daniels College of Business, at the University of Denver. She holds a BS in Housing and Design, an MS in Construction Management, and a PhD in Education and Human Resources. With over 20 years of experience as a licensed contractor and design-builder, she is a nationally recognized speaker and consultant on design-build project delivery, integrated teaming, and leadership and culture in the AEC industry.

Introduction

Congratulations! You are about to embark on an adventure. This book is about the processes, the people, and the practices that we call construction management—a term and a profession that may be unfamiliar to many people. Construction, as most individuals understand it, is an activity or a series of activities that involves some craftspeople, building materials, tools, and equipment. But you will learn that there is a great deal more to it than that. If you think that construction is all about brawn and not much about brains, then you probably haven't been paying very close attention to what has been going on in the built environment in the past several decades. Buildings today can be very complicated, and the building process has become extremely demanding. It takes savvy professional talent to orchestrate all of the means and methods needed to accomplish the building challenge.

This book's focus is not on construction per se. Its focus is on the construction process and those individuals who manage that process. Construction management involves the organization, coordination, and strategic effort applied to the construction activities and the numerous resources needed to achieve the building objective. Construction management combines both the art and science of building technology along with the essential principles of business, management, computer technology, and leadership.

Construction management as a profession is a relatively new concept, which may explain why you have not heard of it before. Up until the 1960s, the management tasks associated with large construction projects were typically handled by civil engineers. But in 1965, faculty from nine universities gathered in Florida to form the Associated Schools of Construction. What started as a movement to upgrade the status of construction education at universities evolved into a standardized construction management curriculum leading to an exciting new career choice, one for which there was increasing demand. Men and women who love the idea of transforming a lifeless set of plans and specifications into something real—a single-family home, a high-rise office building, a biotech facility, a super highway, or a magnificent suspension bridge—had

found an educational program that provided both the academic course work and the practical management tools needed to plan, organize, and coordinate the increasingly complex construction process.

If you are one of the many individuals who desire the intellectual challenges of architecture, engineering, technology, and business, yet long to be outside in the thick of things, getting your hands dirty and ultimately producing a tangible result—something of lasting value—then construction management might just be the ticket for you.

The purpose of this book is to give you a jump-start on understanding what construction management is all about. After reading this book, you will have a good sense of what the job of a construction manager entails and what is needed to be good at it. You will learn about the diverse tasks associated with planning, organizing, and managing a construction project to a successful end. You will also discover the many opportunities available for an individual interested in pursuing a career in CM.

You can continue to explore these opportunities by reading other books about construction management, by taking construction management classes, and by networking with practitioners in the industry. And for those of you who want to take your interests and careers in construction to the next level, you can consider pursuing professional certification through either the American Institute of Constructors (AIC) or the Construction Management Association of America (CMAA). Both of these organizations and their certification programs are introduced in [Chapter 1](#).

And after you've read this book, the next time you see some construction, I hope that, besides being fascinated by the activity, you will also be impressed by the ingenuity, creativity, and heart of the people who can achieve such feats. It's also my goal to give you a new appreciation for the men and women who built this nation in the past and who continue to contribute to the built environment in a significant way. Enjoy!

Who Should Read This Book

If you have picked up this book, I suspect that you have already experienced construction at some level and are curious about what construction management is. You may currently be working in construction on the building side as a craftsperson or laborer and want to know how you can move over to the management side. Or you may be a construction management student wanting a glimpse into the day-to-day challenges faced by the construction professional. On the other hand, you may currently have nothing to do with construction other than having a longtime interest in the building process. Some of you may have had a home built or a room added on and are simply interested in learning what the fuss was all about.

I hope that architects and engineers will pick up this book to get a better understanding of the contractor side of the equation. Some designers, tired of sitting behind a desk all day, may even contemplate giving construction management a try just for the heck of it. I suspect that there will be more than a few real estate agents, mortgage brokers, and interior designers who will use this book to become better informed regarding the construction process, integrating the new knowledge into the services they provide their clients. Then, of course, there are those of you who are already working in construction management but have been looking for a resource that will help explain what it is you do for a living!

No matter what your reason for buying this book, I feel confident that it will be money well spent. For those of you who have little or no experience with construction, I venture to guess that someday you will, and when you do, your knowledge and understanding of construction management will become quite valuable.

As for those of you who already have experience in construction, I have tried to write a comprehensive overview of the construction management process from the constructor's perspective. I'm sure you will relate to the Real World Scenarios presented throughout the text and enjoy the human aspects conveyed in the pages of this book. They are intended to drive home the challenges associated with construction and express the contribution that construction professionals make to the built environment. This book will assist

you in communicating to clients, colleagues, and the public at large the significant role that the construction manager plays in the overall success of a construction project.

What This Book Covers

This book walks you through the construction management process—explaining how you take a project from a set of two-dimensional drawings to a three-dimensional wood, steel, or concrete building, bridge, or highway. Along the way, you will learn about the seven functions of construction management and how each of them contributes to the successful delivery of the construction project. Here's an overview of what this book covers:

Chapter 1 This chapter introduces you to the construction industry and the opportunities that it offers. Here you will learn about the different industry sectors and the roles of the various participants in the construction process.

Chapters 2–5 These chapters explain in greater detail what construction management is and how construction work is obtained in the first place. You will also learn about the construction contract and about each of the stages leading from design to post-construction.

Chapter 6 Nothing happens in construction without the efforts of a team of highly skilled and talented individuals—all of which are necessary to execute and deliver a successful project. In this chapter, the critical task of managing a diverse group of designers, contractors, subcontractors, vendors, and many other people who make up a project team, will be discussed. Critical aspects of team management such as trust, communication, and collaboration, to name a few, will be presented.

Chapter 7 As alternative project delivery approaches have become much more popular, pre-construction services have become much more critical. This chapter discusses many of the common pre-construction services that are necessary to be successful with any of the integrated design and construction approaches. Services such as feasibility studies, constructability reviews, conceptual estimating, value engineering, and life-cycle cost analysis are some of the common services that will be explained.

Chapter 8 Figuring out what a project is going to cost is one of the first steps to getting a construction contract. This chapter deals with the estimating function of construction management. Here you will learn about the different types of estimates and how you price construction work.

Chapter 9 In this chapter, you will learn all about the conditions of the contract and what it takes to manage them. Contract administration is all about handling the red tape, business details, and paperwork of the construction project.

Chapter 10 Once the contract is signed and everything is a go regarding the project, you are ready to start construction. This chapter deals with organizing the job site and coordinating all of the manpower, materials, and equipment needed to get the work done.

Chapter 11 This chapter stresses the importance of good project planning and identifies the various tools used to schedule all of the activities associated with moving the project from startup to completion.

Chapter 12 The only way to know whether your project has met its goals for cost, time, and quality is to monitor and track individual components of performance. This chapter gets into the details of project control and explains how to get a job back on track if it should start to go off course.

Chapter 13 In this chapter, you will learn the importance of quality control and safety management throughout the construction process. No project can succeed without well-established quality and safety plans.

Chapter 14 Bottom line: Construction management is all about managing risk. In this chapter, you will learn about a standardized process for identifying, analyzing, and quantifying project risks so plans can be made to mitigate their impact.

Chapter 15 This chapter introduces you to building information modeling (BIM) and how it is commonly used in the design and construction process. BIM is expanding way beyond the 3D dimension to a whole new level by applying 4D, 5D, 6D, and even 7D dimensions to the building model. The chapter will

also introduce some of the newest technologies being applied in construction such as virtual reality, augmented reality, and holograms.

Chapter 16 This final chapter discusses the impact that green building and sustainability is having on the entire building industry. The key principles of sustainable building design will be presented, along with the concept of achieving triple bottom line results associated with the economic, environmental, and social performance of building projects.

Making the Most of This Book

At the beginning of each chapter of *Construction Management JumpStart*, you'll find a list of the topics that I cover within the chapter.

In addition, several special elements highlight important information.

To help you absorb new material easily, I've highlighted *new terms* in italics and defined them in the page margins.

New terms

provide explanations of important concepts in the margin of the page, where you can easily spot them.

NOTE

Notes provide extra information and references to related information.

You'll also find a list of “Terms to Know” near the end of each chapter to help you review the new terms introduced in the chapter. These terms are compiled in the Glossary at the end of the book. In addition, in [Appendix A](#) you'll find a list of the many acronyms commonly used in construction and mentioned throughout the book.

At the end of each chapter, you can test your knowledge of the chapter's relevant topics by answering the review questions. You'll find the answers to the review questions in [Appendix B](#).

Chapter 1

The Construction Industry

In This Chapter

- ◆ The economic impact of construction
- ◆ How construction was transformed from a craft to an industry
- ◆ The five primary sectors of the construction industry
- ◆ The roles of the project participants
- ◆ How the construction industry is transforming
- ◆ The advancement of technology in construction
- ◆ The construction industry's impact on sustainability
- ◆ Opportunities in construction management

The construction industry is vast and varied. Just take a look around—from homes to highways to hospitals—and you see the results of this industry. Starting with the need for shelter, we first built primitive huts and houses. Then we constructed buildings for assembly and churches in which to worship. As our needs expanded, so did our building capabilities. We eventually built political capitals, great cities bustling with business and commerce. Though the means and the methods have changed over the centuries, the construction industry is still about building communities that serve people.

Construction is big, big business—reaching \$10.6 trillion in spending worldwide in 2017, and projected to reach \$12.7 trillion by 2022, and \$15.5 trillion by 2030, according to the Construction Intelligence Center, Orbis Research, and other sources. And there appears to be no slowdown in sight. The industry employs more than 7 million people directly (plumbers, carpenters, welders, and so on) and hundreds of thousands more indirectly. It gives rise to the steel industry, the lumber industry, the carpet industry, the furniture

industry, the paint industry, the concrete industry, the paving industry, and so on. It goes even further than that if you consider the trucking, shipping, manufacturing, and mining industries. Architects, engineers, drafts people, building inspectors, code officials, and other professionals would not have jobs if it weren't for construction. As construction projects become increasingly more complex, the challenges associated with managing these projects become more complicated. The need for qualified construction managers is tremendous, and opportunities abound for those interested in the work.

Let's take a closer look at the construction industry and the position it has in our economy and our lives.

The Scope of the Industry

Let's first make sure that you understand what construction is really all about. I have found that most people, including many who are already engaged in construction, do not understand the significance of the industry. So, let's start by considering the scope and the magnitude of construction and take a look at its impact on our society and our economy.

“It's Just Construction”

In my experience, the average observer of construction regards the process as rather insignificant and inconsequential—nothing special, nothing unique, not an industry of any major importance—mostly filled with non-influential blue-collar macho types. After all, when compared to medicine or law or even architecture, the common notion is “it's just construction.” This is why our great buildings and structures are typically identified only with the designer, and not with who built them. The contractor is incidental. Let me give you a few recent examples to drive home my point.

The distinctive architectural designs of Frank Gehry are known all over the world. One of his newest creations, the Walt Disney Concert Hall in Los Angeles, is “the most challenging of all Frank's buildings... an enormously complicated structure because of the curved shapes and intricate joinery,” according to Terry Bell, project architect for Gehry Partners, LLP, as quoted on the Walt Disney Concert Hall website. The website mentions that “extraordinary state-of-the-art construction techniques” were needed for the Concert Hall— “[o]ne of the most technically advanced structures in the world, [with] its lack of right angles and the overall sculptural quality.” At any one time as many as 550 construction workers were on-site to transform the concrete and steel into one of the most acoustically sophisticated concert halls in the world. However, you would be hard-pressed to find one mention of the building contractor of this magnificent construction feat in the popular press or on the Concert Hall's website. Not one single mention! This incredible construction challenge was accomplished by the M.A. Mortenson Company.

base isolators

Large shock absorbers made of alternating layers of rubber and steel attached to a building's foundation to allow movement of the structure without causing damage.

Let's consider another example. In 2002, the third-largest cathedral in the world and the first cathedral to be built in the United States in more than a quarter of a century was constructed in downtown Los Angeles. Designed by the world-renowned Spanish architect Professor Jose Rafael Moneo, the Cathedral of Our Lady of the Angels stands 11 stories tall and weighs a whopping 151 million pounds. The cathedral rests on 198 *base isolators* so that it will float up to 27 inches in any direction during an 8-point magnitude earthquake. It has been stated that the design is so geometrically complex that none of the concrete forms could vary by more than $\frac{1}{16}$ th of an inch.

Having visited the cathedral several times during its construction and been witness to the extraordinary efforts made by the construction team to ensure the quality of the design along with the requirements for the budget and schedule, I was very disappointed, again, not to find one mention of the contractor, Morley Builders, on the cathedral's website.

Consider any of our architectural jewels: the Willis Tower (formerly known as the Sears Tower) in Chicago, the Space Needle in Seattle, the Transamerica Pyramid in San Francisco, and the Empire State Building in New York. With a little research, you would find that each of these buildings is easily identified with their designers. However, it would be a real challenge for you to discover that Morse Diesel International, Inc., was the builder of the Sears Tower, that Howard S. Wright Construction built the Space Needle, that the general contractor for the Transamerica Pyramid was Dinwiddie Construction (now Hathaway-Dinwiddie), and finally that Starrett Brothers & Eken, Inc., was the builder of the Empire State Building.

To me, not recognizing and acknowledging the contractor along with the designers of these buildings is a grave injustice—but, unfortunately, indicative of how our society views the construction

industry. Apparently, to some people it is not very important. Well, let me explain why it is *very* important. Drawing a pretty picture on paper or calculating a complex engineering formula does not make a building real—construction does, and that takes tremendous creativity, ingenuity, tenacity, skill, blood, sweat, and tears. So remember, no matter how outstanding the design, it is not architecture until somebody builds it! “Just” construction? I don't think so!

Construction's Contribution

Our society does not take the contributions of the construction industry very seriously. But it should, because without these contributions, this world would be a very bleak place. When you walk out of your office, home, or classroom today, just take a good look at the world around you. I want you to notice the houses, the churches, the hospitals, the shopping malls, the theaters, the baseball stadiums, the bridges, the streets, and even the cars driving around. None of these would exist without construction. There would be no cars or any other manufactured products because there would be no manufacturing plants—no Nike shoes, no McDonald's restaurants, and no iPhones. There would be no commerce, no transportation, and no manufacturing. Progress and construction go hand in hand—we can't have one without the other. Our society, our economy, and our culture are all dependent upon the construction industry. So, the next time you hear someone complaining about construction workers stirring up dust at the intersection or delaying their trip to work in the morning, I hope that you will take the time to point out what our world would be like without construction.

NOTE

When a building is notably impressive, people ask, “Who designed that wonderful building?” But when a building design is particularly unimpressive, people ask, “Who built that eyesore?” Why aren't people as curious about who builds the great structures as they are about who designed them?

Construction Statistics

Let's put it all in perspective. Construction is one of the nation's largest industries, accounting for approximately 4.3 percent of the gross domestic product. It is larger than the automobile and steel industries put together. Housing starts (which are identified by building permits issued) are one of the major economic indicators reflecting the overall health and direction of our economy.

According to the U.S. Census Bureau, 2017 ended with approximately \$1.257.0 trillion worth of construction (all private and public sectors) put in place for the year. The U.S. Department of Labor estimates that there are at least 791,772 private construction companies employing approximately 6.7 million people in the United States. Construction offers more opportunities than most other industries for individuals who want to own and run their own businesses, and statistically an additional 1.6 million individuals do just that.

Construction impacts the quality of life for every human being and plays a major role in all of society and has for a very long time. Anyone who is involved in construction—from the grading laborer to the electrician to the estimator to the construction manager to the construction company executive—needs to understand that what they do makes a *big* difference in the world.

Construction has been around a very, very long time. Construction means, methods, and motivations have changed over the past 12,000 years or so, and the trek has been absolutely fascinating. Let's continue this adventure by taking a look at some of the factors that have influenced this very significant industry.

A Historical Perspective

The purpose of spending some time on the history of the construction industry is to further reveal the impact of construction on society. As you read this brief history, imagine the creativity, ingenuity, and tenacity that these early constructors must have possessed in order to achieve such extraordinary building achievements. What started as a craft motivated by necessity (shelter from the elements) gradually turned into building science motivated by curiosity, intrigue, and genius. The building challenges of today are just as complex as in the past and are even more sophisticated, inspiring the same attributes exhibited by the early master builders. Let's take a brief walk through time and visit some of the world's greatest construction accomplishments.

Ancient Times

Although agriculture is probably recognized as the oldest industry in history, construction is most likely a close second. The construction industry can trace its roots back to at least the Stone Age, as early as 12000 BC. Using materials readily available—mud, wood, and stone—early man began constructing simple structures for protection from the rain, cold, heat, and snow. During this same period, the development of bronze and iron allowed man to make stronger tools that significantly expanded the possibilities in building construction, allowing builders to develop their skills.

As construction skills and tool development increased, real expertise in the building trades began to emerge. Simple shelter grew into planned settlements, villages, and cities. Soon, the need for common gathering places became part of the building challenge, and this period saw the start of public building for special events, religious ceremonies, manufacturing, and commerce. Small villages became large cities, and large cities grew into great civilizations, and at the heart of it all was construction.

Egypt and the Pyramids

Many of these early civilizations were building with one of the first manufactured building materials, dried mud bricks. However, the

Egyptians began to use stone as their primary building material. Although the process of moving these very large masses of rock was difficult, to say the least, the ingenuity of these ancient builders conquered these challenges, resulting in some of the most fascinating building projects in all of history—the great pyramids.

At this time, there was really no distinction between architecture, engineering, or construction. All three disciplines were embodied in one person—the master builder. The master builder concept would survive for many years, until the complexity of structures and construction techniques warranted a separation of disciplines.

It was during the building of the pyramids that the first known building code was recorded, dating back to approximately 1792–1750 BC. These written rules and responsibilities were among the laws carved into stone tablets, collectively known as the Code of Hammurabi. The building code dictated acceptable workmanship standards for the master builder. Failure to meet these standards brought stiff penalties, in some cases including death.

Greek Influence

During the pyramid-building era, the Egyptians used large numbers of unskilled workers to construct their massive undertakings. However, the Greek master builders, who were building many beautiful temples made of marble and limestone (such as the Parthenon in Athens), started to organize and utilize small groups of skilled stonemasons. This idea of congregating workmen around a particular craft represents the beginning of the building trades concept, in which a particular building skill is honed to a level of expertise associated with a master craftsman. Although much of the work was still performed by an unskilled workforce, the use of skilled artisans allowed for a finer detail and design to be applied to the architecture. This is clearly a turning point in construction history.

The Roman Empire

The Roman Empire represents one of the most influential periods of time for architecture, engineering, and building science. During the Roman Empire, significant strides were made in construction techniques. An early form of concrete, a staple in every present-day

building project, was invented by the Romans. This early version consisted of a pasty, hydrated lime and pozzolan ash mixture made from rock. In addition to utilizing concrete in the foundations of their structures, the Romans began adding domes and arches to their buildings, achieving engineering and construction feats that were astounding. During this time, some of the world's most impressive structures were built, including the Colosseum and the Pantheon. The first glass was also incorporated in the first century AD and decorated many Roman structures. Road construction was another highlight of the Roman Empire, and many of these ancient pathways are still carrying travelers today.

Around 40 BC, a Roman writer, engineer, and architect named Marcus Vitruvius Pollio wrote the first design and construction handbook. His writings included topics on building materials, construction processes, building styles, road and bridge design, water-heating techniques, acoustics, and other building physics. With Vitruvius' writings, the concept of master builder or architect took on even greater distinction. The master builder was responsible for both the design and the supervision of the construction. Surprisingly, Vitruvius' work was recognized as the authority on building and design for centuries.

The Middle Ages

With the downfall of the Roman Empire came a real decline in building activity and technology. Then around 900 AD, the powerful Roman Catholic Church revitalized stone construction as it intensely pursued church and cathedral building throughout Europe. Even during this somewhat stagnant period, great building efforts were taking place. Glorious Gothic cathedrals highlighted the European landscape, and many other impressive structures were being designed and built all over the world.

Craft training and education became a major focus, and craft guilds were organized, even forming special brotherhoods around specific trades. Building construction became a major industry in and of itself. The two most important building trades were carpenters and stonemasons. Three distinct stages of ability were recognized—

master, journeyman, and apprentice. These three stages of organized labor are still widely recognized today among the trade unions.

The Renaissance

Toward the end of the Middle Ages, a renewed interest in architecture, building, and science took place, continuing the transformation and evolution of construction and building design. It was during this time that the concept of the master builder began to be questioned as the most efficient way to build. Leone Battista Alberti, considered by some to be the precursor to the modern-day architect, argued that he could create drawings and models as a way to direct master craftsmen without actually being involved in the building process. Alberti was a theoretical architect rather than a practical hands-on architect-builder. He furnished plans of his buildings but never participated in the actual construction. This was the first application of a new philosophy that would eventually separate design and construction as distinct functions. Interestingly, there is a real push today to return to the master builder concept—but with the recognition that the modern master builder is a collaborative team.

The Industrial Revolution

The Industrial Revolution had a major influence on all of society. The construction industry was no exception. As construction became recognized as separate and unique from design, more theoretical concepts involving physics, mathematics, chemistry, and thermodynamics were being applied, and building science as a discipline began to emerge. The various building professions took on increasingly defined roles—the art of architecture, the science of engineering, and the craft of building became even more distinct. As architecture moved further away from the building process, the engineering disciplines took on a greater role for overall technical coordination, while general contractors were left to assemble, organize, and manage the labor force, equipment, and materials on a project. Cast iron and wrought iron became the building materials of choice. These materials were being used to build bridges, railways, great exhibition halls, and various other buildings. New machinery and equipment such as steam shovels, steam hammers, and pile

drivers were being invented to support building. The transformation of construction into a modern industry began during this period of time.

The Age of the Skyscraper

During the late 1800s, the production of steel and electricity really took center stage as factors that would influence the construction industry in a big way. It was a time of immense growth in building technology. Steel framing replaced iron framing and allowed for high-rise building. Portland cement and reinforced concrete were invented. Glass was now being mass-produced and was used to clad many of these new building frames. The dream of constructing tall buildings reaching to the sky became a reality when E.G. Otis invented the first passenger elevator. Building skyscrapers was seen as a way to conserve land as the pace of growth in American cities became a concern. Technological advancements in building science continued, electric power became commonplace in all structures, and advancements in heating and cooling systems made life easier for people in all climates of the world.

Construction started showing up as big business during this time. Although most building was still being performed by small and medium-sized companies, much larger organizations were forming, and the globalization of the construction industry had begun. Opportunities for extensive projects in housing, industry, transportation, and city development were popping up all over the world. The construction industry developed into a major economic sector.

The 20th Century

Although only a few advances in materials or technologies took place during the 20th century, new challenges were being imposed on the construction industry. After World War II, there was a construction boom in the United States and around the world. The demand for housing, industry, and *infrastructure* was enormous. Time, cost, and quality became critical concerns for those needing new facilities. The construction industry responded. Mechanized tools, panelized construction, and prefabrication inspired a whole new way to view the

building process. New techniques emerged to help regulate and standardize building materials and methods. Building codes, standards, and *specifications* were established to help regulate and control the quality of materials and methods. Over time, as more residential, commercial, and industrial development started to spring up, new issues such as the environment, energy conservation, sustainability, safety, and workforce diversity started to add to the complexity of the building process in a way that had never been seen before.

infrastructure

The basic roadways, bridges, and railroad networks that support a community or society.

specifications

The written instructions from an architect or engineer accompanying the project plans pertaining to the quality of materials and workmanship required for the project.

The industry began to recognize that the correlation between sound management techniques and successful building practices was very important to the success of a project. The ability to measure and monitor progress and economic effectiveness of the construction process became more important as projects became increasingly complex. Although the discipline of engineering had been tapped to provide the management function for years, a new distinction was being drawn.

As early as 1935, a new educational program that focused specifically on construction was popping up at a few universities across the country. These early programs eventually evolved into what is now recognized as construction management. The idea was to merge management principles, methodologies, and techniques with the art, science, and craft of building and create a unique educational experience. In addition to teaching building science, the program

introduced estimating, scheduling, project controls, and project administration techniques.

In 1965, representatives from nine universities met in Florida to form the Associated Schools of Construction (ASC). This organization's distinct mission was to promote construction management as a legitimate and unique area of study at the university. The organization's goal was to establish a four-year degree program that clearly identified construction management as a recognized discipline among allied disciplines such as engineering and architecture.

Today, there are more than 160 four-year colleges and universities listed with ASC offering construction management curricula. The programs are typically identified as construction management, construction engineering, engineering technology, building science, or construction science, and they are often affiliated with colleges or schools of engineering, architecture, or technology. The educational opportunities available today are discussed in greater detail later in this chapter; see the “Educational Offerings” section.

The Age of Technology

New technologies are impacting every aspect of our lives. The construction industry is no exception. There are computer applications across all aspects of the construction management function: programs for estimating, scheduling, project administration, building design, cost accounting, project controls, quality control, and information transfer. Computers are available on every job site, and increasingly we are seeing all kinds of field mobility software and tablet computers being applied to every aspect of the construction management process that can be used to initiate a schedule or purchase order change in an instant. But the technology doesn't stop there. Technologies such as global positioning systems (GPS), computer-aided earth-moving systems, building information modeling (BIM), and virtual and augmented reality are allowing construction managers to enter and interact with buildings that exist only in cyberspace. These virtual mock-ups are real enough to evaluate things as simple as whether welders have enough room to work in a confined space, and more serious issues such as the impact

of a powerful hurricane on an entire facility. (You'll learn more about BIM and other technologies in [Chapter 15](#).)

The technological opportunities in construction methods, materials, and management are endless. In the future, we can look forward to the use of nanotechnology, metallic polymers, and micro-electromechanical systems that will allow for embedded intelligence in building materials and produce products such as interactive, “talking” doors, windows, walls, and even kitchen countertops.

NOTE

If you want to learn more about the history of construction, look for Gyula Sebestyén's *Construction: Craft to Industry* (Spon Press, 1998). It is a fascinating read and takes a very comprehensive look at the many factors that influenced the growth of the construction industry from the collapse of the Roman Empire to planning for the global frontiers of the future.

Industry Sectors

The facility needs of a society are vast and varied. People need places to live, worship, work, receive medical care, shop, be educated, exercise, vacation, and generally engage life. From a facilities standpoint, all of these needs taken together are often referred to as the *built environment*. Although many other industries assist in creating the built environment, construction ultimately delivers it.

Each of these different facility needs is manifested as a different market or sector of the construction industry. There are five basic sectors of the industry:

- ◆ Residential building
- ◆ Commercial building
- ◆ Heavy civil construction
- ◆ Industrial construction
- ◆ Environmental construction

Each sector is characterized by different means, methods, and materials of construction. The types of equipment, the type of structural framework, the manufacturers, the suppliers, the specialty contractors, and even the sources of funding vary with each sector. For example, structural steel frames, steel erection, and steel fabrication are all common components of the commercial, but not residential, sector. On the other hand, wood frame structures, rough carpentry, and lumber are common components of the residential, but not commercial, sector of the industry.

Each sector requires specific expertise and familiarity in order to optimize the construction operations and management efforts. Therefore, the majority of builders focus their attention on only one sector or market of the industry. Furthermore, each sector has a particular “personality” or character. Everyone interested in pursuing a career in construction management will ultimately have to choose which sector they are most attracted to. So, let's take a closer look at each of these sectors.

Residential Building

Residential construction addresses the housing needs of a society. Housing construction takes many forms: individual homes, apartments, condominiums, townhouses, and prefabricated units such as modular and manufactured homes.

NOTE

Individual homes are classified as *single-family dwellings*. Apartments, condominiums, and townhouses are all referred to as *multi-family dwellings*.

Residential construction is typically funded by private individuals or developers for their own use or for sale. Builders of individual homes generally fall within one of three categories: they are *custom builders* constructing one-of-a-kind homes for specific customers on specific lots, they are single-family *small-volume builders* who build 25 or fewer homes a year, or they are single-family *production builders* who build more than 25 homes a year.

Although custom and small-volume builders account for approximately 70 to 80 percent of all residential builders, they produce only about 20 percent of the homes. On the other hand, production builders construct almost 80 percent of the homes in the United States.

Although some custom homes may be designed by an architect, many house plans are available from catalogs and plan books. In some cases, the contractor may provide the design for the customer. Engineering services are rarely required, and construction techniques are relatively simple. The project duration for a typical single-family home is in the three- to six-month range. Even high-end custom homes can be built in one year or less. Large production builders focus their efforts by creating communities of 50 to 400 houses in one location. These large projects will build out over several years.

NOTE

Production builders used to be called *tract builders*. Tract builders gained a reputation in the 1940s, 1950s, and 1960s for producing “cookie-cutter” homes—homes that all looked alike. Today's production builders offer numerous custom options and upgrades while still utilizing standard designs and floor plans.

Means and Methods

Residential construction is relatively low-tech in terms of the means and methods needed to produce its product. Hammers, nails, drills, and saws still make up the primary tools and equipment needed to perform the construction tasks, although the hammers are now pneumatic nailing guns. Many contractors joke that any two guys with a pickup truck, a cell phone, and a dog can start a residential construction company. This exaggeration is not far from the truth. The residential construction market is relatively easy to get into; however, because so many of the companies are very small, they are also at high risk for failure. One bad job can put the contractor out of business in a hurry. However, the large production builders are big business, generating annual revenues and profits surpassing those of many large commercial construction companies. They are engaged in every aspect of home building, from land acquisition to financing, and are often publicly owned and traded on the stock market.

Primary Materials

Residential construction is often referred to as *wood frame construction* or *light framing*. The building materials utilized in this sector are typically wood products such as lumber and plywood. Over the past 25 to 30 years, attempts have been made to replace traditional wood framing with light gauge steel framing in an effort to conserve natural resources. The use of light gauge steel is still quite limited in residential framing; however, great strides have been made in better utilizing every piece of a harvested tree: the branches, the wood chips, and even the sawdust. Numerous engineered wood

products have emerged, such as roof and floor trusses, laminated beams, oriented strand board, and wood I-beams. These products are now commonplace.

Exterior finishes for residential buildings are usually limited to siding, brick, or stucco. Single-family dwellings are most often designed with pitched roofs utilizing various types of shingles or tiles made of asphalt, clay, concrete, or slate. Interior finishes typically include drywall partitions and ceilings with paint or wall coverings and carpet, tile, hardwood, laminate, or sheet vinyl floors.

Characteristics

Whether the residential construction firm is a small mom-and-pop operation or a huge publicly owned enterprise, there are certain characteristics of this market that anyone contemplating a career in building should understand. Home building is personal. Your client is usually an individual family with individual personalities. This is probably not the sector for you if you are not a people person. Home buyers are spending their personal funds on these projects, and usually it is the single largest amount of money they have ever spent.

As a construction manager, you will be directly involved with the owner on a regular basis. You will get to experience the full range of emotions and temperaments associated with the home-buying public. There is a great deal of personal service and hand-holding that will be required of you. Many construction professionals delight in this aspect of the business, anxious to address every detail and concern that an owner might have regarding the building process, while others cringe at the thought of having to deal with someone at such an intimate level.

Residential construction companies come in all sizes. Some limit their service area to a local market, others might expand operations regionally or nationally, and a few are even building overseas in Europe and South America. Of all the construction industry sectors, the residential sector probably requires the broadest scope of knowledge. Construction is only one facet of the home-building business. An understanding of sales, marketing, financing, land development, entitlement, building codes, purchasing, construction

operations, customer service, and warranty are all needed to participate in this sector of the industry.

Commercial Building

This sector of the industry primarily addresses the needs of commerce, trade, and government and makes up about a third of the total construction market. This is the category that includes banks, schools, office buildings, hotels, shopping malls, religious facilities, baseball stadiums, theaters, universities, amusement parks, hospitals, courthouses, government buildings, and other facilities where people gather. These projects may range in size from a small medical office to large high-rise office buildings to state-of-the-art biotechnology facilities. The building costs are significantly higher than with residential construction, and the project duration is much longer. It is not uncommon for a commercial project to last three years or more.

Funding for these types of building projects may be private, public, or combined in a special private-public partnership. Commercial construction companies are usually categorized by their dollar volume per year. For example, a company that does less than \$10 million per year might be classified as a small commercial contractor, whereas a large commercial contractor completes more than \$250 million of work annually. Of course, everything is relative to a given market. What might be considered a large company in Nebraska could easily be classified as a small company in California.

Commercial projects are very wide-ranging in scope, and it's difficult to develop expertise in all areas. For example, hospitals and clean rooms, which have very specialized systems, require contractors who possess the special knowledge needed to successfully perform the construction. Therefore, it is not unusual for a commercial contractor to focus their attention on only a few building types.

Commercial projects are typically designed by architects. The building systems can be complex, and various specialty engineers are engaged to support the architect with the electrical, mechanical, and structural design. Additional consultants may also be brought in for unique requirements of the project. For example, a sound and acoustics engineer is a likely participant on a concert hall project but would not be called in for a retail facility. And given the interest in sustainability,

a LEED consultant would be a “must-have” member on the construction team. (LEED is discussed in more detail later in the chapter; see the “Sustainability” section.)

Means and Methods

Commercial construction tends to be far more technically complex than residential construction. Special construction processes are utilized in the building of commercial buildings, and specially trained technicians are required. The use of concrete casting beds, *cofferdams*, and *slip forms* are common techniques in commercial construction but would seldom ever be utilized in residential construction. Although plumbers, electricians, and painters are some of the trades required in both the commercial and residential sectors, ironworkers, pipefitters, and glaziers are more likely to be exclusive to the commercial (and industrial) sectors. The equipment needs in commercial construction are much more extensive as well. Cranes are a common sight on most commercial projects, as well as pile drivers, welding machines, and concrete pumps.

cofferdams

Temporary watertight enclosures erected to prevent water from seeping into an area, allowing construction to take place in the water-free space.

slip forms

Concrete forms that rise up the wall as construction progresses.

As a construction manager involved in commercial building, you will be required to work with numerous specialty contractors and union workers employed in various trades. The labor management aspect of commercial construction can be complex and requires special knowledge of labor laws and collective bargaining.

Primary Materials

Just take a look at any downtown city area, and you will see a variety of combinations of the three basic building materials associated with commercial building: steel, concrete, and glass. These three materials compose the primary materials utilized in commercial construction. Commercial buildings consist of some type of building frame or structure and an exterior cladding to cover the frame. The cladding material is usually applied as a *curtain wall* of brick, stone, concrete, aluminum, steel, or glass or as an exterior insulation panel. In some cases, reinforced concrete masonry (RCM) is the material of choice for commercial buildings of limited height.

curtain wall

An exterior cladding system that is supported entirely by the frame of the building, rather than being self-supporting or load-bearing.

The frame of a commercial building is designed to withstand certain loads and conditions. Architects and engineers will determine whether a steel frame or reinforced concrete frame is best suited for the building. Glass is a common cladding material for commercial buildings, although other materials are available for this purpose. In some cases, the entire building frame and cladding are concrete. There is very little wood used in commercial buildings because of the higher fire-resistive design standards required by building codes.

Interior partitions are most often constructed of light-gauge steel studs covered with drywall. Interior finishes include paint, wall coverings, carpet, tile, marble, granite, and acoustic ceilings.

Most commercial buildings have flat roofs covered with a bituminous membrane with gravel ballast or some type of a vinyl or rubber covering. Commercial buildings with sloped roofs are often covered with prefinished metal roofing.

Characteristics

Unlike the residential sector, commercial buildings are typically funded by corporations, agencies, or the government. Personal dollars are not involved, and the owners are typically not as concerned with

the day-to-day operations of construction. However, they are concerned with meeting the schedule and getting their operations up and running as quickly as possible. This need for speed to market has prompted many changes in *project delivery* that will be discussed later in this book.

project delivery

A comprehensive process by which a building, facility, or structure is designed and constructed.

The primary focus in commercial building is actually the construction itself. If you are fascinated with tall buildings, towering cranes, and complex construction details, then commercial construction may be your niche. Depending on the size of the company, opportunities exist at the local, regional, national, or international levels.

Whereas residential construction requires an across-the-board understanding of the home building business, commercial construction requires a deep understanding of construction processes and techniques. Commercial contractors are rarely involved in the sales or marketing or land acquisition components of the project.

Heavy Civil Construction

This sector of the industry impacts all of society in a very big way. Often referred to as *horizontal construction*, the heavy civil sector includes roadways, bridges, tunnels, dams, airports, and railways. Basically, any work that is associated with infrastructure, transportation, and how we move about involves the heavy civil construction market. Similar to the industrial sector, heavy civil projects are complex, usually high-dollar endeavors that take special engineering know-how. This market is huge and growing larger every day. The need for building and rebuilding of our nation's roadways, airports, sewage plants, and bridges is great.

These projects are typically designed by civil engineers, and often the construction management team has a strong background in civil engineering as well. Heavy civil construction firms are generally very

large operations that can offer opportunities nationally and internationally. However, the heavy civil sector of the industry is difficult to enter because of the huge capital outlay required for entry, not to mention the specialized knowledge required to be successful.

Means and Methods

Only a few trades are engaged in heavy civil construction compared to the other three sectors. There is no need for carpet layers or drywall finishers in this sector of the market. On the other hand, equipment and equipment operators play a huge role in the work of a heavy civil project. Heavy civil contractors make huge investments in equipment. Keeping the earth movers, excavators, scrappers, and trucks rolling is the name of the game for this sector of the industry.

Primary Materials

Asphalt, gravel, concrete, steel, and dirt make up the primary materials used in heavy civil construction. Most of us have witnessed highway road crews as they lay down new asphalt on our highways and streets. We watch as they bring in loads of gravel and rock dust before they place the hot asphalt and roll out the roadway.

Other heavy civil projects such as bridges and dams make use of large amounts of concrete and steel. For example, a dam project may require that a concrete-batching plant be constructed right on the building site in order to accommodate the quantities of concrete needed.

Characteristics

These projects are usually publicly funded and tend to last for a long time. Building miles of roads can take many years. It is not unusual for individuals involved in this sector of the market to move temporarily to where the project is located. There are also occasions when your work might require that you be located in isolated areas for long stretches of time. However, anyone intrigued by big machines, tractors, and excavators will be attracted to this sector. This sector of the market is the least affected by economic fluctuations and, therefore, can offer a reasonable measure of job stability.

Industrial Construction

This sector of the industry is highly specialized and requires firms with vast resources and significant construction and engineering expertise. The number of contractors qualified to work within the industrial sector is limited. The project types included in this category are defined primarily by the production activities that occur within the facility. Manufacturing plants, electrical generating facilities, oil refineries, pipelines, steel mills, and chemical processing plants are all examples of industrial construction projects.

Means and Methods

Industrial buildings are often very basic in their exterior design. The building shell does not need to be very fancy for its intended purpose. The success of an industrial project is usually determined by how well the facility is able to perform relative to its production goals. In industrial construction, the processes that go on inside the shell constitute the real construction challenge. Unlike residential or commercial construction, the installation of equipment makes up a big piece of the industrial construction process. Massive boilers, reactors, and processors that need to be installed under strict quality standards and regulatory guidelines are what really count here.

Because of the complex process considerations, engineers are typically the lead designers on these types of projects. The means and methods associated with the construction of the building shell are quite simplistic; however, the installation of the equipment and process systems require technological savvy, sophisticated knowledge, and great attention to detail.

Primary Materials

The building materials utilized in industrial construction are very similar to those used in commercial construction. Steel, concrete, and reinforced concrete masonry make up the primary components. These buildings often house specialized equipment, machinery, or process piping, and the interior finishes are usually quite stark for ease of maintenance. Often the concrete or block walls are simply painted, concrete floors are left unfinished, and no ceiling finish is applied, thus leaving exposed piping and ductwork in full view. In

some cases, special materials, such as glass piping or heat-sensitive tiles, may be utilized in the construction of industrial buildings.

Characteristics

This sector of the industry deals with building huge facilities that take many years to complete. In some cases, a project may be under construction for as long as 5 to 10 years, and the possibility of the construction management team having to relocate is quite high. The funding for these projects is usually provided by private sources, and the contract amounts are generally large. There are many international opportunities in industrial construction, and anyone seeking a chance to travel abroad will most likely find it within this sector. Having an interest in international business, international law, or even world politics could be an asset for anyone considering this sector. And, of course, fluency in a foreign language is always a plus.

Sometimes industrial projects are located in remote areas, even to the point where modern conveniences are in short supply. Depending on the facility type, there may be requirements for high security clearance and government oversight. It is very important that the engineers and construction managers on these projects work closely together because the consequences of poor communication can be serious.

Environmental Construction

Although some people may lump environmental construction under the heavy civil category, it is unique enough to have its own classification, especially considering the increase in market share that this sector is currently experiencing and probably will for some time to come. Generally, this sector of the industry is comprised of projects that improve the environment, maintain public health, and contribute to a community's quality of life. Think clean water, sanitary sewers, and waste management. And although these projects may not seem very glamorous at first glance, in reality they represent one of the most vital sectors of the industry and one that demands a significant investment in order to sustain our communities.

brownfield sites

A property that is abandoned or underused because of historic environmental contamination.

In the United States, we don't give much thought to what happens to the water that we release down the drain after taking a bath or what happens once we flush a toilet. Most people don't even consider where our drinking water comes from, especially with many of us buying a bottle from the local convenience store. And then there's what happens to the plastic bottle that the water we purchased came in. But the fact is that each one of these daily occurrences is directly tied to the environmental construction sector. This sector builds the conveyance systems, treatment plants, and operations facilities necessary to collect, treat, reclaim, and distribute water. It works to build desalination plants, clean up hazardous sites, and handle other ecological endeavors such as managing and restoring watersheds and wetlands. It is also the sector of the industry that deals with landfill remediation and the redevelopment of the *brownfield sites* left behind. Often these sites become golf courses, parks, or other recreational areas, and the contractors who mitigated the hazards are often the same contractors who get to complete the restoration work as well. Quite rewarding work, wouldn't you say? If you are one of those individuals who is particularly interested in improving the environment and sustaining the planet, then environmental construction may be the perfect opportunity for you to get your feet wet—literally!

Means and Methods

There is a great deal of earth moving and site work that usually takes place with any environmental project along with trenching and pipe laying, asphalt removal and installation, tunneling, blasting, and other means of excavation. However, many environmental projects still require a building or structure to house the specialized instrumentation, monitoring equipment, incinerators, and process piping to operate the system. Therefore, the same means and methods associated with typical industrial or commercial

construction also come into play in this sector. These facilities still need foundations, exterior cladding, windows, doors, roofing, and finishes, as well as mechanical and electrical systems. These support buildings may not be as fancy as a bank or a museum, but they still need to provide a proper work environment for the people who operate the facilities.

Primary Materials

Environmental projects are often comprised of a combination of commercial, industrial, and heavy civil building materials. However, in addition to dirt, gravel, asphalt, concrete, rebar, steel, and piping, we also need specialized materials such as pumps, valves, filters, membranes, and aerators, just to name a few. Special electronic equipment and controls are also part of the mix on these projects, and a vital one at that. Because the facility isn't really of much use unless it can operate and perform as designed, these elements become a critical part of the equation. The construction manager, who often has an engineering background, must be familiar with these items and their operation so they can manage their procurement, delivery, installation, and sometimes even performance after installation.

Characteristics

Because construction managers are often involved with public health issues in environmental construction, you can expect to spend a significant amount of your time dealing with governmental and regulatory agencies such as the Environmental Protection Agency (EPA) and the Center for Disease Control (CDC), not to mention the myriad of state and local authorities. For this reason, individuals involved in this sector of the industry not only need to be familiar with construction means, methods, and management but also need to be familiar with the law, particularly those laws and regulations dealing with public health and the environment. As a matter of fact, many construction management graduates who go on to work in the environmental sector often get graduate degrees in environmental engineering or environmental law.

NOTE

I once asked the president of an international environmental construction firm why he left the commercial building side of the industry to dedicate his life to building water systems and sewage treatment plants. He told me he got bored with commercial construction. He admitted that it may seem “sexier” to build high-rises, but in reality, when you spend your day building facilities that ensure a clean and fresh water supply, safe and sanitary wastewater treatment, and a healthy environment for communities, then you go home at night knowing you made a difference, whether anyone notices or not.

Furthermore, you will find yourself working with individuals beyond the usual group of construction colleagues. In environmental construction it is not unusual to be collaborating with chemists, biologists, ecologists, and other scientists who deal with the actual quality of the water, soil, and other materials that flow through or interact with the systems that you build. As you can see, there are many opportunities to expand your knowledge and learning beyond construction in this sector of the industry.

Similar to the heavy civil industry, environmental construction projects are usually not a luxury item—they are necessities. And given the current state of our existing municipal water and wastewater systems in the United States (many are 50 or more years old—the entire life expectancy of a typical system), and the fact that most projects are publicly funded, we will see a great deal of work in this area and, therefore, the need for construction managers who have a propensity toward projects that support the environment.

The Project Players

As our brief walk through construction history revealed earlier, the days of the individual master builder are long gone. No longer is it practical to expect one person to design, engineer, and build construction projects. Today's master builder is a collaborative team with diverse skills and expertise. Many, many players are involved, and they all make a valuable contribution to the effort while at the same time adding to the complexity of the process. It is very important to understand the various roles and responsibilities of these many players as they influence the construction management process.

In addition to getting to know the primary players in the game, you need to know the secondary players involved and the various layers of influence and risks associated with their involvement. Understanding the intricacy of these relationships will help you appreciate the management function in construction.

Primary Players

The three principal players in any construction project are the owner, the designers (architects and engineers), and the contractor. Although these three parties are always involved in a project, the alignment and contractual relationships among them will vary depending on the project delivery system utilized to deliver the project. Project delivery will be discussed in [Chapter 2](#), “What Is Construction Management?” Each of these parties provides distinct services and has specific accountabilities necessary to fulfill the building objectives.

Owners

No construction would ever be accomplished without owners. They are the driving force behind the construction industry. Their demands for housing, commercial facilities, industrial products, and infrastructure are the chief motivation to build. After determining need and deciding to build, the owner is accountable for four primary duties:

program

A written statement that identifies and describes an owner or end user's needs and requirements for a facility. Every design starts with a program.

- ◆ Developing the *program* and outlining the needs and requirements of the end users
- ◆ Determining the quantity, extent, and character of the project by defining the scope of work
- ◆ Creating the overall budget for the project, including land acquisition (if necessary), development, design, and construction costs
- ◆ Providing the funding for the project and making periodic payments to the designers and the contractor

How an owner accomplishes these tasks is often determined by what type of owner they are. There are basically two types of owners—public owners and private owners. Public owners are typically government agencies such as the General Services Administration, the Army Corps of Engineers, or the state departments of transportation. These agencies represent the public and spend tax dollars to build courthouses, military bases, and federal highways. Private owners make up the bulk of construction spending and may take the form of an individual building a single home, a developer who builds speculatively, a small manufacturer enlarging operations, or a national firm that owns numerous facilities. Funding comes from private sources such as banks, investment brokers, and venture capitalists.

Design Professionals

Two types of professional designers are engaged in the construction process, and each deals with different parts of the project design. Architects deal with the function, life safety issues, and aesthetics of the building, and engineers deal with the systems. They typically work

together to complete the design function with one or the other taking the lead, depending on the type of facility being constructed.

NOTE

I will use the term *designer* throughout the text to imply either an architect or an engineer.

The construction manager works with both the architect and the engineer on a regular basis throughout the construction process. The following are the primary responsibilities of the designers:

- ◆ Assisting the owner in developing the facility program and determining end user needs and requirements
- ◆ Advising the owner regarding the image and character of the facility and establishing broad design goals
- ◆ Assisting the owner in selecting products to fit the program and the budget
- ◆ Advising the owner on special and aesthetic issues and generating graphic solutions to problems
- ◆ Developing the final building plans, construction details, and specifications

To better understand the distinctions between architectural design and engineering design, consider the human body. Just as a body has a particular functional design with arms, legs, and a head, as well as skin and hair to protect it from the elements, so does a building with various rooms, porches, stairs, an exterior cladding of brick or siding, and shingles or asphalt on the roof to keep it dry. The body has a skeletal system to keep it straight and upright, and a building has a structural frame to keep it straight and upright. The body has a circulation system to move blood and nutrients. A building has a plumbing and mechanical system to move water, waste, heat, and air conditioning. The body has a central nervous system to send energy to our legs and arms. A building has an electrical and communications system to send messages and deliver power to our

offices and living spaces. Basically, architects deal with the arms, legs, hair, and skin, and engineers deal with the bones, blood, and nerves.

Architects

Architects are licensed professionals trained in the art and science of building design. They transform the owner's program into concepts and then develop the concepts into building images and plans that can be constructed by others. In addition to completing a four- or five-year college program, architects are also required to have a number of years of experience and pass an exam before they can become licensed.

Architects design the overall aesthetic and functional look of buildings and other structures. The design of a building involves far more than its appearance. Buildings also must be functional, safe, and economical, and they must suit the needs of the people who use them. Architects also specify the building materials and, in some cases, the interior furnishings. In developing designs, architects follow building codes, zoning laws, fire regulations, and other ordinances, such as those requiring easy access by people who are disabled. Several specific roles within the typical architect's office support the architectural design function:

Design architects Design architects are the creators of the aesthetic solution—they are the concept and idea people. Although most design architects can only hope to achieve celebrity status, some become quite famous. As previously mentioned, we often recognize their names in association with their creations—Frank Lloyd Wright, Alvar Alto, I.M. Pei, Julia Morgan, and Frank O. Gehry, to name a few. They are sometimes referred to as *signature architects*. Owners often seek them out because of their reputations. They are typically the senior associates or principal partners within the architectural firm. Their function first and foremost is to come up with the creative expression. They convey their ideas to their design staffs through sketches and schematic renderings. They do not typically engage in the actual production of the construction drawings. They are supported by architectural technicians and specification writers in the preparation of the final construction documents.

Architectural technicians Architectural technicians are typically the drafters of the building plans. They are the ones who actually produce the drawings that are used for construction. They work from preliminary sketches and concept drawings provided by the design architects. However, the days of sitting at a drawing board with a mechanical pencil in hand using a T-square and a triangle are all but gone. Today, drafters have become computer operators and produce their drawings electronically using computer-aided design (CAD) software. Some CAD operators have expanded their skills to include 3D building information modeling (BIM) as well. As the trend toward information modeling continues, these technicians will become more and more valuable in the marketplace.

Specification writers Accompanying the plans for a new building is a written project manual that contains the specifications for the project. The plans and specifications compose two parts of the legal contract for construction. (A third component is the contract forms themselves.) The specification writer is responsible for spelling out the specific products and methods that are to be used on a project in order to ensure a particular level of performance and quality.

Engineers

Engineers are usually the lead designers for heavy civil and industrial projects. Engineers are regulated by professional licensing requirements that include a four- or five-year college program, a specific number of years of experience, and the passing of a professional licensing exam. However, in building design, they are most often hired as consultants by the architects. In this scenario, they have no direct contact with the owner.

There are many different engineering specialties; the most common ones associated with construction activities are described next:

Structural engineers Structural engineers design the timber, concrete, or steel structural systems that support a building and basically hold it up to withstand the forces of wind, gravity, and seismic activity. They design the foundations, beams, girders, and columns that make up the skeleton of the structure.

Mechanical engineers Mechanical engineers design the heating, cooling, ventilating, plumbing, and fire suppression systems within a building. They coordinate their efforts with the architectural design, the structural design, and the electrical design.

Electrical engineers Electrical engineers design and calculate electrical loads and determine the circuitry, lighting, motors, transformers, and telecommunications needed for a building. They typically work closely with the architect to ensure that the owner's expectations are met and often coordinate their efforts with the mechanical engineer.

Civil engineers Civil engineers design roads, bridges, tunnels, dams, site drainage, parking lots, runways, and water supply and sewage systems. Civil engineering, considered one of the oldest engineering disciplines, encompasses many specialties. Civil engineers are the ones who take the bare land and excavate it, move it, drill it, and shape it to meet the needs of the architectural design and the construction. Site work is one of the most unpredictable and expensive aspects of any construction project, and good design makes all the difference in the world.

Landscape Architects

I am including landscape architects as a separate design professional because they are. Many people do not understand the distinction, but landscape architects are professionals licensed and regulated by an entity separate from building architects. Landscape architects deal with the building site and outside environmental issues surrounding the structure. They are involved with such things as plantings, sidewalks, retaining walls, and water features to enhance the project. Large architectural firms may employ landscape architects on staff and utilize their services in the overall design. Or the landscape professional may be hired directly by the owner or work under a separate contract with the builder.

NOTE

Great landscape design can make an ordinary building look extraordinary. Likewise, an ill-conceived landscape design can make an extraordinary building look ordinary. Unfortunately, many owners fail to see the significance of this design element and shortchange the budget for landscape design.

Interior Designers

Not all projects will engage the services of an interior designer. They may be hired directly by the owner or be a consultant to the architect. They deal with the building's interior finishes or schemes and make decisions regarding furniture selection and placement, paint colors and accessories, light fixtures, window treatments, floor finishes, and ceiling treatments. The contractor may or may not have direct dealings with the interior designer.

Construction Professionals

According to the American Institute of Constructors, the term *constructor* is generally used to define the professional responsible for all construction activities whether they work as a general contractor, a construction manager, or a specialty contractor. The profession of constructor includes job titles such as, but not limited to, project manager, general superintendent, project executive, operations manager, construction manager, and chief executive officer. The constructor's job is to do the following:

- ◆ Interpret the plans and specifications and prepare cost estimates and time schedules to meet the requirements of the owner.
- ◆ Determine and implement the best construction practices, means, and methods to satisfy the owner's requirements for time, cost, and quality.
- ◆ Oversee and manage all of the construction operations into a single, safe coordinated effort.

General Contractors

The general contractor, also known as the *prime contractor*, enters into a contract with the owner to deliver the construction project in accordance with the plans and specifications that have been prepared by the architects and engineers. They may or may not actually perform any of the actual construction work with their own forces. When they do, they are said to be doing *self-performed work*. When they don't, they arrange for subcontractors or trade contractors to perform the specialized craftwork such as excavation, concrete placement, painting, or plumbing. Today, more often than not, the general contractor maintains only a management staff and a field staff as permanent employees. The construction management staff includes estimators, schedulers, and purchasing agents, while the field management staff consists of superintendents, foremen, field engineers, and lead workers. The work of the trades is performed under separate subcontracts with various specialty contractors.

self-performed work

Construction work that is performed with the general contractor's own forces or labor. This is work that is not subcontracted.

Construction Managers

Construction managers may be employed by construction management firms, general contractors, architects, engineers, owners, or specialty contractors. The primary responsibility of the construction manager is to organize the project team to perform the construction management function that is the topic of this entire book.

Specialty Contractors

Specialty contractors are often referred to as *subcontractors* because they perform their work under a contract with another contractor (typically the general contractor) to do a portion of the contractor's work, as opposed to contracting directly with an owner. These

subcontractors, in turn, may engage other subcontractors. Thus, there can be several levels of subcontracting to a general contractor.

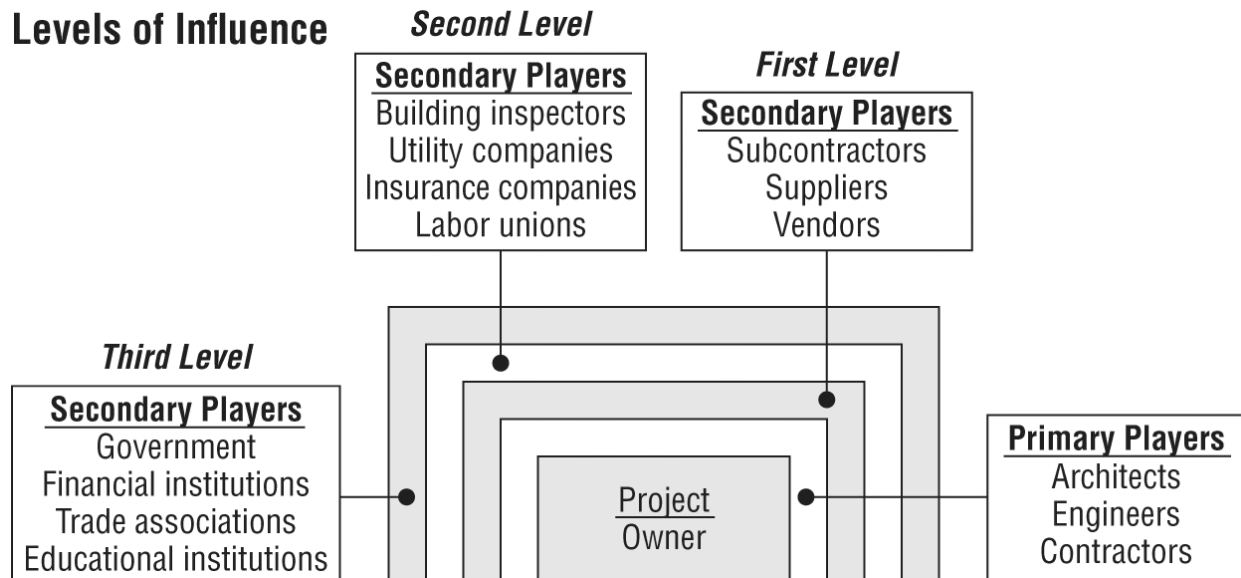
The Building Trades

It is important to include the trade workers as part of the construction professionals' discussion because, without them, there would be no construction at all. These are the men and women (plumbers, electricians, ironworkers, and so on) who actually perform the work. These skilled and semi-skilled workers are the construction industry's most valuable asset, although they are rarely recognized for their immense contribution. Unfortunately, too, their ranks are dwindling to crisis proportions, despite relatively high compensation, because of decreased training opportunities, traditionally provided by labor unions and vocational schools. However, various trade associations such as the Associated General Contractors (AGC), Associated Builders and Contractors (ABC), and the National Association of Women in Construction (NAWIC) have tried to pick up the slack by introducing educational opportunities through special initiative programs.

Secondary Players

Construction is second only to the restaurant business when it comes to high-risk business endeavors. Four out of five construction companies will go out of business during their first year. There are many factors for this. One of them is the power that outside parties have over the entire construction process and outcome. These secondary players, or what I call *layers of influence*, are beyond the immediate control of any of the primary players. I have divided these layers of influence into three levels.

Levels of Influence



First-Level Players

This level of influence includes subcontractors, material suppliers, and equipment vendors. This layer directly influences the outcome of a job in a serious way. Although this group is often directly connected to the primary players via a subcontract agreement or a purchase order agreement, they are primarily independent operators and not under the immediate control of the owner, the architect, or the contractor. And because they are not under direct control and yet provide vital services, they always add risks to the project. For example, a subcontractor is scheduled to start their portion of the work on a certain date but instead shows up three weeks later, delaying the startup of other related work and, therefore, delaying the completion of the overall project. Or a material supplier promises to deliver the concrete block for a commercial building on a Monday, and your masonry subcontractor has a full crew waiting to start the work at 7 a.m. The delivery doesn't arrive, and the subcontractor goes off to start another job. The block delivery then shows up on Tuesday, but the subcontractor is unwilling to return to your job until he finishes the one that he has already started.

Second-Level Players

This level of influence includes insurance companies, utility companies, bonding companies, building code officials, zoning, labor unions, and manufacturers. Although this level has no contractual

connection or obligation to any of the three primary parties, they hold great influence over your project. For instance, a building inspector can shut down operations on a job for even the slightest code infringement, causing work stoppage for trades not even involved in the infringement. Or an insurance agent who fails to issue certificates of insurance on subcontractors in a timely fashion can put a monkey wrench in the administrative requirements and ultimately put the project schedule at risk. Or a strike at a manufacturing plant thousands of miles away can delay the delivery of your air conditioning units for a new retail store, delaying the completion of the job, delaying the opening of the store, and, therefore, costing the owner thousands of dollars in lost revenue for each day of delay.

Third-Level Players

This layer of influence includes the courts and attorneys, local government, state and federal government, trade associations, education and training, bankers, and others. Like the second level mentioned previously, these parties do not have a direct link to the primary players but do influence construction projects on a regular basis. Although the effects are not always immediate, actions and decisions by this group of players can have a significant impact on the whole industry, which eventually trickles down to the project level. For instance, government agencies that adopt policies or create new laws relative to such things as growth, wetlands, or endangered species are constantly having an impact on the construction industry. With the stroke of a pen, a project can be stopped dead in its tracks, and millions of dollars can be at stake for the owner, the contractor, and even the architect, not to mention the eventual end users. Decisions to eliminate craft training and educational opportunities at vocational high schools and the decrease in labor union training have greatly affected the industry. The shortage of skilled workers immediately impacts the ability of the construction manager to deliver a quality product on time and within budget to the owner. It is the single most important issue facing the industry today.

The Industry Image

In my estimation, construction is one of the most honorable professions that a person can pursue. However, the image of the construction industry is admittedly not always a positive one. As so often is the case, the negative aspects of this industry get the most coverage in the media and through word-of-mouth. The positive aspects—and there are many—are less often communicated, leaving us with the stereotypical images of construction. Practitioners who are all brawn and no brains, an unreliable workforce, a dangerous and dirty work environment, unscrupulous contractors posing as professional contractors, and entrenched discriminatory and sexist attitudes are some of the imagery conjured up regarding the construction industry. Don't get me wrong, the industry has its challenges; however, I find the industry to be filled with principled, hardworking, dedicated individuals, committed to building better communities. The industry may not have done the best job projecting its image in a positive light over the years, but that is changing. And as a teacher of the next generation of construction professionals, I can tell you that the future is looking very bright.

An Industry in Transition

Turning the image of the construction industry around is no easy task. Millions of dollars have been invested by several construction associations over the past several years in an effort to change the public's perception, and it appears to be paying off. The Associated General Contractors (AGC) has developed an exciting campaign called *Construction Futures*, an initiative designed to alter the current perception of the construction industry and to inform and educate youngsters, their parents, and teachers about the career opportunities that the construction industry has to offer.

The National Association of Home Builders (NAHB) created a public service campaign called *Home Builders Care* to recognize contractors who have contributed millions of dollars in cash, building materials, supplies, and countless volunteer hours to community charities through local community service projects.

Another effort, *ABCares*, is a national community service initiative undertaken by the Associated Builders and Contractors (ABC) to

recognize chapters that contribute significantly to their communities.

NOTE

Even the toy industry appears to be contributing to the rebuilding of the industry's image, although unintentionally, I'm sure. The *Bob the Builder* television franchise has sold millions of dolls, storybooks, and assorted toys in recent years.

It is hard to tell whether the efforts by the various construction associations have paid off, but it seems that the industry is clearly in transition, and there are clear signs that a new respect for construction is emerging. The days of the individual master builder are long gone, but the new master builder, the collaborative team, is taking on challenges the likes of which have never been seen before, and the world is watching. The rebuilding of the Pentagon after September 11, 2001, is a good example. A project that was slated to take five years by federal government estimates was completed by September 11, 2002, in only 364 days by men and women determined to show what the American construction industry can do.

In 2004 and 2006 the Construction Users Round Table (CURT) published two white papers. The 2004 paper was entitled “Collaboration, Integrated Information, and the Project Lifecycle in Building Design, Construction and Operation.” The 2006 paper was entitled “Optimizing the Construction Process: An Implementation Strategy.” (You can access both papers on the CURT website at www.curt.org. The papers are free for members and available for a small fee to nonmembers.) These white papers stress the need for more collaboration and teamwork among project players in the design and construction process and the implementation and use of advanced technology to address design and construction integration issues. The Construction Users Round Table represents owners—our clients, stakeholders, and end users in the construction business—and it is very important that we listen to what the organization is saying. These white papers articulate a clear message about the direction owners want the industry to take, and it appears that contractors and construction managers are responding.

Technology

As with most industries, advancements in technology have revolutionized the way that we do business in construction. Software programs are available to assist with almost every management function in construction. Programs for estimating, scheduling, cost control, project administration, and team collaboration are common. Projects are managed using web-based “project integration” programs that allow all members of the team to exchange information, access building plans and specifications, process change orders, and even view construction activities and progress via a webcam from thousands of miles away. Building foundations and layouts are pinpointed using laser levels and GPS on a regular basis. Just as CAD revolutionized architecture practice in the early 1980s, architects, engineers, and constructors can now develop three-dimensional *BIM models* and virtual reality to improve design, constructability, safety, and training. Now the project team can conduct *constructability reviews* and anticipate and address construction problems before the first shovel of dirt is ever turned on the job site.

constructability reviews

A design review process in which experienced contractors and construction managers work with designers to ensure that the details of the design actually can be built in an efficient and cost-effective manner. The process entails review of materials, application, installation techniques, field execution, and building systems.

The construction environment is becoming more and more complicated, and the need for innovation is paramount. Not only has technology changed the way that we manage projects, but building materials, construction methods, and the projects themselves have become more sophisticated. Buildings are becoming “smart.” Automated homes, offices, plants, and other facilities are using computers, networks, and programs to control specific operations such as temperature, airflow, lighting levels, and access.

BIM model

A digital representation of the physical and functional characteristics of a building displayed as a 3D model, with the added capability to integrate a whole array of design and construction data related to cost, schedule, materials, assembly, maintenance, energy use, and more.

Simply knowing how to swing a hammer or wield a power drill will not cut it anymore. It is not uncommon for even the smallest of construction firms to have laptop computers in the job trailer and computer tablets in every job foreman's hand. Anyone who perceives the construction industry to be all brawn and no brains certainly has not visited a job site lately. "Toto, we are not in Kansas anymore!"

Globalization

With annual revenues expected to reach over \$15 trillion worldwide by 2030, more and more U.S. companies are pursuing international opportunities. It is projected that China, the United States, and India will account for 57 percent of all global growth in construction over the next decade according to PwC (Price Waterhouse and Coopers).

Each year, the weekly construction magazine *Engineering News Record* (ENR) publishes a list of the top 250 international construction firms. In 2018, 36 U.S. companies made that list, or just under 15 percent of the total. Eight U.S. companies were listed in the top 10 international firms.

ENR's Top 250 International Construction Companies – US Companies in the Top 10	2017 Ranking	2018 Ranking
BECHTEL, San Francisco, Calif., U.S.A.	5	12
FLUOR CORP., Irving, Texas, U.S.A.	16	13
PCL CONSTRUCTION ENTERPRISES INC., Denver, Colo., U.S.A.	36	30
AECOM, Los Angeles, Calif., U.S.A.	81	75
KIEWIT CORP., Omaha, Neb., U.S.A.	70	81
JACOBS, Dallas, Texas, U.S.A.	65	84
CB&I, The Woodlands, Texas, U.S.A.	49	91
KBR INC., Houston, Texas, U.S.A.	77	93

*2018 rankings.

Today anyone working in the construction industry should anticipate a future involving an international experience. The world is getting smaller, and the demand for infrastructure and building programs for roads, dams, power plants, water and sewer facilities, mass transit, and even housing in emerging and third-world countries is immense. Individuals pursuing careers in construction management who are interested in the international market will undoubtedly have the opportunity to track that venture.

Sustainability

Today, a much greater emphasis is being placed on the environment and the relationship between our buildings and the communities in which they are constructed. In recent years, a voluntary, market-driven building-rating system called the Leadership on Energy and Environmental Design (LEED) program, developed by the U.S. Green Building Council (USGBC), has been making its way into segments of the construction industry. This program, which evaluates environmental performance from a “whole building” perspective over a building's life cycle, is becoming so popular that many states are requiring LEED certification of its public buildings. The LEED Green Building Rating System is a third-party certification program and the nationally accepted benchmark for the design, construction, and operation of high-performance green buildings. LEED provides building owners and operators with the tools they need to have an immediate and measureable impact on their buildings' performance.

Green building and green building technologies are being applied to every sector of the industry, and construction practitioners are

playing a vital role in carrying out and implementing sustainable goals and objectives on projects.

Not only are buildings being certified LEED but so are the individuals who design and construct them. Today it is quite common to see the initials “LEED AP” (for LEED Accredited Professional) printed on a business card after the name of a construction manager. As a matter of fact, there are many construction management students who have already achieved their LEED AP designation by the time they graduate. This is a testament to the dedication and commitment that has been expressed by the construction community toward building sustainable communities. It is clear evidence that sustainability is not some passing fancy—rather, it's an accepted and standard way of doing business in the construction industry today. You will learn much more about Sustainability and the Built Environment in [Chapter 16](#).

Efficiency

Historically the design and construction industry has had the notorious reputation of being one of the most wasteful and inefficient industries in the United States. However, in 1993 a group of contractors started to apply *lean principles*, typically associated with manufacturing, to the construction industry. Basically, lean principles, originally derived from the management philosophy known as the Toyota Production System (TPS), are centered on creating more value with less work. In other words, it's the elimination of waste in all forms—wasted materials, wasted time, wasted movement, wasted manpower, and so on. Today, the Lean Construction Institute (LCI) has developed a number of processes and procedures specifically focused on the construction industry that support the lean philosophy. One such technique is called the Last Planner System, which focuses on stabilizing workflows in the construction process, thereby adding reliability to the schedule.

lean principles

Stemming from the Toyota Production System, principles that focus on creating more value for customers with less work and the elimination of waste. These principles are now being applied to the construction industry.

With such innovations, along with the ever-increasing use of advanced technologies such as BIM making their way into construction firms, it is indeed a very exciting time to be in construction. (To find out more about the last planner approach, go to www.leanconstruction.org/lastplanner.htm.)

Diversity

There is no doubt that the construction industry in the United States is still a white- and male-dominated industry. However, the demand for construction managers is so significant that the only way the need can be met is by opening the doors to attract the best and the brightest to join in the effort to take on the building challenges around the world. And just as in other traditionally male industries, the face of construction is changing. As a professor of construction management, I have a chance to talk with recruiters from every sector of the industry and from all over the country. There is a conscious effort being made to bring diversity to the forefront of the profession, and tremendous opportunities for women and minorities in the construction industry exist today.

Collaboration

The Web is no longer a passive place where people idly surf, read, listen, or watch without engaging. Today, the Web is also a business tool that allows us to network together, participate in dialogue, and collaborate. Facebook, LinkedIn, and Twitter are just a few of the networks people are using regularly to interact socially and professionally.

Although the construction industry, in general, has been slow to take advantage of many digital innovations, several peer-to-peer

messaging and meeting platforms are growing in popularity and use by the next generation of construction professionals. Examples include: GroupMe, WeTxt, GoToMeeting, and Zoom. These collaboration and communication platforms allow team members to easily reply to hundreds of contacts at once, or organize team communications into groups to quickly send project updates and jobsite broadcasts. The challenge of scheduling meetings has been mostly eliminated by using any number of online meeting services to connect and discuss projects while sharing files and images right on our computer screens. And these examples don't even represent those designed specifically for construction. I'll discuss those in more detail in [Chapter 15](#).

Making a Difference

The contributions of the construction industry relative to the changing needs and demands of our society are becoming more apparent. Construction management holds the promise to help close the gap between design and end user satisfaction by offering team leadership, project feasibility reviews, constructability analysis, value engineering, and life-cycle cost evaluation.

There are not many professions where you can look around and actually see the difference that you are making in the world. In construction, the results of your work are right there for the whole universe to see. This became very apparent to me just as I was about to leave the construction industry and return to the university to complete a master's degree and doctorate.

In 1995, I left Virginia, where I had had my design and construction business for 10 years. On my last Sunday there, a woman from my church whom I did not know came up to me. She took my hand and, with tears in her eyes, thanked me for the wonderful contribution that I had made to the community. Her husband had worked for me as a subcontractor before his passing, and she spoke of how proud he'd been to be working on some of my buildings. Well, I too began to get teary-eyed, and when I left church, I rode around that town and looked at the many homes, restaurants, and office buildings that I had designed and built. Until that day, I had never realized the impact that I and others make every day we go to work in construction.

Knowing that I can return to that community 50 years from now and still view the fruits of my labor is a pretty awesome thing. The truth is that my work will still be standing long after I am gone—if not quite as long as the pyramids have lasted, at least long enough to impress my grandchildren's grandchildren.

Career Opportunities

According to the U.S. Bureau of Labor Statistics, “employment of construction managers is projected to grow 10 percent from 2016 to 2026, faster than the average for all occupations.” Construction managers are expected to be needed to oversee the anticipated increase in construction activity over the coming decade. Those with a bachelor's degree in construction science, construction management, or civil engineering, coupled with construction experience, will have the best job prospects. The bottom line is that the industry needs more construction managers than the universities can turn out. This is the case across the nation. As the level and complexity of construction activity continues to grow, so will the demand for qualified construction managers.

Distinguishing Construction Companies

One of the things that makes a career in construction so appealing is that the firms that perform construction services come in all shapes and sizes, across all sectors of the industry. One of the ways we distinguish construction companies is by their geographical reach. Construction companies may be identified as local, regional, national, and even international. Anyone choosing a career in construction will be able to easily match their personal and professional preferences when it comes to selecting a size and type of firm to work for. You can find sector-specific companies within each type of geographical distinction—residential, commercial, civil, industrial, and environmental.

Characteristics, Advantages, and Disadvantages

Each type of company will have various pros and cons relative to a number of factors. For example, number of employees, number of offices, location of offices, organizational structures, annual revenue, wage and salary ranges, training opportunities, use of technology, relocation requirements, scope of services offered, and opportunities for advancement and promotion are just a few of the distinguishing characteristics.

- ◆ **Local companies**—Local companies are just that—they are local and serve a narrow clientele usually limited to a city or county area. The advantages to a local company are that they are most likely well known in their communities and often family owned. The number of employees could range from just a few to 50–100+ depending on the type of construction performed and the sector of the industry. Similarly, annual revenues will vary depending on the same variables—type of construction and sector of the industry. One of the advantages to working for a smaller, local company, is that you have an opportunity to learn many aspects of the business because you have to wear many hats. This could also be construed as a disadvantage. But the biggest complaint that I have heard from employees of smaller local companies is that there are fewer opportunities for advancement and often a lack of formalized training and limited use of technology. You may also see lower wages and salaries. On the upside, most likely you won't get pigeon-holed and stuck doing narrowly defined tasks for long periods of time. More than likely you will be tasked to do multiple jobs—sometimes all at the same time. But if you like being part of a smaller organization where everyone knows your name, then “local” is good. There will be little to no distance between the field and the leadership of the company—you may expect to have daily interactions with the president of the company. And you won't have to worry about being asked to pull up stakes and move to a new location when one job ends and another one begins.
- ◆ **Regional companies**—These companies usually will branch out across an entire state or may even work in a multistate area such as the Rocky Mountain region, or the Mid-Atlantic region, or the Northwest Region. Once again, the number of employees and revenue will depend on sector of the industry and type of construction. It's likely they will have more employees than a local company, but still have a pretty good grasp of the names of the individuals who work for them. Compensation will likely be more than a local company can afford, but still may be shy of what the nationals can pay. You may enjoy some perks at a regional company that would not be available at many local companies, such as a company truck. A regional company may or may not have more than one office. Or they may have a main

office with perhaps one or two smaller satellite offices.

Expanding to a regional market is often a first growth step for successful local companies. This can sometimes lead to a good opportunity for an up and coming younger employee who seeks advancement in responsibility and compensation. They may be charged with setting up a satellite office and soliciting for new business in a new area. The growth of regional companies often begins with a single satisfied client who wants their “local firm” to do work for them elsewhere. In other words, the contractor follows their client to a new location and then grows from there. Once you have a reasonably sized job in a new locale, it may make sense to pursue additional clients and additional business which leads to the company having a presence in a new area. This scenario is a common impetus for expansion.

- ◆ **National companies**—National companies generally do business all across the United States and have offices in many cities with a headquarters or home office in one of them. The number of employees, annual revenues, and volume of work will correlate with the size of their geographic range and scope of services. Generally, national companies will have more formalized employee recruiting and training programs, as well as more formal organizational hierarchies. You can also expect higher wages and salaries with more expansive benefits and job-related perks like company vehicles, cell phones, and iPads. There are many advantages to working for a large national company. These companies often employ the latest technologies and provide training to employees in their application and use. They will also have more formal administrative and management processes and procedures. One of the disadvantages is that you will most likely not know your fellow workers in all of the various branch offices. You'll be familiar with your group but certainly not the entire company. And there is a great distance between the frontlines and the executive level leadership of the company. Opportunities for advancement and promotion will be greater than with a local or even regional company. However, it is far more likely that you will be relocated at least once in your career from one office to another.

- ◆ **International companies**—If you choose to work for an International company, more than likely, travel and relocation becomes a common experience for you. The projects that international companies are often involved in are large-to-mega in size. Salaries and wages will be similar to the nationals with added “hardship” compensation paid for extensive travel, multiple relocations, or remote assignments. All the benefits and perks, trainings, technology, and opportunities that exist with a national company are going to be equivalent with an international company. It's common for the international companies to have thousands of employees located in offices and on projects all over the world. You often see international companies create distinct divisions like the U.S. Division, or a North American division. This is particularly helpful when cultural and operational protocols differ from one area of the globe to another. Obviously, the opportunities for advancement are immense—as is the accountabilities that come with those advancements. Anyone who likes to travel and experience other cultures could be right at home in an international company. The biggest challenges usually involve family matters associated with having school-age children or a working spouse. It's not so easy to pick up and move every one to two years once you have a need to establish roots. But if you have risen to an executive level in an international company, the need to relocate your family is most likely no longer necessary, although regular overnight travel is very common, along with the accumulation of a lot of frequent flyer miles!

Sample of Types and Sizes of Companies				
Company Name	Scope	Primary Sector	Employees	Headquarters
Vertex Builders	Local	Commercial	14	Frederick, CO
Thrive Home Builders	Local	Residential	21	Denver, CO
Texas Cordia Construction	Local	Civil	45	Edinburg, TX
Haselden Construction	Regional	Commercial	302	Centennial, CO
Pahlisch Homes	Regional	Residential	111	Bend, OR
Wollam Construction	Regional	Civil	32	Sandy, UT
Hensel Phelps Construction	National	Commercial	3167	Greeley, CO
Lennar Homes	National	Residential	9111	Miami, FL
Granite Construction	National	Civil	3600	Watsonville, CA
Skanska	International	Commercial, Civil, Residential	42,903	Stockholm, Sweden
Balfour Beatty	International	Commercial, Civil, Industrial	26,000	London, UK
Bechtel Group Inc.	International	Commercial, Civil, Environmental	55,000	Reston, VA

*Employee numbers are approximate for 2017–2019.

Advancement Opportunities

Construction managers may go to work for a number of different organizations. On the private side, general contractors, construction management firms, architectural or engineering firms, developers, financial institutions, and large corporations may all hire construction managers. On the public side, various state and federal agencies, public schools and universities, departments of transportation, federal prison systems, and others may seek their skills as well.

As in any profession, advancement opportunities for construction managers vary depending on an individual's performance, ability, and the size of the company they work for. The customary progression for a new construction management recruit is to start as a field engineer and then move to an assistant superintendent position, superintendent, estimator, assistant project manager, and then project manager. Within larger firms, highly qualified construction managers may eventually become top-level managers and executives, often moving to the vice president level or higher. Many construction managers will opt to branch out and start their own businesses.

Educational Offerings

The ideal construction management candidate is typically an individual who has a bachelor's degree or higher in construction management, construction engineering, or construction science, as well as practical experience working in construction. The work experience and hands-on knowledge of construction are as valuable as the degree. For this reason, many construction management students combine their formal university educations with paid internships while attending school. It is also not uncommon to find experienced field personnel pursuing their degrees in construction management as nontraditional older students.

Opportunities for education and training in construction management are numerous. As previously mentioned, the Associated Schools of Construction (ASC) lists about 160+ colleges and universities offering four-year accredited degree programs in construction management or construction science, in the United States and abroad. There are also a number of two-year colleges that offer construction management or construction technology courses. For graduate studies, there are dozens of universities that offer a master's degree, and at least a half-dozen universities that offer a PhD in Construction Management. In addition, several of the construction, engineering, and architecture trade and professional associations regularly host educational seminars on various construction management topics.

Typical course offerings in construction management include construction methods and materials, site surveying and layout, contract administration, construction documents, value analysis, cost estimating, scheduling, cost controls, accounting, business and financial management, building codes and standards, inspection procedures, engineering and architectural sciences, mathematics, statistics, computer applications, and information technology. Several of these topics will be discussed throughout this book.

Professional Affiliation and Certification

One of the easiest ways to get acquainted with the construction management profession is to become familiar with the various professional organizations affiliated with the industry. At least 250

organizations are associated with construction and its practitioners. Two of these organizations offer voluntary certification programs for construction managers. Requirements combine a written examination with verification of professional experience.

The American Institute of Constructors

The American Institute of Constructors (AIC) helps individual contractors who meet the requirements to achieve professional status through an examination and certification program. AIC is the certifying body for the designation of Certified Professional Constructor (CPC) and Associate Constructor (AC). The organization was formed in 1971 and serves the industry in a professional capacity similar to the professional organizations for architecture and engineering. You can learn more about the AIC at www.aicnet.org.

The Construction Management Association of America

The Construction Management Association of America (CMAA) is dedicated to promoting the professional practice of construction management. The organization welcomes members from all construction and design disciplines as well as owners and various service providers to the industry. The CMAA offers professional designations through its Certified Construction Manager (CCM) program for individuals who complete its self-study course, pass the certification exam, and meet other requirements set forth by the organization. To learn more about the CMAA, go to its website at <http://cmaanet.org>.

Other Associations

Several other recognized professional associations warrant mentioning. Each of them offers training courses and seminars on various construction and construction management topics on a regular basis.

Associated General Contractors of America Formed in 1918, the Associated General Contractors of America (AGC) is the oldest major organization serving the interests of general contractors. Its membership includes general contractors and specialty contractors as well as suppliers and service vendors

such as insurance agencies, bonding companies, and technology merchants. You can learn more about the AGC at www.agc.org.

Associated Builders and Contractors Associated Builders and Contractors (ABC) is a national trade association comprising contractor and subcontractor members who support a merit job philosophy. As such, members adhere to the belief that construction contracts should be awarded on the sole basis of merit regardless of labor or union affiliation. Their membership also includes material suppliers, vendors, and industry service providers. If you want to learn more about ABC and the merit shop philosophy, visit its website at <http://abc.org>.

National Association of Women in Construction The National Association of Women in Construction (NAWIC) was formed in 1955 in the state of Texas. It now has members in 49 U.S. states and 3 Canadian provinces. NAWIC is dedicated to advancing career opportunities for women who are engaged in the construction industry. Its membership includes women working on the management and administrative side of the business as well as women who are working in the trades, such as electricians, carpenters, and welders. To learn more about NAWIC, check out its website at <http://nawic.org>.

National Association of Minority Contractors The National Association of Minority Contractors (NAMC) is a nonprofit trade association that was established in 1969. In addition to providing training and networking opportunities, the organization's primary mission is to address the needs and concerns of minority contractors. Although membership is open to people of all races and ethnic backgrounds, the group focuses on construction industry concerns common to African Americans, Asian Americans, Hispanic Americans, and Native Americans. To learn more, go to www.namcnational.org.

National Association of Home Builders The National Association of Home Builders (NAHB) is the largest of the construction associations with 211,000 members nationwide. Among its ranks are individuals from home building and remodeling companies of every size. A large percentage of the organization's members come from related business venues such

as building supplies, manufacturing, mortgage banking, real estate, and insurance. You can learn more about NAHB by going to its website at www.nahb.org.

Design-Build Institute of America The Design-Build Institute of America (DBIA) is one of the newest professional organizations serving the design and construction industries. Founded in 1993, DBIA is dedicated to the practice of integrated project delivery, representing members of the entire project team: contractors, architects, engineers, and owners. In 2001, DBIA initiated a professional designation program recognizing design-builders as unique service providers in the industry. Individual practitioners, who complete a required educational program, successfully complete the designation exam, and meet the experience requirements of the program are recognized as Designated Design-Build Professionals, displaying “DBIA” after their names. In 2009, DBIA added an entry-level category to its designation program. The Associate DBIA certification is now available to college graduates who complete the education and testing requirements but who have not yet met the experience requirement. To learn more about design-build, visit the DBIA website at www.dbia.org.

Project Management Institute The Project Management Institute (PMI) serves individual members from around the world who are dedicated to advancing the practices and methods associated with professional project management. PMI has members from a wide variety of industries, such as information technology, business, engineering, pharmaceuticals, financial services, telecommunications, and construction. It offers a Project Management Professional (PMP) certification program that is recognized around the world. If you want to learn more about PMI, go to its website at <http://pmi.org>.

United States Green Building Council In 1993, the United States Green Building Council (USGBC) was formed as a nonprofit, nongovernmental organization with a diverse membership of architects, contractors, owners, product manufacturers, environmentalists, and others who are interested in the promotion of green building in the United States. In 1998, the organization launched a nationally recognized rating system

for benchmarking the design, construction, and operation of “green buildings.” The system, referred to as LEED, is a voluntary rating system that identifies a definitive standard for what constitutes “green building.” The goal of LEED is to evaluate the environmental performance of a building from a holistic perspective and measure that performance over the building's lifecycle.

Individuals can become accredited as LEED AP professionals by passing an exam administered by the Green Building Certification Institute (GBCI). You can learn more about the USGBC by going to its website at www.usgbc.org.

Lean Construction Institute The Lean Construction Institute (LCI) was founded in August 1997 and is now a nonprofit corporation. The institute is involved in research to develop knowledge regarding project-based production management in the design, engineering, and construction of capital facilities. To learn more about the LCI, visit its website at www.leanconstruction.org.

Terms to Know

base isolators	lean principles
brownfield sites	program
constructability review	project delivery
cofferdams	self-performed work
curtain wall	slip forms
infrastructure	specifications

Review Questions

1. What is the name of the stone carvings dating back to the pyramids that contained the first written regulations pertaining to construction, commonly referred to as the first known building code?
2. By what specific measurement is construction used as an economic indicator for the U.S. economy?
3. What are the five primary sectors of the construction industry?
4. What is the name of the organization credited with promoting construction management as a legitimate and unique area of study at four-year universities?
5. What is the role of the owner on a construction project?
6. What is the name of the weekly magazine dedicated solely to the construction industry?
7. Name three associations affiliated with the construction industry.
8. What does LEED stand for, and what is its purpose?
9. What two construction associations offer voluntary certification programs for construction managers?
10. What is lean construction, and from what industry does its concepts stem?

Chapter 2

What Is Construction Management?

In This Chapter

- ◆ What makes the construction project unique
- ◆ What factors determine the success of a construction project
- ◆ The owner's role in initiating the project delivery process
- ◆ How owners select and procure their construction services
- ◆ Trends in project delivery
- ◆ The various construction management functions
- ◆ What it takes to be a construction manager

In [Chapter 1](#), “The Construction Industry,” you discovered that construction is about much more than just bricks and sticks or mud and mortar. You understand that buying construction is very different from buying cars or computers. Construction is complex, and many factors influence the outcome of a construction project. The job of the construction manager is to take a set of written plans and specifications and a raw piece of land and then coordinate all of the materials, manpower, and equipment necessary to guarantee the set price, schedule, and quality of the project—without any accidents or errors, regardless of weather conditions, interest rate fluctuations, acts of God, or any other unforeseen conditions. (Whew!)

Today the pressure for speedy delivery, cost efficiency, and high quality is immense. The success of any construction project depends on the men and women who plan, organize, and perform the work that transforms someone's dream into a reality. The process of constructing a building or a bridge does not happen in a factory under controlled conditions. It occurs in a dynamic environment where risk is inherent and the decision-making and problem-solving abilities of the construction management team are crucial to the success or failure of the project.

Let's now focus on the construction process itself and the specific management functions unique to that process.

Construction Management Defined

One of the best definitions that I have come across over the years is from Charles Patrick's *Construction Project Planning and Scheduling*. According to Patrick, "Construction management (CM) entails the planning, scheduling, evaluation, and controlling of construction tasks or activities to accomplish specific objectives by effectively allocating and utilizing appropriate labor, material, and time resources in a manner that minimizes costs and maximizes customer/owner satisfaction."

Although this definition explains the function of construction management, the discipline or profession of construction management is not quite so easy to understand. That's because construction management is not just a single task or activity. It comprises several tasks and is usually delivered by a construction management team. At the same time, an individual member of a construction management team performing even one of the CM functions is said to be doing construction management. Is it any wonder that the general public is by and large unaware of construction management as a distinct career?

If that isn't confusing enough, let's also consider the different ways the construction management function is offered as a service to the consuming public. In the most traditional sense, the construction management function is simply provided alongside the actual construction services. In other words, when an owner hires a general contractor to perform work for them, they get that contractor's construction management services as part of the package. The general contractor uses these skills to keep the project running on time, within budget, and in accordance with the plans and specifications provided by the owner's design professionals. However, if there are errors or omissions in the plans and specifications that were not discovered prior to construction, the contractor is not liable for any resulting cost overruns or time delays.

On the other hand, construction management may be contracted by the owner as a professional service separate from the work of the general contractor. In this case, part of the construction manager's job is to review the plans and specifications before construction begins. Doing so will reduce unwanted consequences and repercussions resulting from a lack of oversight by a construction professional. Construction management in these circumstances is usually provided as a distinct service or project delivery method.

I realize that much of this may seem a bit confusing right now, but later in the chapter I will spend time discussing the various project delivery methods and the functions of construction management. For now, I just want you to understand that many different people perform construction management services. This group of people includes general contractors, subcontractors, project managers, construction managers, construction estimators, general superintendents, job foremen, safety officers, quality control managers, and many other construction professionals. It takes a whole team of players to manage the construction project.

NOTE

Throughout this book, when I use the term *construction manager*, *project manager*, or *constructor*, I am referring to any one of the entities that delivers construction management services: the general contractor, the construction management team, the construction management firm, or any individual construction manager trained in all aspects of construction management.

The Construction Project

As discussed in [Chapter 1](#), construction projects are extremely diverse and come in every size, shape, and flavor. However, some characteristics about construction projects are common to all types, and these characteristics clearly distinguish them as unique from other industry sectors.

When we build a computer, a piece of furniture, or even an airplane, we typically build a prototype first and then test it and work out the bugs before we put it into production. We do all of this under controlled conditions, using state-of-the-art mechanics, robotics, and technology. These projects are usually built utilizing a relatively constant workforce, standard parts, and stable materials.

Now let's take a look at the construction project. Every project is built as a one-of-a-kind facility, which means that each is built on a different building site, under variable weather conditions and particular environmental and topographical conditions. Each one is a prototype in and of itself. There is no testing it first to make sure it works. Instead, the bugs get worked out as we go. Our workforce is primarily transient practitioners of an assortment of trades moving from job to job as assigned, coming in and out of the process at various stages throughout the duration of the project. Although more automation is being utilized, for the most part, our labor is still performed by the human hand—laying the brick, forming the concrete, and setting the steel. Finally, many of our materials, such as lumber, concrete, and steel, are sourced from nature-made components. They react to the heat, the cold, and the humidity on any given day.

In spite of these uncertainties and unique circumstances affecting the project, a construction manager is expected to deliver a high-quality facility on time, within budget, and accident free. That's one heck of a management challenge, to say the least! But let's identify exactly what it is that we are trying to achieve. The primary objective of the construction management function is to control three main factors or values. They are time, cost, and quality. These three factors are commonly referred to in the industry as the *three-legged stool*.

However, there is actually one more very important factor, and that is safety. Construction can be a dangerous business, and safety must be the foundation upon which all other values are placed; without it, the whole project is at risk.

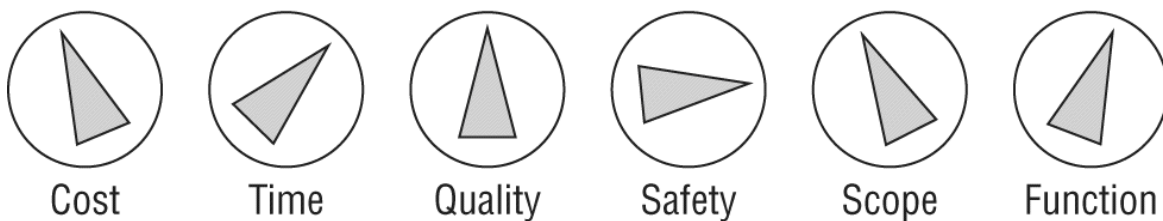
Let's take a closer look at all the factors that influence the construction project and how the construction manager considers each of them as part

of the management challenge.

Project Values

In 1996, a group of owners, architects, contractors, and engineers gathered in San Francisco to discuss common goals and opportunities for collaboration in the building industry. This group formally organized themselves as the Collaborative Process Institute (CPI). During their discussions, they came up with what I think are the best descriptors of the factors that need to be managed and controlled on a construction project in order to produce a successful outcome for the owner and all parties involved. They referred to these factors as the *six dials of project value*: cost, time, quality, safety, scope, and function.

The Six Dials of Project Value



The idea is that each of these dials has a most advantageous setting for any given project, and it is the project team's job to optimize these settings. As noted earlier, only the first four project values are within the traditional range of services provided by the construction management team: cost, time, quality, and safety. The last two, scope and function, are typically determined by the owner and their design team prior to the construction manager being involved. However, some project delivery methods bring the construction professionals onto the team early in the process so that they may assist with scope definition, overall function, and programming. I will discuss project delivery in greater detail later in this chapter.

NOTE

Although the Collaborative Process Institute (CPI) is no longer a functioning organization, its work and the ideas that came out of those first meetings are noteworthy and, in my opinion, reflect current trends in construction management.

These dials of values and how they are monitored and controlled are illustrated in the following list. The Collaborative Process Institute describes them as follows:

Cost It is essential to predict and control what the construction project will cost. Costs are established, targeted, and controlled by means of an estimate or budget. As the work progresses, expenditures for materials, labor, equipment, and subcontracts are tracked and measured against the estimates. The fundamental goal is to maintain costs within or below budget parameters. The construction manager who can minimize cost while maximizing overall value to the owner will optimize the cost dial.

Time As the saying goes, time is money. For many projects, the speed with which the building can be brought on line is more important than almost any other factor. Time is monitored and controlled by a detailed schedule, breaking each item of work down into its component parts. Once all of the purchasing, fabrication, installation, and construction steps are identified, a time element is assigned to each step. The goal is to complete each of the work items within the time frame assigned.

The construction management team that can guarantee the schedule and actually beat it is invaluable to the owner.

Quality Quality is the grab bag that covers all the aspects of the building not addressed by the other five values, such as aesthetic impact, user perceptions, appropriateness of building materials, and so on. Quality is monitored and controlled by a variety of means, including specifications, punch lists, inspections, tests, and user surveys. Special care must be taken to establish appropriate measures early in the project to focus attention and effort on the quality expectations of the team.

Safety No matter how valuable a facility or structure may be, it is never more valuable than the health and welfare of the people who build and use the building. Care must always be taken to ensure that the building process and the building itself do not create unacceptable hazards to workers or users. These hazards range from risks during the building process (for example, falls, accidents, injury, and death) to risks from the completed buildings (for example, toxic gases, biohazards, and structural failure). Safety is best monitored and controlled proactively by identifying potential risks and taking prudent steps to mitigate those risks.

Scope Scope is monitored and controlled by means of an architectural program, which identifies the space needs and tracks compliance of the building design with those needs. An optimal scope outcome would match the enduser's needs to the facility design over the life of the building with no gaps in between. The ultimate goal is high end-user satisfaction.

Function The best project teams try to meet all of the functional requirements of the end-user group. An optimal outcome would satisfy their short- and long-term needs, allowing for sufficient flexibility to adapt to changes in the market. Function is monitored and controlled by means of process flow diagrams and utilization analyses, which document the efficiency of the processes that will be performed in the completed facility.

Keep in mind that these dials are all interconnected and that adjusting one will ultimately cause a change in the others. For example, if an owner requests that we crank up the time dial and complete the project earlier than we had contracted to do initially, then it is likely that the cost dial will also be turned up. Likewise, if an owner increases the project scope, then both the time and the cost dials will be turned up. So, the job of the construction management team is to figure out how to best adjust, manage, and monitor these dials in order to optimize the performance of each value relative to the owner's requests. Throughout this book, I will focus on just how to do that for cost, time, quality, and safety.

The Owner Sets the Stage

Without project owners there are no projects. Every construction project starts with an owner who has a need for new, improved, or expanded facilities to serve their purpose. The purpose might be personal, such as a growing family that requires a bigger home with an additional bedroom or two. Or the purpose might be associated with a business endeavor that requires a manufacturing facility or an office complex. Then again, the purpose might be directed at serving the public such as the construction of a new railway station or a new high school. Whatever the purpose, the owner's needs must be articulated and defined in terms of the project values discussed in the previous section along with a description of the various architectural requirements and features necessary to meet those needs. Although this task, referred to as *architectural programming*, is the owner's responsibility, the owner often solicits the services of architects or other programming specialists to collect end-user information and conduct the research needed to develop it. The architectural program establishes the parameters for the design of the project and ultimately sets the stage for developing the *scope of work* that the contractor will be responsible for delivering.

architectural programming

The research and decision-making process, initiated by an owner, usually with the help of an architect or other programming specialist, that identifies the basic needs of the client and the parameters of the project to be designed and ultimately built by a construction professional.

scope of work

The parameters defining the overall extent of work to be included in a construction contract. The project scope is commonly communicated through construction plans and written specifications.

For building projects, at a minimum the architectural program typically includes information relating to the following:

- ◆ The building site and any known constraints or challenges associated with it
- ◆ The building's primary function and what is required in terms of square footage to meet the intended function
- ◆ The types of spaces that will be required, their adjacency to each other, and how they will be used
- ◆ Who will be using the spaces and what types of activities they will engage in
- ◆ The mechanical and electrical needs of the facility
- ◆ Aesthetics and architectural image
- ◆ Any unique or special requirements associated with the project

NOTE

As used throughout this book, the term *owner* has broad meaning. It generally implies the party responsible for financing the project. Therefore, in most cases, the term *client* could be substituted. However, in many instances, the term *owner* can also be construed to mean the enduser who ultimately uses the space. The term *owner* can also apply to the various stakeholders who may not have financed the project or use it directly but who have an interest in it. For example, in terms of a public school project, the owner responsible for financing the project would be the school district. At the same time, a teacher or student would be an enduser, and parents would definitely be classified as stakeholders. So, as a construction manager responsible for satisfying the “owner's” needs, it is important to understand exactly how deep that responsibility goes.

The reason the programming stage is so critical is because the program establishes the basis for the project scope.

Scope Definition

The architectural program provides the basis of the design, and the design directs the construction. In other words, the building details described in

the design define the limits or scope of work to be performed by the contractor.

The *scope of work* sets the parameters for the construction project and identifies the work to be done. Generally, the scope of work is presented in the plans or “blueprints” (so called because of the blueprint machines once used to reproduce them as white lines on blue paper) and in the written specifications, all of which are developed by the designer. The scope describes the building layout, site work, square footage, number of rooms, number of floors, types of materials (windows, siding, floor covering, roof, and so on), dimensions, special equipment, storage requirements, and so on. The scope of work detailed in the plans and specs also defines the level of quality for the project. For example, the architect may detail and specify brick exterior walls in lieu of siding and, by doing so, add a measure of life expectancy, durability, and aesthetic appeal not available with siding.

Part of the construction management challenge is to make sure that the scope of the project is being delivered as intended throughout the construction process. First, contractors need to make sure that they've included the entire scope of work in their estimates. Then it takes oversight to ensure that the correct materials specified and estimated are actually purchased and delivered to the job site for installation. And during construction, the details of the design must be checked and rechecked against the plans and specifications to verify that they are in compliance with the requirements stipulated by the contract.

The key to delivering a successful project is to start with a really well-defined project scope. A poorly written scope will usually result in a poor response from the contractor. Obviously, a contractor can't plan for something that is not defined as a requirement of the project to begin with. A well-written scope, more than any other factor, will help reduce risks for all parties involved. It is critically important that the owner takes the time, does the planning, and solicits the professional help needed to do a good job before the project begins. It will pay off for everyone in the long run.

Project Delivery Methods

Anyone who has ever taken on a construction project is well aware that most projects display some cost overruns, time delays, and conflicts among the various parties. Of course, the object of the game is to mitigate these risks as much as possible. One of the ways you can accomplish this is by choosing the right project delivery method to start with.

It is the owner who ultimately decides which project delivery method to use. Unfortunately, many owners are illequipped to make a thorough assessment of the many factors that can impact project success relative to the owner's specific criteria. Too often they choose a traditional methodology simply because they are familiar with it. Ultimately, they end up accepting less than stellar results, not realizing that their decision for project delivery had set the stage for inefficiencies and trouble before the project even started. However, I am getting ahead of myself. I will provide some insight into project delivery selection criteria later in this chapter. For now, let's just focus on what project delivery is and how construction management plays into it.

What Is Project Delivery?

Project delivery is the process by which all the procedures and components of designing and building a facility are organized and put together in an agreement that results in a completed project. The process begins with the compilation of needs and requirements of the owner spelled out in the architectural program. These needs and requirements are first expressed in preliminary plans from which initial material, equipment, and systems selections are made. With these selection decisions, the design becomes further refined until all design decisions are made and a final set of contract plans and specifications is completed. The owner then determines which procurement methodology (purchasing steps) to use to buy the construction services and the criteria that will be used to select the contractor. Finally, the owner selects which type of contract to employ. Once selected, the contractor goes about planning an overall strategy for delivering the project in accordance with the plans and specs that have been developed. All the parts and pieces of the agreement are put in place, and the game plan is established.

This game plan also determines how the players will interact and communicate with one another over the course of the project.

Types of Project Delivery

There are basically four primary project delivery methods: design-bid-build, at-risk-construction management, design-build, and integrated project delivery. Keep in mind that the functions associated with construction management are required in all four methods even though only one of them is actually named *construction management*. As I said earlier, this can get a little confusing.

These four project delivery methods differ in five fundamental ways:

- ◆ The number of contracts the owner executes
- ◆ The relationship and roles of each party to the contract
- ◆ The point at which the contractor gets involved in the project
- ◆ The ability to overlap design and construction
- ◆ Who warrants the sufficiency of the plans and specifications

Regardless of the project delivery method chosen, the three key players—the owner, the designer (architect and/or engineer), and the contractor—are *always* involved. The traditional roles and responsibilities for the three parties were spelled out in [Chapter 1](#), but keep in mind that the accountabilities and relationships change with the various project delivery methods, as I described in the previous list. And additional players will be added to the project team, usually as subcontracted partners. This will become clearer as you read the individual project delivery descriptions that follow. Each of these methods has specific advantages and disadvantages, and it is the owner's responsibility to assess the project delivery choices in relation to their project needs.

Design-Bid-Build

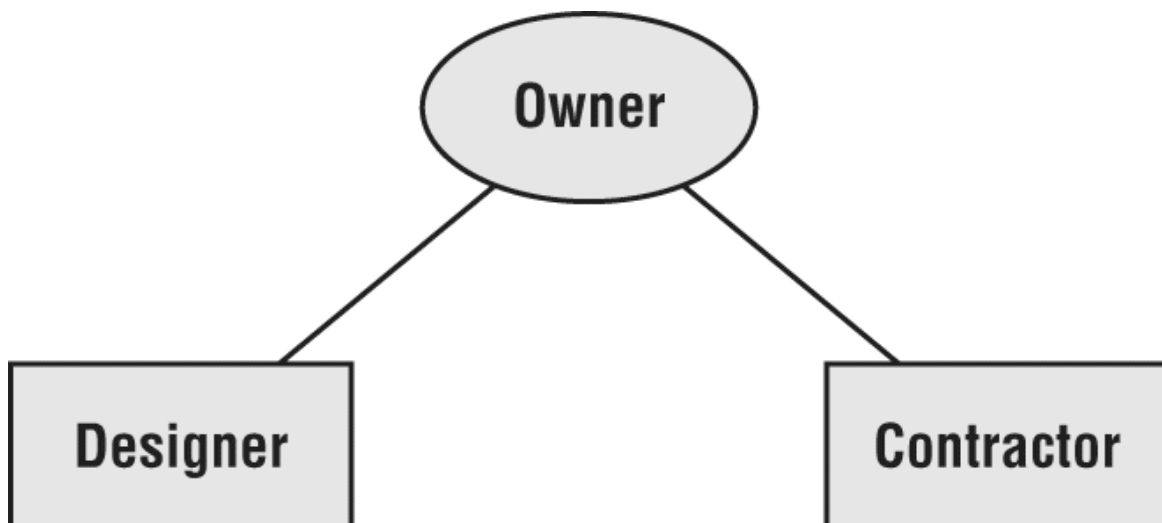
design-bid-build

A project delivery method in which the owner holds two separate contracts for design and construction. This method is often referred to as the traditional project delivery method.

Design-bid-build is commonly referred to as the traditional method of project delivery, and the traditional accountabilities apply. In this scenario, the owner first hires the architect or engineer to design the building or structure. The design professional prepares a design, moving through the three standard design phases: schematic design, design

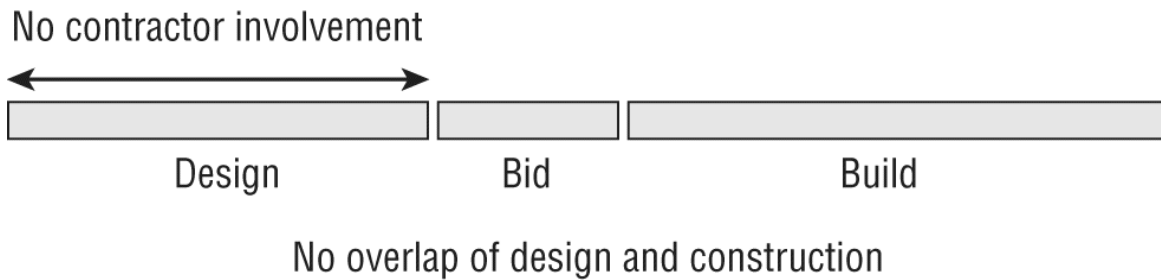
development (the design development drawings are often referred to in the industry as DDs), and finally contract documents (referred to as CDs). Under this arrangement, the design professional is usually selected on a qualifications basis and then is typically paid a fee or a percentage of the building cost for their services. (Contract documents will be discussed in greater detail in [Chapter 4](#), “The Construction Contract.”)

After the plans and specifications are complete, the owner selects the general contractor who will provide the construction and construction management services. The most common means for selecting the general contractor under this method is by low price or low bid: several competing contractors estimate the project based on the contract documents, and the builder with the lowest price gets the contract. The general contractor typically subcontracts various sections of the work to specialty contractors. Under this method, the owner holds two separate contracts, one with the designer and one with the contractor.



In this arrangement, all dealings between the designer and the contractor go through the owner. There is no legal agreement between the designer and the contractor. This method is very linear in nature, and the contractor does not have any input regarding the design of the project. The contractor is only responsible for carrying out the work as spelled out in the plans and specs and will utilize the various construction management functions to accomplish this task.

Design-Bid-Build Linear Approach



Under the design-bid-build method, the owner warrants the sufficiency of the plans and specs to the contractor. If there are gaps between the plans and specs and the owner's requirements or any errors and omissions in the design, the owner is responsible for paying for those corrections. I mention this because the contractor is often the one who discovers the errors and submits the change orders necessary to correct the work. This is never a happy occasion for the owner. A constructability review, which will be mentioned later, can help prevent such surprises.

Construction Management

As you now know, *construction management* may be viewed from several different perspectives, and one of them is as a specific project delivery method. Under this approach, construction management services are provided to the owner independent of the construction work itself. The owner has two options to choose from as to how they want the CM to interact with the actual construction of the project.

construction management

The planning, scheduling, evaluation, and controlling of construction tasks and activities to accomplish specific objectives outlined in the contract documents.

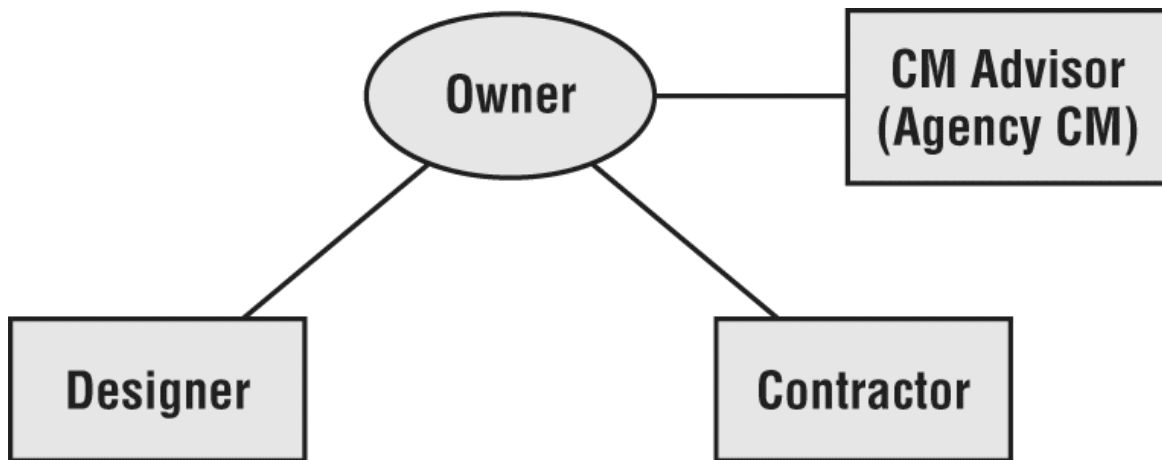
Option 1: agency CM The Construction Management Association of America (CMAA) defines *agency CM* as a fee-based service in which the construction manager is responsible exclusively to the owner and acts in the owner's best interests at every stage of the project. In this case, the construction manager offers advice uncolored by any conflicting interest because the construction

manager does not perform any of the actual construction work and is not financially at risk for it.

agency CM

A construction management option in which the construction manager acts in the owner's best interests at every stage of the project from design through construction. In this capacity, the construction manager provides only advice and management oversight services to the owner, and has no legal authority, operational responsibility, or financial obligation for the delivery of the design or construction of the project. Therefore, agency-CM is not a project delivery system, but simply a professional service.

This arrangement involves three contracts: one between the owner and the designer, one between the owner and the contractor, and one between the owner and the construction manager. The owner hires a designer and a contractor exactly as described under the design-bid-build scenario. In addition, the owner also contracts with a third party, a construction management firm that provides construction management functions but as an independent agent or representative of the owner.



The party responsible for the construction work is still an individual general contractor, and that contractor still carries out construction management functions relative to their internal requirements for managing the project to completion. In some unique situations, the owner may elect to bypass a general contractor and contract directly with several

specialty contractors and allow the CM firm to manage each of them. These are called *multiple prime* contracts.

Option 2: at-risk CM (also called CM/GC) The CMAA defines the *at-risk CM* project delivery method as an option that entails a commitment by the construction manager to deliver the project within a guaranteed maximum price (GMP). The construction manager acts as consultant to the owner in the development and design phases but does the work of a general contractor during the construction phase.

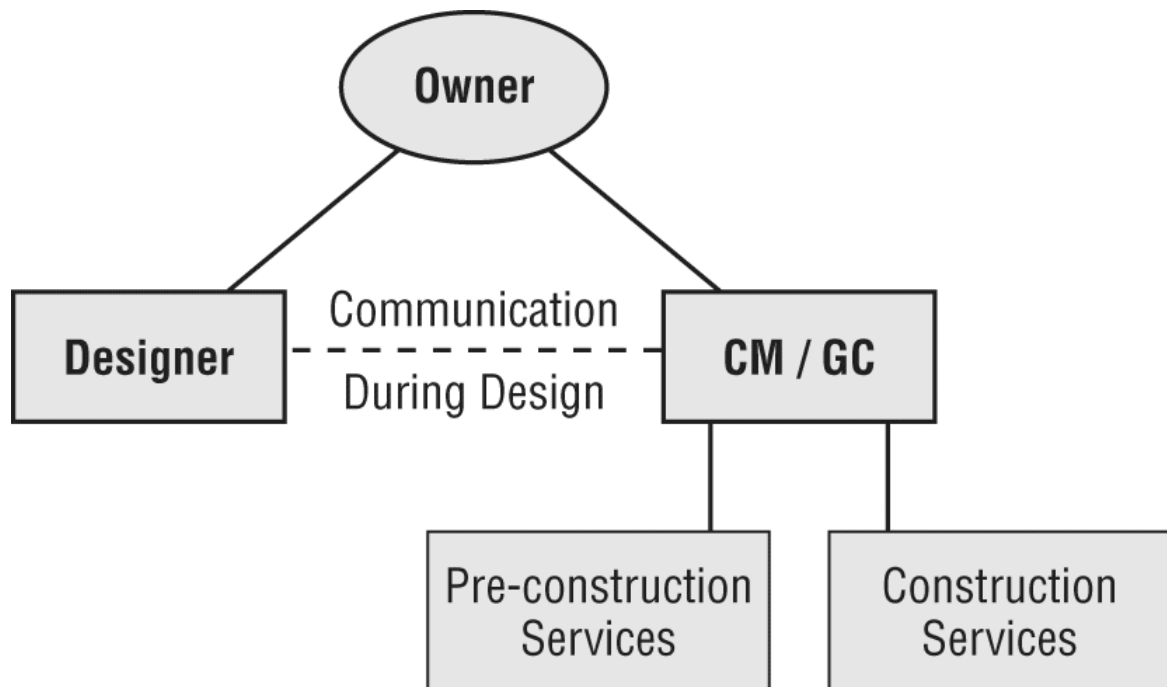
multiple prime

A contracting methodology in which the owner bypasses the use of a general contractor and enters into multiple separate contracts with trade or specialty contractors for the various sections of the work associated with the project, such as concrete, framing, mechanical, and electrical work. Each of the specialty contractors involved becomes a prime contractor on the project.

at-risk CM

A project delivery method where the construction manager acts as a consultant to the owner in the development and design phases but as the equivalent of a general contractor during the construction phase.

In this scenario, there are only two contracts, one between the owner and designer and one between the owner and the at-risk CM.



Although this might seem like a tricky relationship to manage, owners are comfortable with it because the at-risk CM is also responsible for performing the construction and carries financial liability for bringing the project in on time and within budget. By contrast, under the agency CM model, which is not classified as a project delivery method, the construction manager is not at risk for the budget, the schedule, or the performance of the work.

value engineering

A process in which various alternative approaches are evaluated and considered regarding design, product selection, or building system in an effort to provide the most efficient, cost-effective solution possible relative to value in response to the desires of the owner.

constructability reviews

A design review process in which experienced contractors and construction managers work with designers to ensure that the details of the design actually can be built in an efficient and cost-effective manner. The process entails review of materials, application, installation techniques, field execution, and building systems.

One of the great things about construction management project delivery is that it provides a contractual avenue by which the owner can bring the CM function into play early in the project planning and make direct dialogue with the design team possible. In these circumstances, the construction manager, acting on behalf of the owner, can contribute by providing *value engineering*, life-cycle cost analysis, conceptual estimating and scheduling, and what is called *constructability reviews* during the design process and head off possible incompatibilities between design and construction, which typically result in cost overruns, time delays, conflicts, and legal claims down the road.

NOTE

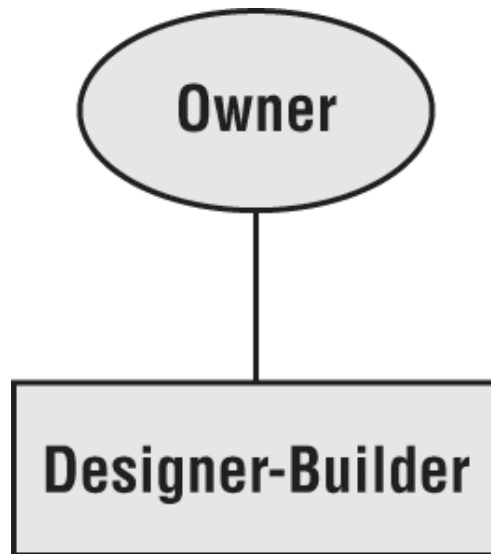
One of the most frustrating things that happens with traditional design-bid-build project delivery is when the estimates all come in too high. Then the project goes back to the drawing board for redesign and is significantly delayed, leaving everyone involved deeply disappointed. The way to avoid this common occurrence is by using a project delivery method that allows for early contractor involvement and encourages a team approach.

Design-Build

The *design-build* methodology continues to grow in popularity. It is often referred to as single-source project delivery and is the closest method we have to the master builder approach of old. In this arrangement, there is only one contract. The owner contracts with a design-build entity, which will be responsible for both the design and the construction of the project.

design-build

A project delivery method in which there is only one contract between the owner and a design-build entity. The design-builder is responsible for both the design and the construction of the project. This method is often referred to as single-source project delivery.



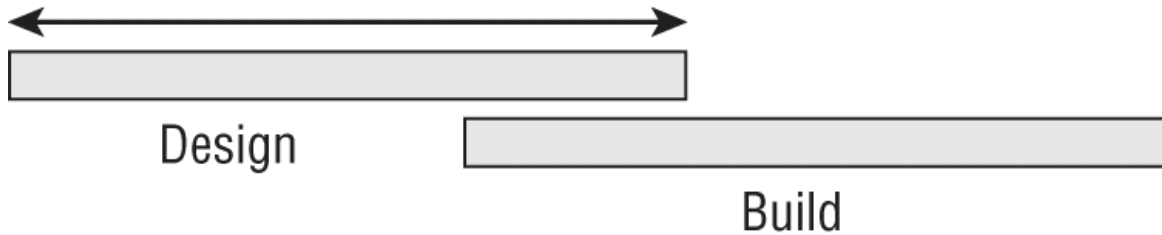
fast tracking

A practice utilized to speed up a job by overlapping the design phase and the construction phase of a project. It's often applied in design-build or construction management project delivery.

Whereas design-bid-build has linear sequencing of the work, design-build often integrates and overlaps design and construction and allows for something called *fast tracking*. If you remember me stating earlier in the chapter how important time is for many clients, you will understand why design-build has become the project delivery method of choice for many owners today.

Design-Build Integrated Approach

Extensive contractor involvement



Overlapped design and construction

Under the design-build method, the design-builder warrants the sufficiency of the plans and specs to the owner. The design-builder is liable for any gaps between the plans and specs and the owner's requirements for the performance of the building. If there are any shortfalls, the design-builder picks up the tab.

One of the greatest advantages to design-build is the possibility for early contractor involvement. Under this method, all of the team players—the designers, the contractors, the material suppliers, and the manufacturers—have an opportunity to be in continuous communication throughout the project.

NOTE

Today there is an evolved application of design-build identified as *Progressive Design-Build* where the owner and the design-builder engage even earlier, before any design or pricing has been established by the owner. This approach has become quite popular with very large, complex projects such as the \$2.4 billion San Francisco Airport Terminal 1 Redevelopment project, where the owner wants to take full advantage of the multidisciplinary team and its expertise at the earliest stages of project planning. You can access the Progressive Design-Build Primer published by the Design-Build Institute of America at <https://dbia.org/wp-content/uploads/2018/05/Primer-Progressive-Design-Build.pdf>.

progressive design-build

A qualifications-based design-build application where the design-builder is selected primarily on qualifications, followed by a process whereby the owner then progresses toward a design and contract price with the delivery team.

But what is a design-build entity, anyway? Where are the architect and the contractor in all of this? Actually, they're still two of the primary players, but how they organize themselves to do business is what differs. The design-build entity can be configured in three basic ways:

Contractor and designer partnership In this scenario, two firms simply decide to work together on a single project with one of them at risk for the project. A construction firm and a design firm join forces to go after a project. One of the two partners takes the lead and actually enters into a contract with the owner to provide both the design and construction services. For example, under the contractor-led design-build model, the architect is hired by the builder (not by the owner as in design-bid-build), and the builder actually holds the contract to deliver both design and construction. If it is a designer-led design-build model, the opposite is true. The architect or engineer hires a contractor and is obligated for both the design and the construction. The partnership created is simply an agreement to work together. There is no new legal entity created under this setup. The second party is a subcontractor to the first but has no direct contract with or obligation to the owner. Contractor-led design-build is the most prevalent form practiced today.

NOTE

Approximately 54 percent of all design-build projects are led by contractors. Construction managers who have a desire to participate on design-build projects should be knowledgeable regarding the design process and enjoy working with architects in a team environment.

Full-service design-build firm This is probably my personal favorite when it comes to design-build, of which I am a big fan. In this

model, the design professionals and the construction professionals work for the same firm under the same roof. This situation permits no excuses for not communicating! One can just walk down the hall when a question or problem arises. You can imagine how efficient this process can be compared to the phone tag and email lag problems that are common when team members try to communicate from a distance. Additionally, there commonly exists a higher level of trust among the various disciplines working under the same roof than what you would find under the other models. This, of course, adds to the efficiency.

Joint venture The joint venture configuration is similar to the designer and contractor partnership with one exception: the design firm and the construction firm actually create a legal entity, the joint venture, for the purpose of carrying out the design and construction of a specific project. Under this arrangement, both parties are at financial risk for delivering the project.

NOTE

Teamwork and trust are really the keys to successful project delivery regardless of what method is used. Although the design and construction industry has historically been known more for its adversarial nature than for its collaborative spirit, things are gradually changing. The bottom line is that today's projects are simply too complex and too expensive to let petty issues and egos get in the way.

Integrated Project Delivery

Although the term *integrated project delivery* (IPD) is not new, it really gained prominence in 2007 when the American Institute of Architects formally began to articulate it as a unique approach to designing and constructing projects. You can learn more about IPD in the AIA's 2007 "*Integrated Project Delivery: A Guide*" document found at http://info.aia.org/siteobjects/files/ipd_guide_2007.pdf. In that document Integrated Project Delivery is defined as follows:

integrated project delivery

Any project delivery method that contractually engages the contractor responsible for constructing the project at the beginning of the design process. Both design-build and at-risk CM are considered integrated project delivery models. However, there is a more formalized method of IPD that utilizes a multiparty agreement and represents a unique project delivery approach.

Integrated Project Delivery (IPD) is a project delivery approach that integrates people, systems, business structures, and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.

IPD principles can be applied to a variety of contractual arrangements, and IPD teams can include members well beyond the basic triad of owner, architect, and contractor. In all cases, integrated projects are uniquely distinguished by highly effective collaboration among the owner, the prime designer, and the prime constructor, commencing at early design and continuing through to project handover.

Generally speaking, integrated project delivery is any form of project delivery that brings the contractor on board as part of the team at the onset of the design process. In other words, instead of waiting until the design is complete, the contractor who is going to build the project is on board while the design is being developed. In this arena, the construction manager will have an opportunity to contribute their expertise relative to constructability, building costs, labor availability, scheduling issues, and the like. Because the design has such an impact on all of these construction issues, having the contractor's input up front helps the architect make better design decisions and avoid project delays, cost overruns, or unconstructible building details.

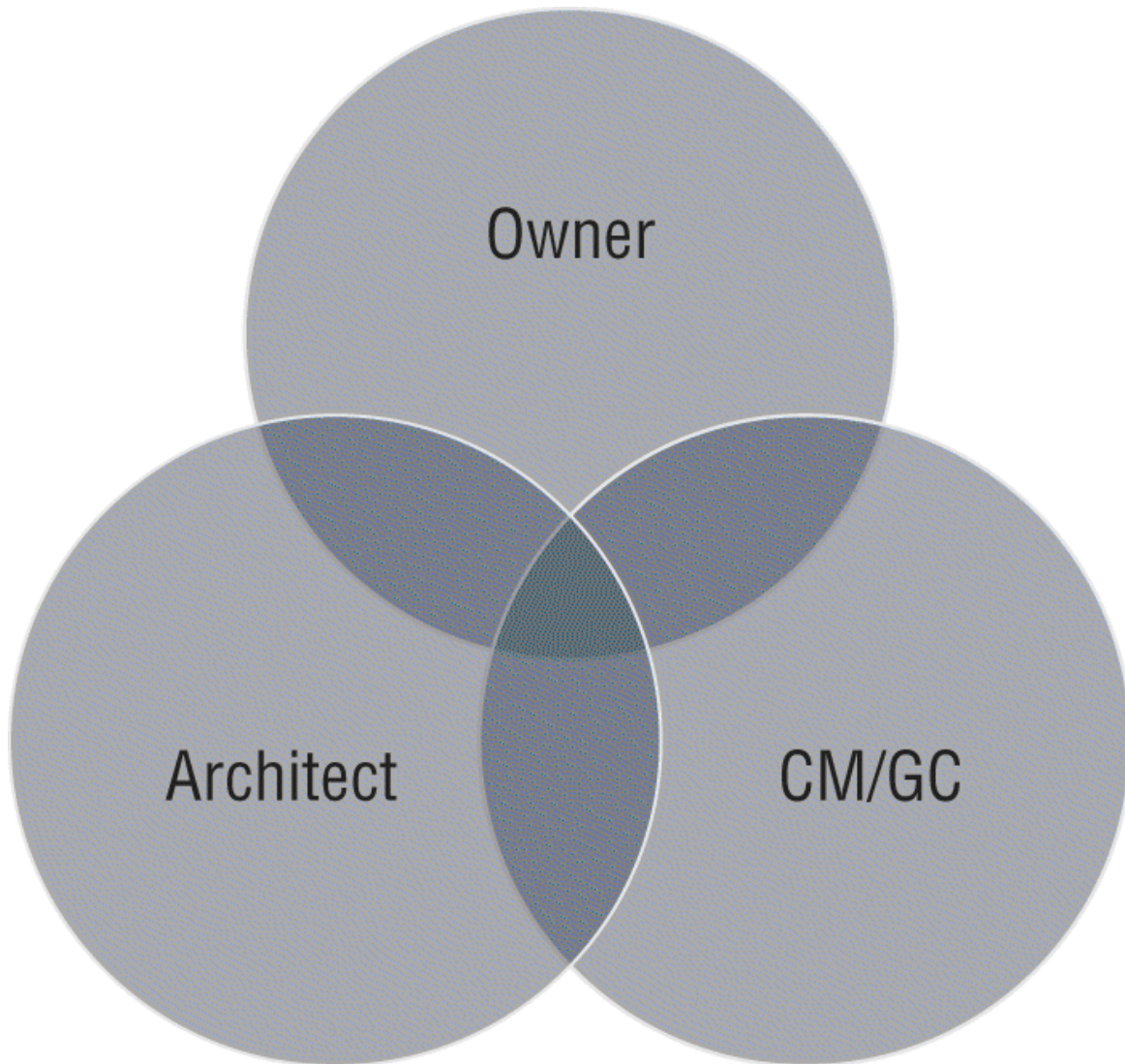
Under this definition, both design-build and at-risk CM can be classified as integrated project delivery models. However, there is also an IPD approach that has a unique contracting format known as an *Integrated Form of Agreement* or IFOA. An IFOA is a multiparty agreement, whereby the owner, architect, and contractor (O/A/C) all sign one agreement and share liability for the development and delivery of both the design and

construction of the project. In this sense, the owner is actually accountable for the delivery of their own project, and may benefit from financial gains, or suffer financial losses, associated with the project's performance. According to Hanson Bridgett's *Executive Summary of IFOA*, the purpose of the IFOA is:

“To provide a legal relationship among the owner, design team, and construction team that aligns them on what is best for the project as a whole.”

NOTE

Hanson Bridgett is a law firm based in the San Francisco Bay area known for its expertise in Integrated Project Delivery. They have published a number of white papers on the subject. To learn more go to www.hansonbridgett.com.



Integrated Form of Agreement

Integrated project delivery provides a unique opportunity for construction professionals who desire a more collaborative approach to the design and construction process to participate at the design stage in a proactive fashion. Construction practitioners who have a particular appreciation for design excellence are generally well suited to these approaches.

Participating as a member of an integrated project delivery team requires cross-disciplinary knowledge, expertise, and experience beyond construction management. Because the integrated project delivery approach is gaining popularity among owners, individuals who have this unique interest or background will find many opportunities in the future to contribute to a project's success.

integrated form of agreement

A multiparty agreement that includes the owner, design professional, and constructor as signatories to the same construction contract. This unique legal relationship is also referred to as an IFOA.

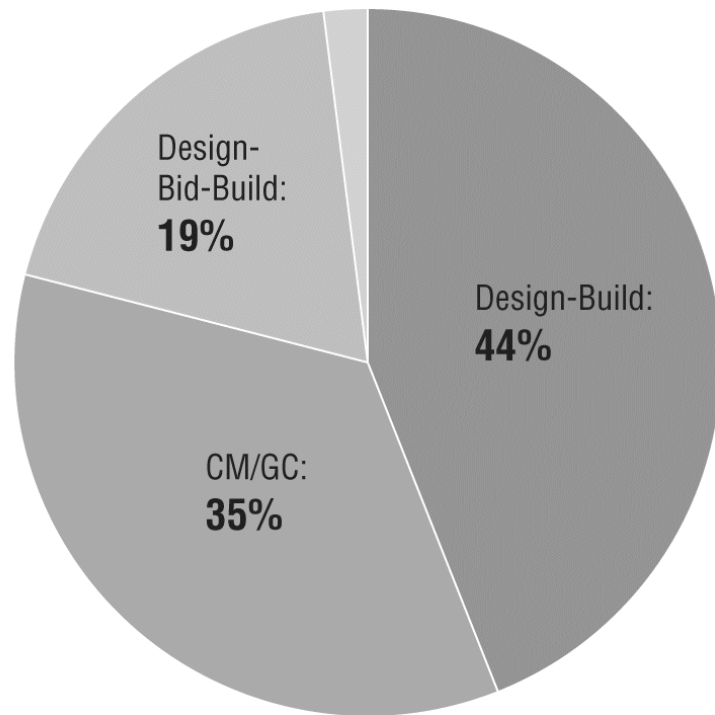
NOTE

When construction managers are engaged in the early stages of a project, they are often able to add value to the project by considering owner needs relative to the construction process. For example, a construction manager may recommend a phased approach to the construction if an owner needs to get a particular production line or function up and running before the completion of the entire facility. Good construction managers are great at solving these kinds of problems, and it is a smart owner who brings them on board to discuss end-user needs during the predesign phase.

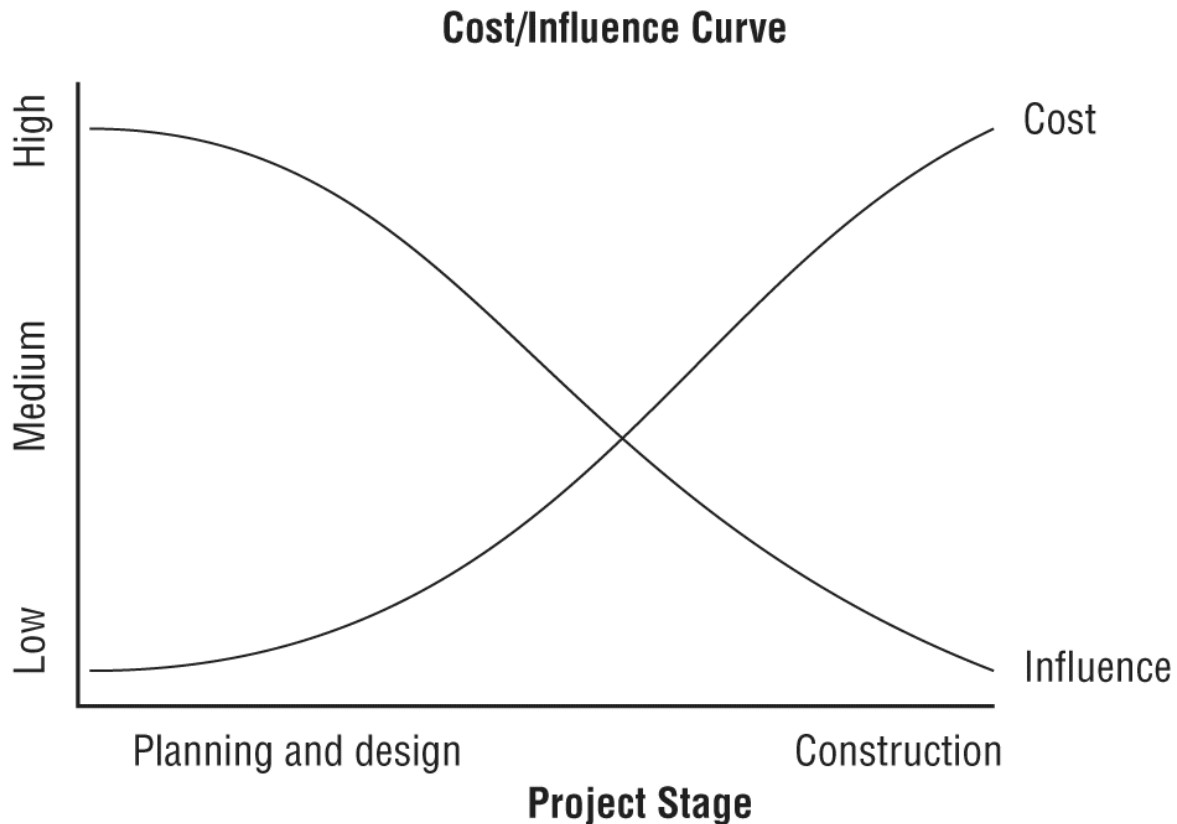
Trends in Project Delivery

It is important for anyone involved in, or planning to get involved in, construction management to fully understand the concept of project delivery, especially today. Today there is an increasing trend toward the more collaborative integrated project delivery methods such as construction management and design-build.

Market research by FMI, released in June of 2018, shows design-build is the fastest growing and most popular delivery method in the nation, accounting for nearly half of all construction spending by 2021.



Bringing in construction professionals at the earliest planning stages of a project saves money in the long run and usually means that the project will be delivered earlier with fewer conflicts and higher quality. Now that awareness of these benefits has become widespread, the role of the construction manager is expanding, and by most accounts this is a good thing. The following cost-influence curve highlights this fact.



As you view the graph, consider the process of building a new home. It would be far less expensive to decide to add extra electrical outlets during the wall framing stage than it would be to make that decision after the drywall was up and the walls were painted. It would be even more cost effective to make that decision while the plans were still on the drawing board. Early contractor involvement helps flush out deficiencies in the design.

To some, bringing the contractor on board early in the planning stages may seem unnecessary and expensive, but if their input during design will help head off problems during the construction phase later when making changes becomes very costly, then the money is well spent.

Project Delivery Selection

Each of the project delivery methods I've discussed has advantages and disadvantages. It is the owner's job to select the best project delivery method relative to the requirements for the project. Some factors that influence an owner's project delivery selection include cost, schedule, quality, design, risk tolerance, and construction expertise. Every project is different, and there is not one single method suited to all situations or project types. It is very important to assess the goals for every new project being considered.

For example, if schedule is the most important criterion on a project, then selecting the design-build method would be the smartest choice because it is typically the fastest project delivery method. However, if high owner involvement in the design process is desired, then design-bid-build would be the better choice, because the owner hires the designer directly.

It is not the intention of this book to have you become an expert when it comes to project delivery, but I do want you to understand that just as scope definition has a significant impact on project risk, so does the project delivery method. The ability of the construction manager to discern the thoroughness of the scope definition and the suitability of the project delivery method goes a long way in mitigating risk from the start.

NOTE

You can learn more about the various project delivery approaches by accessing McGraw Hill's Smart Market Report entitled *Project Delivery Systems* at <https://dbia.org/wp-content/uploads/2018/05/Research-Project-Delivery-Systems-SmartMarket.pdf>.

What Does a Construction Manager Do?

You are now aware of exactly what it is that you are supposed to be managing as a construction manager—cost, time, quality, and safety, right? And basically your job is to mitigate the risks associated with each of these factors and optimize project performance. But there's more. Before you have anything to manage, you must first compete for the opportunity to actually build the project. I haven't yet talked about one definitely critical task associated with construction management: actually getting the work in the first place. ([Chapter 3](#), “How We Get the Work,” is dedicated solely to this aspect of the process.)

So to clarify, the flow of events in construction management is to first get the work and then to do the work, and as we do the work, we must keep score by assessing our progress toward meeting the project goals for time, cost, and quality. Eight basic functions are performed to accomplish these three tasks. Some of them address only one of the primary tasks, while others overlap and apply to more than one task. Although each of the 10 functions is covered in [Chapters 6](#) through [14](#), I'll introduce you to them now so that you can get an overall sense of just what construction managers do before I discuss what it actually takes to be one.

- ◆ Managing the project team
- ◆ Performing pre-construction services
- ◆ Estimating the project
- ◆ Administering the contract
- ◆ Managing job site and construction operations
- ◆ Planning and scheduling the project
- ◆ Monitoring project performance
- ◆ Managing project quality
- ◆ Managing project safety
- ◆ Assessing and managing project risks

Construction Management Functions

The construction management functions are typically performed by a team of construction professionals trained in various aspects of the job. The experienced construction professional will be competent in just about all of the following management functions.

Managing the Project Team

Because it takes a team to perform all of the functions associated with getting a project built, it just makes sense that management of that team would be identified as an essential function. In addition to selecting the right personnel, teaming partners, subcontractors, and suppliers, the construction manager must also work to align the team's efforts with all of the goals for the project. In most cases, the responsibility for the overall management of the team lies with the boss of the construction company, or perhaps a project executive, or a project manager, or maybe a superintendent. It's this leader's job to create a culture and working environment in which every member of the project team can excel and perform at their best. There is a lot to this management function, which you will learn more about in [Chapter 6](#).

Performing Pre-construction Services

Pre-construction services have become an especially important function, particularly with at-risk CM and design-build project delivery approaches. These services are performed during the design phase of the project, before construction begins, and help guide the owner, architects, and engineers by providing important information associated with material selection, costs, schedule challenges, labor and constructability issues, site logistics, safety, and overall project feasibility. It is during the pre-construction phase that the team can anticipate challenges and find efficiencies that generate greater value and save dollars for the client.

Estimating the Project

Given that cost is one of the major factors or values of the construction project, estimating is probably one of the most important construction management functions. Estimating entails the calculation and pricing of all materials, equipment, and man-hours needed to complete the work. We use estimating to get the work and also to help us keep score. In other words, we constantly compare the actual cost of the project with the estimated cost of the project and monitor any discrepancies. Significant variances are often the first sign of trouble, and a good project manager takes immediate steps to determine the cause and mitigate the problem.

Administering the Contract

Contract administration (or project administration) is all about the “red tape” and paperwork associated with a construction project. As you might imagine, there are tons of reports, submittals, shop drawings, time cards,

payroll records, change orders, inspection records, and numerous other documents that must be processed in order to manage a project as complex and expensive as a building, bridge, or highway. Basically, project administration deals with managing all the business affairs related to the contract parties and their obligations. This function usually requires the effort of many different construction management personnel and is vitally important when it comes to doing the work and keeping score relative to the targets for cost, time, and quality.

Managing Job Site and Construction Operations

This is where all the action happens and we get to build something! This function considers every detail associated with the logistics of actually doing the work and getting it done. Think about all the activities and needs linked with workers doing their jobs: tools, equipment, traffic, parking, deliveries, storage, security, communications, signage, safety, trash, drinking water, lunch breaks, and so on. It includes everything right down to when to deliver and where to place the portable toilet! These may be things that you have never thought of before relative to the construction project. But all of these things must be planned, organized, managed, and controlled on the job site in order for the construction to move forward in the most productive manner.

Planning and Scheduling the Project

Project planning is a critical component for the successful completion of any type of building or structure. Planning is about organizing the activities that have to take place in a logical sequence in order to get the project from the ground-breaking phase (or earlier) to the occupancy phase, where the completed project can be used for its intended purpose. Scheduling introduces real time into the plan and is the tool used to communicate the scheme to all parties associated with the project. This function is all about doing the work as planned within a defined time span as well as helping keep score. The schedule is monitored and adjusted throughout the process.

Monitoring Project Performance

This is really one of the primary “keeping score” functions of construction management. There are two key components to controlling project performance: cost and time. Controlling is the process of measuring, monitoring, and comparing actual efforts with estimated inputs and adjusting the plan accordingly to get the project back on track for

completion as intended. Estimates and schedules are the tools used to examine this progress.

Managing Project Quality

The quality standards on any project are established in the plans and specs prepared by the designer. Within these documents, specific measurable conditions are given. These include dimensions, tolerances, test results, temperatures, and so on. It is the contractor's responsibility to see that all such quality standards are met and verified. For the builder to accomplish this goal, they must organize, institute, and adhere to a quality control plan. The quality control plan usually consists of a number of inspections, field tests, lab tests, and observations. It is very important that the contractor be able to document and report satisfactory compliance because only after the standards have been met will the owner accept the work and release payment.

Managing Project Safety

The ability to do work on a construction site is directly related to safe surroundings. Every construction manager is responsible for creating and maintaining a safe working environment. This function cannot be taken lightly. People get hurt and can even lose their lives on construction projects. This function, by necessity, must be a priority on every project regardless of size. The personal and economic costs associated with accidents, injuries, and deaths on the job site are clearly avoidable, and a proactive, rigorous approach to safety planning and management is one of the most important construction management goals.

Assessing Project Risks

Construction is a very risky business, for both the owner and the contractor. Part of the challenge is trying to place the risk in the hands of the party who can best manage that risk (see [Table 2.1](#)). That's why an owner hires a contractor to begin with—to shift the risks for the construction cost, time, quality, and safety to someone trained to manage them. Once the risks are identified, understood, and analyzed, proper allocations can be made for reasonable schedules, estimates, and management plans.

Table 2.1 Risks Allocation Table

Type of Risk	Responsible Party		
	Contractor	Owner	Designer
Site conditions		X	
Weather conditions	X		
Project funding		X	
Subcontractor failure	X		
Job site safety	X		
Material deliveries	X		
Quality of the work	X		X
Delays in the work	X	X	
Defective design			X
Defective work	X		
Code compliance	X		X
Estimate errors	X		
Labor strikes	X		

Problem Solving and Decision Making

Although it is very important for a construction manager to be trained in all the functions listed earlier, the two most important skills needed to succeed in construction management are decision making and problem solving. I'm sure you have determined by now that construction is not an industry for the weak of heart. The stakes are enormously high on every project, and the environment is very unpredictable.

Throughout this book, I will provide “Real World Scenario” sidebars to give you a little taste of the decision making and problem solving that relate to the various functions. What I want you to understand is that the solutions to many construction issues cannot be found in a book or relayed in a seminar—they are discovered by using critical and creative thinking skills and by being very resourceful.

Although being skilled in estimating, scheduling, or project administration will provide you with the tools to evaluate and assess situations, it will be your ability to think on your feet, make tough decisions, and find solutions that may never have been tested before that will actually carry the day.

What It Takes to Be a Construction Manager

By this time, you are probably in one of three places. You are very excited about what you have learned so far, you are not quite sure what to make of this thing called *construction management*, or you are wondering who in their right mind would ever get themselves involved in such a business! So before I take you any further, maybe this would be a good time to discuss exactly what it takes to be a construction manager.

General Requirements

The Bureau of Labor Statistics presents the following character synopsis in its *Occupational Outlook Handbook* when describing the necessary attributes of the construction manager:

Construction managers should be flexible and work effectively in a fast-paced environment. They should be decisive and work well under pressure, particularly when faced with unexpected occurrences or delays. The ability to coordinate several major activities at once, while analyzing and resolving specific problems, is essential, as is an understanding of engineering, architectural, and other construction drawings. Good oral and written communication skills also are important, as are leadership skills. Managers must be able to establish a good working relationship with many different people, including owners, other managers, designers, supervisors, and craft workers.

Although this profile pretty much hits the nail on the head, so to speak, I would have to add a few more attributes to the list. I have found most construction managers to have a strong work ethic and an enthusiastic and highly motivated nature. They are tenacious and very results oriented. And, above all else, they are noted for being risk takers.

It is also very important for the construction manager to actually know something about building. It is much easier to manage a process when you have an appreciation for what it actually takes to get the work done, and believe me, you will have a greater appreciation for it after you dig a couple of ditches and manhandle some 90-pound sacks of mortar all day long. The best way to get this experience is simply to go out there and do the job.

Most companies look for individuals with both industry work experience and formal training or education in construction management. Therefore, it is not uncommon for construction management programs to require (or

highly recommend) summer jobs and internships in the field for exactly this reason. I grew up in a family of carpenters and electricians, so I was lucky enough to be exposed to the building side of construction very early on. Even if you have never been on a construction site before, it is very important to get this experience and not be intimidated by the environment.

NOTE

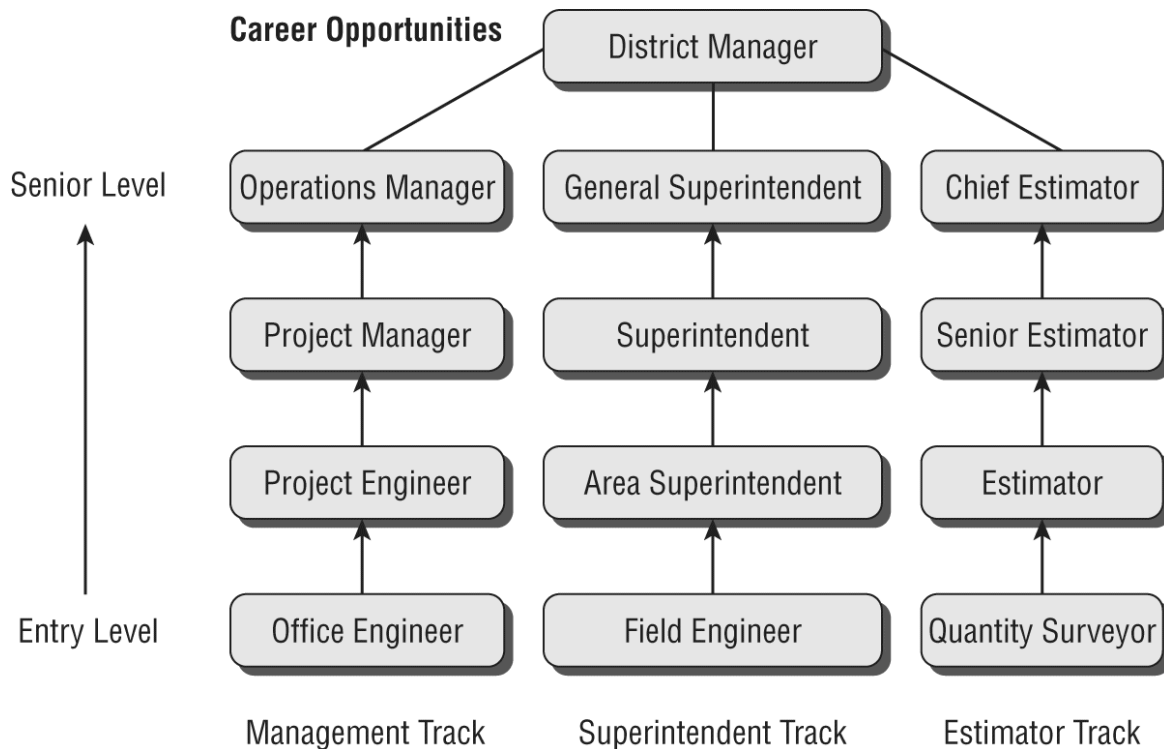
If you are interested in pursuing a career in construction management but think that your lack of hands-on field experience might hold you back, then you might try volunteering with such organizations as Habitat for Humanity or AmeriCorps.

Business knowledge is another factor that can really influence your capabilities and chances for success in construction management. After all, building is first and foremost a business, and all the criteria needed to flourish in business are required to flourish in construction.

And last but not least is having a good grasp of technology. An understanding of computers and software is vital to a career in construction management. Today, every function associated with construction management involves a computer application.

A Typical Career Track

A typical career track for an entry-level construction manager might look something like this:



Although there are many excellent companies to select from, I chose to use the Hensel Phelps Construction Company career path model because of its reputation for consistent performance and reliability. Hensel Phelps is consistently ranked among the top general contractors and construction managers in the nation by the *Engineering News Record* (ENR).

Construction Management Job Descriptions

Job titles and job descriptions vary across company types and sizes, but most organizations will offer field engineer, project engineer, superintendent, project manager, and estimator positions. The following list will give you a clear understanding of what it takes to become a full-fledged construction management professional and give you some sense of the depth of knowledge and experience needed to achieve that goal. These descriptions convey a typical chain of command scenario for a large, national construction firm.

Field engineer This is an entry-level position. This individual works directly for the project superintendent. The field engineer (by title only; not actually an engineer) is responsible for project layout and dimensional accuracy of the project, interpretation of the project plans and specifications, communication with the craftspeople and

subcontractors, jobwide safety, production of detailed concrete form work drawings for field use, and tracking and reporting of daily job production.

Office engineer This is an entry-level position. An office engineer (again, an engineer in title only) acts as the chief assistant to the project engineer and as support for the field. The office engineer's responsibilities include all procurement and timely delivery of materials to the project, review of shop drawings, processing of material submittals and requests for information, and assisting the project engineer.

Project engineer This position acts as the chief engineer on the project. The project engineer's position includes responsibilities ranging from developing bid packages to managing project schedules. A project engineer coordinates all shop drawings, reviews submittals, expedites deliveries, oversees project cost accounting, and processes owner and subcontractor billings. A project engineer is trained to successfully estimate and negotiate all change orders and direct the project administration. This person supports the project manager and area superintendent in material deliveries, staff development, and overall project coordination. The project engineer plays an essential role in a successful project.

Quantity surveyor This position is an entry-level position that works directly with the lead or senior estimator on a bid. The quantity surveyor is responsible for estimating quantities of building materials, doors, and windows, as well as miscellaneous finishes. A basic understanding of construction and good plan-reading skills are prerequisites to this position.

Estimator This position is acquired after valuable years of field experience. The estimator is part of a project's estimating team and may be responsible for advanced quantity surveys of self-performed work such as concrete and carpentry work along with quantification of select subcontractor trades. An estimator learns more advanced estimating procedures along with the basics of pricing self-performed work. Additionally, the basics of bid closing are learned through shouldering the responsibility for specific sections of the bid.

Lead estimator Lead estimators work as members of the bid team on large, complex projects or may be in charge of small to medium-sized projects in a support role. Lead estimators are responsible for the survey and pricing of complex self-performed work. In this

position, the estimator learns to manage others to achieve goals and develops an understanding of the company's self-performed work production history, as well as the fundamentals of bid assembly, buyout, and subcontracting.

Senior estimator The senior estimator reports to the chief estimator. The senior estimator is in charge of procuring an entire project. A successful procurement effort includes managing the bid team, developing the bid strategy, maintaining subcontractor relationships, and training other employees in the estimating department. The senior estimator is completely familiar with company production history and has a thorough understanding of subcontracting and procurement strategies.

Chief estimator Reporting to the district manager, the chief estimator is responsible for all estimating personnel and budget issues. Additionally, the chief estimator is responsible for identifying and tracking leads for future projects and deciding which projects to pursue. The chief estimator is also responsible for reviewing all estimates.

Area superintendent This position serves primarily on larger projects, assisting the project superintendent. The area superintendent supports the development of the project schedule and prejob planning and accepts responsibility for a specific area of the project or phase of work. Responsibilities entail safety compliance, craft supervision and production, subcontractor coordination, scheduling, material handling, daily reports, quality control, and craft training.

Project superintendent The project superintendent is the company's representative with the responsibility and authority for daily coordination and direction of the project so that it is safe, within budget, on schedule, up to the company's quality standards, and satisfactory to the customer. To accomplish this, the project superintendent must conceptualize a plan to construct the project and ensure that the daily and weekly activities are consistent with this plan. The project superintendent and the project manager work together as a complementary team. The sum of their combined effort is greater than their individual efforts. The project superintendent concentrates most of their time on the daily and short-range direction of the project.

Project manager This is the company's "management representative" who is responsible for the safe completion of projects within budget, on schedule, to the company's quality standards, and to the customer's satisfaction. It is their responsibility to initiate required action to achieve these objectives and to ensure that all project activities are consistent with contract documents and company policy. The project manager's duties vary as required to support the project superintendent and other personnel assigned to the project. The project manager's first responsibility is to support the effectiveness of the superintendent and the project staff. Generally, the project manager concentrates on long-term planning, scheduling, and identifying and resolving possible roadblocks and pitfalls prior to their having an impact on the project. The project manager is also responsible for ensuring that all logistical support is completed in a timely manner so that the project superintendent can concentrate on the daily and weekly direction of the company's resources and coordination of subcontractors.

As you can see, many levels of position and training are involved in construction management. There is definitely a lot of room for advancement regardless of your starting level. Construction managers come from all walks of life and with every kind of background. There are many examples of high-ranking construction executives with major firms across the country who started out as laborers in the field when they were fresh out of high school. Today the training may be more sophisticated, but the opportunities are still available to those who are willing to work for them. It is not an easy accomplishment to achieve the project manager level in construction, but it is a very rewarding one. In addition to all of the project level positions, there are also opportunities to advance to a number of leadership roles in business development, risk management, business finance, and executive leadership.

Want to See If You Have the Right Stuff?

FMI Corporation is one of the nation's leading consulting firms to the construction industry (see its website at www.fminet.com). It has been conducting research and tracking construction management and manager success for more than 65 years. Based on its research, I have put together a little fitness quiz. Just for fun, get out a pencil and respond to the following questions, using the instructions given. When you are all done, add up your responses, divide by the total number of questions, and note

your average score. As you work through the quiz, keep in mind that there are no right answers.

Construction Management Aptitude Quiz

Use the following scale of 1–7, where 1 = Strongly Disagree, 2 = Disagree, 3 = Somewhat Disagree, 4 = Neutral, 5 = Somewhat Agree, 6 = Agree, and 7 = Strongly Agree, to rate your reaction to each statement.

1. I consider myself detail oriented and take pride in making sure that everything is done correctly.

Strongly Disagree **Strongly Agree**

1 2 3 4 5 6 7

2. I have strong written communication skills.

Strongly Disagree **Strongly Agree**

1 2 3 4 5 6 7

3. I have strong verbal communication skills.

Strongly Disagree **Strongly Agree**

1 2 3 4 5 6 7

4. I am good at meeting with people and finding new opportunities.

Strongly Disagree **Strongly Agree**

1 2 3 4 5 6 7

5. I usually do whatever it takes to get the job done, even if it means working long hours.

Strongly Disagree **Strongly Agree**

1 2 3 4 5 6 7

6. I have a good sense of humor.

Strongly Disagree **Strongly Agree**

1 2 3 4 5 6 7

7. I like to look at problems in a systematic way, making sure that all aspects have been taken into account.

Strongly Disagree **Strongly Agree**

1 2 3 4 5 6 7

8. I am very creative and am likely to find unique approaches to problems.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

9. I listen to what other people say and am willing to incorporate other people's suggestions into my plans.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

10. I like to work on projects that are visible and out there for the whole world to see and touch.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

11. I would rather work outdoors than in an office.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

12. I enjoy taking on risky projects, and I don't mind if there's some downtime between project activities.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

13. I don't mind getting dirty at work.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

14. I am more concerned about my own happiness in my choice of career than I am in what other people think of my choice.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

15. I like to compete.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

16. I do not take rejection personally, and I look at failure as an opportunity to learn.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

17. I do not give up easily.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

18. I like working in teams and with people of diverse backgrounds.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

19. I am able to prioritize and balance working on several tasks concurrently.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

20. I believe that there is always a solution to any problem and am willing to negotiate until a satisfactory solution can be found.

Strongly Disagree

1 2 3 4 5

Strongly Agree

6 7

So, how did you do? The nature of the questions should give you a pretty good insight into the type of characteristics that tend to show up in the most successful construction managers, at least according to FMI. If your overall score averaged a 4.0 or higher, you are probably well suited for a career in construction management. Remember, the industry is filled with every kind of personality and character type. There are so many positions to fill and functions to perform in construction management that it takes a variety of skills, aptitudes, and characteristics to get the job done. But one thing is sure: every day is different in construction, and you could spend a lifetime learning all there is to know about the industry. Let's continue on the journey and begin to take a look at what this career is really all about.

Terms to Know

agency CM	design-build
architectural programming	fast tracking
at-risk CM	integrated project delivery
constructability reviews	multiple prime
construction management	scope of work
design-bid-build	value engineering
progressive design-build	integrated form of agreement

Review Questions

1. Distinguish between construction management as a function and construction management as a project delivery method.
2. Identify at least three characteristics that make the construction project unique from other industry sector projects.
3. Name the four primary project values to be managed, monitored, and controlled.
4. Why is scope definition so important in the construction process?
5. What is meant by the term *project delivery*?
6. Identify the four primary project delivery methods and discuss how they differ contractually.
7. Explain how agency CM is different from at-risk CM.
8. What is meant by the term *fast tracking*?
9. Name the three basic ways in which a design-build entity may be configured.
10. Identify the 10 functions of construction management.

Chapter 3

How We Get the Work

In This Chapter

- ◆ How the contractor tracks down projects to bid on
- ◆ How the bidding process works
- ◆ How the constructor prepares for the competition
- ◆ The different criteria used to determine the winners
- ◆ The various factors considered before competing

Before you can start managing any project, you must have a project to manage. To get a project to manage, the contractor must first find projects to bid and then win the opportunity to build them. Finding and getting work is a crucial factor in the success of a construction firm. Obtaining information about upcoming projects is a big part of the overall marketing effort of the construction company.

Some companies can boast of a certain number of negotiated projects that are just handed to them because of reputation or prior dealings with a happy client. However, in the majority of cases, contractors must compete for their work and their livelihood. In the past, this competitive process was pretty straightforward. But increasingly it has become quite complex, and the strategies employed to win the project require abilities that were not needed before, such as negotiation, presentation, team-building, and communication skills.

The construction industry has always been a very competitive business, and today the competition has become even more aggressive. The stakes are higher, the margins are lower, and the skills that must be employed are at a different level. Today all aspects of your game must be operating at full capacity in order to win projects. Owners are much more sophisticated and make much greater demands. But the game is indeed a challenging one, and the rewards can be significant.

Finding the Work

Like most industries, construction firms must battle for their share of the market. The good portion of a company's workload will be secured through a rigorous price-bidding competition. But even before contractors decide to compete, they must first do some reconnaissance work and determine where the projects are, what they entail, and when they will be put out for bid.

The first step in the process is to determine who is preparing to build new projects and when they will be ready to start. It is imperative that the contractor find and maintain a relatively constant stream of potential jobs in order to stay in business. For a construction company to be successful, it must engage in an intelligence-gathering effort—scoping out new work and keeping an ear to the ground, so to speak, regarding project design starts and capital improvement campaigns among investors and the corporate world. An uninformed contractor who does not find out about a project until it has already broken ground with equipment and materials being delivered has missed an opportunity to win that project. The bottom line is that there are more contractors competing for the work than there is work to compete for, and any missed opportunity is a mistake.

I do not mean to imply that contractors should go after every single job out there, but they must know about what is coming up in order to decide which ones are worth pursuing. Later in the chapter, I will discuss several factors that are considered when deciding whether to compete for a project.

Although almost every member of the construction management team shares in this task at some level, it is typically the senior estimators, senior managers, and business development personnel who are charged with this most important assignment.

Marketing Efforts

The recognition of construction management as a vital and valuable service relative to the construction process has opened the door for genuine marketing efforts among the most successful construction firms. Today most construction companies have a marketing arm in-house whose sole function is to be on the watch for upcoming projects. The marketing efforts are no longer limited to persuading owners to put them on the bid list so they can compete for the contract. Today, as construction management services become more and more sophisticated, the real effort is focused on convincing owners that they should bring the construction management team on board early to ensure the greatest chances for project success. As you learned in [Chapter 2](#), “What Is Construction Management?”, the earlier

the construction manager is engaged in the design and construction process, the greater the benefit to the owner and the overall construction process. Opportunities for value engineering and constructability reviews as well as budgeting and scheduling during design are just a few of the benefits of early CM involvement. Conveying these benefits to the owner is a high priority of the marketing personnel within the construction firm.

Although contractors are familiar with and accustomed to competing for the work they get, they understand that what they have to offer is quite valuable in the overall scheme of things. A major goal of most construction firms is to find opportunities to submit proposals and negotiate to win projects, rather than compete on price only.

The Rules of the Game

Although the competitive environment is changing in the construction industry, there are still some rules associated with the game that remain the same. Many states' public contract laws have required the selection of building contractors solely on the basis of the lowest responsible bid. For years, many private owners adopted similar procedures for buying construction services, and it was rare for a private owner to consider any other option for buying construction other than the same method that was mandated for public work. Interestingly, today legislative reforms have resulted in both public and private owners having a few more options available to them. Much of this chapter will address those options. However, before getting into those options, let's first take a look at the aspects of the contracting laws that remain the same.

The Public or Private Domain

In [Chapter 1](#), “The Construction Industry,” you learned that construction projects are classified as either public or private by virtue of how they are funded. Public schools, highways, and government buildings are examples of projects funded with taxpayer dollars. On the other hand, building types such as retail outlets, private offices, private schools, and apartment complexes are usually financed by private sources.

Public Projects

When public funds are being used to sponsor a project, there are certain regulations that must be followed when it comes to bidding for the job and awarding the contract. The *open bid* process must be used. In open bidding, the project must be publicly advertised in newspapers and trade journals, and any contractor is allowed to submit a bid.

open bid

A competitive bidding requirement for most public projects. An open bid is one that is advertised publicly and allows any qualified contractor to submit a bid on the project.

Although the logic behind the open bid system is understandable, there are some worrisome problems that go along with it. For example, with open bidding, the owner cannot restrict the number of contractors who will participate in the competition, and they must allow all comers, even if the contractor's technical or financial capabilities are questionable.

A few preventive measures are associated with public work to safeguard the public from problems regarding contractor competency or financial capability. The law requires contractors who compete for public projects to post three bonds: a bid bond, a performance bond, and a labor and material payment bond (also called a *payment bond*). These bonds are issued by a surety company and act somewhat like a form of credit. Although the surety does not actually lend the contractor money, it uses its financial resources to back the obligations of the contractor. For example, the bid bond assures the owner that if the contractor is the low bidder, the contractor will indeed enter into a contract with the owner. However, if the low bidder simply cannot go forward with the contract, then the owner can award it to the second highest bidder with the surety stepping in to cover the difference between the two bids. The owner is protected from having to pay the higher price. Likewise, if the contractor is unable to perform the work as promised or fails to pay suppliers and subcontractors, the performance and payment bonds kick in, and the surety pays for completion of the work done by another contractor. Obviously, the contractor must have an excellent reputation and show evidence of sound financial standing before any surety will give its backing, so this safeguard is a pretty reliable one. However, given the risky nature of construction, things can go wrong, and in reality no one ever wants to see this safeguard used if it is at all avoidable.

prequalification

The process in which an owner, based on minimum financial, management, and other qualitative data, determines whether a construction firm is fundamentally qualified to compete for a certain project or class of projects.

Prequalification is another process available for use in the public domain if an owner chooses to employ it. This helps with weeding out those contractors who are not qualified to bid the project in question. The contractor community has mixed views regarding prequalification. Some applaud it for placing the competition on a more even keel, while others abhor it as being unfair and an invasion of privacy.

Private Projects

Private owners are not restricted by the rules set forth in open bidding. They may solicit bids from whomever they choose. In other words, bidding is “by invitation only.” The owners often send out an *invitation for bids* in letter form to a select number of contractors. They may choose contractors with whom they already have good working relationships or handpick contractors who have a reputation for quality and performance relative to the project type. Under this *closed bid* system, the owner has much more flexibility. The owner can narrow the qualification criteria and limit the number of contractors who are allowed to compete. However, it is not unusual for private owners to instigate the same safeguards mandated by law under public contract laws. Prequalification, bid bonds, performance bonds, and labor and material payment bonds are common requirements of contracts for private work as well.

invitation for bids

A notification sent to a selected list of contractors, furnishing information on the submission of bids on a private project.

closed bid

Used with private projects and is not open to the public. Bidding is by invitation only, via an invitation for bids, to a selected list of contractors.

Public-Private Partnerships

In recent years, a hybrid approach has emerged that combines the resources of both public and private organizations to deliver needed facilities to cities, counties, states, and even the federal government. A *public-private partnership* (PPP), also referred to as a P3 or P³, is a contractual agreement between a public agency and a private sector entity, in which the private party assumes substantial financial, technical, and operational risk in the

design, financing, building, and operation of a public project. Through this agreement, the skills and assets of each party are shared to deliver a facility for the use of the general public. In addition to sharing resources, the parties also share in the potential risks and rewards associated with the project.

public-private partnership

A business venture approach whereby a public sector authority and a private enterprise join forces and combine resources to deliver government projects aimed at serving the public good.

Although PPPs have been in use in the United States for more than 200 years, this creative approach is becoming more and more popular as a mechanism for getting construction projects completed in a timely manner, particularly in instances where there is a significant lag between public funding availability and need. Public-private partnerships have become a common mechanism for delivering water, wastewater, transportation, and urban development projects, just to name a few. The use of PPPs is increasing because they provide an effective tool in meeting public needs, maintaining a high level of public control, and improving the quality of services, and they are more cost effective than the traditional design and construction delivery approaches.

Sources of Information

All construction projects are advertised in one form or another. How they are advertised differs depending on whether the project is public or private. Public projects may be advertised in newspapers or trade journals as required by law. They are also advertised in various online government publications such as *Commerce Business Daily* (<http://cbd-net.com/>) or governmental bid and request-for-proposal listing services such as GovernmentBids.com.

Most contractors subscribe to some type of electronic construction news service. Electronic news services are one of the easiest ways to keep up with projects that are coming up for bids. For a nominal service fee, these services provide up-to-date information on the status of projects from concept to completion. This allows the construction firm to anticipate work, pick and choose which jobs to go after, and develop an overall bidding strategy. Construction Market Data (<https://www.cmdgroup.com/>) is a popular service that allows contractors to find and track projects easily. A

contractor can target construction project leads by location, project type, or industry sector. The intent of these services is to provide accurate, in-depth project information. Both public and private jobs are advertised in the reports, which convey the status of construction projects from the feasibility stage to the completion of the project.

advertisement for bids

A public notice, usually published in newspapers, trade magazines, and journals, providing information regarding bidding procedures for public projects.

Another type of public notice, the *advertisement for bids*, contains all of the pertinent information that a contractor would need to know in order to pursue a job. The types of information typically included in an advertisement are as follows:

- ◆ Project name and description
- ◆ Project location
- ◆ Owner name and address
- ◆ Architect or engineer name, address, and contact information
- ◆ Bid due date and time
- ◆ Where to access the plans and specs
- ◆ Project duration with anticipated start and completion dates
- ◆ Bonds required
- ◆ Restrictions on bidders
- ◆ Project budget or anticipated price range

ADVERTISEMENT FOR BIDS

Sealed proposals will be received by ABC School District at the Central Administration Building, 1111 Penny Lane, Paso Robles, CA, until 2:00 p.m., April 1, 20__ for a

New Administration Building
(located at 101 Schoolhouse Circle, Paso Robles, CA)

at which time and place, they will be publicly opened and read.

A cashier's check or Bid Bond payable to the ABC School District in an amount not less than five (5) percent of the amount of the bid, but in no event more than \$10,000, must accompany the bidder's proposal. Performance and Payment Bonds and evidence of insurance required in the bid documents will be required at the signing of the contract.

Drawings and specifications may be examined at the office of A.B. Architects & Associates, 2000 Ponderosa Street, Atascadero, CA and at the Jackson County Builders Exchange.

Bid documents may be obtained from the Architect upon deposit of \$125 per set, which will be refunded in full on the first two sets issued to each general contract bidder submitting a bona fide bid, upon return of documents in good condition within ten days of bid date. Other sets for general contractors, and sets for subcontractors and dealers, may be obtained with the same deposit, which will be refunded as above, less the cost of printing, reproduction, handling, and distribution.

Bids must be submitted on proposal forms furnished by the Architect or copies thereof. Incomplete bid proposals will invalidate the bid proposal and the bid will be rejected and returned to the bidder. The right to accept any bid, or to reject any or all bids and to waive all formalities is hereby reserved by the ABC School District.

A pre-bid conference will be held on Friday, March 15, 20__ at 1:00 p.m. on the site of the proposed project. All bidders are required to attend the conference.

In addition to subscribing to construction news services or depending on public advertisements, the private sector looks to established relationships with the design and business community at large for impending projects and bid opportunities. When I was in business, I made a habit of making monthly phone calls or lunch dates with various business leaders and designers just to scope out opportunities that might be on the horizon. It was not uncommon for an architect with whom I may have had a good working relationship to contact me when starting a new design project, giving me a heads-up regarding potential work for the future.

Construction management personnel contact owners and designers on a regular basis to inquire about upcoming projects or the status of projects already on the drawing boards. They also look for news articles and stories about facility expansions and new enterprises emerging and then follow

those leads with letters of interest and company brochures. This is all part of the marketing effort. Even craftspeople have grown accustomed to being in on the intelligence-gathering effort, especially during slow economic times. Without this effort to keep finding new work, a construction company cannot survive.

The Competition

One of the reasons I always liked the construction business is that I love to compete. I like the idea that I have the opportunity to pit my team's skills, talents, know-how, and ingenuity up against another team to solve a problem, with one side being declared the victor. When it comes to getting the work in construction, it is very much a high-stakes game. As a matter of fact, the game carries on long after you are announced the winner—all the way through to the end of the project and beyond. That will become evident to you when I get to the “keeping score” aspects of construction management. In the end, what will ultimately determine if you are a winner of this game is whether you have met the owner's expectations for price, schedule, and quality and whether they are satisfied with your team's performance. Although it is important for you to make a fair profit on the project, keep in mind that building a good working relationship with your client is just as important. The ability to satisfactorily work through challenging project issues using open communication and dialogue is a skill that goes beyond the bricks and mortar of construction. Remember, a happy client often results in repeat business, and that's a competitive advantage that is hard to beat.

The Competitive Bidding Process

The purchasing of construction services is often referred to as *procurement*. Procurement signifies the purchasing steps that the owner takes to obtain goods and services. The most prevalent procurement method used to buy construction services is competitive bidding. Anyone who has ever gotten work done on their car or had their roof repaired is probably familiar with the competitive bidding process. The old adage is to get three prices on the work and award the job to the lowest bidder.

The competitive bidding process has been used to buy construction for a very long time. It came into play in a big way during World War I and World War II. Government contracts for both commodities and services were numerous during that time, and taxpayers were supplying the revenue to make those purchases. Competitive bidding was implemented to reduce the risk of fraud, favoritism, and undue influence and to reassure taxpayers that their tax dollars were being spent properly.

Although this method has worked fairly well for the construction industry for a long time, satisfaction is waning, and new procurement methods are on the rise. There is a big change taking place in the construction industry, and today there are several ways in which to compete. Let's take a closer look at the options.

NOTE

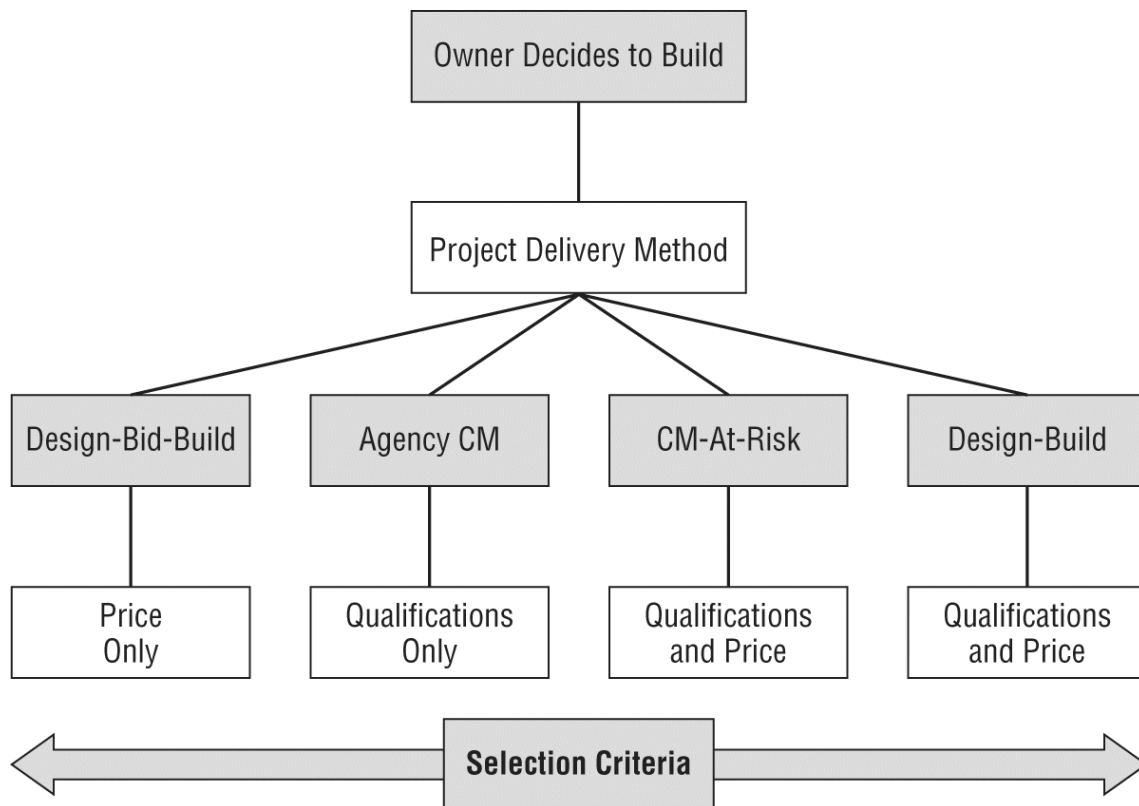
Everyone understands that competition can be a powerful tool for maximizing the value of a dollar. However, construction can no longer be viewed as a simple commodity. Projects are very complex, and the ability to perform, not just low price, should be a compelling criterion for contractor selection. Poor management of the process will result in a delayed project or a project over budget or both, and no one can afford that.

How We Play the Game

How the game is played is really at the discretion of the owner. As discussed in [Chapter 2](#), the owner decides which project delivery method they will employ for their project. Their choice ultimately sets the stage for the competition. There are really only two competition criteria used to determine the winner of the game: price, qualifications, or a combination of both. Each of the project delivery methods is designed around one or more of the criteria.

Competition Criteria and Project Delivery

In traditional design-bid-build, price is the primary criterion used to determine who will win the project. Basically, the contractor who submits the lowest price will be awarded the contract. With construction management (specifically, agency CM), qualifications become the main factor in determining which CM firm will win the competition. And with at-risk CM and design-build, a combination of price and qualifications are considered when selecting the winning team. The following graphic illustrates the connection between project delivery method and selection criteria. Although there are exceptions to these standard practices, for the purposes of this book, I will stick with the more common situations.



Selection Methods

Once the owner determines which project delivery method and corresponding competition criteria they will use, the framework for the actual selection process has been set. There are basically three selection methods utilized for purchasing construction and construction management services:

- ◆ Low-bid selection
- ◆ Best-value selection (BVS)
- ◆ Qualifications-based selection (QBS)

request for qualifications

A document issued by the owner prior to an RFP to solicit contractor or design-builder qualifications. The RFQ may be used by the owner to shortlist potential proposers, or it may be used by itself as the final competitive submittal employed in qualifications-based selection.

request for proposals (RFP)

A solicitation document, written by the owner, requesting pricing and a technical solution for design and/or construction services.

Each of these selection methods uses a different solicitation instrument to advertise the project. For example, low-bid selection, which is most commonly associated with traditional design-bid-build project delivery, utilizes the invitation for bids (IFB). Best-value selection utilizes a *request for proposals* (RFP), and qualifications-based selection employs a *request for qualifications* (RFQ). These solicitation instruments are what the contractor responds to in an effort to win the project. Each of these instruments is designed to measure the appropriate criteria associated with the analogous selection method. The way in which the contractor prepares to compete for the work differs with each of the methods. [Table 3.1](#) reflects the relationship between the criteria, selection method, and solicitation instrument for all three competitions.

Table 3.1 Selection Methods

Criteria	Selection Method	Solicitation Instrument
Price only	Low-bid selection	Invitation for bids (IFB)
Qualifications only	Qualifications-based selection (QBS)	Request for qualifications (RFQ)
Qualifications and price	Best-value selection (BVS)	Request for proposals (RFP)

Owner preferences have shifted from the traditional low-bid selection method to more frequent use of the best-value and qualifications-based selection methods (design-build and at-risk CM). However, traditional design-bid-build is still a prominent selection method for many owners, especially in the public sector.

Each of the selection methods represents a different kind of competition, and the steps required to move through the process vary. Because the market is wide open now for any one of these methods to be utilized, it is important to be familiar with each of them.

Low-Bid Selection

The low-bid selection method is all about price, and it is still the most common way for contractors to get their work. It all starts with a set of contract documents. (Contract documents will be discussed in detail in [Chapter 4](#), “The Construction Contract.”) The main components of the contract documents are the plans and specifications prepared by a design professional. The plans and specs describe the overall scope of the project in great detail. They are like a set of written instructions for how to build the project. Under this selection method, the plans and specs are classified as being 100 percent complete, meaning that the architect has taken them through the final stages of design before putting them out for bids. In other words, all bidding contractors bid on a single design, making for an “apples versus apples” competition. The object of this game is for all competing contractors to evaluate the plans and come up with a price based on their own unique strategies for doing the work.

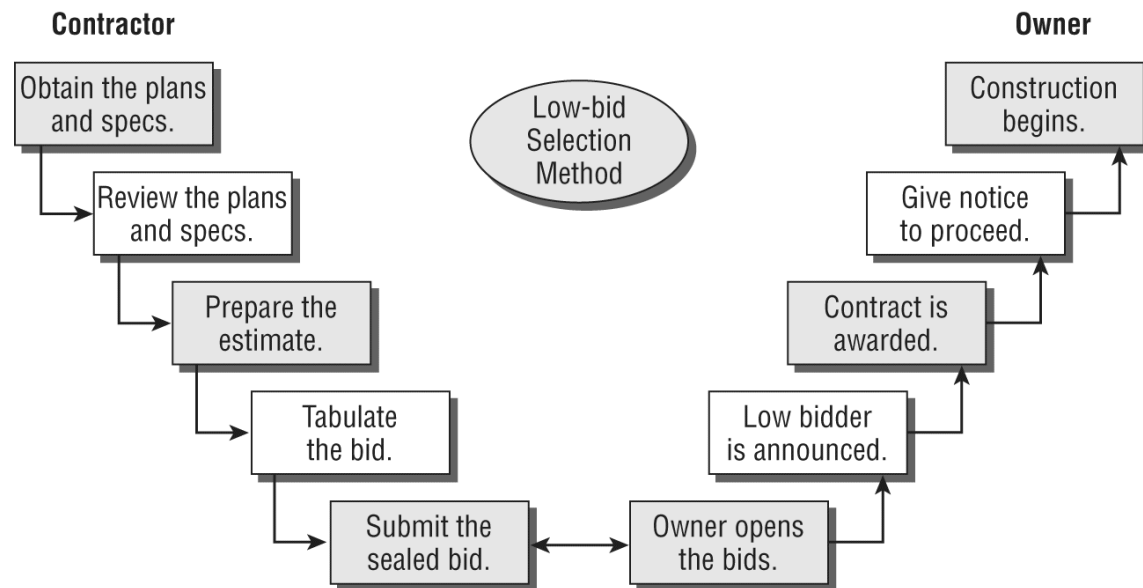
responsive bid (or proposal)

A bid or proposal package that meets all of the requirements of the solicitation instrument.

notice to proceed

The owner authorizes the contractor to begin work on a project on a particular day or as soon as possible. This notice is linked to the duration of the project.

Each contractor thoroughly reviews the plans and specs and then prepares an estimate for the cost of the project. The estimate includes all of the materials, labor, equipment, subcontracts, overhead, and profit necessary for the job. The estimates are then compiled into a sealed bid form and are due to the owner on a particular day and at a particular time. The sealed bids are opened, and the contractor with the lowest *responsive bid* will be awarded the job. An official contract will then be executed between the contractor and the owner. Shortly thereafter, a *notice to proceed* will be issued by the owner providing the go-ahead for construction. This flow chart identifies each of the steps in the process.



The low-bid selection method is characterized by a very standardized procedure. All competing contractors pretty much follow the same steps for arriving at their bids. Let's walk through these steps one at a time to get a better sense of the way the game is played:

Obtaining the plans and specs Once the contractor selects a project to bid on, the contractor must then get copies of the plans and specs. The advertisement for bids or invitation for bids typically stipulates how the contractor can obtain the plans and specs. They are normally

available from the architect's or engineer's office. There is usually a limit on how many sets of documents may be distributed to each contractor, and a refundable deposit is required to check out the documents.

Although the number of sets available for each contractor may seem like a minor detail, it is actually quite significant in terms of managing the bid preparation process. Today, most general contractors subcontract out a majority of the project's work to specialty contractors. Each of these subcontractors must also review the plans and specs so they can submit their price quotes to the general contractor. Obviously, limiting the sets of documents available to the contractors is a challenge when dozens of subcontractors will be submitting price quotes to the prime contractors. For this reason, most design firms also place drawings at local plan service centers during the bidding period. These centers are usually managed by various trade associations or builders exchange groups and make the drawings available for viewing live or online. The subcontractors often review the documents right at the facility and do not check them out, so no deposit is required. However, today many contractors will access the plans electronically and review them online. Clearly, it is very important for all interested parties to have access to these documents.

Reviewing the plans and specs This is a very important step in the process. Even though the plans and specs have been obtained, no commitment to a bid has fully been made. Not until a complete and thorough review of the documents has been made should a commitment be made. There are many factors to consider when deciding whether to proceed with the bid. At this stage, the primary consideration is the quality of the documents themselves. The main purpose of these documents is to convey the overall scope of the project and what exactly it is that the contractor is responsible for. If the scope definition has been communicated well, it will allow the contractor to do a much better job of coming up with an accurate estimate. If the drawings are poor, then the contractor (and the owner for that matter) is at greater risk and must try to anticipate the gaps while still remaining competitive. Although reputable designers make every effort to produce quality documents, it is virtually impossible to create a perfect set of plans, free from errors or omissions. Generally, the better the set of drawings, the closer the bids will be. Poor sets of documents may result in an erratic set of bids.

NOTE

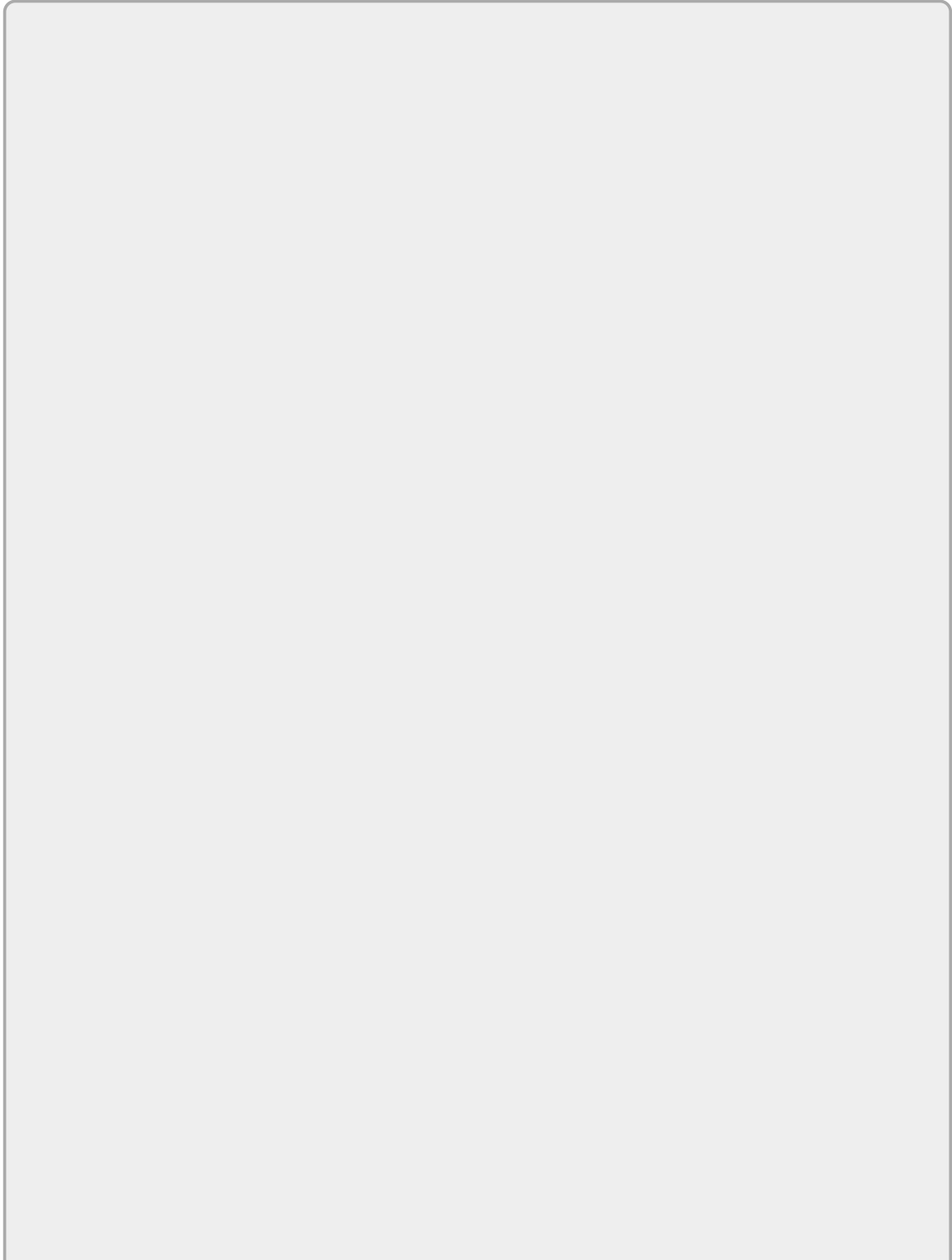
In today's very competitive market and with today's complex construction projects, the quality of the plans and specs is of the utmost importance. Quite frankly, the quality is slipping, which is another reason why other selection methods are growing in popularity.

Preparing the estimate Although [Chapter 8](#), “Estimating Project Costs,” will deal exclusively with this very important function, I want to give you a sense of how it plays into the bidding process. After the contractor scans the plans and specs to get a good feel for the job and decides that indeed they will go forward with the bid, a much more thorough examination takes place in order to quantify all the parts, pieces, and people necessary to build the project. Think about planning a vacation. You must come up with all the items you are going to need to have a successful trip: money, passports, reservations, transportation, medications, clothes, toys, beach towels, and so on. You try to anticipate everything you might need. This is similar to doing an estimate—except that with an estimate, the stakes are much, much higher if you forget something!

Tabulating the bid Once all the quantities for materials, equipment, subcontractors, and labor are determined and added up, prices are applied, and a total cost is calculated. The contractor adds the necessary overhead for managing the project and a profit for the firm's efforts and comes up with a total price for the job. This price is then reviewed by senior management, and a final bid is agreed upon. This bid is eventually recorded on the bid proposal document supplied by the owner and goes into a sealed envelope with the job name and contractor name written on the outside of the envelope.

Submitting the bid Usually, a member of the contractor team hand-delivers the sealed bid to the location designated in the bid advertisement. It is crucial that the bid be turned in prior to the cut-off time. For example, if bids are due in the architect's office at 2 p.m. on a particular date, it must be there by 2 p.m. If a bid is received at 2:01 p.m. on that day, it is automatically disqualified. Exceptions to this hard-and-fast rule are very rare, and when such an instance does occur, it opens up the possibility for protests from other bidders, which often leads to litigation, which is the last thing that anyone needs.

Although one would think that the contractor's bid tabulation would take place long before the due date and time, the reality is that the final bid number is rarely ever available until literally the last minute. I have spent many hours in the bid room of my office on bid day adjusting numbers right up until five minutes before the bid is due.



Why Would You Do It This Way?

Why would someone wait until the last minute to submit their bid? Ah, but remember, this is a low-price competition. Keep in mind that the material suppliers, vendors, and subcontractors are competing against each other as well, and they too are changing their prices right up until the last minute, trying to gain a strategic advantage by discounting their bids at the very last second. If you expect to win at this low-bid game, then you must be prepared to play it the same way as everyone else.

Opening the bid and announcing the low bidder The bid opening is when everyone learns who the apparent low bidder or winner is. Sometimes this occurs immediately after the bids are received and is an event that is open to the public. Most public projects require a public bid opening. The bidding contractors typically have a representative present at the opening (often the runner mentioned earlier). The bids are announced and recorded on an official bid tabulation sheet, similar to the one shown here.

Bid Tally Sheet

Project: Administration Building Complex

ABC School District, Paso Robles, CA

Date: April 1, 20____

Bidder	Rank	Base Bid Amount	Addenda		Noted	Sub List	Bid Bond	Noncollusion Affidavit	Insurance Confirm	Experience Certification
			#1	#2						
1. Acme Construction	5	\$6,789,900	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
2. Basic Builders, Inc.	1	\$4,900,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
3. Quality Plus Contractors	3	\$5,678,100	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No
4. Build-It-Best Construction	4	\$6,100,500	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
5. Hammer Head Construction	2	\$5,250,850	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
6. Superior Construction, Inc.	6	\$6,940,000	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

NOTE

At a public bid opening, the selection committee is careful to announce the low bidder as the apparent low bidder. The selection committee needs time to review all submitted documentation to determine whether the contractor with the lowest bid actually complied with all of the requirements of the solicitation. Typical additional requirements include bid bonds, noncollusion affidavits, certificates of insurance, and subcontractor lists. If any of the required documents are missing or are found to be in error, then the bid may be deemed nonresponsive and disqualified. In such an event, the job would go to the next lowest responsive bidder.

Awarding the contract Once the smoke clears and the victor is finally determined, the owner and the contractor enter into an official agreement. This usually occurs several days after the bid opening. Several other submittals are often required before signatures actually reach the paper. For example, it is not uncommon for the owner to request a proposed schedule and schedule of values from the contractor before the agreement is signed. These documents become an official part of the contract. (More will be said about these two items in [Chapter 9](#), “Contract Administration.”)

Basically, the agreement stipulates the responsibilities of the parties as they embark upon the construction of the project. At this point, the contractor and construction management team are essentially obligated to fulfill the requirements of the contract in accordance with the plans and specs for the agreed upon price submitted in the bid.

Giving notice to proceed The contract is signed, and all of the legal paperwork is in order. However, the actual start of construction does not take place until one more document is executed. That document is an official notice from the owner to proceed with the work. The notice to proceed is an important document in that it starts the clock running for the construction. As previously indicated, time is often a critical factor with any project, and there must be an official start and end to the job in order to measure performance, especially when penalties are assessed for late completion.



Real World Scenario

The Bid-Running Challenge

On bid day, before cell phones, I would send someone to the bid location several hours before the bid time and have them commandeer the closest telephone to the bid depository location and guard it with their life. We would synchronize all watches with the official clock on-site. Then we would time just how long it took our point person to run (and I mean run, hence the nick name *runner*) from that telephone location to the desk of the person receiving the bids. We would deduct the run minutes from the official bid time and calculate up to the absolute last minute when we must finalize our bid number. Today, with cell phones, the runners can be standing next to the depository desk when they receive the final call. But don't think it is any less stressful (or exhilarating, depending on how you look at it). The final bids are often still determined during the last few minutes of the competition. Anyone who works a bid on bid day has to have nerves of steel because, as stated before, the stakes are very high, as are the opportunities to make a mistake.

One of the challenges of the construction manager is to actually be ready to start the job when the official notice to proceed arrives. Remember, at this point we have not thoroughly planned the job, we have simply priced the job in order to win the competition. Having been awarded a contract, we now have to very quickly mobilize a project team and all of the apparatus that goes along with that. Think of it as trying to deploy troops to a new engagement on a moment's notice, and imagine all the planning needed to accomplish that. The average building contractor bids on many jobs a year, not knowing exactly which ones they will win. Once the win is announced, the construction manager must revisit the bid, check the availability of resources, and begin to develop an overall strategic plan, setting the stage for the rest of the game and ensuring an ultimate win in the end.

Beginning construction Now it is time for the second part of the game to begin! All of the work that it took to get the job in the first place will now be passed on to the construction management team. The estimates that were calculated during the bidding process will now be used as benchmarks for managing the performance throughout the duration of the job. The skills of the entire construction management team will come into play and carry the job to the finish line.

NOTE

Although competitive low bidding is still a popular method used to determine contract award in construction, the best-value approach is gaining popularity as the procurement method of choice, even in the public sector.

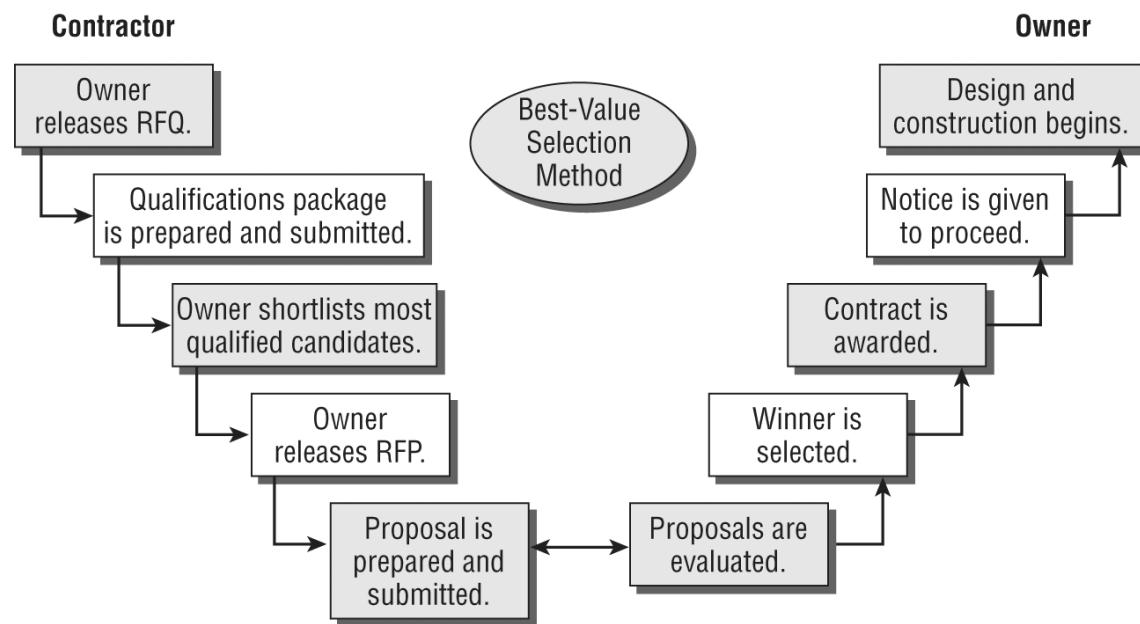
Best-Value Selection

This competition is very different from low-bid selection in numerous ways. For one, in this game, the judges consider qualifications as well as price when determining a winner. When applying the best-value selection method to design-build project delivery (which is the most prevalent application of this selection method), the owner may choose to evaluate the design as part of the qualifications criteria. In other words, the design is not 100 percent complete when the competition begins, as it is in design-bid-build. So, part of the team's challenge is to design, or complete the design, as a requirement of the competition. As you learned in [Chapter 2](#), design-build project delivery makes use of an interdisciplinary team of contractors and designers and features a single-source responsibility.

best value

Any selection process in which proposals contain both price and qualitative components and the award is based upon a combination of price and qualitative considerations.

So, unlike low-bid selection, where the fundamental premise is to compare price based on a single design (or compare apples with apples), the premise under *best value* may actually compare different designs and their correlated prices (like comparing apples and bananas). It is an absolutely fascinating game to play, in my opinion, and is gaining ground as the selection method of choice in many sectors.



Just as with low-bid competitions, there are several steps to take when playing this game. However, the steps are very different in that the best-value method is not solely a bidding game. Qualifications, which may entail any number of factors, are also solicited and may even include a technical proposal component consisting of the project design.

Releasing request for qualifications (RFQ) Similar to the low-bid method, the project is typically advertised through all the usual channels. However, the advertisement is not an invitation for bids. Instead, it all starts with a request for qualifications, followed by a request for proposals. (Sometimes the two solicitations are combined.)

Qualification factors commonly include: experience, financial and bonding capabilities, record of design and technical excellence, staff expertise, project organization and management plans, quality control plans, and budget and schedule performance. The owner can ask for any criteria they want. They can ask for information on safety records, the use of women- and minority-owned business affiliates, individual team member credentials, and so on.

Preparing the qualifications package and shortlisting candidates In response to the RFQ, the contractor or design-build team prepares a package that is submitted to the owner by a certain date and time specified in the advertisement. The qualifications packages are received and reviewed by the owner. The owner often puts together a jury panel made up of several representatives and stakeholders to judge the submittals. The panel selects preferably three, but not more than five, of the best-qualified contractors or design-

builders in a process called *shortlisting*. The shortlisted competitors are then invited to respond to the request for proposals. No pricing is involved at this stage.

shortlisting

Narrowing the field of offers through the selection of the most qualified proposers on the basis of qualifications.

Releasing request for proposals (RFP) The RFP, prepared by the owner, is a very important document in that it will represent the legal requirements and criteria for the entire project. The RFP includes: information regarding the owner's program, budget, schedule, and other requirements associated with the project. As previously stated, the plans and specs may not be 100 percent complete at the time of the competition under the best-value selection method. Final design schemes and cost proposals are solicited from the shortlisted contractors or design-builders.

technical proposal

The part of a design-build proposal that contains the conceptual design for the project. It may also include information regarding schedule, team makeup, and overall management plan for the project.

price proposal

The part of a design-build proposal that stipulates the price at which the design-builder will provide the design and construction services necessary to complete the project.

Preparing the proposal The team of designers, builders, and estimators develops the design for the project along with a corresponding price. The team prepares drawings, written specifications, and sometimes a physical model as their response to the RFP. This package, often referred to as the *technical proposal*, along with the separate *price proposal*, constitutes the total response to the RFP. This is a far cry from simply submitting a bid under the low-bid model. As you can imagine, the work involved under this method is

much greater and significantly more costly. It is not unusual for contractors and design-build teams to spend \$20,000 and even upwards of \$200,000 in the preparation of these proposals. Contractors in this game play to win or they don't play at all. That's why the shortlisting component of the competition is so critical. Limiting the competition to only three or four opponents increases your odds and makes the investment worthwhile.

Submitting the proposal Although there is a specified date and time for the receipt of the proposals, there is not an immediate opening of the proposals. As you might imagine, it takes time for the jury to review all the materials submitted by the participants. The initial review period can be two weeks or more. It is not unusual for the owner to request the design-build teams to make in-person presentations to the selection committee before making a final contract award. This way, the panel has the opportunity to ask for clarification on any items that are not clear concerning the proposals.

Evaluating the proposals and selecting the winner Under the best-value selection method, an evaluation panel or jury is appointed by the owner. This panel usually consists of individuals who will ultimately be associated with the new facility. For example, if the project were an elementary school, you might find a school board member, the principal, a teacher or two, the maintenance supervisor, and the director of facilities on the jury.

There are numerous ways in which to evaluate the responses to the RFP. The proposals are evaluated on the basis of quality, functional efficiency, aesthetics, price, and other factors. The technical proposal components and the price component are scored separately.

weighted criteria

An evaluation method used in best-value selection in which maximum point values are assessed for qualitative and price components of a proposal. Contract award is based on the highest total points earned.

One of the most common methods for scoring the technical proposals is called *weighted criteria*. Basically, the owner ranks each of the criteria relative to its importance to the project. Then each jury member assesses a score to each team for each criterion. The weighted

criteria are multiplied by the score for each factor, and a total score is calculated.

[Table 3.2](#) illustrates how an evaluation matrix with criteria and weights works. When price is part of the competition, a similar scoring occurs relative to price. The price score and the weighted criteria score are added together, and the proposal with the highest score wins the competition.

Awarding the contract The winner of the best-value competition enters into a contract for two things: the design of the project and the construction of the project. This is quite different from low-bid selection. Whereas in low-bid the plans and specs are part of the contract, with best-value the plans and specs are nonexistent or not complete yet and, therefore, cannot govern the contract at this point. What does govern the work of the contract are the requirements of the RFP, the technical proposal, and the price proposal. Just as with the low-bid process, several days usually pass before a contract is actually signed.

[Table 3.2](#) Weighted Criteria Evaluation Matrix

Best-Value Proposal	Team A		Team B		Team C	
	Score	Points	Score	Points	Score	Points
Design solution (weight 10)	4	40	3	30	5	50
Financial capability (weight 8)	3	24	4	32	5	40
Energy efficiency (weight 6)	5	30	4	24	3	18
Management plan (weight 10)	5	50	4	40	4	40
TOTAL POINTS		144		126		148 WINNER

Scoring: 5 = Excellent; 4 = Good; 3 = Fair; 2 = Poor

Giving notice to proceed The notice to proceed document under best-value selection is very similar to that issued under low-bid selection. The difference is that with best-value selection, the notice is to start the design process followed by the construction.

Beginning design and construction Some design has to be completed before construction can begin. But as you learned in [Chapter 2](#), a portion of the design and construction may be overlapped in order to speed up the entire process.

NOTE

Although the steps set out earlier describe the best-value selection method when used with design-build, keep in mind that best-value selection may also be used with design-bid-build project delivery. When used with design-bid-build, design is not a factor in the competition. The design is already complete and presented in the RFP. The participating contractors compete on qualifications and price only; design is not one of the criteria being judged.

Qualifications-Based Selection

There are no limitations to using qualifications-based selection (QBS) for construction in the private market. Basically, any private owner could decide to ask a number of contractors to compete on qualifications only. However, our society is so accustomed to low-bid selection for construction that QBS is not a common occurrence in the building industry, even though most architects and engineers have always been selected this way. For public projects, there's actually a statute that prevents architects and engineers from competing on price. The Brooks Act (1972) requires that qualifications-based selection be used by federal design and construction agencies to purchase architecture and engineering services. (See <https://www.acec.org/advocacy/qbs/brooks2/> for more information.) Price quotations are not a consideration in the selection process. Prices are negotiated after the selection has been made on the basis of demonstrated competence and qualifications.

You Get What You Pay For

The presumption behind the Brooks Act is that we don't want professionals who are responsible for the public safety to be the low bidder. After all, you wouldn't select your doctor based on the lowest price, would you? Based on the same logic, you would not select your architect on the basis of being the cheapest practitioner. On the other hand, construction has historically been viewed as a commodity, so competition based on price seemed appropriate. But today, construction requires skills far beyond the trades—it requires professional management to handle all of the regulatory bureaucracy, entitlement, contract administration procedures, procurement, contract negotiations, estimating, scheduling, cost control, quality assurance, safety mandates, and so on. In my opinion, construction management is just as much a profession as architecture and engineering, and qualifications should also be the primary discriminator.

The qualifications-based selection process is utilized for both agency and at-risk construction management services. It is also becoming a preferred selection method for design-build projects. There are some state jurisdictions that even allow this method to be used for public projects procured under the design-build project delivery model. When it is used, the process basically follows the first steps outlined earlier under the best-value approach, except that price is not a factor. In other words, a request for qualifications is advertised, with proposers responding with qualifications packages. An evaluation matrix similar to that shown for the best-value matrix in [Table 3.2](#) is used to evaluate the competitors, with the high scorer winning.

NOTE

Qualifications-based selection is sometimes called *direct selection*. Basically, an owner simply decides that they want to work with you because of your reputation and past performance. This is a position that many contractors strive for: an opportunity to be recognized and selected for the quality and professionalism of their work.

Making the Bid/No Bid Decision

As you can probably tell, the task of finding and getting work in the construction industry is an ongoing challenge and takes a lot of effort. Regardless of which type of competition that contractors engage in, the decision to bid or not to bid is not one to be made lightly. A great deal of time and effort is spent in preparing a detailed estimate or a technical proposal with no guarantee of winning the job.

Finding jobs to bid on or propose is one thing, but deciding to invest the time, money, and effort it takes to win them is another. Numerous factors must be weighed before you go forward with the effort. There are some jobs that you do not want to get. For example, there may be a project that you are interested in, but you learn that the client has a reputation for being a “slow payer” (delinquent in paying invoices) or has unrealistic performance expectations. No matter how attractive the project might be, the challenges associated with getting paid in a timely fashion may not warrant the effort or the risk to your cash flow position. The construction manager must discern which jobs are worth going after.

Table 3.3 Making the Decision to Bid

Factor	Considerations
Who the owner is	Some owners are known for being easy to get along with, and others are known for being difficult. Those who have a reputation for being controlling, highly litigious, or difficult to please have a harder time getting contractors to bid their work.
Who the architect is	There are architects who are noted for the quality of their plans and specs and architects who are noted for poor-quality documents. Contractors stay away from architects with reputations for producing poor-quality plans and specs.
Location of the project	If the project is located close to the contractor's office, this usually gives the contractor a strategic advantage. The person is familiar with the local labor market, and job site overhead can be kept to a minimum. If the project is far away, then the expense to run the job goes up, and the labor market is unknown and, therefore, a higher risk. On the other hand, the contractor may want to establish a presence in a particular area to increase business opportunities associated with that market and, therefore, targets the area intentionally and makes the investment to be there.
Present workload	The contractor's workload always has an impact on when to bid and when not to bid. When there is plenty of backlog, contractors are pickier regarding which jobs they go after. Conversely, when work is slow, contractors will usually bid on jobs that they would otherwise stay away from just to keep their operations going.
Technical aspects of the job	Contractors have to assess their own technical expertise and ability to manage and supervise the work relative to the technical complexity of the work. Whenever contractors decide to bid on work with materials, equipment, or systems that are new to them, they take on greater risk.
Is it a high-profile project?	There are reasons to take on a high-profile job and reasons to stay away from them. Obviously, if contractors want to increase their own visibility and reputation, taking on a high-profile project is one way to do that. In other circumstances, such visibility may have a downside, especially on a project that is controversial to begin with.
Type of project	Contractors often become specialists in certain types of work and scout for those kinds of jobs specifically, wherever they may be located.

Factor	Considerations
Size of project	Contractors are generally limited as to the size of the project that they can go after because of their bonding capacity. Larger companies are attracted to the larger projects. Smaller companies look for the smaller projects.

There are many motivations for bidding work. The most obvious has already been stated: to stay in business. But just as in any competition, it is best to pick your battles wisely. [Table 3.3](#) outlines a number of common factors that contractors consider before making the decision to bid or not bid on a particular project.

The bidding process is getting more competitive, and profit margins are getting thinner. For this reason, the marketing effort in construction is ever increasing. Companies are positioning themselves as reputable leaders in the industry and pressing for opportunities to negotiate directly with owners, bypassing the very expensive and risky bidding process altogether—and it is working. As owners become more interested in high-performance results over low price, many construction firms are increasing the percentage of work performed under negotiated contracts versus low-bid contracts.

A Final Note

The primary construction management function associated with getting the work, regardless of which selection method is used, is the estimating function, which will be discussed in great detail in [Chapter 8](#). In my opinion, this is probably the single most important function in the process. Without good estimating skills, a construction company won't be in business very long. Estimates that are consistently too high will result in a lack of work, and estimates that are consistently too low will result in jobs losing money—and either scenario will eventually lead to the company going out of business. It is no wonder that one of the highest-ranking positions in construction management is senior estimator. These positions often lead to a director or vice president position in the construction firm.

Terms to Know

advertisement for bids	public-private partnership
best value	request for proposals
closed bid	request for qualifications
invitation for bids	responsive bid (or proposal)
notice to proceed	shortlisting
open bid	technical proposal
prequalification	weighted criteria
price proposal	

Review Questions

1. Why is open bidding required on public projects?
2. Name a tool used to reduce the number of bidders on a public project and increase the quality of the contractor pool.
3. What is the purpose of a labor and materials payment bond?
4. Identify the notice document that informs the public of upcoming construction projects funded with taxpayer dollars.
5. Name the three selection methods used to buy construction services, and identify the solicitation instrument used for each one.
6. Which procurement method is the most commonly used today, and what is the selection criteria used to determine the winner?
7. What is the name of the official document that the owner uses to notify the contractor to start construction?
8. Name the two primary selection criteria categories considered when using the best-value method.
9. Describe how the weighted criteria evaluation process works.
10. List at least three factors that are commonly considered before deciding to bid on a construction job.

Chapter 4

The Construction Contract

In This Chapter

- ◆ The various documents included in the contract
- ◆ How the contract documents impact the construction
- ◆ The standard protocols used when preparing the contract documents
- ◆ The various types of contracts used for construction

Wow—you survived the bidding competition and were announced the winner. Great! Now what? Well, now it's time to look closely at what exactly you're accountable for. What you're accountable for is outlined in the contract, but what makes up the contract in construction is a little more complicated than, say, the contract for buying lawn service. A construction contract is an agreement between the owner and the contractor and is enforceable by law. Generally, the contractor agrees to perform a service for some consideration or payment. Many documents make up the construction contract.

Up until now, I have been referring to the “plans and specs” as the contract documents. The contractor is responsible for delivering the project in accordance with the plans and specs. However, it is time to get into the nitty-gritty of exactly what is meant by that common term. This chapter examines all of the procedural and administrative details of the construction contract.

The consequences of failing to understand the obligations of the contract are significant, and every construction manager must be completely familiar with what constitutes the contract for construction. The bottom line is that every aspect of the project will be controlled by these documents, and the work of the contractor will basically be judged by them.

The Contract Documents

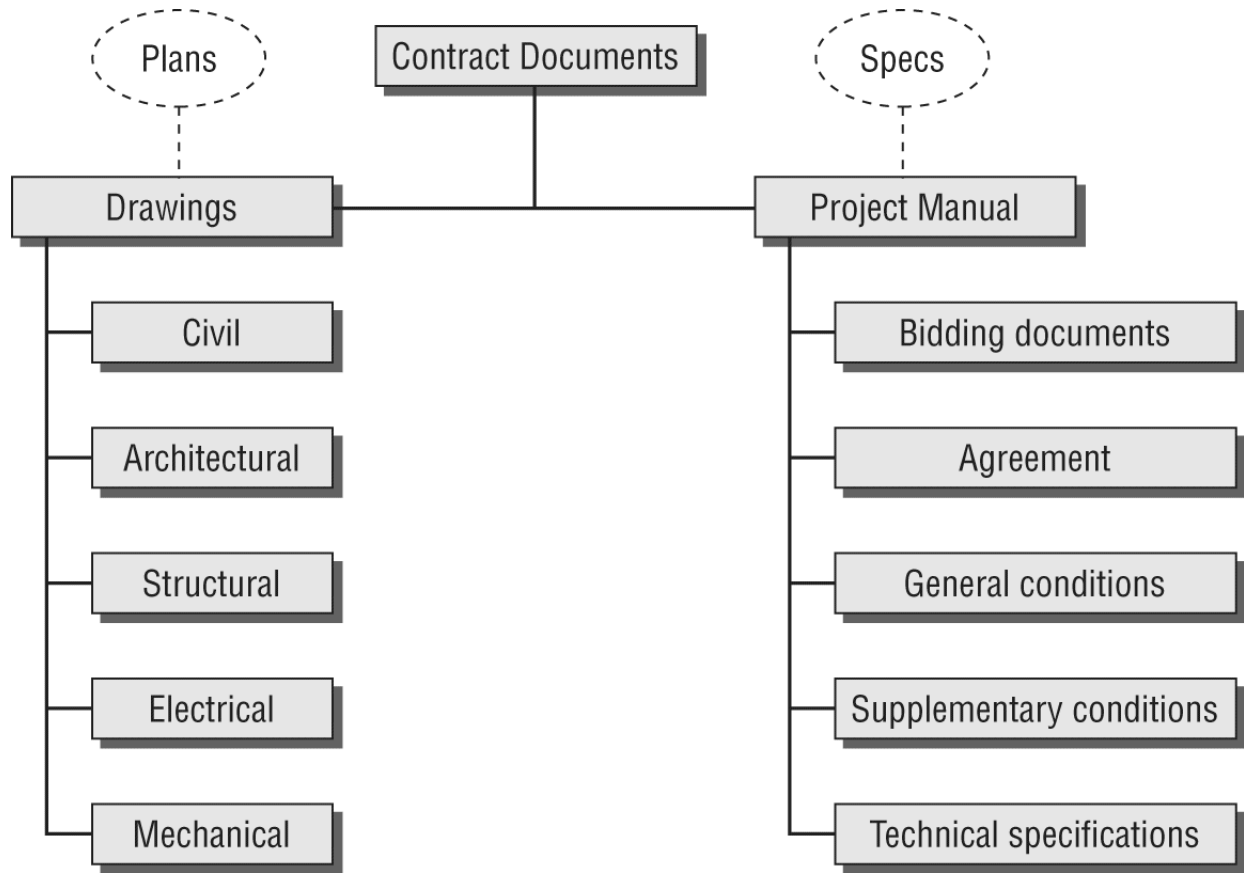
The contract for construction consists of much more than just a simple agreement form. Although an agreement form is eventually executed between the owner and the contractor, there are many more documents that direct the construction of the project and responsibilities of the parties. All of these documents taken together make up the construction contract, and they are referred to as the *contract documents*.

contract documents

The construction drawings, conditions, terms, and specifications setting forth the requirements for constructing the project.

Under most circumstances, the contractor is not involved in the actual design of the project. The contract documents are the medium through which the architect or engineer communicates the design intent to the contractor. Therefore, you can certainly understand just how important it is that the documents be as complete and free from error as possible.

The contract documents consist of two major components: the construction drawings and the project manual. The construction drawings, also called construction documents or working drawings, basically define the quantity of the work—the length, the width, the area, the volume, and so on. The project manual, which includes the specifications, defines the quality of the work. The construction team must fully familiarize itself with these documents before bidding a job and should know them inside out before proceeding with construction. The components of the contract documents are discussed in detail here.



The Drawings

If I were to choose the most basic skill necessary for anyone involved in construction, it would be the ability to read construction drawings. Anyone who has ever built a house is probably very familiar with the consequences of failing to understand exactly what is in those darn drawings. They are filled with symbols and abbreviations generally unknown to the public at large, and many of the lines on the sheets are meaningless to the layperson. Yet every one of those symbols, abbreviations, and lines represents an instruction to the builder.

The drawings are a graphical set of directives prepared by the architects and engineers in order to communicate the wishes and desires of the owner. They are the single most important communication tool employed by the industry to convey the work of the contract. They are critical to the process, and their quality is of utmost importance.

Prior to the Renaissance, the master builders communicated their design intent by building models and drawing sketches to help

explain what they wanted the builders to do. During the Renaissance, architects decided that they could simply make drawings and write instructions on paper to communicate their desires. The process went from the idea of showing the builders how the work was to be done with a model to telling them how to do it with plans and specs.

Today, most contractors are again using computer-generated 3D models to supplement the building process. The sophistication of the models corresponds to the sophistication of the project owner and the contractor team the owner hires. Buildings and structures are so complex today that it is almost impossible to figure out all of the intricacies of the building process in a two-dimensional mode. In most of life, history has a way of repeating itself, and design and construction communication is no exception. Two-dimensional plans are becoming obsolete, and computer modeling is becoming the communication tool of choice for all building projects, regardless of size. But, in the meantime, it is important for anyone interested in construction management to understand what exactly constitutes a set of construction drawings.

Drawing Production

Back in the old days, the plans or drawings were often called *blueprints*. That term came from the way in which documents were printed: produced by hand using lead pencils or ink and reproduced using blueprint machines. The paper used to reproduce the drawings was actually blue paper, and all of the lines on the paper printed in white. The printing process used today produces blue lines on white paper, and the correct term for the drawings is actually *bluelines*. However, many people still refer to the drawings as blueprints.

Most drawings today are actually produced electronically using computer-aided design software known as CAD, and the prints are produced on digital plotters using multiple ink colors. So, the expression “back to the drawing board” is actually passé, because when redesign must take place, today it actually means “back to the computer.”

Drawing Size

Drawings can range in size from a three- or four-sheet set used to build a simple house up to a monstrous set of more than 100 sheets required to build a magnificent structure such as the Cathedral of Our Lady of Angels in Los Angeles. Obviously, the bigger the project, the bigger the set of drawings.

NOTE

A single drawing sheet can range in size from 24" × 36" to 36" × 48" to even larger sizes. Trying to manhandle some of the larger drawing sets can actually be physically challenging.

One of the great advantages of CAD is the capability to manage all of the drawings electronically. Today, a 100-sheet set of drawings weighing 40 pounds or more can fit on one flash drive and be carried in your pocket.

The users of these drawings (contractors, subcontractors, and vendors) must be able to find the information that they are looking for as easily and quickly as possible. Standardization of the documents facilitates ease of use and helps maintain a consistent quality of graphic communication. Therefore, standard protocols have been established for organizing drawing sets and for organizing each sheet.

Organization of the Drawings

As you can imagine, a lot of information must be conveyed to the construction team when trying to build a complex facility. Although the architect is the lead designer on a building project and is accountable for providing the architectural design for the facility, the architect does not do all of the work alone. Various engineers are hired by the architect to assist with specialized areas of design, such as civil engineering and structural, mechanical, and electrical design. The architect is in charge of coordinating all of these efforts and is responsible for compiling the final set of design documents. Therefore, the drawing set is organized by the various types of designs required to fully communicate the extent of the construction (such as

civil drawings, architectural drawings, structural drawings, and so on), and they are numbered accordingly for easy reference.

perspective drawing

A two-dimensional drawing representing a three-dimensional object and displaying the width, length, and height of a structure.

Most sets of drawings start with a cover sheet providing general information about the project. For example, the project owner is noted, as are the architect, the engineers, and sometimes even the financier. The location of the project is often noted on the cover sheet as well, using vicinity maps and subdivision plats. Sometimes a *perspective drawing* of the building is also shown on the cover sheet. After the cover sheet, it is common to order the drawings in accordance with a standard protocol. That standard protocol calls for the civil drawings to be placed directly behind the cover with architectural, structural, mechanical, and electrical drawings to follow.

Civil drawings These drawings are usually prepared by a civil engineer working with the architect and describe all items of work associated with the site. The site work includes such things as grading, demolition, excavation, site utilities, streets, curbs, and gutters and their details. Sometimes landscaping is also included under this section. The civil drawings are typically numbered as C1, C2, C3, and so on.

Architectural drawings The architectural drawings are prepared by the architect and usually constitute the bulk of the set. They describe the overall aesthetics of the facility, including project size, shape, and appearance. Detailed information regarding dimensions, materials, and quality are graphically depicted through the architectural drawings. The architectural work includes such things as floor plans, exterior elevations, and sections; door, window, and finish schedules; and architectural details. These drawings are numbered A1, A2, A3, and so on.

Structural drawings The structural drawings are prepared by a structural engineer working as a consultant to the architect. Coordination between the architecture and the structure is very important. Good synchronization here can help avoid expensive conflicts down the road during construction. The structural drawings identify the major components making up the structural frame of the building, such as columns, beams, and girders. The structural engineer also provides the structural calculations, which analyze the vertical loads as well as lateral loads consisting of wind and earthquake loads. These drawings are typically numbered S1, S2, S3, and so on.

Mechanical drawings The architect will hire a mechanical engineer to prepare the mechanical drawings. The mechanical work splits between two major support components for any building—the plumbing and the heating, ventilation, and air conditioning (HVAC). The plumbing portion of the drawings typically includes information describing the installation of water lines, sewer lines, and gas lines. The HVAC portion of the drawings covers ductwork, air handlers, compressors, and other equipment associated with climate control. Fire protection can also be included with the mechanical drawings. The mechanical engineer also provides heating and cooling calculations used to determine the required capacity of the heating and cooling equipment and the requisite energy compliance forms to demonstrate that the building complies with energy-efficiency requirements. The mechanical sheets are numbered M1, M2, M3, and so on.

Electrical drawings The electrical engineer, working as a consultant to the architect, prepares the electrical drawings. The electrical work includes all of the rough wiring, transformers, and panel boxes, as well as receptacles, switches, and light fixtures. Communications and computer wiring are also included in the electrical drawings. The electrical engineer provides calculations to determine the proper wire size, conduit size, and over-current protection device (fuse or circuit breaker) capacity. These drawings are numbered E1, E2, E3, and so on.

NOTE

Although the construction manager is not expected to be an expert technician in all facets of the construction, the person must be able to interpret and understand all of the work described in the different drawings. This is no easy task, and it can take years of experience before one becomes knowledgeable in all areas.

Types of Drawings

As previously mentioned, fundamental to construction and construction management is the ability to read and interpret the plans. Within every set of plans, there are specific types of drawings that help the reader obtain a better understanding of the construction. Because so much information must be communicated to explain how the structure is to be built, each layer of drawings becomes more and more specific, emphasizing greater detail. There are four basic types of drawings that can be used to communicate the intent of the design and construction. They are plans, elevations, sections, and details.

Plans A plan view is a horizontal “cut” or slice through the entire building. Every set of construction drawings includes at least one plan view of the building. That's why we often refer to the drawings as plans. Often there are several different plan views incorporated into the drawings. For example, foundation plans, floor plans, and framing plans are common elements of a quality set of drawings. Most plans are drawn using a $\frac{1}{4}$ " scale, but some large buildings must be drawn at a $\frac{1}{8}$ " scale in order to fit on the drawing sheet.

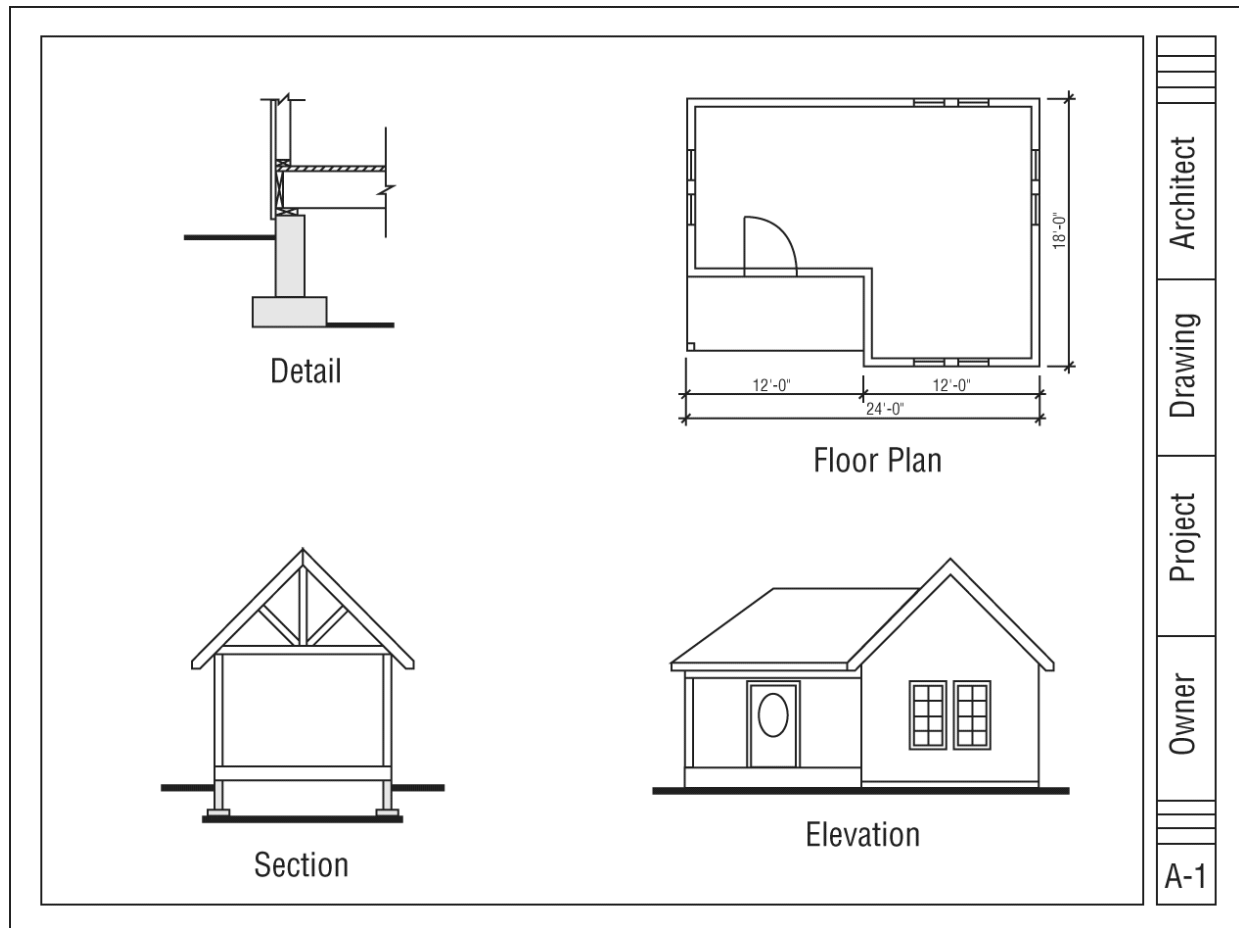
NOTE

A 1/4" scale means that every 1/4" measured on the drawings represents 1" in true dimension. Because there are 12 inches in a foot, the building will actually be 48 times (4 x 12) larger than the drawing itself. The architect uses a special measuring rule called an *architect's scale* to lay out drawings.

Elevations Elevations depict what the building or structure looks like from the outside. All four sides of the building are typically shown in elevation. They are usually drawn to a 1/4" scale, depending on the size of the project and the size of the sheet being utilized. Again, sometimes a 1/8" scale might need to be employed. The elevations are often named according to which direction the exterior wall faces. The south elevation of the building is the wall that faces south.

Sections Section drawings are used to present a deeper understanding of the design at certain key spots in the plan or elevation. A section drawing represents a vertical "cut" through the building from top to bottom. There are usually several section drawings included in a set of plans. They are very helpful in trying to visualize exactly how all of the parts and pieces come together at a particular point in the structure. These drawings are often drawn using a 1/2" scale but may need to be downsized to a 1/4" scale if room on the sheet is limited.

Details Detail drawings depict portions of the building "blown up" in scale to help explain finer elements of the design. They are drawn very large, comparatively speaking, utilizing 1", 1 1/2", or even 3" scale. They are particularly helpful for viewing connections, intersections, special features, or tricky construction details.



Again, given the amount of information that must be conveyed in these documents, it is not unusual for there to be discrepancies between the various levels of drawings. As a matter of fact, it is so common that specific guidelines are often established in the general conditions to the contract provided in the project manual to address the problem.

Typically, the more-detailed drawings take precedence over the more-general drawings if there is a conflict between the drawings. In other words, the detail drawings take precedence over the sections, and the sections take precedence over the plans. For example, a foundation plan might indicate that the concrete footings are 24" wide and 10" deep. But the wall section shows that the footings are 24" wide and 8" deep. The wall section would take precedence over the foundation plan, and the footing would be presumed to be only 8" deep. However, it should be noted that the specifications take precedence over the drawings altogether.

Obviously, the opportunities for error in interpreting these documents are numerous. It is the construction manager's job to try to eliminate the conflicts before the construction ever starts. Unfortunately, the pace of the work after winning the contract award is usually fast and furious, and the project team must be constantly on the lookout for such discrepancies in the plans and specs in order to avoid costly mistakes.

The Project Manual

The project manual is the second part of the contract documents. This is the part that is often referred to as the *specs*. Although the technical specifications do make up the bulk of this manual, a number of other documents are included in the book. The project manual contains all the written construction documents about the structure to be built. Those documents include the bidding requirements, contracting requirements, and written specifications for every detail of the building.

Whereas the project plans provide the graphic instructions for the builder, the project manual provides the written instructions. These instructions deal with many of the “red tape” or administrative items associated with the building project. And, believe me, a lot of red tape is involved when building a construction project.

Understanding, organizing, coordinating, and managing all of this red tape is actually a primary function of the construction manager. And remember, the ability to fulfill the requirements addressed in these documents and in the drawings is what will be judged if there is a problem on the job. The project manual typically has four primary sections:

- ◆ Bidding documents
- ◆ General conditions
- ◆ Supplemental conditions
- ◆ Technical specifications

Let's take a look at each of these sections and consider how they relate to the construction manager's job.

Bidding Documents

The first section of the project manual provides information regarding the bidding process. There are four documents included under this heading:

Advertisement or invitation for bids This item usually appears at the very beginning of the project manual. The information found within these documents was covered in [Chapter 3](#), “How We Get the Work.” Basically, the invitation for bids acts as a notice to interested parties regarding the project and the requirements for bidding.

Instructions to bidders This section includes specific instructions regarding the bidding process and goes into much more detail than the invitation for bids. Although many of these instructions are pretty standard, it is always wise for the construction manager or estimator to review the document thoroughly. In addition to the basic information regarding the project, the instructions to bidders also include the following:

- ◆ Procedures for submitting questions and obtaining clarifications regarding the contract documents.

addendum

A change or addition to the contract documents issued after the documents have been released but before the bids are due.

- ◆ Information regarding *addendum* receipt and inclusion as part of the contract documents.
- ◆ Rules concerning bid submission including bond requirements, bid opening, rejection of bids, and notification of successful bidder. Rules pertaining to bid withdrawal would also be disclosed.
- ◆ The expectations for post-bid deliverables including such items as the schedule of values, cash flow projections, the construction schedule, payment and performance bonds, or

any other documentation requested by the owner prior to the signing of the contract.

Bid forms The actual forms that need to be filled out when submitting the bid are included in this section of the manual. The bid or proposal form includes information regarding the bid price, completion date, subcontractors, alternate pricing if requested, and receipt of addendum. Some projects require specific verification regarding special requirements. For example, the project may require Minority and Women's Business Enterprise (MWBE) participation. In this case, an MWBE compliance certification form would be included with the bid forms. (To learn more about MWBE go to <https://www.mwbe-enterprises.com/>.)

The agreement form A copy of the contract form is also included in the project manual. This is the document that will actually be signed by the parties after the contract is awarded. There are different types of contracts that may be executed, and the builder must know which one is going to be used. The various contract types are discussed later in the chapter.

General Conditions

The general conditions document is one of the most important documents associated with the contract for construction. In essence, it sets the ground rules for playing the game. The responsibilities of each of the parties are clearly delineated, and the specific terms of the contract are defined in this section of the manual. It is vital that the contractor know exactly what is contained in this section. In the following list, I identify the standard clauses that typically appear in the general conditions and give a brief description of each:

General provisions This section provides fundamental definitions for the contract, the work, and the drawings and specifications. It also clarifies the ownership, use, and overall intent of the contract documents.

Owner responsibilities This section stipulates the information and services that the owner is required to supply. It also identifies the owner's right to stop the work and the owner's right to carry out the work.

Contractor responsibilities This section lays out the obligations of the contractor regarding construction procedures and supervision of the work, labor and materials, warranty, taxes, permits, fees and notices, schedules, samples and product data, and cleaning up.

Administration of the contract This section assigns duties to the architect for the administration of the contract. Specific clauses dealing with the architect's responsibility for visiting the site and making inspections are included. The section also addresses how requests for additional time and claims and disputes will be handled.

Subcontracts and subcontractor relations This section deals with the awarding of subcontracts to specialty contractors by the general contractor for portions of the work.

Construction by owner or others This clause deals with the owner's right to perform some of the construction work with their own forces or to award separate contracts to other parties besides the general contractor.

Changes in the work This section explains how changes are to be authorized and processed. This is a very important clause in the contract because changes in the work are one of the areas of greatest contention between the owner and the contractor.

Time and schedule requirements Time is always an important factor on any project. This section defines project startup, progress, and completion relative to the specific project schedule. It also addresses issues associated with delays and extensions of time to the contract.

Payments and completion This section is very important because it identifies how the contractor will be paid. It specifies how applications for progress payments are to be made. It also deals with the withholding of payments and failure-to-pay issues.

Protection of persons and property This section addresses concerns for the safety of both the owner's property and the people on the project. It deals with specific issues such as the handling of hazardous materials and emergencies, as well as overall safety programs and requirements.

Insurance and bonds This section deals with insurance and bonding requirements of the parties.

Uncovering and correction of work This clause has to do with acceptance of the work by the architect (as agent of the owner). It stipulates how and when the contractor is responsible for uncovering and/or correcting any work deemed unacceptable.

Miscellaneous provisions This section addresses various miscellaneous matters such as typical successors and assigns issues, tests and inspections, and interest on delayed payments.

Termination or suspension of the contract There are reasons for terminating a contract, and either party has the right to do so under certain conditions. This section deals with the conditions under which parties may terminate or suspend the contract.

NOTE

There are many standard general conditions documents that have been developed by various trade and professional organizations. The most common among these is the general conditions document published by the American Institute of Architects, AIA Document A201. The advantages to using a standard form such as the A201 are that most contractors are already familiar with it and it has been tested in the courts.

Supplemental Conditions

The supplemental conditions, or special conditions, usually deal with matters that are project specific. In other words, they are considerations beyond the scope of the standard general conditions and serve as an augmentation to the terms laid out in the general conditions. Examples of some project-specific information that may appear in these conditions are listed here:

- ◆ Soils and soil-testing information provided by the owner

- ◆ Survey information provided by the owner
- ◆ Materials or other services provided by the owner
- ◆ Job signage requirements
- ◆ Traffic control and pedestrian safety requirements
- ◆ Phasing or special schedule requirements
- ◆ Requirements for security
- ◆ Temporary facilities and sanitation requirements

Technical Specifications

Technical specifications make up the bulk of the project manual. Whereas the bidding documents, general conditions, and supplemental conditions deal primarily with the administrative aspects of the contract, the specifications deal more directly with the construction. They are used in conjunction with the plans and describe the detail that cannot be conveyed by the graphic depictions alone. The specifications identify the requirements of the project relative to the labor, materials, equipment, and procedures needed to accomplish the work of the contract. The plans and specifications taken together are intended to aid in pricing the job as well as performing the work. The primary purpose of the specifications is to clarify and describe the following aspects of the job:

- ◆ Quality of materials
- ◆ Standard of workmanship
- ◆ Methods of installation and erection
- ◆ Quality control and quality assurance procedures

Between the drawings and the specifications, every material and every installation that goes into building a project must be identified and specified. That includes everything from the concrete and steel in the foundation to the smallest knob on a drawer front. As you might imagine, this task is a massive undertaking. Fortunately, an organizational structure has been developed to assist designers and contractors in keeping track of all of this very important information and presenting it in a logical order. The information is organized into

a master format consisting of 50 standard divisions. This format was developed by the Construction Specification Institute.

The Construction Specification Institute

The Construction Specification Institute (CSI) was founded in 1948. The CSI serves all of the major disciplines involved in the building design and construction industry. Although it has developed many tools to assist the industry, one of the most important is the specifications organizational structure known as the MasterFormat.

The MasterFormat is the most widely used system for project manuals and specifications. This format also becomes the reference framework for construction product information, market data, and pricing databases. This standardized format for specifications fosters clearer communication among designers and builders and all the other project players as well. That makes it much easier to meet the owner's requirements for time, budget, and quality, which is the whole point to begin with.

The CSI MasterFormat

All work in construction is organized and managed under this format. It is not only used for organizing and communicating design data and information but is also used to organize estimates and track project costs. The MasterFormat is something that every construction manager will be required to utilize and reference throughout the construction process from start to finish. That is the reason that I take the time to list all 50 standard divisions next. I have also identified a few examples of the types of items that are addressed under each category to help you recognize the work of each division.

The MasterFormat is organized into two primary groups. They are the Procurement and Contracting Requirements Group and the Specifications Group. The Procurement and Contracting Requirements Group covers the introductory information, procurement requirements, and the contracting requirements associated with the project. The Specifications Group is broken down into 5 subgroups. They are:

- ◆ General Requirements Subgroup – Division 1
- ◆ Facility Construction Subgroup – Divisions 02–19
- ◆ Facility Services Subgroup – Divisions 20–29

- ◆ Site and Infrastructure Subgroup – Divisions 30–39
- ◆ Process Equipment Subgroup – Divisions 40–49

Each group and subgroup has divisions under it. The Procurement and Contracting Requirements Group has only 1 division associated with it – Division 00. The Specifications Group has 49 divisions associated with it identified under the various subgroups.

Next, let's take a closer look at the 5 subgroups and the 49 divisions that are affiliated with them. You'll note that some divisions are held in “reserve.” This is in anticipation of potential changes associated with advancements in the built environment in the future.

The General Requirements Subgroup

This subgroup generally addresses issues associated with carrying out the requirements of the contract and job-specific overhead items. Every project, regardless of type or size, will include items under this category. And although they are not “construction related,” they are nonetheless very important factors and may impact both the estimate and the schedule in a significant way.

Division 01: General Requirements Includes requirements associated with contract procedures such as work restrictions, payment procedures, submittal procedures, security procedures, quality control requirements, and other regulatory requirements. This section also includes overhead items directly associated with the project such as job trailers, supervision, field testing, temporary utilities, security fencing, and project cleanup. Versions after 2004 also address life-cycle activities such as commissioning, facility operation, maintenance, and decommissioning.

The Facility Construction Subgroup

This category of the specification deals with all of the standard architectural divisions of work that generally apply to any commercial construction project. It does not include the divisions of work that are associated with the more technical aspects of a building such as electrical, mechanical, and plumbing divisions.

Division 02: Existing Conditions Includes the assessment of existing conditions associated with a project including demolition requirements, site remediation, decontamination, and hazardous waste handling.

Division 03: Concrete Includes such items as cast-in-place concrete, concrete forms, reinforcing steel, concrete finishing, concrete curing, grouting, and concrete cutting and boring.

Division 04: Masonry Includes items such as brick, concrete block, glass masonry units, stone, and mortar.

Division 05: Metals Includes items such as steel beams, girders, columns, ornamental iron, metal decking, and pipe railings.

Division 06: Wood, Plastics, and Composites Includes items such as rough carpentry, interior trim, paneling, cabinets, shelving, stairs, plastic decks and rails, cultured marble fabrications, composite lumber, and glass-fiber-reinforced plastic.

Division 07: Thermal and Moisture Protection Includes items such as insulation, roofing, vapor retarders, waterproofing, gutters, downspouts, flashing, fire and smoke protection, and caulking.

Division 08: Openings Includes metal doors and frames, wood doors, overhead doors, sliding doors, storefronts, windows, skylights, louvers, vents, hardware, and glass.

Division 09: Finishes Includes items such as drywall, paint, acoustic ceiling, carpet, wood flooring, access flooring, wall coverings, and tile.

Division 10: Specialties Includes items such as flagpoles, toilet partitions, bathroom mirrors, fire extinguishers, white boards, signage, cubicles, fireplaces and stoves, exterior shutters, awnings, and pest control devices.

Division 11: Equipment Includes items such as kitchen appliances, range hoods, medical equipment, parking meters, loading docks, bank vaults, walk-in freezers, projectors, telescopes, climbing walls, and other recreational equipment.

Division 12: Furnishings Includes items such as draperies, art, murals, rugs, bookcases, pews and benches, stadium seating, plants, and planters.

Division 13: Special Construction Includes items such as swimming pools, hot tubs, fountains, tennis courts, kennels, special instrumentation, and security systems.

Division 14: Conveying Systems Includes items such as pneumatic tube systems, dumbwaiters, elevators, escalators, moving walks, wheelchair lifts, turntables, and scaffolding.

Divisions 15 through 19: (Reserved) Not designated at this time.

The Facility Services Subgroup

This category homes in on the detailed construction associated with critical building systems such as mechanical, electrical, plumbing, automated functions, and security. Whereas concrete and doors or windows are “fixed” items, these systems require constant oversight and monitoring from a facilities perspective in order to keep the building functioning as expected. You might say that the systems included in this category are continuously “active,” while the divisions in the previous category are “fixed.”

Division 20: (Reserved) Not designated at this time.

Division 21: Fire Suppression Includes items such as fire extinguishing systems, fire pumps, and storage tanks for fire suppression.

Division 22: Plumbing Includes supply and waste piping, plumbing fixtures, pumps, water softeners, water heaters, drinking fountains, swimming pool plumbing systems, and gas and vacuum systems.

Division 23: Heating, Ventilating, and Air Conditioning Includes heating, ventilating, and air conditioning items such as furnaces, air handlers, compressors, HVAC piping and pumps, fans, cooling towers, solar collectors, and duct work.

Division 24: (Reserved) Not designated at this time.

Division 25: Integrated Automation Includes equipment and instrumentation for any type of automated system such as routers, switches, hubs, modems, remote control devices, monitors, valves, dampers, transmitters, relays, and sensors.

Division 26: Electrical Includes items such as electrical wiring, transformers, receptacles, outlets, light fixtures, generators, and battery equipment.

Division 27: Communications Includes items such as cabling, network equipment, hardware, software, voice communications, and audio-video systems.

Division 28: Electronic Safety and Security Includes items such as alarm systems, electronic surveillance systems, intrusion detection equipment, and fire alarm systems.

Divisions 29: (Reserved) Not designated at this time.

The Site and Infrastructure Subgroup

This is one of the most important categories associated with a project. The divisions listed next relate to the work that takes place *before* the work takes place. In other words, every structure has to sit on a site, and every structure needs utilities in order to function properly. This category deals with bringing those utilities to the building. It also deals with a couple of unique project types such as transportation and marine projects.

Division 30: (Reserved) Not designated at this time.

Division 31: Earthwork Includes work items such as site clearing, earth moving, grading, excavation, fill, erosion control, soil treatment, soil stabilization, slope protection, shoring, pile driving, caissons, tunneling, and mining.

Division 32: Exterior Improvements Includes items such as paving, curbs, gutters, fences, gates, retaining walls, fabricated bridges, wetlands, irrigation, planting, and landscaping.

Division 33: Utilities Includes work associated with site utility installation for water, sanitary sewer, storm drainage, gas, electrical, and communications.

Division 34: Transportation Includes items such as rail tracks, monorails, cable transportation, traction power, transportation signaling and control equipment, airfield signaling and control equipment, fare collection equipment, and bridge machinery.

Division 35: Waterway and Marine Construction Includes items such as seawalls, jetties, levees, flood walls, floating piers, offshore platforms, underwater construction, marine buoys, mooring devices, and dams.

Divisions 36 through 39: (Reserved) Not designated at this time.

The Process Equipment Subgroup

Industrial projects that require unique process equipment are a whole unique category in and of themselves. There are special pieces of equipment and systems that you would not find in a typical commercial construction project. This category addresses the requirements of these types of projects.

Divisions 40 through 43: Process Integration, Material Processing and Handling Equipment; Process Heating, Cooling, and Drying Equipment; and Process Gas and Liquid Handling, Purification, and Storage Equipment Include the unique requirements associated with the work, installation, equipment, and protection for process plant facilities.

Division 44: Pollution Control Equipment Includes items that are associated with air pollution control, noise pollution control, water treatment equipment, water filtration, and solid waste control.

Division 45: Industry-Specific Manufacturing Equipment Includes the equipment requirements for various special industries such as oil and gas extraction, mining, food manufacturing, beverage and tobacco, textiles, leather, wood products, paper, printing, petroleum and coal, chemical, plastics and rubber, metals, machinery, computer and electronics,

electrical and appliance, transportation, furniture, and other manufacturing equipment.

Divisions 46 through 47: (Reserved) Not designated at this time.

Division 48: Electrical Power Generation Includes items associated with electrical, nuclear, hydroelectric, solar, wind, geothermal, electrochemical, and fuel cell power generation.

Division 49: (Reserved) Not designated at this time.

NOTE

It's important to keep up with the latest edition of the CSI MasterFormat. For example, the 2018 MasterFormat had over 100 detail additions and changes over the 2016 edition. You may access the newest edition by going to <https://www.csiresources.org/practice/standards/masterformat>.

The CSI Numbering System

The MasterFormat utilizes a six-digit numbering system, providing more expansion spaces for organizing various work items under each division. The first two digits represent the division of work, otherwise known as *level one*. The next pair of numbers represents level two, and the third pair represents level three. Level four numbers may also be used in the MasterFormat when the amount of detail merits the additional level of classification. When this occurs, the additional pair of numbers comes at the end, preceded by a dot. Here is an example:

Division Numbers	Division Names	Numbering System
Level 1	Unit Masonry	04 20 00
Level 2	Clay Unit Masonry	04 21 00
Level 3	Brick Masonry	04 21 13
Level 4	Brick Veneer Masonry	04 21 13.13

The CSI system is very sophisticated. Some architects make full use of the system when putting together their project manuals, and others may limit the level of detail provided. Regardless of the extent, knowledge of the CSI organizational framework will help the construction management team quickly and easily access the information they need, when they need it.

SECTION 06 10 00 <u>ROUGH CARPENTRY</u>		
PART 1 - GENERAL		
1.01	Description	
	A.	Section Includes: Provision of all lumber, framing, rough hardware and blocking as required.
	B.	Related Sections:
		1. Section 03 11 00 - Concrete Forming
		2. Section 06 17 00 - Shop Fabricated Structural Wood
1.02	References	
	A.	Requirements of GENERAL CONDITIONS and DIVISION 1 apply to all Work in this Section.
	B.	Published Specifications standards, tests, or recommended methods of trade, industry, or governmental organizations apply to Work in this Section.
1.03	Submittals	
	A.	Shop drawings of all specially fabricated rough hardware.
1.04	Product Delivery, Storage and Handling	
	A.	Provide proper facilities for storage of materials to prevent damage to edges, ends and surfaces.
	B.	Keep materials dry. Where necessary, stack materials off ground on level flat forms.
1.05	Job Conditions	
	A.	Environmental Requirements: Maintain uniform moisture content of lumber at not more than 19 percent before, during, and after installation.
	B.	Sequencing, Scheduling: Coordinate details with other Work supporting, adjoining or fastening to rough carpentry Work.
PART 2 - PRODUCTS		
2.01	Material	
	A.	Rough Carpentry
		1. Sills on Concrete: Foundation grade redwood or pressure treated Douglas Fir.
		2. Lumber: Studs, plates, beams, joists, posts, and blocking - Douglas Fir No. 1.
	B.	Rough Hardware
		1. Nails: Common wire, typical. At exposed conditions and pressure treated lumber use hot-dipped galvanized nails.
2.02	Source Quality Control	
	A.	Lumber shall bear grade-trademark or be accompanied by appropriate certificate of compliance.
	B.	Plywood shall bear APA grade-trademark.
PART 3 - EXECUTION		
3.01	Examination	
	A.	Examine areas to receive rough carpentry Work and verify that the spacing, direction, and details of supports are correct to accommodate installation of blocking, backing, furring and nailers.
3.02	Installation	
	A.	Studs, Joists, Beams, and Posts: Install all members true to line. No wood shingle shims are permitted. Place joists with crown up; maximum 1/4-inch crown permitted.
	B.	Nail joints in accordance with applicable requirements of the CBC Table 23A-II-B-I unless otherwise shown or specified.
3.03	Field Quality Control	
	A.	The Owner's Testing Agency shall:
		1. Inspect erected rough framing as required to establish conformity of work with Drawings.

The specification sample provided illustrates a very simple area of work for a very simple project. Compound the level of detail in this sample about 10 to 20 times, and you might get a sense of just how

much information the construction manager *must* pay attention to in order to ensure that the project will be built in accordance with the contract documents, on time, and within budget.

Many of the directives posted in the specifications, especially those associated with the execution of the work, are standard operating procedures for experienced contractors. However, the specifications establish the expectations for quality and contractor performance, and all work will be measured against them. It is an awesome challenge, to say the least. If you had any doubts about how demanding a construction manager's job is, this close look at what constitutes the contract for construction should dispel them!

All of this detail, along with the drawings, general conditions, and supplemental conditions, make up the part of the contract that tells us “how” we are to do the project. But there is another piece to the contract that addresses the “how much” element of the agreement. This important component can be structured in a number of ways, and you need to understand all of them.

Contract Types

Just as the owner makes the decision regarding the type of project delivery to be employed, the owner also determines which contract will be utilized for the project. Generally, which form is used depends on the type of project and the amount of risk that the owner is willing to accept. It is important that the construction manager be familiar with each type. There are four basic types of construction contracts: lump sum, cost-plus-fee, guaranteed maximum price, and unit cost. All of them contain the standard sections that I described earlier; however, they differ in two fundamental ways:

- ◆ How the contractor's price is quoted to the owner
- ◆ How risk is allocated to each of the parties

Lump-Sum Contracts

Lump-sum contracts are the most common type of contract, especially for building construction. Under this arrangement, the contractor agrees to complete the work specified in the plans and specs for a single fixed amount of money. From the owner's standpoint, this is probably one of the safest contracts because the cost is known up front. However, this is assuming that the plans and specs from which the contractor's estimates are made are accurate and complete. Once the contract is signed, both parties must live with the terms of the contract, and any flaws, errors, or omissions in the plans and specs will result in a *change order*. Change orders result in extra work and/or extra time, both of which result in extra cost to the owner. And although most owners are adamant about “no change orders” when they bid the job, it is completely unrealistic to assume that the contract documents will be flawless; change orders should always be anticipated for design-bid-build work utilizing a lump-sum contract.

change order

Requests made by the owner to add features to or subtract features from the scope of the project resulting in changes to the contract.

On the other hand, if there are cost overruns associated with the work that have nothing to do with errors or omissions in the design but instead are the result of poor management, rework, or even weather, then the contractor must suffer the loss with no additional compensation from the owner. Likewise, if superior performance by the construction management team results in a cost savings, then the contractor will solely benefit from that savings. [Table 4.1](#) illustrates the various scenarios.

[Table 4.1](#) Lump-Sum Contract

Contract Amount	Actual Cost	Contractor Impact	Owner Impact
\$2,000,000	\$2,029,000	Contractor suffers a \$29,000 loss.	No impact, because the contract amount remains the same.
\$2,000,000	\$1,990,000	Contractor earns an additional \$10,000.	No impact, because the contract amount remains the same.

Cost-Plus-Fee Contracts

Under a cost-plus-fee contract (also referred to as *time and materials*), the owner reimburses the contractor for all actual costs associated with the work plus a fixed fee or percentage of the cost. This type of contract is often utilized in situations where it is difficult to define the scope of the project accurately or when time is of the essence and construction needs to start before the full plans and specs are complete.

time and materials

Another name for a cost-plus-fee contract. These are the two cost factors that are reimbursed under a cost-plus-fee contract. Time equates to the cost of the labor, and materials equate to the cost of the building products used in the construction.

For the contractor, this type of agreement guarantees a profit on the job regardless of project cost. However, the owner is at significant risk under this arrangement because there is no limit set for the project cost, and the contractor really has no incentive for minimizing that cost. For this reason, it is very important that the owner clearly spells out up front exactly which costs will be reimbursed and which costs will be viewed as part of the contractor's fee. For example, labor, materials, equipment, and subcontracts are always reimbursed. But soft costs such as overhead and supervision may be disputed as reimbursable expenses.

Another important consideration for both the owner and the contractor with a cost-plus-fee contract is the amount of paperwork involved. Each billing requires a full accounting of exact project costs with receipts. This adds a tremendous administrative burden to both parties. The construction manager must prepare the bill, and the owner or architect must review and approve the bill. All of this extra work adds overhead expense on both sides and must be accounted for. [Table 4.2](#) illustrates this scenario for a \$2,000,000 budget.

Table 4.2 Cost-Plus-Fee Contract

Actual Cost	Fee as % of Cost *	Contract Amount	Contractor Impact	Owner Impact
\$1,994,500	\$99,725	\$2,094,225	None. The contractor still earns a 5% fee.	\$94,225 over budget amount of \$2,000,000.

* Presuming a 5% fee

Guaranteed Maximum Price Contracts

The *guaranteed maximum price (GMP)* contract is a variation of the cost-plus-fee contract and has become very popular, particularly with owners using design-build project delivery. This contract contains the best features of the lump-sum and cost-plus-fee contracts (see [Table 4.3](#)). The guaranteed maximum price offers a firm cap on the overall contract price and at the same time stipulates that the owner is obligated to pay only actual costs plus a fee. Under this scenario, the owner is protected by the guarantee of a maximum price and yet receives the benefit of any realized savings. It also allows for an early start of construction because the pricing of the job can occur before plans and specs are 100 percent complete.

guaranteed maximum price (GMP)

A contract methodology in which the contractor is reimbursed for actual costs of materials, labor, equipment, subcontracts, overhead, and profit up to a maximum fixed-price amount. Any costs over the maximum price shall be borne by the contractor. Any savings below the maximum price will revert to the owner. This type of contract is often implemented when design is less than 100 percent complete.

Table 4.3 GMP Contract

GMP Contract Amount	Actual Cost Plus Fee	Contractor Impact	Owner Impact
\$2,000,000	\$2,029,000	Contractor suffers \$29,000 loss.	No impact. The contract amount remains the same.
\$2,000,000	\$1,990,000	No impact.	Owner receives benefit of \$10,000 savings.

NOTE

When using a GMP contract, a smart owner often provides an incentive to the contractor for working as efficiently as possible by agreeing to split any savings with the contractor. The owner may offer splits in the 60/40 range or even 50/50 range. However, even without shared savings, there is still a great incentive for the contractor to perform well. Any time a contractor can return money to an owner, the odds for repeat business go way up.

Table 4.4 Unit-Price Contract

Work Item	Estimated Quantities *	Contract Unit Prices	Bid Amount	Actual Quantities	Final Cost
Trench excavation	14,000 CY	\$5.25	\$73,500	13,500 CY	\$70,875
8" pipe	1,750 LF	\$18.24	\$31,920	1,750 LF	\$31,920
Engineered fill	4,500 CY	\$22.50	\$101,250	4,700 CY	\$105,750
Backfill	9,500 CY	\$4.00	\$38,000	9,800 CY	\$39,200
TOTAL			\$244,670		\$247,745

* — Provided by owner

Unit-Price Contracts

Unit-price contracts are used when the work to be performed cannot accurately be measured ahead of time. Unit pricing is common for heavy civil and highway-type projects. Even though engineered site plans and specs are prepared for this type of work, it is very difficult to make exact quantity estimates because the material you are working with is not something you can physically count off like bricks or steel beams. The material quantities are much more imprecise (such as dirt or the removal of dirt), and the work is often performed

by large equipment such as bulldozers or backhoes instead of by installers such as electricians or carpenters.

For this reason, the owner typically provides fixed quantities for the contractors to apply their unit pricing to. This arrangement provides for a competitive bid situation via unit prices even though the exact quantities cannot be accurately determined from the plans and specs. For example, the owner could provide quantities for excavation, pipe laying, and backfill. The contractor would quote a dollar amount per cubic yard for soil excavation, a dollar amount per linear foot of piping laid, and a dollar amount per cubic yard of backfill installed and come up with a total bid based on the quantities that the owner provided.

The risk to the owner under this contract method is obvious; see [Table 4.4](#) for an illustration. If the owner's quantities vary greatly from the actual requirements of the job, then the owner will be responsible for the additional costs. The final price for the project is not known until the work is complete. The only sure thing about this approach is that the unit costs for each item of work remain the same throughout the project.

Terms to Know

addendum	guaranteed maximum price (GMP)
change order	perspective drawing
contract documents	time and materials

Review Questions

1. What two major components make up the contract documents?
2. When did architects first begin to use drawings to communicate their design intent?
3. What does CAD stand for?
4. There is a particular way in which the drawings are organized in a set of drawings. Identify the order of drawings in a typical set of plans.
5. What is the difference between a plan view and a section view in a set of drawings?
6. Name the four primary sections of a project manual.
7. The CSI MasterFormat is broken down into how many divisions?
8. Under which CSI division would you find building insulation?
9. Name the four basic types of construction contracts.
10. Under a guaranteed maximum price contract, what happens if the actual cost is less than the guaranteed maximum contract price?

Chapter 5

Project Stages

In This Chapter

- ◆ The design process
- ◆ Construction planning
- ◆ Project startup
- ◆ Selecting the project team
- ◆ Buying out the job
- ◆ Project closeout

By now, it should be very clear to you that the construction project is a complex undertaking and numerous people, activities, and requirements are involved to accomplish the goals set forth by the owner. Obviously anyone involved in construction management must be familiar with the stages in the overall process in order to move the project from concept to occupancy and utilization by the end user.

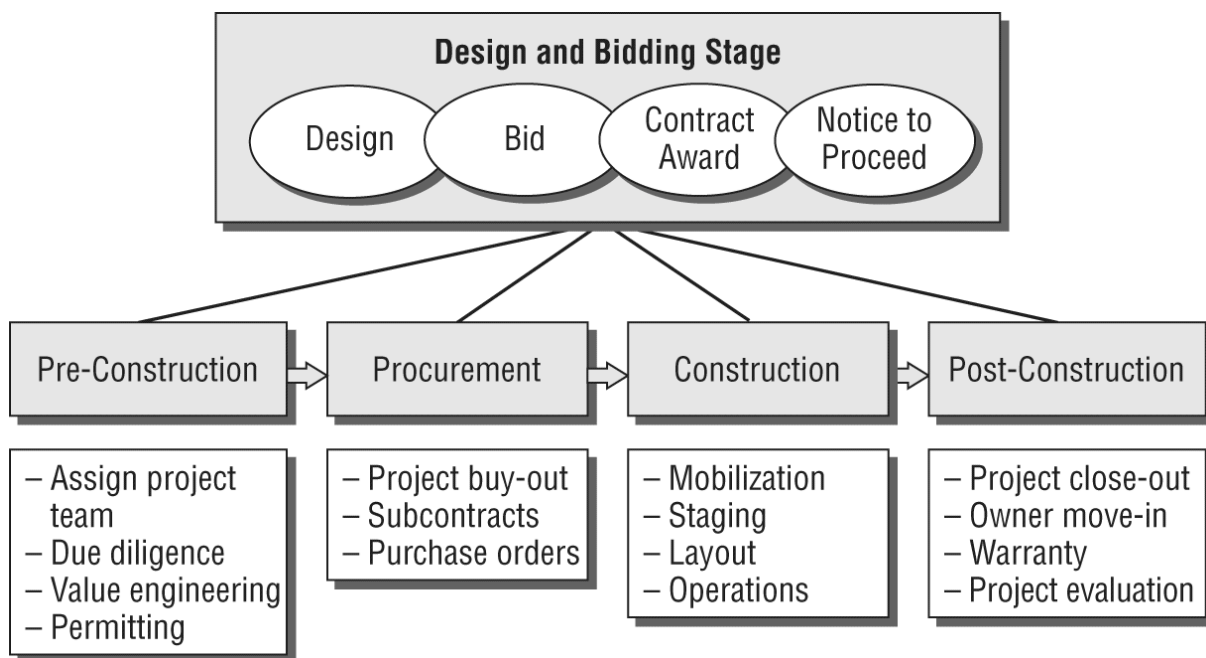
The overall design and construction process is very linear in nature and requires a systematic, comprehensive approach. Each of the stages is unique, and specific management techniques and skills are needed to keep everything on track. The project team works together in a coordinated effort, hoping that the ball doesn't get dropped and nothing falls through the cracks. After all, there is a lot at stake, and everyone looks forward to a successful completion of the project.

It is time to take a look at just what the design and construction process entails. This chapter focuses on the stages of the process and the tasks associated with each of them.

The Design and Construction Process

Even though the construction process is complex and often overwhelming, there really is a method to the madness. The design and construction of buildings, bridges, and roadways follow a consistent linear path from initial concept to occupancy. We move through the process one step at a time, eventually arriving at the successful delivery of the construction project. These stages are as follows:

- ◆ Design
- ◆ Pre-construction
- ◆ Procurement
- ◆ Construction
- ◆ Post-construction
- ◆ Owner occupancy



The Design Stage

Every project starts with a design, and the design process involves an intensive study and a lot of considerations. Architects and engineers

basically take ideas combined with certain requirements and develop the two into comprehensible plans and specifications that are used to construct the new building or facility. Traditionally, contractors are not directly involved in the design process unless the project delivery method is design-build or CM. But whether or not they are involved in this stage, good contractors are aware of what occurs during this first step in the project sequence.

In addition to aesthetics, the design stage is about function and layout. But the ultimate purpose of the documents is to communicate graphically to the contractor what to build and, in some instances, how to build it. There are five steps to the design process:

- ◆ Programming and feasibility
- ◆ Schematic design
- ◆ Design development
- ◆ Construction documents
- ◆ As-builts

These steps are sequential and build on one another. As the designers work through the process, they move the design from concept to detailed drawings. Let's consider each of these steps one at a time:

Programming and feasibility Programming is typically done prior to the design process and engages the owners and end-users to clarify needs, goals, and objectives for the facility. Some of the information that comes out of the programming stage is the overall building size, the number of rooms and their adjacencies, how the spaces will be used, who will be using them, and what the requirements are for their function. The owner will inform the designer about what they like and what they don't like. Often the project budget is also discussed during programming, and it is the designer's responsibility to try to carry out the design with this budget in mind. That's where the feasibility comes in. Obviously, if the final design comes in over budget, then adjustments must be made to the original design. Unfortunately, this happens more often than not.

Schematic design Schematic, or conceptual, design is the first step of the creative process. These drawings consist of rough

sketches identifying general spaces and adjacencies, shapes, circulation patterns, orientation, and perhaps massing. The design team starts to consider such things as materials, sizes, colors, textures, and other aesthetic factors. At this point, the design is far enough along for the design team to outline preliminary specifications and estimates.

Design development (DD) The design development stage is where much of the detail work gets done. A great deal of research and investigation takes place regarding the use of materials, equipment, and systems that will go into the facility. The specifications become more developed at this stage, and more accurate pricing can now take place. It is during the design development process that value engineering and constructability reviews are typically performed.

construction documents

The final detailed drawings used to build the project. They're also called working drawings. These final drawings, along with the full project manual, specifications, and agreement forms are together referred to as the contract documents.

Construction documents (CDs) The final detailed drawings are called the *construction documents*. These drawings may also be referred to as *working drawings* because they are the plans that the builder will actually use for construction. You are already familiar with the makeup and significance of these design documents and know that they indeed constitute a major component of the legal contract. These are the documents that are used to solicit bids and pricing from the contractor. The quality of these documents will impact the quality of the pricing. If a significant design feature is not presented in the drawings, then it will not be priced by the contractor. And although we often refer to the construction documents as 100 percent complete, the truth is that they rarely are; all parties must be prepared for the changes that will inevitably arise as the project goes forward. Managing these changes can make up a large part of the construction management challenge.

As-builts There are often design or detail changes that occur during the construction process that vary from what the original drawings indicated. Sometimes these changes are a result of errors in the plans that no one caught before the project went to the field. And sometimes changes occur because the team saw a way to improve on the original design. Either way, even though the changes are documented in written change orders, any field modifications made during construction that deviate from the original design must further be documented in the construction drawings. These final drawings are called *as-built drawings* and they confirm what was actually built. Even if there were not changes made, there still must be a set of as-built drawings for record. The contractor, and not the architect, is responsible for completing this last design documentation stage. This is very important, because those individuals who will be responsible for maintaining, renovating, repairing, or operating the building after the construction is complete, will depend on the information in the as-built drawings or model to be an accurate representation of the facility and how it was constructed. The as-built drawings are turned over to the owner as part of the final documentation at project close-out.

as-built drawings

Record drawings completed by the contractor and turned over to the owner at the end of the project identifying any changes or adjustments made to the conditions and dimensions of the work relative to the original plans and specifications.

Codes and Compliance Issues

One of the major responsibilities of the design team is to make sure that the design meets all building codes and complies with various statutory regulations such as environmental impacts. In the overall scheme of things, this task can sometimes turn out to be the most frustrating for all parties involved. Throughout the design process, the plans are submitted to the appropriate planning, zoning, and building authorities for plan checks and compliance reviews. This process can take weeks, months, or—yes—even years. There are indeed projects that

get tied up in the red tape and political bureaucracy of planning commissions and town councils and take an eternity to see the light of day. Fortunately, the contractor is usually not involved until after the final design stage, when all that remains is to obtain the building permits. But even this process can take weeks or months depending on the number of resubmittals that must take place and the workload of the particular jurisdiction. Once again, the quality of the construction documents relative to code compliance will influence the ability of the contractor to expedite the permitting process.

The Bidding Stage

The design phase culminates with the competitive bidding stage. The drawings and specifications are complete, and now it's time to select the builder and award the contract. The architect produces multiple sets of documents for distribution to the contractors during the bidding stage. The architect also sends several sets to the building department for a plan check. The plan check by the building department occurs at the same time that bidding is taking place among the selected contractors.

The competitive bidding process and contract award were discussed in [Chapter 3](#), “How We Get the Work.” Traditionally, the architect coordinates the bidding procedures and assists the owner in making the contractor selection. A notice to proceed is issued to the winning contractor, and now the work that will transform the design into reality begins.

The Pre-construction Stage

Up to this point, the only members of the construction team who have been involved with the project are the estimators. Now with contract in hand and a notice to proceed from the owner, it is time to bring on the rest of the team. This is when the estimators pass the job over to the project manager. The project manager is the captain of the construction management team. This is most likely the first time that the project manager has seen the job, so the quality of the information passed from estimator to project manager is very important. Keep in mind that cost control is one of the most crucial components of the construction management task, and poor transfer of information here will result in significant headaches for the construction management team down the

road. I will discuss estimating and its importance in detail in [Chapter 8](#), “Estimating Project Costs.”

The project manager's job at this point is to set the course of action and put together the team that will carry this project through to satisfactory completion for all parties involved. This is the pre-construction stage (sometimes referred to as job startup), and it is all about project planning. This very important step can set the stage for success or failure and because of its importance, an entire chapter ([Chapter 7](#), “Performing Pre-construction Services”) has been dedicated to it. Unfortunately, sometimes this pre-construction phase is fast and furious because of schedule constraints, and finding the time needed to create a fully thought-out plan of action can be very difficult. As I said earlier, receiving the notice to proceed is something like receiving orders to deploy troops and equipment in an urgent military maneuver; time is of the essence, and you don't always have the people or the resources that you need right at the moment you need them. Most construction managers will tell you that job startup and job closeout are the two most difficult processes to manage. Let's take a quick look at a few of the tasks associated with the startup or pre-construction process.

NOTE

The key to good project planning is the ability to anticipate potential problems before they become actual problems. It is very important that project managers take the time to completely familiarize themselves with the project goals and come up with a plan that will ultimately meet the owner's expectations for time, cost, and quality, while still realizing a fair and equitable profit for the construction firm.

Assigning the Project Team

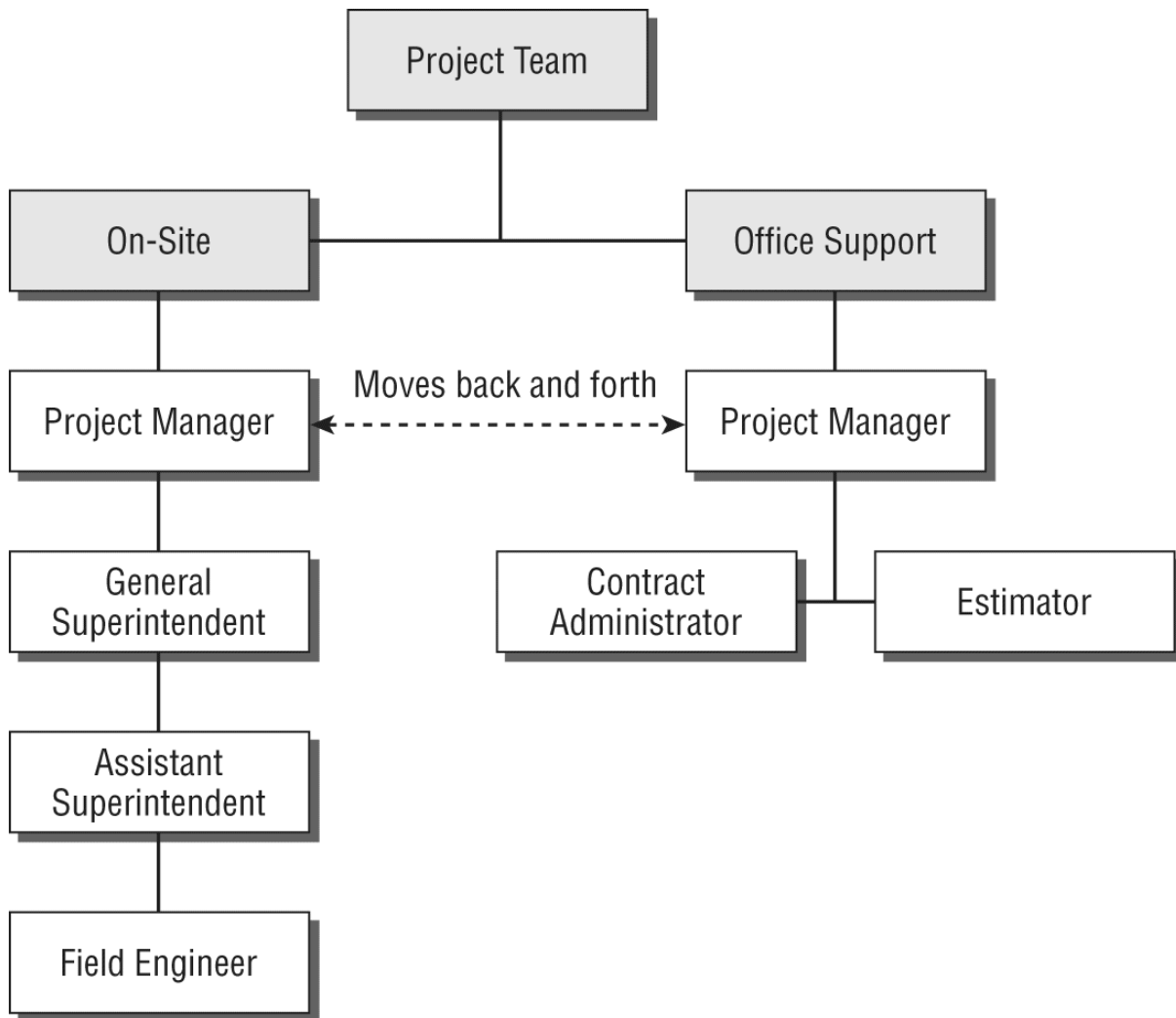
One of the very first tasks that must be taken care of by the project manager is putting together the project team. Depending on the size and complexity of the job, the typical construction project will have a project manager, contract administrator, general superintendent, maybe an assistant superintendent, and at least one field engineer. The on-site project team is supported by the office management team in the

form of estimating, contract administration, accounting, job costing, and payroll.

NOTE

Construction project managers are often accountable for more than one job at a time. It is not uncommon for them to be running two or three projects simultaneously, visiting each one at appropriate intervals.

Superintendents and field engineers are assigned to only one job at a time and typically remain on-site for the duration of the project. Once the project is complete, the team will disband, and individual members will be assigned to various other sites as needed.



Having the right project team makes all the difference in the world when it comes to a smooth-running job. The members must get along, support each other, and be able to work together under stressful conditions. The construction site is a unique environment—sometimes a tough environment—and the team must be up for the challenge. I have seen projects where as many as 100 different craftspeople were trying to do their job under intensely difficult conditions: cramped spaces, inadequate resources, and limited time. Tempers get short and frustration runs high. If you are a member of the management team, you had better have a relatively high “emotional intelligence quotient” because your ability to be flexible and responsive will far outweigh any benefits from being rigid and reactive. Let's take a closer look at the individual team members and consider their respective roles:

Project manager (PM) As stated earlier, the project manager is the captain of the team. Project managers usually have extensive experience in construction and a broad background in all aspects of the management process. Although the size of the company and the size of the project ultimately influence the specific duties of the PM, generally the PM is charged with four fundamental management tasks: assembling the best possible team for the project, developing the overall project schedule, setting up the cost control system, and establishing a quality control plan. The PM guides and directs the project team and monitors the schedule, cost, and quality, making adjustments as needed to bring about a successful outcome.

The project manager's accountability is twofold: they must see to it that the obligations spelled out in the contract documents are met to the owner's satisfaction, and they must also make sure that the project runs as efficiently as possible, taking advantage of every opportunity to save time and money to ensure a fair and reasonable profit to the construction firm.

Contract administrator This person assists both the project manager and the superintendent with many of the details of the contract—especially the general and supplemental conditions of the contract discussed in [Chapter 4](#), “The Construction Contract.” For example, the contract administrator may process progress payment applications, change orders, or submittals on behalf of the project manager. The contract administrator must be completely familiar with the contract stipulations and provisions and accustomed to working with all of the common forms, policies, and procedures.

Superintendent If the project manager is the captain of the team, then the superintendent is the first lieutenant. The superintendent is responsible for coordinating all of the construction activities on-site and keeping the project on schedule. Superintendents must be very knowledgeable when it comes to construction methods and details, because they are in charge of all direct labor and subcontractors and must ensure that the work complies with the requirements of the contract documents. The superintendent must also manage the flow of materials, deliveries, and equipment to create the most efficient and productive environment possible. And, of course, safety planning and

management is a major function for which the superintendent is responsible.

The superintendent is the daily point of contact for the owner and must maintain good working relations with all of the owner's representatives. Sometimes this can be the most challenging aspect of the job; however, it is a critical one. Nothing can turn a job sour more quickly than having the wrong superintendent on the job. The days of the rough-and-tumble construction superintendent are long gone. Today the man or woman in charge of running the job on-site must be as much a diplomat as a construction expert.

Field engineer This entry-level position is usually the first step to becoming a project manager. Field engineers are responsible for handling much of the paperwork that passes through the field office. They are usually assigned the tasks of processing and tracking requests for information (RFIs), submittals, and shop drawings. (These three processes will be discussed in detail in [Chapter 9](#), “Contract Administration.”) They may also assist with the project layout, payment verification, subcontractor coordination, and any other tasks assigned to them by the superintendent. Although the field engineer is an entry-level position, the role is a vital one on every project. (By the way, field engineers are not necessarily licensed engineers. The term *field engineer* is simply a job title.)

Once the project manager has established the project team, the person needs to bring everyone up to speed as soon as possible, especially the superintendent. The PM and superintendent will usually spend several hours or even days together planning for the project—developing schedules and strategies for a successful outcome. It is important that they become as familiar as possible with the drawings, the specs, the project scope, the budget and schedule, the subcontractor bids, and every other aspect of the job. Once the work starts, it can speed along like a runaway train, and the captain and first lieutenant had better have a really good plan in place to keep it on track! But you'll learn much more about this critical component of construction management in [Chapter 6](#), “Managing the Project Team.”

NOTE

The superintendent's role is a critical one. In years past, the supers came up from the ranks, first working in the field as a laborer or craftsperson. Today a superintendent is more likely to be a college graduate with a degree in civil engineering or construction management who has a particular bent toward the construction operations side. Good superintendents are worth their weight in gold, and supers actually are often among the highest paid members of the team.

Due Diligence

Due diligence is not a term that is proprietary to the construction industry. Many industries understand the concept. In simple terms, due diligence is the process of identifying any problems or areas of concern that exist so that those problems can be factored into the decision making that takes place during the pre-construction stage. Surprises increase risk and are not welcome during construction—they hinder the work progress, impacting the schedule, the cost, and in some instances even the quality of the job. The bottom line is that surprises should be avoided at all cost.

unforeseen conditions

Unknown physical conditions at the site that were not anticipated by the owner or the contractor.

Site investigation Although due diligence can be performed with any section of construction work, product, or procedure, the one area of construction where due diligence is of utmost importance is with site work. Site work deals primarily with site clearing, grading, and excavating and is generally considered one of the riskiest divisions of work. Surprises such as hidden geological problems, hazardous material, or historical remnants may be discovered after the job begins. Anything that the contractor can

do to mitigate *unforeseen conditions* associated with the site should be done before the work begins.

Soil testing and engineering One of the most reliable practices utilized to eliminate surprises associated with subsurface conditions is soil testing. Owners should insist upon these tests being conducted, and designers should ensure that the reports are made part of the supplemental conditions to the contract. The conscientious contractor will use the information in these reports to properly price the job and conduct the work. This information is commonly used by civil and structural engineers to design various site improvements and foundation systems as well.

However, even a soil report may contain flawed data. Some owners, in an effort to cut costs up front, rely on old reports and information. The results can be disastrous. It is often the classic case of an owner or designer being penny-wise and pound-foolish, and the courts have seen more than one case where such tactics have resulted in millions of dollars in claims.

Value Engineering

Value engineering is a process that may or may not be conducted during the pre-construction phase, depending primarily on which project delivery method is being used. In the low-bid, design-bid-build scenario, the owner is not really asking you for this evaluation. However, in the more integrated collaborative approaches, it is often a matter of course to conduct value engineering analysis as the design is being developed. In my opinion, value engineering is actually one of the most valuable services that a construction management team can deliver.

In this process, a thorough analysis is conducted of the design, products, and materials and their application, installation, and execution to determine whether the proposed design solutions are really the best solutions relative to their cost. The purpose of value engineering is to optimize resources to achieve the greatest value for the money being spent. The designers, contractors, building trades, engineers, manufacturers' representatives, and end-users are engaged to brainstorm the best possible solutions. A project team that can propose creative and cost-effective solutions can really shine and add tremendous value to the overall project.

One of the most underutilized resources available to the design team in the development of their solution is the engagement of the field personnel who actually install the systems, equipment, and products specified and the end-users who actually use the facility every day. They can provide great insight into what works and what doesn't work but are rarely ever called upon to join in the design team discussions.



Real World Scenario

Getting Burned by Bad Information

Recently, a custom home builder friend of mine was building a beautiful custom home on a Santa Barbara hillside in California. When pricing the grading and excavation for the bid, the contractor relied on the grades and elevations in the site plan provided by the architect. After getting the project, the contractor proceeded to lay out the house according to the site plan. The contractor presumed that the architect had performed the proper due diligence in preparing the drawings. Unfortunately, when the contractor started to lay out the house, he discovered that there was not enough hilltop to support the foundation of the house, and massive amounts of fill dirt had to be brought in to build out the bank. Talk about big surprises!

When the contractor asked the architect where he got his information for the site plan, the architect indicated that it was from aerial photographs. The accuracy of site grades presented in an aerial photograph can be counted on only within a 5-foot (plus or minus) range at best. When you are trying to situate a rather large house on top of a relatively small hilltop, 5 feet makes all the difference in the world. The contractor relied on the information that the architect had provided and therefore was not liable for the error. However, the architect failed in the due diligence process, and, unfortunately, the owner was left to pay a significant price. The contractor, being the bearer of the bad news, was put in a very uncomfortable position and vowed that he would never again trust the site information provided in the contract documents without first doing checks and reviews for himself. If he had known that the site plan elevations were taken from aerial photographs instead of being ascertained by standard surveying practices, he would have anticipated a large margin of error and would not have proceeded with the project until all information provided in the site plan could be verified. This was a costly lesson for all involved and delayed the job considerably.

The Permitting and Inspection Process

As mentioned earlier, before construction can begin, building permits must be issued by the local building authority. This is probably the single most crucial aspect of the pre-construction process. Although the owner may secure building permits before the project is let out for bids, in most instances this task is typically handled by the construction management team. If this task is mismanaged, the entire project is at risk for failure.

Time is of the essence on virtually every construction project. A delayed permit has caused many a contractor's hair to turn gray before its time. Unfortunately, even when the contractor is on top of the permitting process, circumstances beyond their control may throw a monkey wrench into the works. For example, new compliance requirements or revised building code regulations will typically cause the process to be deferred.

The construction management team must be vigilant in pursuing timely building permit release. The building permit establishes the inspection schedule for the project. The number of inspections required depends on the building authority jurisdiction and project type. It is very important that the superintendent be fully aware of the inspection requirements connected to the project. More information regarding inspections will be presented in [Chapter 10](#), “Construction Operations and Job Site Management.”

The Procurement Stage

To procure means to buy or obtain. The procurement stage of construction management is often referred to as “buying out” the job or purchasing the labor, materials, and equipment needed to complete the project. A great deal of the construction management function has to do with managing contracts—contracts to secure the labor and trades needed to perform the work and contracts to secure the materials and equipment that will be placed on the project. The two primary instruments associated with this effort are subcontracts and purchase orders.

The procurement operation can be a very simple process handled on a local basis by the superintendent, or it can be a major department or division within the construction company whereby purchases are made on a regional or national level. Some projects warrant a combination of both approaches. In the home-building business, for example, the very

large national companies typically have procurement departments that purchase labor and materials for hundreds of homes at a time, securing the best prices available on a national basis. On the other hand, on a high-rise office complex or other large commercial project, the superintendent may purchase small quantities of miscellaneous materials, such as lumber for wood blocking from a local building supply, or may hire local labor for a small contract item, such as caulking. However, larger material purchases such as steel framing might be made by the estimating, purchasing, or procurement department back at the main office. It depends on the size of the job and the size of the construction organization running the job. Either way, project procurement constitutes much of the direct cost associated with the construction project. Let's briefly look at the two primary instruments used to manage this part of the work. Each will be discussed in greater detail in [Chapters 8](#) and [9](#).

Subcontracts

Today, very few general contractors self-perform the construction work that actually builds the structure or facility. General contractors buy trade labor through subcontracts. During the bidding process, various trade contractors offer up bids for various sections of work. These bids (usually the lowest of the submitted bids) are what get placed into the general contractor's price to the owner in the contractor's bid. At this point, there is no contract between the general contractor and the trade contractor. There is just an offer of services (sometimes including materials) at a specified price. Once the general contractor is determined to be the winner of the job, the contractor will select which trade contractors to hire to do the work of the project. A subcontract is executed with each of these trade contractors. A big part of the project team's job is to manage each of these subcontracts—to see that all of the conditions of the contract are adhered to and that the work is performed in accordance with the plans and specifications. This process will be explained in detail in [Chapters 8](#), [9](#), and [10](#).

NOTE

When selecting subcontractors, price is only one of the factors to consider. Many general contractors have determined that it is sometimes better to forgo the low bidder and choose a subcontractor with a reputation for excellent service and dependability, even if their price is a little higher. It is not unusual for general contractors and subcontractors to develop strategic alliances based on past experience.

Purchase Orders

Almost every business is familiar with the concept of purchase orders. A purchase order is an agreement between a vendor and a customer to provide certain products that meet a particular specification for a specified price. Purchase orders work in construction the same way they work in other businesses.

As you know, there are hundreds of products and materials that go into building a new structure or facility. Keeping up with all of these orders and delivery dates is an awesome challenge but a critical one. Order mishaps and delayed deliveries have caused many jobs to suffer costly consequences for the contractor and the owner.

One strategy used by contractors to better manage this process is assigning a member of the project team to function as the purchase order expeditor. This person's responsibility is to focus on the procurement schedule relative to construction progress and to track purchase orders and deliveries. Failure in this area can be devastating to the success of the project. This topic will be revisited in [Chapters 9, 10, and 11](#), “Project Planning and Scheduling.”

The Construction Stage

Once the work is ready to start, the superintendent will call for a pre-construction meeting with all the subcontractors and major material vendors. This meeting essentially establishes the ground rules for working together. The superintendent also uses this opportunity to go

over issues such as work sequencing, work hours, material storage, quality control, site access, and many other pertinent topics.

These first meetings on-site help set the tone for the whole project. It is important to establish an environment of trust and cooperation right up front. Starting out on the wrong foot by being overly demanding and rigid does not make for a pleasant working relationship down the road. Remember, every construction project brings together a new group of people, most of whom are working together for the first time. There is a tremendous amount of coordination among the trades that must take place during construction, and the really good superintendents know that they must spend almost as much time building relationships as they spend building the facility. [Chapter 10](#) provides much more detail relative to the management of the day-to-day operations associated with the construction phase of the project.

Mobilization

Mobilization is all about setting up and getting ready to start construction. Construction cannot begin until all of the proper personnel, materials, and equipment are in place. This is a very important part of the process because it sets the stage for all that is to follow. The mobilization activity is often discussed under Division 01, General Requirements of the specifications, referenced in [Chapter 4](#). The following are some of the activities that should be done during the mobilization process:

- ◆ Set up field office.
- ◆ Set up temporary storage facilities.
- ◆ Secure the site.
- ◆ Organize adequate parking and site access.
- ◆ Develop a materials and handling plan.
- ◆ Secure temporary electric, water, and telephone service.
- ◆ Arrange for trash and debris removal.
- ◆ Provide and place portable toilets.
- ◆ Install job signage and barricades.
- ◆ Assemble survey and layout personnel.

- ◆ Confirm testing agencies and personnel.
- ◆ Establish job site management systems.
- ◆ Establish safety programs and protocol.
- ◆ Obtain and pay for all required permits.

Staging and Layout Plans

Mobilization addresses all of the activities that you must accomplish in order to start the construction. But where are you going to put all of these materials, equipment, mobile office facilities, trash dumpsters, portable toilets, storage trailers, and the like? The superintendent must formulate and diagram a site layout plan and staging strategy that will provide the highest productivity and efficiency of movement. You will get a much closer look at this requirement in [Chapter 10](#), including some of the factors considered when making site layout decisions. For right now, just keep in mind that the organization and layout of the overall project site will indeed impact just how well the construction proceeds.

Construction Operations

The heavy equipment operators are moving dirt, the concrete finishers are pumping concrete, and the steel erectors are setting beams and girders. There are cranes hoisting equipment and trucks delivering materials and workers making noise and stirring up dust everywhere. To the innocent bystander, this scene may appear quite chaotic, but to the knowledgeable observer, this is what construction is all about. This is where it all happens. All of this apparent chaos is actually a well-orchestrated effort directed by one of the most valuable players on the construction management team—the superintendent—often with support from an assistant superintendent and at least one field engineer.

The pace is hectic, the stakes are high, and it is one of the most exciting environments to be a part of. Whether your project is a highway, a manufacturing facility, a hospital, or a home, you get to literally have a hand in the building of society, the building of a nation, and the fruits of your labor will be right there for the whole world to see for generations to come.

The on-site project team must be very familiar with all elements of construction. Lots of questions and requests for information are going to arise regarding the intent of the plans and specifications, and it is the project team's job to obtain the answers and clarify confusing aspects of the work to keep things moving forward. The team works together to sequence all activities and coordinate all efforts by the various building trades, material suppliers, building inspectors, and safety officials, adjusting the schedule as they go.

[Table 5.1](#) highlights some of the typical work items associated with various building elements. Keep in mind that each work item may require the coordination of several building trades and numerous materials. For example, a standard foundation can include excavation, formwork, fill, reinforcing, concrete, masonry, anchors, and embeds. Every project requires the management and coordination of hundreds of materials and activities on the job site daily, not to mention all the people and personalities involved. It's an awesome challenge, to say the least!

The Post-construction Stage

You might think that once the construction is complete, the job is over. Not quite. Just as when you cook and serve a magnificent dinner for a roomful of people, you still have to clean up afterward. The post-construction stage is the cleanup stage. It is very important that this stage be handled with as much energy and enthusiasm as the project startup and operations, because a slipup here can have costly consequences down the road. And you always need to remember that no matter how well the first 90 percent went, if you make mistakes and drop the ball during the last 10 percent of the job, that's all the owner will remember. The team still has a number of tasks to manage before they can call it a wrap.

The Project Closeout

The final step in the construction process is the project closeout. As previously stated, along with project startup, this step often becomes the most difficult to manage. This is the stage where all the loose ends get taken care of as the construction team readies the facility for occupancy by the end-users. This is the time when the contractor turns the building over to the owner. However, before the owner actually

takes possession of the facility, there are a number of sequential steps that must be performed by the contractor. The construction management team must complete the following list of final standard procedures before they can celebrate the completion of a job well done:

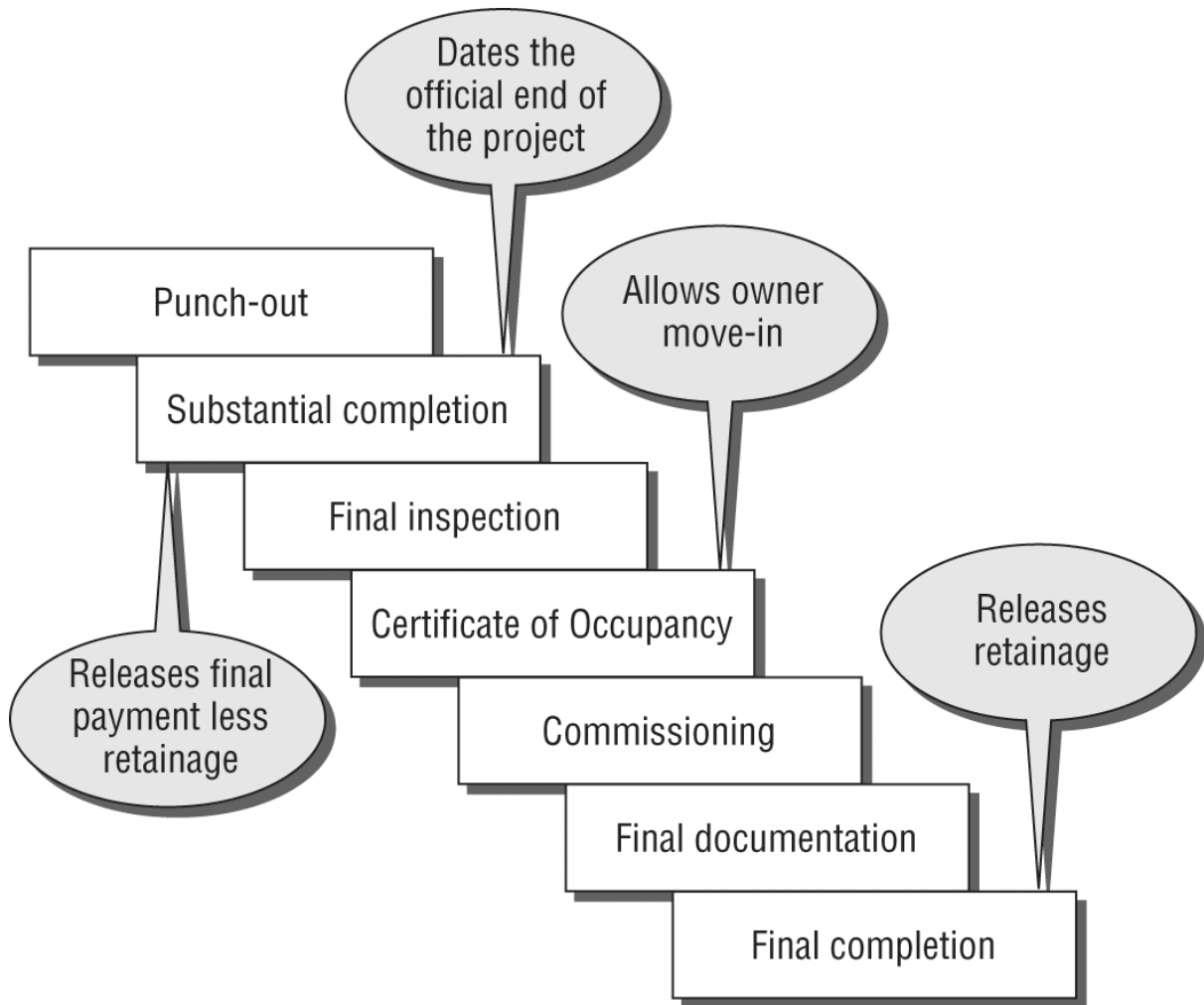
- ◆ Project punchout
- ◆ Substantial completion
- ◆ Final inspection
- ◆ Certificate of occupancy
- ◆ Commissioning
- ◆ Final documentation
- ◆ Final completion

Table 5.1 Building Elements and Work Items

Building Element	Work Included
Site work	Clearing, grading, utilities, layout, landscaping, irrigation, paving, exterior concrete
Foundations	Excavation, standard foundations, special foundations, slabs on grade
Basement construction	Basement excavation, basement walls, basement floors, waterproofing, perimeter drains, backfill
Superstructure	Floor construction, roof construction
Exterior closure	Exterior walls, exterior windows, exterior doors
Roofing	Roof coverings, flashings, roof openings
Interior construction	Partitions, interior doors, specialties
Staircases	Stair construction, stair finishes
Interior finishes	Wall finishes, floor finishes, ceiling finishes
Conveying systems	Elevators, escalators, moving walkers, material-handling systems
Plumbing	Plumbing fixtures, domestic water distribution, sanitary waste, rainwater drainage, special plumbing systems
HVAC	Energy supply, heat-generating systems, cooling generating systems, control and instrumentation
Fire protection	Fire protection and sprinkler systems, standpipe and hose systems, fire protection specialties
Electrical	Electrical services and distribution, lighting and branch wiring, communication and security systems
Equipment	Commercial equipment, institutional equipment, vehicular equipment, other equipment
Furnishings	Fixed furnishings, movable furnishings
Special construction	Special structures, integrated construction, special construction systems, special facilities

Building Element	Work Included
Selective building demolition	Building elements demolition, hazardous compounds abatement

As you might imagine, project closeout can often be a time of great stress and anxiety on the part of the construction management team and the owner's staff. The owner is anxious to move in, and the project team is usually anxious to move on to the next job. It becomes especially stressful if the owner schedules some major event such as a “grand opening” or, with school construction, the start of a new academic year. The dates for these events are established way in advance, and there is usually very little wiggle room if things aren't going well for the contractor as the job moves toward completion. This is when the management of the project becomes a real challenge and creative strategies come into play in order to meet the critical deadlines. The school buses will be arriving with children whether the contractor is ready or not.



Project punchout At the end of every project there are always minor items of work that must be taken care of. They may include little items that have been overlooked, such as the installation of a robe hook or doorstop, or minor repairs or adjustments, such as replacing a cracked floor tile. Each of these items must be addressed before the project is acceptable to the owner. The project punchout activity is managed through a project punch list.

punch list

The minor adjustments, repairs, and work items that must be done before substantial completion can be achieved. The list is prepared jointly by the owner, architect, and contractor. The architect confirms completion of each item on the list.

The punch list contains all of the work items remaining to be done to complete the project. The list is a compilation of observations noted by the owner, designer, and contractor as they conduct the formal project walk-through. The challenge for the construction management team is to summon all of the various trades involved to return to the project to adjust, fix, or complete the multitude of small items that need attention. As you might guess, this is not an easy task—most subcontractors are well on their way to starting their next job and would really rather not be bothered by some little nuisance work item. However, to the owner, attention to these small things makes all the difference in the world. And the completion of the punch list is of considerable importance to the general contractor because the completion of the list ultimately leads to the release of the final payment. Delay in this stage of the project is of no minor consequence. Just how this challenging task gets managed will be discussed in greater detail in [Chapter 9](#).

Project punchout Every project has a beginning and an end. The notice to proceed defines the start of the project. However, there are two steps to defining the end of the project.

substantial completion

The point at which all punch list work has been completed and the owner can occupy or take possession of the new facility.

Substantial completion *Substantial completion* is the first step. Substantial completion occurs after the punch list work has been completed and is approved by the architect. At this point, the architect determines that the new facility can be utilized for its intended purpose and actually issues a formal certificate of substantial completion. This date is very important because it marks the official end of the project and establishes the beginning of the warranty period. Now all payments due to the contractor are released, with the exception of a small percentage called retainage. (Retainage will also be addressed in more detail in [Chapter 9](#).)

Final completion Final completion is accomplished after all remaining contract requirements have been met, such as the

issuance of all final paperwork and documentation (warranties, product manuals, and so on). This step is also certified by the architect and sets up the release of all remaining payments due to the contractor.

Certificate of occupancy After the architect issues the certificate of substantial completion, the contractor or the architect will call for the final inspection by the building official. The building official then issues a certificate of occupancy (CO). This regulatory device signifies that all life safety code requirements are met prior to anyone occupying the building. The primary concern is that the building be safe to occupy. The owner cannot move in until this certificate is issued. Sometimes a conditional CO can be issued allowing the owner to occupy a portion of the facility prior to completion of the entire facility.

Commissioning When you buy a new car, you need a little instruction about its design and workings before you can operate it. Likewise, there are many areas of operation throughout a new facility that need to be explained to the owners. This process is called *commissioning* and may be conducted by the general contractor, by subcontractors under the direction of the general contractor, or by the architects or engineers involved in the project.

First, commissioning is a process of testing systems and equipment to make sure that they are all working properly before turning the facility over to the owner. This process can be as simple as running the dishwasher, testing the air conditioner in a new home, or as complex as starting up huge turbines in a hydroelectric facility.

commissioning

A process of testing and checking all equipment and systems within the facility at the end of a project to assure proper functioning and operation. This may also include the training of owner personnel in the operation and maintenance of the equipment.

The second part of the commissioning task deals with training the owner's personnel in the operation and maintenance of the

equipment and systems installed in the new facility. Because the contractor is accountable for the equipment and its operation at least during the warranty period, it is a very important part of project closeout and should not be shortchanged. It is in the contractor's best interest to make sure that all owner staff charged with operating the new systems are up to speed regarding their function and receive the proper operation manuals.

Final documentation Sticking with the car analogy, when you buy a new car, it is customary to find an owner's manual in the glove compartment. When you build a new facility, there is also a set of documents delivered to the owner that might compare to an owner's manual, except that the product is substantially larger and more complex than a car. Some of the documentation associated with the turnover of a new facility includes the following:

- ◆ Warranties
- ◆ Operation manuals
- ◆ Inspection and testing reports
- ◆ As-built drawings or record drawings

Pulling together all of this paperwork for distribution at the end of the project can be one of the most tedious aspects of the job. For this reason, it is always helpful to have a good contract administrator on the project team. The management of this effort is discussed in further detail in [Chapter 9](#).

Owner Move-In

Finally, you have moved through all the stages of the process and have turned the keys over to the owner. This is always an exciting time for the owner. Keep in mind, though, that with all the moving-in activities come dings, dents, and scrapes to the new finishes. That's why it is customary for the contractor to inventory any spare parts and surplus materials associated with the project, such as a partial gallon of paint, a half box of floor tiles, or a few ceiling tiles, and leave them behind. With these extra materials, the owner's maintenance personnel can make the touch-up repairs that are inevitable when furniture and equipment are being pushed around and shoved into place.

The Warranty Period

Most construction contracts contain warranties. From a legal standpoint, there are two types of warranty that the construction professional must be concerned with: express warranties (written into the contract) and implied warranties (established or required by law). Express warranties deal mostly with the workmanship and installations. The following are examples of express warranties routinely included in construction contracts:

- ◆ A warranty that work will be performed in a good and workmanlike manner
- ◆ A warranty that materials will be new and of good quality
- ◆ A warranty that the work will conform to the requirements of the contract documents

Implied warranties in construction deal primarily with the products, materials, and equipment installed in the new facility, such as appliances, equipment, or other goods typically installed by subcontractors. Most of these are what are commonly referred to as manufacturer's warranties. However, the contractor is liable to the owner if the product fails. In such a case, the contractor will first look to the subcontractor and then to the manufacturer to back up the warranty. The following are examples of implied warranties common in construction:

- ◆ A warranty of fitness for a particular purpose (that the goods will serve the buyer's intended use)
- ◆ A warranty of merchantability of goods (that the goods will be of at least average quality and conform to any labels or advertising about the product)

As noted earlier, the warranty period starts immediately after the certificate of substantial completion has been issued by the architect. Most contracts require a one-year minimum warranty or correction period on most installations on the project. Many products carry a manufacturer's warranty longer than that. It is in the contractor's best interest to be very familiar with the warranty requirements of the contract from both a management and a legal perspective. The actual project team will most likely not be directly involved in the management of any warranty work on the project, but they will set the

stage for the implementation of that activity by compiling, preparing, and distributing all warranty documentation to the owner at the end of the project. This can actually be a daunting task given the number of subcontractors involved and the various equipment installed, but it is one that must be coordinated nonetheless.

NOTE

It is very important for the contractor to communicate a clear distinction between punchout and warranty. If this line gets blurred even in the slightest, it will cause a nightmare for the construction management team. Obviously, there will be minor items of work that show up after the punch list is complete. However, they should be addressed under the warranty provisions. No new items should be added to the punch list after the final walk-through. Otherwise, there will be no end to the punchout operation, and the contractor will never achieve substantial completion.

Project Evaluation

This is the last step in the post-construction stage. Project evaluation is an opportunity for the construction management team to debrief the project and consider what worked and what didn't work. This very valuable step allows the lessons learned to be passed on to other project teams. Information regarding subcontractor and vendor performance, equipment glitches, inspection snafus, or owner-relations issues are all grist for the mill. Unfortunately, this important step rarely gets executed. The team members are all off to the next job, and the wisdom never gets communicated to the organization as a whole. This is one habit that I always tried to institutionalize within my own company and that I believe should be developed as standard operating procedure for construction firms.

I will discuss project evaluation in greater detail in [Chapter 12](#), “Monitoring Project Performance.”

The Successful Project

Whew! Finally! We adjusted the last doorknob, delivered the last warranty, and turned over the keys. But wait a minute—just because the owner moves in and takes occupancy of the facility doesn't mean that the contractor's job is done. For one thing, the contractor must organize a plan to address warranty items and callback issues in a systematic and timely fashion. In addition, it is always in the contractor's best interest to stay connected to the client and make sure that they are satisfied with the final product.

Ongoing communication and contact after the owner moves in should tie right back into the overall marketing strategy for the company. It costs a lot less to stay connected to a customer you already have than it does to woo a new one, and we all know that word-of-mouth is the best advertising you can have. Of course, if the owner isn't satisfied, that will also influence your market. So, before moving on to the details of the various functions of construction management, let's analyze what constitutes a successful project.

Measuring Project Success

There are really two perspectives when it comes to measuring the success of the project. First, did the project meet the requirements of the owner for aesthetics, function, cost, quality, and time? And second, did the contractor make a fair profit as planned? If the answer to both questions is yes, then the project team can acknowledge a win all around. However, there are many steps involved in delivering a project from an idea to occupancy—and many people involved, as well.

Sometimes this process goes smoothly; other times, the process is a long, bumpy ride. Many factors influence the outcome, but there are fundamentally two criteria that contribute to the overall success: good design and excellent construction management.

Let me put it this way: even the best construction management team will have a hard time delivering a bad design to the owner without painful change orders and schedule delays. However, even a great design runs the risk of suffering under the leadership of a mediocre construction management team. Either way, I hope you can grasp how important it is for the owner to make smart choices all along the way by selecting the best design and the best construction team available. Squeezing the design team up front by low-balling their fee in an effort

to save money will only prove to be extremely expensive when the design has to be remedied in the field. Likewise, unrealistic expectations regarding schedule, cost, or quality frustrate the construction team and often result in needless conflict and dissension.

Terms to Know

as-built drawings substantial completion
commissioning unforeseen conditions
punch list working drawings

Review Questions

1. Name the four fundamental stages of the construction management process after the design stage.
2. What are the five distinct stages of the design process?
3. How does the quality of the design drawings impact the quality of the construction?
4. In relation to construction, what is meant by the term *due diligence*?
5. What are the two procurement instruments used to buy out the construction job?
6. Name at least three positions that make up the members of the on-site construction management team.
7. What occurrence marks the official end of the project?
8. What is the name of the tool used to keep track of and manage the completion of all of the loose ends, minor repairs, adjustments, and missing items at the end of the project?
9. What is value engineering, and what is its purpose?
10. Why is it important to have a clear distinction between the project punchout and the warranty period?

Chapter 6

Managing the Project Team

In This Chapter

- ◆ Who is on the project team
- ◆ Building team trust
- ◆ The value of accountability
- ◆ Communication methods and strategies
- ◆ The differences between management and leadership
- ◆ Creating effective collaboration and team integration

Although construction looks like the work is all about concrete and steel, bulldozers and front-end loaders, and managing costs, schedules and quality, in reality, one of the most important aspects of the construction business is people. Many experienced construction managers will tell you that construction, first and foremost, is a people business. The ability to lead and direct the many different individuals and relationships, all with various backgrounds and areas of expertise, and from different disciplines and companies, is key to success of any project. That's why the first construction management function that we will consider is how construction managers establish and maintain relationships, build trust and confidence, and lead project teams. In construction, this is no easy task. In fact, it is a very difficult task, and yes, more so than most other businesses or operations. That's because the way we get construction projects built is unique. Construction doesn't happen in a manufacturing plant or by people within a single company where the workforce is consistent and static. Projects are built by teams comprised of individuals from a multitude of different companies, and even the companies that are involved may vary from project to project. In the construction business, the bulk of the labor workforce is transitory. You could have 5, 10, 20, 50, or even hundreds of different people, from different

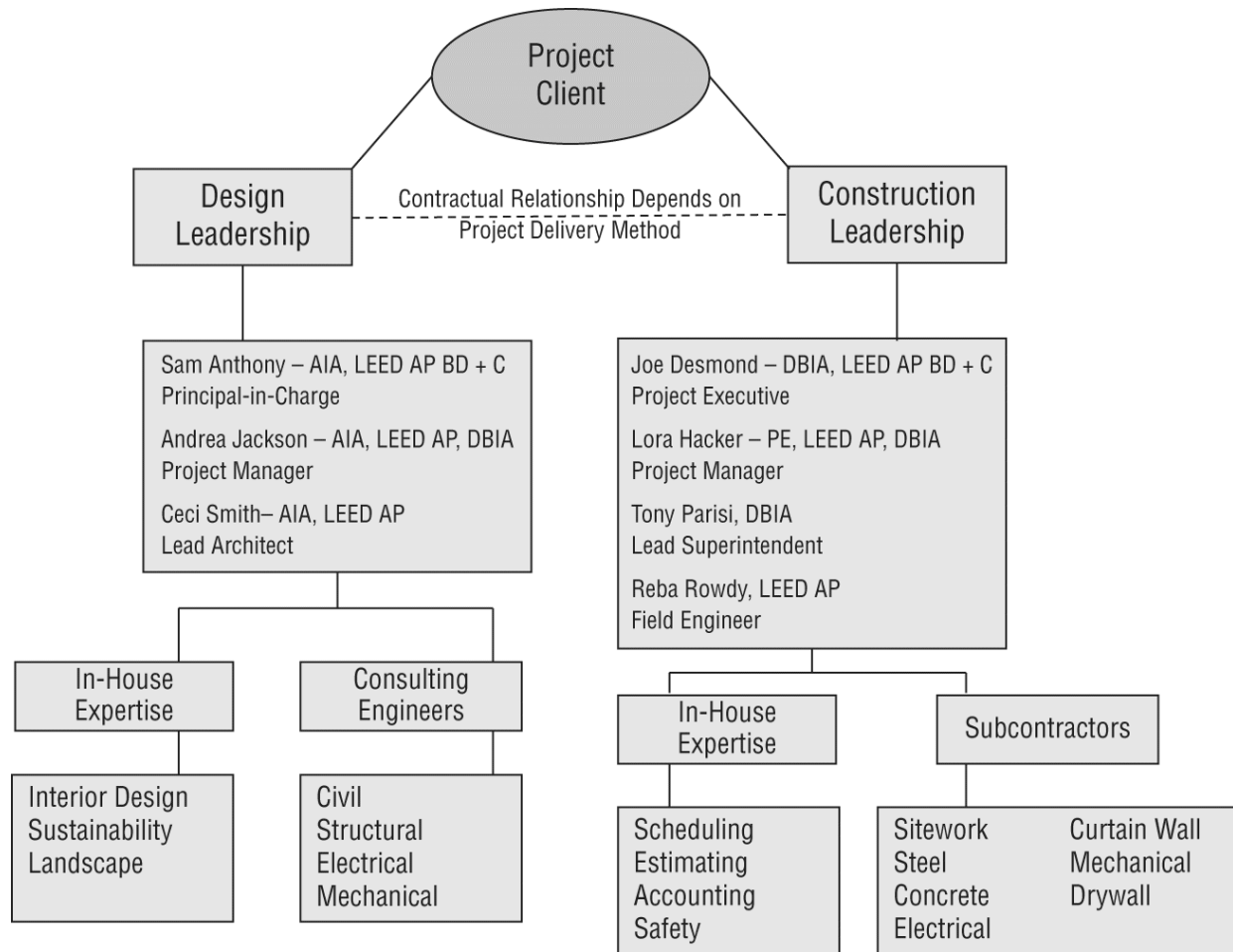
companies, working on the same project, with just a handful from any single company. The project team members often start out as strangers, having never worked together before, and, who may never work together again as a team on another project. Every new project pulls together a new team to execute all of the tasks and activities needed to build the project as a temporary organization. Although you may get to know many of the individuals, especially when working with local or regional contractors, and even develop lifelong friendships, there is no guarantee that you may ever work together again. That's one of the things that makes the construction team unique, and what makes it a challenge to lead.

NOTE

The smaller and more localized the company, the more likely it is that you will get a chance to work on projects with many of the same people over and over again. If you work on projects for a local or regional company, it is common to see the same subcontracting companies and their employees on various projects within the same regional geographical area. This is the case for most sectors, but especially within the residential and light commercial markets. This is often the preference for all involved. On the other hand, the large national, or international companies, who work on much larger projects, nationwide and abroad, will have less opportunity to limit their workforce placement to a small geographic area. When you choose to work for a large commercial, heavy civil, or industrial company, the likelihood of you working in multiple geographic areas throughout your career is high. You will have the opportunity to work with a majority of new people on just about every project.

The Project Team

Just as a construction company has an organizational chart, so will each project have its own organizational structure. In commercial construction, the project organization chart will always show the three key participants associated with the project that you learned about back in [Chapter 1](#)—the owner organization, the principal design firm (architecture or engineering depending on project type), and general contracting company. In addition, each of these entities will have a tier or tiers of other service and labor providers that they subcontract with in order to perform the work necessary to complete the project. Usually, the more complex the project, the more subcontracted parties there are. Every subcontracted party becomes a part of the project team. You can begin to see the network of organizations involved in delivering a construction project in the commercial project organization chart, and each of the specialty trade organizations is represented by a number of individual team members whose work must be planned, coordinated, and quality checked throughout the building process. From a field operations perspective, each trade company will assign a manager or foreman to oversee the work of their own personnel, but it is the general contractor's superintendent who has the ultimate responsibility to create the project schedule and coordinate all of the work associated with the project at the field level. As for the coordination required between the owner's group and the design team, with the construction operations, that responsibility typically falls on the general contractor's project manager's shoulders. Considering how complex the project team structure is, it should be apparent what makes the project team “management role” such a challenge. The number of people and players involved with building even a modest size project is immense. You can have all the best materials, most experienced workforce, and most advanced technologies, but if you have the wrong leader heading up the team, the risk for failure increases. Just like with a great sports team, effective management makes a huge difference. However, there are a number of factors that impact one's ability to effectively manage today's project teams. Let's take a look at a few of them.



People

As previously stated, construction is a people business first and foremost, so it just makes sense that we would start by looking at the “people factors” that influence your ability to be an effective manager. All of us have heard or seen company mission statements that reference people being the company's greatest asset. This is a very nice sentiment, but in all honesty, it's not words that make it so. It's the interactions between management and the people performing the work that will demonstrate how valued team members are, and how effectively they can perform as a cohesive unit. The fact is, valued people show up differently. They show up ready to work and to solve problems. There's a big difference between willing collaborators, and resistant followers. And the best way to create willing collaborators is by truly valuing the contribution that each individual makes to the team and solving the problem. It's also important to let people have a say in the process and planning—to allow people the opportunity to

figure things out and to engage their abilities, skills, and values to solve a problem. No one wants to be told what to do all the time, or have someone looking over their shoulders. So often managers believe that their job is to “control” the people on their teams, but nothing could be further from the truth. No one wants to be controlled—they want to be challenged, and then trusted to meet that challenge. The job of the manager is to encourage, empower, and inspire people to bring their best game to the challenge. Here's some tips for being the right kind of manager.

Respect

Respect is so fundamental to creating high-performing teams. Once we understand that none of us is as good as all of us, it makes collaboration so much easier. Unfortunately, over the years, the segregated services mentality that has been fostered by the traditional design-bid-build project delivery method has pitted the various different project players against one another. To this day, there are still people associated with projects who claim that architects or engineers are more important than the contractors. Or that the general contractor is more important than the subcontractors. The fact is, every team member's contribution is necessary to deliver the whole. The network of services, talent, expertise, knowledge, and skills that comprises the project team works together, like a building ecosystem. As in any kind of ecosystem, the failure of one element means the failure of the whole. Clients need every aspect of their projects to meet their expectations—the design, the budget, and the schedule. In fact, they would do all of the work to design and build their project themselves if they could—but they can't, so they hire the estimators, architects, plumbers, superintendents, project engineers, pipefitters, carpenters, delivery drivers, and all of the other project personnel necessary, with the expectation that they will perform as “one team” regardless of their discipline, rank, license, or title. It is critical that team members know that their efforts and contributions are respected and valued, by their fellow team members, and especially their boss. Developing an atmosphere of respect starts at the top, and an understanding that respect begets respect—and sometimes you've got to show some to get some.

NOTE

Many years ago, I was asked to facilitate a teaming session on a design-build project that was failing to deliver the owner's expectations. The project team had all but stopped talking to one another and the level of distrust was palpable when I walked into the room. It was my job to try and figure out what was at the root of the problem, and it didn't take very long to discover what the problem was. We began to discuss the three primary deliverables on any project—design, budget, and schedule. As the architects were describing how the contractors were constantly saying no to many of the design features they wanted to incorporate, and the contractors were complaining how the architects were ignoring the budget constraints, one very angry architect stood up and screamed across the table to one of the contractors—why are you even in this meeting? You are nothing but an estimator! I couldn't believe my ears. Everyone stood silent for a long moment, and the contractor quietly sat down. It became crystal clear that trust was not the fundamental issue. Respect was the underlying issue—or more precisely, the lack of respect. You'll never get to trust on a team if you can't first show respect for one another. I was appalled at the disrespect that I witnessed in the room. It is really important that every participant of the team realize the benefit and value that every other participant on the team brings to the table. In order for us to deliver a comprehensive, successful project to our clients, every talent and area of expertise needs to contribute and be respected for the specialized knowledge they bring.

Motivation

Many years ago, someone shared with me that the number one motivator for human beings is that they want to make a difference. The chance to make a difference beats money or any other extrinsic

factor when it comes to motivating your team. Team members want to have good relationships with the people they work with—especially their managers. In the United States, research has shown that employees identify “having a good boss” as the number one factor as to whether they stay with their company or not. The way they describe a good boss is someone who cares about them, coaches them, and listens to their ideas, and most importantly, acknowledges them and their contributions. It takes very little effort to acknowledge someone for the difference they make. And it's not just about the big things—it's the little everyday things too. For example, to acknowledge someone for always showing up with a smile on their face and ready to work may be something you think shouldn't have to be pointed out. But by doing so, it shows that you noticed. And given that some studies report that over 60 percent of the American workforce feels invisible at work, it's a very big deal to be noticed. Effective managers know that acknowledgment is key to motivating their project teams.

Appreciation and Recognition

Let me first say that appreciation and recognition isn't the same thing as acknowledgment. Acknowledgment is about noticing people's existence and valuing them just for being who they are—not necessarily related to performance or achievement at all. Appreciation and recognition are more related to what someone does, or accomplishes. It's a thank you for getting the budget turned in a day early, or helping a team member who was running behind. Or achieving a zero punch-list, or preventing an accident by removing some hazards without being asked. There are so many ways that a manager can express their gratitude toward individual team members and the team as a whole. Again, some may feel this shouldn't be necessary, that people should do their jobs and not expect to receive special recognition for it. And the truth be told—it isn't necessary. But the difference it makes in how people show up to work when they feel acknowledged, appreciated, and recognized will change the entire dynamics of a project team. So, if you are interested in developing high-performance teams, then practice showing appreciation on a regular basis—even for things that you expected them to do anyway. And then watch the expressions on their faces when they realize you actually noticed.

NOTE

It goes without saying that there is a financial benefit to showing appreciation and recognition for a job well done. Fair wages and good benefits lead to job satisfaction without a doubt. When people don't feel like they are compensated fairly, they can become resentful and disheartened. But research has shown that money alone is not a sustainable motivator. Being recognized for a job well done, even without a monetary reward, has been found to produce twice the satisfaction among employees, compared to those who are not recognized for their work.

Sharing the “Why”

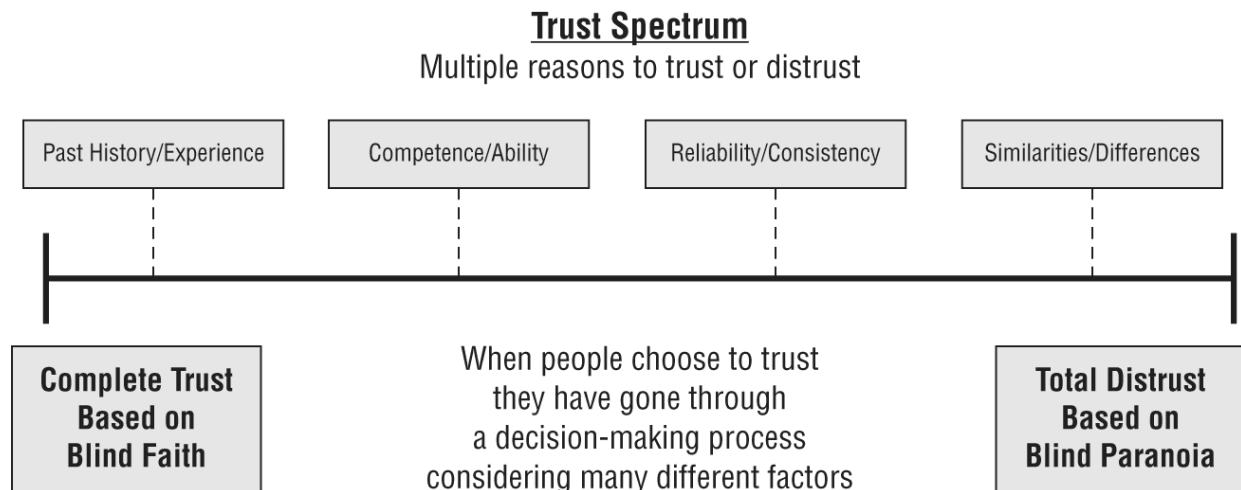
Understanding why the work that the team is doing is important proves to be one of the biggest motivators of all. Although reasons like “it's how the company makes money” or “it's how we keep workers employed,” are legitimate reasons why completing a project on time and within budget is important, they don't really motivate—at least not in a powerful way. This goes back to the fact that the number one motivator for human beings is that they want to make a difference. People want to feel pride in their work and know that the fruits of their labor made a difference in someone else's life. That's what makes construction so fulfilling in the first place. The housing, the hospitals, the schools, the churches and temples, the shopping malls, the parks, the roads, the bridges—these projects impact how people live, work, and play every day. But, unfortunately, most construction managers do a poor job conveying to their teams the significance of the buildings and facilities they construct, and how important their work is to the healing process that takes place in hospitals, or the learning process that takes place in schools, or the comfort a home brings to a family who has never owned a home before, for example. Instead, we usually talk about how important the budget and the schedule are or why it's important that the concrete slab is level, and the steel columns are plumb. And even though these things are crucial in terms of the quality of the structure and the financial success of the

project, they are not the most powerful motivators. Learning to tell the “whole story” about our projects, and the difference they make to a community and the people who live there—now that's a powerful motivator. It's simply a part of what it is to be human, and a good manager knows this and practices sharing “why a project is important” from the human perspective.

Building Trust

There's no doubt that building trust on a team is one of the more challenging aspects of construction project management. It's a very complex issue. People have written books on the subject, and I have read more than a dozen myself on the matter. It's critical to establish trust among team members if you want to achieve high goals and maintain healthy working relationships. In Patrick Lencioni's book, ***The Five Dysfunctions of a Team*** (Jossey-Bass, April 11, 2002), he identifies the “Absence of Trust” as the number one challenge among teams. Trust is the foundation of any successful teaming relationship. Without it, it's very difficult to get other people to follow your lead or do what you ask of them. Remember, most construction project teams are temporary organizations that have been formed to complete a single project, over a relatively short period of time—and to build trust takes time. That's exactly why this is such a challenge for construction project managers.

Trust is a tough concept to get your head around, but we have all experienced when it exists, and when it doesn't. You've probably caught yourself saying something like, “I don't know why, but I just don't trust that guy.” Or, you've heard someone say, “I can't trust a person who doesn't look you in the eye when they speak to you.” There's something about the person or their behavior that you can't quite put your finger on, but keeps you from trusting them. We all have an innate “sense” about who we trust and who we don't trust. That's because everyone seems to have a natural inclination toward being more trusting or less trusting. This inclination probably starts to develop when we are children, based on our circumstances and experiences. But regardless of where this natural tendency developed, the point is to recognize where you stand on the basic trust spectrum now, and how you can learn to intentionally move the dial toward a more trusting tendency, especially when working on a team.



Regardless of where you naturally fall on the trust spectrum, most people do go through a decision-making process to determine whether to trust someone or not. There are several common factors that will influence your tendency to trust or not to trust. They are:

History and Experience

This factor is one of the easiest to understand and explain, especially to someone else. When we have had the chance to work with other people previously, we have had an opportunity to see them in action, and learn how they behave, perform, and interact with others. We have previous knowledge and insight into how it is to work with them. We know if they are competent, dependable, and easy to get along with. We know whether they have delivered on their promises and commitments. In other words, we have history with them. Even if it is in a non-work-related situation, this knowledge is still immensely valuable. For example, they may have been a member of your church group, or your softball team. This history and experience are pretty reliable when it comes to deciding whether to trust or not trust. Unfortunately, as previously stated, in the construction business, we don't necessarily get to work with people we have a previous working relationship with. In so many cases, the project team includes many people we have no history with, and we must build a trusting relationship with them based on other factors.

Competence and Ability

Competence-based trust is also pretty easy to understand. It has to do with a person's experience and skill set. You are going to have much

more trust in a surgeon who has 10 years of experience in performing an operation on you, then a brand-new intern just out of medical school. The same can be said for construction managers. That's why I often tell young project engineers new to the job that they shouldn't expect to be trusted to perform critical items of work right off the bat, and it has nothing to do with them personally. It's just that they lack the experience and longevity in their positions necessary to warrant "being trusted" for their competency. That trust builds up over time, and with experience. When picking team members, selecting individuals and firms with technical competency is the first step in developing high performance teams. It's not too much of a stretch for others on the team to initially trust them because of their technical competency and know-how, even if you have a natural tendency not to trust very quickly.

Similarities and Differences

When we have things in common with other people, it's just easier to trust them. There is a sense of knowing something about that person, even if we don't, simply because we share various aspects of familiarity. These aspects can involve just about anything—where we grew up, what high school or college we attended, which sports team we root for, or what hobbies or social/civic activities we are involved in. Professionally, it might be an organization we have in common, or that we both work within the same field or discipline. Generally speaking, most contractors are going to be more trusting of other contractors initially, and architects are going to be more trusting of other architects initially. Same can be said for engineers, plumbers, bankers, or building inspectors. This is just human nature. It's also why starting a project with some kind of social event that allows the various team members to learn something about one another, outside of the project itself, is always a good idea. Conversely, the more we are different, the more difficult it is to build trust. It can certainly be done but it does take time, and patience. And we have to be more intentional about it. Again, this becomes a management task and one we don't always give enough time and attention to, but is well worth the investment.

Relative Power and Authority

This factor is a little more difficult to explain. Believe it or not, your standing in the company or on the team itself can become a barrier to building a trusting relationship with others on the team. Just by virtue of being the boss, or superintendent, or project manager—you may not be trusted. If you have power or authority over another person in any capacity—paycheck, work shift, signature approval, or next assignment, you are at risk for not being trusted, or being told the truth. Instead, you may only hear what your team members think you want to hear. Your team members may not share their disagreement with you, or tell you when they think your approach is wrong, and thus you won't really know what's going on with your project, or what the true challenges or risks are. This is the number one reason why your ability to build an open, honest, trusting team environment is so very important—because if you don't, it can be a very risky situation. But there is a way to dismantle the trust and truth barriers that come with authority and power, but it takes courage, character, and making yourself vulnerable.

Character

Trust and truthfulness go hand in hand. So, at the core of character-based trust is honesty and integrity—telling the truth, keeping your word, following through on commitments, and communicating openly. Patrick Lencioni describes this type of trust as vulnerability-based trust. With this type of trust, a person admits when they are wrong, or doesn't know something, or doesn't have all the answers. The individual is willing to share their weaknesses, as well as their strengths. Being open about this type of vulnerability is one of the best ways to break down barriers and build trust. On the other hand, lying has been identified as the best way to destroy trust. When team members can trust one another to tell the truth, to openly share when they've made a mistake, or let someone else know when they are in over their heads, that's authentic trust. That's what real trust looks like in action, and is the best working environment that you can create on a project—and the tougher the project, the more important it is to build this type of trust. When people feel like they can talk straight and share the truth, and not be judged, then you've established an environment where solutions can be found to even the toughest of challenges. People feel free to offer suggestions, and discuss options, and even try something and fail, knowing the team is

all working toward the same goal. Building a trusting environment allows people to be human, feel safe, and give it their best.

Please note, I am not promoting the expression of blind trust without proper verification. That would be irresponsible. However, we must be intentional in our efforts and not leave the trust building to happenstance. To be effective as a construction project manager today, requires an awareness of the factors that impact trust building and a skill set that influences its development.

Although trust is a critical component of developing high performance project teams, I also know that we can't expect to have immediate trust on a team. Building trust takes time and doesn't happen overnight. However, one of the fastest ways I have found to build trust, even among team members who haven't worked together before, is to establish a culture of full-transparency, and an *open book philosophy*. Traditionally, owners, contractors, subcontractors, engineers, and architects have operated in an environment of distrust and suspicion—just the opposite of what is needed to develop high performing teams. I believe this atmosphere of distrust primarily stemmed from the low-bid mentality that the design and construction industry has been subjected to for much of its history. Openly sharing information related to contractor costs, budgets, or profits has not been a common practice under the design-bid-build approach. However, today, with projects being delivered using more team-based, collaborative approaches such as design-build and integrated project delivery, where achieving best value is the goal, being transparent with our pricing is a good way to build trust more quickly. Such transparency leads to more open dialogue, which leads to a better understanding of the design, and its impact on the budgets and schedules by all parties, which leads to better solutions for the client.

open book philosophy

A practice of information transparency among all the project parties which benefits the client by leading to open dialogue, a better understanding of the design, and its impact on budgets and schedules.

Accountability

Results and performance matter in construction. Our success is measured by some pretty objective metrics—budget, schedule, quality, and safety. However, when we don't meet the targeted expectations for these various measures, it can sometimes turn into a finger pointing game with the blame landing in the lap of whomever isn't in the room at the time of the charge. However, if we understand the dynamics of team, we should know that any failure associated with any part of the project should be levied against the team as a whole. The entire team either succeeds together or they fail together—and this is exactly why some people don't like being a part of a team. They don't want their individual success or failure to be dependent upon the performance of others, primarily because they don't know how to control that performance. Many team members are very uncomfortable holding another team member accountable. Our usual approach is to expect the team leader, or the manager, to hold those who aren't performing or carrying their load accountable, and when they don't, we become frustrated and annoyed, or even angry—especially when the project begins to fail, and then the finger pointing begins.

Accountability is a crucial element of successful teaming and is a key ingredient in building a trusting environment. However, accountability needs to be practiced peer-to-peer and not just from the top down. The notion of “peer pressure” doesn't end when we leave our teenage years—it can still exist, and actually be useful, when practiced and applied across a team trying to achieve its agreed-to goals. Once a team sets its project goals, and then commits to doing what it takes to achieve them, the rest is a function of accountability.

The practice of accountability isn't just about catching someone failing. It requires us to be aware of the tasks and deliverables each team member is accountable for, and then checking in on one another to see how things are going, and if anyone needs any help. I refer to this practice as *commitment management*, and it's your job as a team member to help fellow team members keep their commitments. That means you need to be in regular communication and conduct periodic check-ins with your team, whether it's your job to do so or not. You see, many people have a tough time letting others know that they

need help, or are having a hard time keeping up. Instead, they plug along on their own, don't tell anyone, and just struggle, hoping it turns out. And when it doesn't, it's usually too late to offer any support and that's all we're left with is finding blame. This is where that *vulnerability-based trust* comes into play. In a trust-based environment, we establish the habit of authentically asking “How's it going?” and expecting an honest answer. This is how we hold each other accountable, by providing the support needed to ensure that all team members succeed, which means the project succeeds. Once you have worked on a team where vulnerability-based trust and accountability exists, you will always want to work in such an environment.

commitment management

The practice of being aware of each team member's tasks and deliverables, checking in with them periodically, and helping when needed for the success of the project.

vulnerability-based trust

Establishing honesty among team members through authentic check-ins and providing the support needed to make sure all team members, and thereby the project, succeed.

Ethical Dealings

The final element I want to discuss in building trust on a team is ethics. In construction, reputation is everything and it's something we have a fair amount of control over managing. Ethical dealings are a big piece of building this reputation. Ethical dealings have to do with keeping your word, being honest, compensating your employees fairly, paying your subcontractors and vendors on time, finding ways to reward people for superior performance, and so many other acts of good faith. We've all heard stories in this business where million-dollar deals have been done on a handshake, and that's certainly a

testament to the integrity of the men and women who have honored their word in such dealings. But unfortunately, we've also heard stories where in the same scenario, one party has been taken advantage of over another, leading to serious consequences both financially and legally. That's why legal counsels exist in just about every large construction firm, and even the smallest company has an attorney on retainer. But when it comes to working one-on-one, team member to team member, it is very important that managers try very hard to treat people fairly and be as transparent and open as possible with their employees, subcontractors, architects, and all team members. It's what the late author Stephen R. Covey referred to as building the emotional bank account, years ago in his book ***The 7 Habits of Highly Effective People*** (Simon and Schuster, 1989, 2004). Covey suggested that it takes time to build up that emotional bank account with continued fair dealings, over a long period of time, to build trust and respect. However, he also suggested that it only takes one or two dishonest or unfair wrongdoings to bankrupt the whole account and destroy all the goodwill that it may have taken you years to establish. In this day and age, when attracting and maintaining a skilled workforce is more important than ever, you really can't afford not to operate in an ethical manner. Today, ethics has become a cornerstone of construction education and is required curriculum by some accrediting bodies who assess construction management programs at many universities.

Communication, Collaboration, and Integration

Effective communication and collaboration are core to being a successful manager of diverse project teams. However, most of us have never had any formal training associated with these two very important attributes. Often referred to as the “softer skills” associated with being a manager, they can actually be pretty hard to learn. They are somewhat abstract in theory, but very valuable in practice. I hope to shed some light on both of these attributes and give you some tools to improve your effective use of them. On the other hand, team integration takes performance to a whole other level and it is truly an attribute that transforms ordinary teams into extraordinary teams. I will share how the combination of effective communication, effective collaboration, and inspiring leadership can create an environment in which integrated teaming is possible.

Effective Communication

All of us know that communication is important. We talk about it all of the time. We use it, or the lack of it, as our excuse for why things don't work out, or why people fail to perform or why we didn't keep a promise, or do what we said we were going to do. However, communication is kind of like how we speak of the weather—everyone talks about it, but no one does anything about it. Even though we all say that communication is important, we do little to improve communications. Communication techniques are not necessarily taught in school. If you went to college, it's likely that you were required to take a speech class, but speech is not communication. There's a nuanced human quality to communication that few of us ever get to learn about through formal educational channels.

However, years ago, I was fortunate enough to learn some distinctions of communication that literally changed my life, and my business. I was struggling with keeping up with the demands of my business. We weren't delivering our projects on time, and we were consistently missing deadlines and keeping our commitments. It wasn't for lack of trying or effort. I thought it was because we were disorganized and didn't have enough systems in place to manage our workflow. It turns out, that wasn't it. One day when I was sitting on an airplane next to a business man who was doing work all over the

world, I shared with him how I was having such a hard time keeping up. As I shared with him that I thought it was because we weren't organized properly, he laughed and then said, "Organization isn't the problem, communication is." Well, I heard what he said as if he was talking about the weather—a real problem, but not one you could actually do anything about. Boy, was I wrong. This gentleman went on to tell me what he had discovered over the years, and he was generous enough to share it with me. Now, I'm going to share some of what I learned with you. The gentleman on the plane introduced me to the work of Fernando Flores.

Fernando Flores developed a way to communicate that he called *language action theory*. It's a way to communicate that results in something or some project moving forward. It results in some action to achieve some objective, or to meet some commitment. A less academic way of saying the same thing is, there's a way of speaking that causes people to do something—to be in action. I'm going to use the term *action language* to cutshell, action language gets people moving, and creates reliable accountability through language. The fundamental concepts, tools, and techniques of action language that I learned from the work of Fernando Flores provided me with the most impactful and useful insights of my professional career.

NOTE

Language action theory—also called action language and action workflow theory—was developed by Fernando Flores. To learn more about the work of Flores, his background, and his books and writings, go to:
<http://conversationsforaction.com/fernando-flores>

Flores suggests that all work is done on the basis of making and keeping commitments. He goes on to suggest that there are five basic “speech acts” that result in people either committing to acting or actually being in action. These five speech acts are:

- ◆ **Declare**—The action is to declare a new world of possibilities for action.

- ◆ Request—The action is to ask someone to take care of something that you are concerned about.
- ◆ Promise—The action is to offer or agree to take care of something that another person is concerned about.
- ◆ Assess—The action is to assess how some action or thing relates to specific concerns or commitments.
- ◆ Assert—The action is to assert or report facts pertinent to the concern at hand.

Flores further suggests that the most powerful of these types of speech acts are requests and promises. These two types of speaking result in a commitment to act—to do something specific. In other words, declarations, assessments, and assertions are just words that may prompt work getting done, but they themselves do not result in work being done. At the same time, just because we make a request doesn't mean that we will get someone else to accept our request. Or, that if we make a promise, we'll end up keeping it. Our ability to make requests that result in actions, and to make and keep promises, is at the heart of effective communication. Did we actually keep our word and do what we said we would do? Did we do it when we said we would do it? And did we do it the way we said we would do it? It depends on how effective and direct we are with our communication of these requests and promises.

This leads me to distinguish two other vital components when making our requests and promises—and that is how we listen and how we speak. Although there are different names for these two components of communication, I will use the terms *committed listening* and *committed speaking*. (For example, some people use the term active listening for committed listening. It's basically the same thing.) We are going to start by distinguishing committed listening first, because all good communication begins with listening.

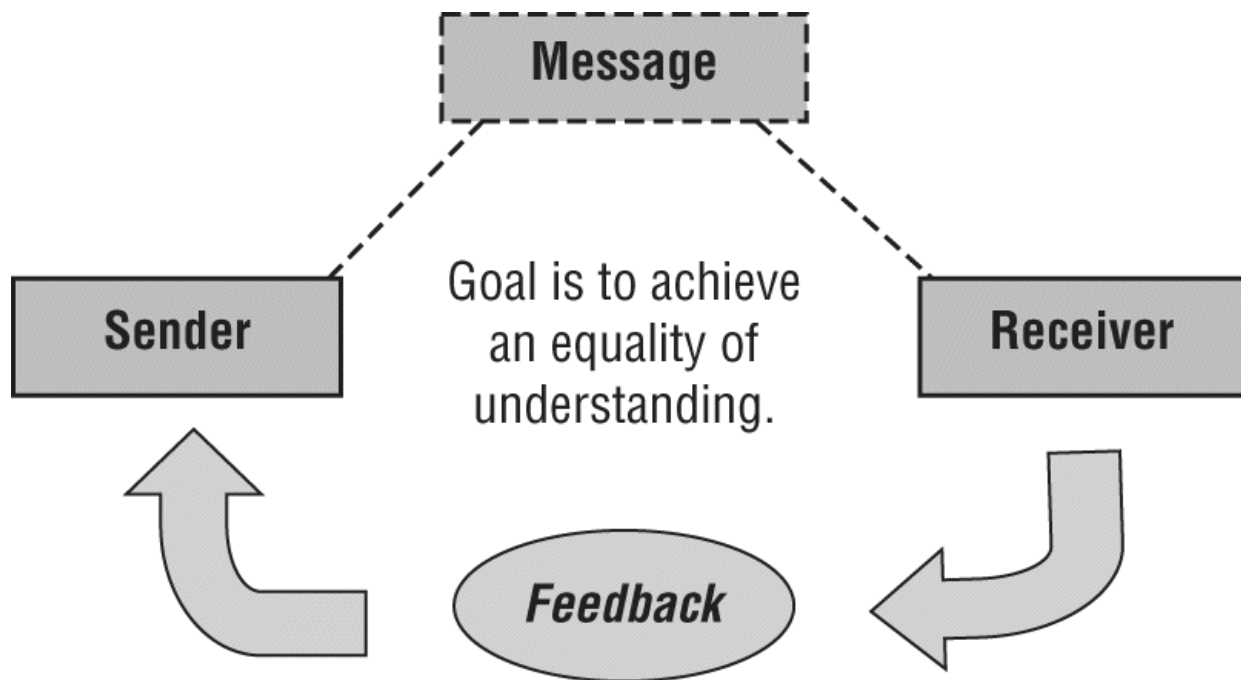
committed listening

Listening intently to another person to make sure that you clearly understand what they mean by the words they are speaking without judging, assessing, or negating what they are saying.

committed speaking

Speaking with intention and purpose, using words specifically to clearly convey your exact meaning.

To listen committedly means to really understand what the other person said, and more importantly, what they actually meant by what they said. The ultimate goal of communication is to achieve an equality of understanding among the parties to any given conversation or interaction. This is harder to do than you might think. The fact is, just because someone is speaking, and another person is listening, doesn't mean that any communication occurred. My husband and I often joke that just because we both speak English, doesn't mean we speak the same language.



Communication Model

Although there are other tips and guidelines for improving listening and speaking, in order to really get the meaning of what another person says requires a particular type of listening. I call it committed listening. Let me distinguish it for you:

Let's presume you are sitting on an airplane while it is still positioned on the tarmac before it takes off. The flight attendants are going over the safety instructions. Let's consider how most people are listening when this is happening. What are we doing? If we are honest we will admit we are not paying attention—we are getting out our music or reading materials, putting on our headphones, or preparing for our nap. Now, imagine the same scenario except the plane is 38,000 feet in the air and the pilot comes on to inform the passengers that one of the engines is no longer working and to prepare for an emergency landing. I assure you, every single passenger is listening differently now. They are listening as if their lives depend on it.

So, what changed? What changed was the urgency of the matter. Something was at stake and it was vitally important that they got what the flight attendants had to say and understood every word.

They intentionally listened in a committed fashion. And here's the good news. The fact that one can listen in such a committed fashion when the plane is at 38,000 feet with only one functioning engine means that we all can listen that way in any situation. It's not a matter of being in an actual crisis. You can create the same kind of urgency when someone is speaking to you about what they did over the weekend, or how they plan to do their work, or what happened when they got to the jobsite. You can listen as if what they say is important. You can listen to learn. You can choose to listen to every conversation as if your life depends on it. That's committed listening. And it is a practice that you can develop.

Now let's distinguish committed speaking. Let's start by referring back to the most powerful speech acts identified by Flores for causing action to occur—making requests and promises. However, unless we speak these requests and promises in a committed fashion, we may not get the results we are after. For example, most of us are pretty nonchalant with our speaking. When we make a request we often avoid being too direct in fear of appearing bossy or demanding. It may sound like this. “If you have time this afternoon, could you please get me those cost reports from last week?” First off, this is a very poor request because there is no “by when” time or date indicated. That's the first rule when trying to improve the quality of your requests—you've got to provide a specific date and time so you can hold people accountable and not be left wondering when you'll receive what you asked for. People can't read your mind, and you will have no reason for blaming them for not getting you what you want, when you want it.

The other person in the interaction may respond to your request with some similar noncommitted speaking such as, “Sure, I'll see what I can do.” Most likely, you hear this response as if they said yes, but they really didn't. Why is this a problem? It's a problem because even though both parties may be well intended, there's no commitment in their speaking, and therefore the reliability of the request or the promise is weak. The likelihood of the requested action taking place as needed, and when needed, is slim. This type of nonchalant speaking is all around us—both professionally and personally. It's not necessarily a personal flaw, but rather it's really human nature. We try to avoid making commitments because we don't like to let other

people down. So rather than promising, we just use sloppy language (probably unconsciously), so we aren't on the hook for anything. The problem is that this sloppy, uncommitted speaking leads to misunderstandings, frustration, and even anger. We stop listening to one another altogether and trust goes out the window. We don't meet deadlines as expected, or other commitments, and thus lose the respect of our clients and colleagues. And on top of that, we get caught up in the blame game and never accept responsibility for our own lack of effectiveness when communicating. Now can you see why communication is so important when managing project teams? This is what the gentleman on the plane meant when he said I didn't have an organization problem, but rather, I had a communication problem. The reason he knew what the problem was, is because most of us have a communication problem, and we don't even know it. However, we can correct these weaknesses in our listening and speaking pretty easily, and increase the reliability of people keeping their promises to us by following a few rules:

- ◆ First, learn how to make powerful requests. Try to always insert a “by when” in your requests and be pretty specific. Try to give a specific date and time, allowing some back and forth for negotiation if needed, before you reach an agreement.
- ◆ Second, only accept a committed response to your request. Flores provided just five options when responding to a request in a committed fashion. They are:
 - ◆ Say yes—I accept your request.
 - ◆ Say no—I decline your request.
 - ◆ Make a counteroffer to the request that you can agree to (negotiate a different date and time for example).
 - ◆ Commit to commit later. Let the person know that you cannot respond one way or another at this time. That you will get back to them after you check your calendar, or schedule, or with others on your team, for example. The point being, don't make a promise until you can confirm your ability to meet it.
 - ◆ Similarly, you may request further information before committing to the request.

- ◆ Third, hold yourself and others accountable for the quality of your request or for what you promised. If you didn't meet the commitment you made, no blaming anyone else. Make no excuses. You simply have to accept that you made a promise and failed to keep it. You won't feel very good about it, but it happens. Presuming this isn't a regular occurrence, your team members will respect you more for owning up to your short fall, than if you make an excuse. And hopefully, you will learn how to communicate in advance of the promised deadline, letting your team know that you need help, or are in over your head, or that circumstances are delaying your progress. (Reference back to vulnerability-based trust discussed earlier in the chapter.). Yes—it's OK to let people know you are struggling to make a deadline as long as you are proactively seeking ways to resolve the challenges in advance of the deadline, and that you ultimately keep your promise.

Bottom line, committed listening and committed speaking doesn't guarantee the delivery of a promise or result, but it does increase the reliability of the promise made. When someone responds to a request in a committed fashion, they try harder, and don't give up on meeting the commitment so easily. Again, it's just human nature, and it works. We can even take it one step further and create a commitment management system, as noted earlier in the chapter, and support one another in the promises and commitments we make. This is a great way to train the people on your team to be open and transparent as they work together—sharing both their struggles and their triumphs through the process. This is how trust is built.

NOTE

The Lean Construction Institute (LCI) adopted the work of Fernando Flores to create a methodology for improving the reliability of construction deliverables that it calls Reliable Promising. According to the LCI, reliable promising creates ownership and responsibility, and helps shift the culture from one of “holding people accountable” to a culture of “being accountable.” Reliable promising reduces rework, defects, and waste—and increases productivity. The basis of this method is grounded in action language.

reliable promising

Developed by the LCI, reliable promising and personal commitment making show respect for people and build trust among team members. Reliable promising creates ownership and responsibility and helps shift the culture from one of “holding people accountable” to a culture of “being accountable.” Reliable promising reduces rework, defects, and waste—and increases productivity.

Here are a several more traditional guidelines for improving your listening and speaking:

- ◆ Guidelines for effective listening
 - ◆ Stop talking.
 - ◆ Give others an extended chance to talk.
 - ◆ Hear their whole question/comment.
 - ◆ Paraphrase.
 - ◆ Assure your understanding.
 - ◆ Show respect and concern.

- ◆ Withhold evaluation.
- ◆ Patience is important.
- ◆ Project positive listening energy.
- ◆ Guidelines for effective speaking
 - ◆ Ask for specifics and/or clarification.
 - ◆ Give examples.
 - ◆ Broad statements do not allow core understanding.
 - ◆ Watch for nonverbal cues.
 - ◆ Facial expressions and eye contact are clues for understanding.
 - ◆ Clarify your perceptions.
 - ◆ Review and summarize.
 - ◆ Rephrase what you determined to be key information.
 - ◆ Clarify what needs to be done now or “by when.”

Communication is a complex phenomenon that you can always improve no matter what your competency level is today. And it is almost assured that as your communication skills improve, so will your effectiveness and success as a project team manager and leader.

Effective Collaboration and Team Integration

Many people use the words collaboration and integration interchangeably, but they are not actually the same thing, although they are similar. However, both are required, especially today, if you want to create a high-performing team. To collaborate means to work together—sharing information and data. But to integrate means to blend into a whole—to share experience, expertise, and ideas. Collaboration is data centric whereas integration is knowledge centric. You can collaborate as a team without ever truly integrating. But it's unlikely that your team will become fully integrated without first being collaborative.

Collaboration is much more akin to cooperation. If the construction manager has created an environment of trust, open communication,

and transparency for the team, and they share common values and project goals and objectives, generally, people can easily work together and collaborate. Especially if they have any history working together from previous projects. Team members are likely to help one another by sharing project information, data, budgets, schedules, and other pertinent items needed to coordinate efforts and get the work done.

Integration is quite different from simply working together, sharing information, and being transparent with your data. I like to describe it as thinking together out loud. It's as much of an art as it is a science. There's a merging of minds that takes place through a dialogue intent upon learning from one another. The team begins to develop their *integrative thinking* skills, even if they don't have formal training in the techniques associated with the practice. In his book ***The Opposable Mind*** (Harvard Business Press, 2008), Roger Martin defines Integrative Thinking as:

the ability to face constructively the tension of opposing ideas and, instead of choosing one at the expense of the other, generate a creative resolution of the tension in the form of a new idea that contains elements of the opposing ideas but is superior to each.

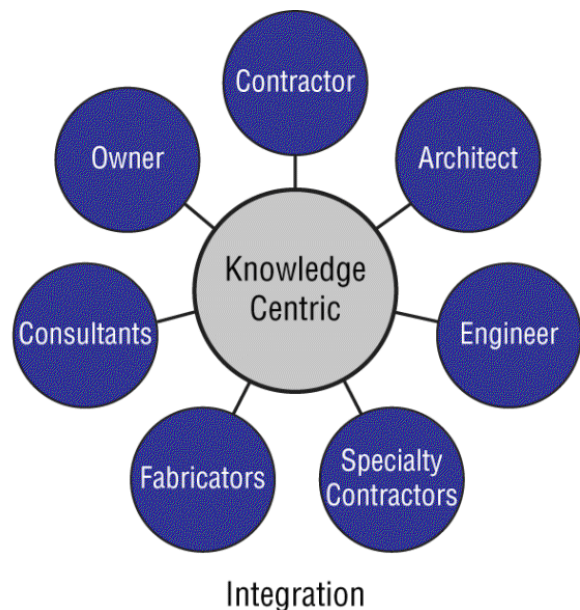
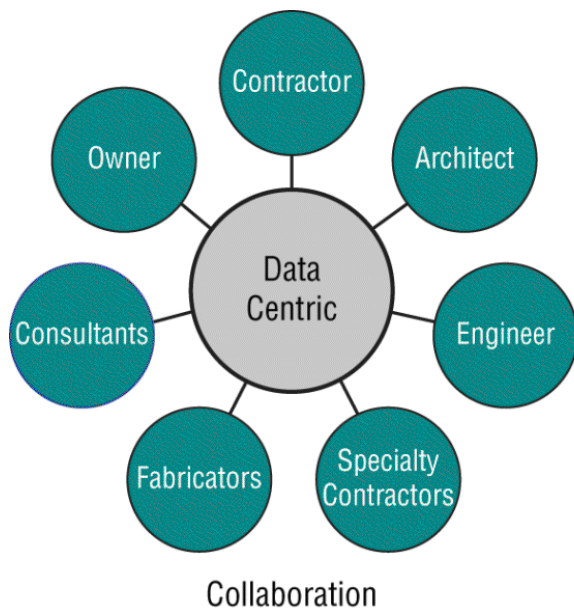
integrative thinking

The ability to face constructively the tension of opposing ideas and, instead of choosing one at the expense of the other, generate a creative resolution of the tension in the form of a new idea that contains elements of the opposing ideas but is superior to each.

It can be quite magical when you witness it, or better yet, if you get to experience it. An integrated team goes beyond simply sharing information and building on what each person already knows. Instead, the team begins to create new options and discover new solutions that otherwise no single person could have come up with on their own.

NOTE

Integrative thinking is a competency that is ideally suited to the development of Integrated Project Leaders for the construction industry. Unfortunately, it is not generally taught at U.S. universities as of yet. It was developed by Roger Martin, who is a former dean of the Rotman School of Management, at the University of Toronto. To learn more about integrative thinking, go to <http://www.rotmanithink.ca/what-is-integrative-thinking>.



The AEC Culture

To add to the complexity of the team management task, today more than ever, the chasm between the old culture and the new culture of the AEC (architecture, engineering, and construction) industry is more apparent than ever, and making the shift has been challenging to say the least. We have been in the midst of this transformation for some time. It started with a shift in delivery approach from traditional design-bid-build, which is epitomized by the low-bid mentality and a command and control style of leadership, to the more collaborative, team-based approaches such as at-risk CM, design-build, and integrated project delivery, where optimized solutions and value generation is the goal. Unfortunately, even when we change delivery methods or contracting methods, so often our attitudes and beliefs themselves don't change. That takes an intentional effort. From a cultural perspective, we are attempting to execute and leverage the benefits of collaborative delivery strategies while maintaining our traditional command and control cultures. The command and control techniques that had been so successful for us when the world, and circumstances, were more predictable, are no longer effective. As a matter of fact, they tend to do more harm than good. Today's project environment requires flexibility, transparency, open communication, collaborative interdisciplinary teaming, and *integrated thinking*. As an industry, our culture has not historically been characterized by these traits. In fact, our culture is generally characterized as being almost the opposite. As an industry we have a long history of operating from a segregated services perspective and it is quite difficult to break the behaviors that such a perspective has bred. Here are just a few of the challenges that are making the cultural shift so difficult.

Low-Bid Mentality

Because we, and particularly, our clients, are so wedded to the low-bid mentality, everything we do, even under more collaborative approaches, is often marginalized. When low price drives the entire project delivery process, there's no room for any real value generation or innovative solution finding, to optimize our clients' returns on investment. Instead of mitigating risks, the low-bid approach

increases them. This culturally embedded mentality is one of the toughest challenges associated with shifting our traditional culture from one of segregated services, to one of integrated services. But with more and more projects being delivered using design-build, and other collaborative approaches, we are seeing the tight grip of this unfortunate mental stronghold in the construction business model loosen.

NOTE

In my opinion, there is no greater risk to a client than a contractor who is losing money, and yet that is exactly the position that some contractors find themselves in after winning a low-bid contract. Many clients think they have won the lottery when the low bidder's price on their project seems to be well below the other competitors. But instead, that client should be very wary—because now the contractor will be operating from a position of fear and survival. It's just human nature. And yet it was the low-bid system that created this risk, and to no one's benefit. I often tell owners, believe it or not, you DON'T ACTUALLY want the lowest price. Instead you want the RIGHT price! And that's why any project delivery approach that promotes full transparency of costs and open communications to discuss and negotiate a reasonable price with a fair profit margin is far less risky than the lowest competitive bid.

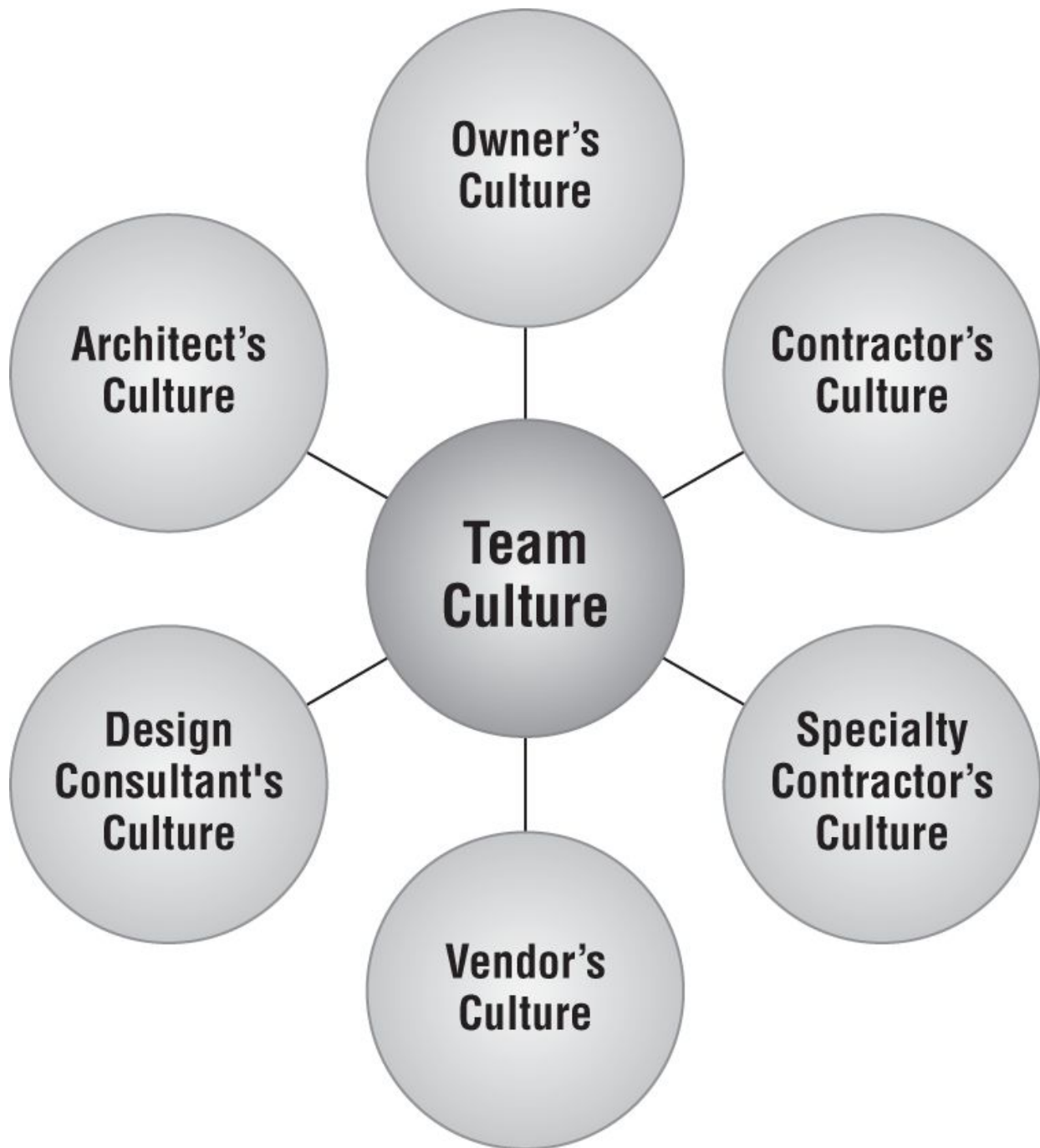
Competing Agendas

The low-bid mentality, and traditional design-bid-build culture, often pits one service provider against another. The architects, engineers, and contractors end up with competing agendas in order to protect their slim margins. This makes collaboration and open communication difficult and creative ideas and innovation almost impossible. And yet our clients expect us to perform and operate as one team, not realizing that their low-bid approach often causes mistrust and skepticism—just the opposite of what owners say they

want and need from us. Again, just human nature. If you feel that you are put in a position where you must make financial survival your number one priority, everything else becomes secondary. There's no room for good ideas when your agenda, and everyone else's is focused on not going broke.

Large Diverse Teams

I've talked a lot about how many people, trades, and teams it takes to complete a large commercial construction project. Even to build a single-family house requires a project team comprised of grading and excavation contractors; concrete specialists; framing companies; electrical, plumbing, and mechanical contractors; tile setters; flooring contractors; painters; drywall and insulation contractors; etc. The list goes on. On top of that, you are working with architecture and engineering firms and municipal entities like building departments and planning commissions. Each organization has its own unique culture and getting them to align around a similar cultural perspective or philosophy is almost impossible. It's hard enough to shift and manage your own company's culture toward behaving and operating in a more collaborative fashion, let alone align the cultures of a bunch of other companies and organizations that you have no influence over.



Even if you get your own company's culture shifted toward a more team-based organization, you still have to work with many other companies and organizations that may adhere to the traditional command and control culture, and that's why this is such a monstrous challenge for our industry as a whole.

NOTE

Finding ways to establish a reciprocal working environment among your most trusted and aligned business and trade partners is well worth the effort. I call such a collaboration a *teaming enterprise or network*. This is where getting the chance to work with the same companies and individuals over and over again really has its advantages. You can begin to align such things as your quality standards, technologies, and reporting systems. Over time you build trust and relationships and you identify shared values and a mutual cultural perspective, which makes working together more efficient and effective. But none of this happens by accident. You must be intentional in this effort to make it happen. And this is where real leadership comes into play.

Multigenerational Workforce

Every business is experiencing the challenges that a multigenerational workforce brings, and construction is no different. Workforce demographics in construction now span four generations—the veteran generation, baby boomers, millennials, and generation Y. Each of these generations bring their own beliefs, values, perspectives, expectations, and work habits. Trying to create a company, or even a project culture, that can satisfy all of these different beliefs, habits, and perspectives is not likely. However, spending the time to identify areas of common ground and shared objectives isn't as hard as you might expect. A good team manager is able to leverage the abilities of their diverse workforce around a set of shared objectives and goals for the project, and let each individual apply their unique talents and skills to achieve those goals and objectives.

teaming enterprise

Finding ways to establish a reciprocal working environment among your most trusted and aligned business and trade partners to create efficiency and effectiveness.

Technology

Like so many other industries, technology is having a profound impact on the construction industry—most notably in how we manage people and processes. However, if the truth be told, the construction industry is still lagging in its adoption of technology when compared to other major industries. This goes back to one of the earlier challenges mentioned—the diversity and size of the companies, teams, and organizations associated with getting projects built. These various entities represent every level of sophistication when it comes to the adoption and use of technology. Some companies are very tech savvy, while others aren't at all. Again, this represents a significant challenge for the industry as a whole, and certainly influences a company's sophistication and culture. In [Chapter 15](#), we will take a closer look at where and how technology is having its greater impact on the industry.

NOTE

The construction industry is not the only consumer group obsessed with the low-bid mentality. It is a phenomenon that infects many citizens, across all market and consumer sectors, in the United States. In her book *Cheap: The High Cost of Discount Culture* (Penguin Books, 2010), Ellen Ruppel Shell suggests that most all Americans are addicted to “cheap.” We love bargains so much, to the point that we expect everything to be offered to us at discount prices—our clothes, our food, our automobiles—and even our multi-million-dollar hospitals, bridges, and schools. Americans are so fearful of paying windfall profits and being ripped off that they rarely think about how much these things actually cost to produce, manufacture, or build. The automatic response to price is that somehow it all equates to profit. However, profits are usually grossly overestimated by consumers—especially in construction. When in reality, most contractors report that profit margins have steadily declined over the past couple of decades, and especially since 2008. According to the 2018 CLA Construction Benchmark Report, the average pretax income, as a percentage of revenue for general building construction is right at 3 percent for the years 2015, 2016, and 2017. Given the multitude of risks associated with delivering projects, this sure seems like a bargain to me! To download the full 2018 CLA Construction Benchmark Report go to CLAconnect.com/construction.

Changing our industry's culture is a heavy lift. Change usually equates to risk, and the rule of thumb for most businesses is to avoid risks at all costs. But construction managers are, first and foremost, very good at managing risk—it's what they do well. Unfortunately, our traditional methodologies for managing risk no longer work as well because project dynamics just aren't as predictable as they once were. However, the good news is that we don't have to be stuck with the way

we have always done things. We can actually take steps to begin to morph our cultures in the direction we need them to go. Anyone entering the construction field today should be aware that a large contingency of the industry understands that we are in the midst of this cultural transformation, even if they don't quite know what to do about it. Making a cultural shift isn't easy, but it's not impossible, either—especially when we recognize that not changing is riskier than changing. Frankly, it's a very exciting time to be entering the construction business. There are tremendous opportunities to learn, grow, and contribute as this new future unfolds.

NOTE

Flexibility and agility, the hallmarks for successful business, especially today, are threats to the low-bid system that is still dominant in our business and our culture. Any good idea that varies from the prescribed plans and specs has to be pushed aside because there is little accommodation for good ideas, improved systems, or better ways in a low-bid model.

Management vs. Leadership

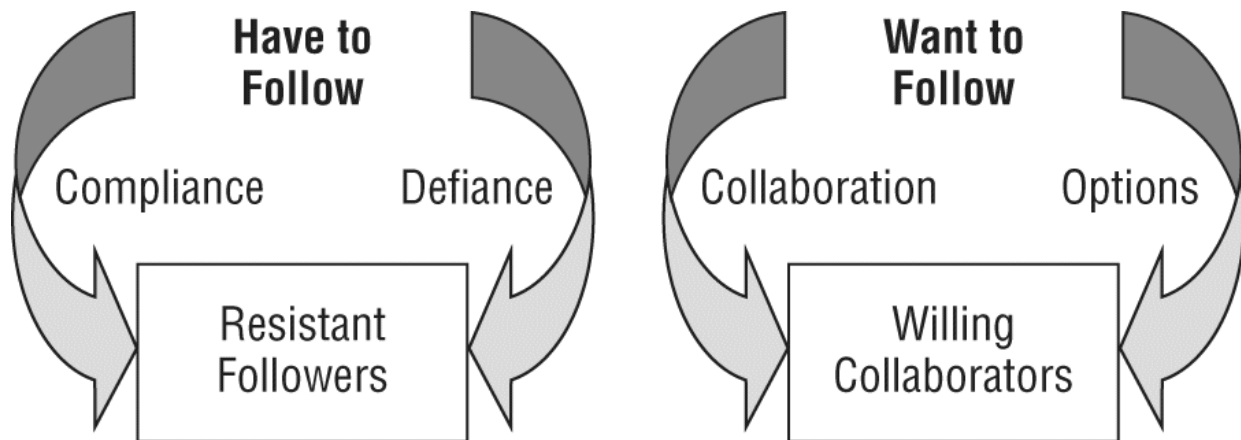
Before we leave the topic of managing project teams, I think it is important that we distinguish between management and leadership when it comes to developing your capabilities as a professional within the construction industry. First, it is important to recognize that management and leadership are not the same thing, and yet they are both required to be effective and successful in achieving project and company goals. There is much written on how these two capabilities are different, but one of the simplest ways to understand the difference is that we manage *things* and lead *people*. For example, we manage things like project schedules, project budgets, and safety programs. But people don't respond well to being managed and, in some respects, the whole notion that people need to be controlled or managed is downright demeaning, especially in this day and age. (It's part of our culture issue noted above.) Leadership is about empowering others, encouraging others, and inspiring others. Leadership is the ability to influence and persuade.

NOTE

In their book *The Inspiring Leader, Unlocking the Secrets of How Extraordinary Leaders Motivate* (McGraw-Hill, 2009), authors John H. Zenger, Joseph R. Folkman, and Scott K. Edinger found that the top 10 percent of leaders were identified by one critical competency—the ability to inspire and motivate. Their research revealed that the top 10 percent of leaders generated twice the net revenue as the middle 80 percent did.

According to Michael Maccoby, in his book *The Leaders We Need and What Makes Us Follow* (Personal Strengths Publishing, 2018), you aren't a leader if no one wants to follow you. Leaders are able to speak a vision in which others see themselves, and choose to follow, as willing collaborators. Managers who exert command and control authority over people may look like leaders to some, but their subordinates are often resistant followers who reluctantly respond

out of fear and intimidation. This type of management or leadership approach has a very negative impact on morale, and under such authority, there's usually a high employee turnover.



Developing an Integrated Project Team

To further distinguish between management and leadership consider that the role of manager usually comes with a title—like project manager, or construction manager, or quality manager. The role of leader doesn't necessarily come with a title. Leadership is not about titles or rank. It's not about seniority or status. It's about taking responsibility. Leadership can be exerted at every level no matter what your rank or title. It's about using your gifts and talents to elevate others and put them on the path to meet the goals and objectives of the project. It's about helping others achieve their own greatness, beyond the dollars and cents, and concrete and steel. What motivates people about their construction projects is usually not about meeting schedules and budgets—it's usually about what the project means to the people who occupy it or whose lives the project impacts. Recently, I asked someone what the construction of a new roadway meant for him personally. He stated, “Well, I get home about 35 minutes earlier now.” I said, and what difference does that make? With a tear in his eye he said, “Now I get to make it to see my daughter's soccer games.” I responded—and most people think it's just construction! This is what leadership is all about—creating a vision that *other people* can see themselves in. If you want to develop high-performing teams, then work at creating an environment in which they can excel, and make sure you express the difference their work makes to the people whose lives will be affected by their efforts.

Due to the shifts we have seen in project delivery approaches, and the need for cultural transformation from command and control to more collaborative approaches, I believe that we are seeing the emergence of a new kind of leader/manager within the construction profession. Let me distinguish this new kind of construction professional for you.

Integrated Project Leaders

The entire construction industry is changing. Although the debate is still active among some industry practitioners, in reality there is no single discipline among the three primary players (constructor, architect, or engineer) who is automatically identified as the leader of the team anymore. We know that the owner is always the ultimate leader of the overall project, but in terms of the project delivery team, discipline identity is no longer a prerequisite for leadership. The lines separating the discipline silos are becoming blurred. The complexities of projects today now demand a new kind of leader. Leaders who can bring more to the table than their discipline expertise. I identify these individuals as *Integrated Project Leaders* or IPLs. The impetus for this new kind of construction professional has primarily been the shift toward more collaborative approaches to project delivery and *procurement* that has been happening since at least the 1980s.

integrated project leader

A title intended to clearly distinguish the primary accountability associated with leading a design-build team. Although every organization is different, an IPL may take the place of a traditional project manager in design-build, or the project manager may be subordinate to the IPL.

procurement

Acquisition of goods and services.

The abilities and knowledge needed by IPLs goes beyond traditional construction management, architecture, or engineering education.

Competencies in communication, *strategic foresight*, and *emotional intelligence* are just a few of the many new skills needed to be effective as a manager/leader of multidisciplined project teams. In addition, I believe that the next-generation construction project manager should also have some awareness of how projects are financed, be familiar with *land development* and *land entitlement* processes, and have an understanding of the various design practices and services provided by architects and engineers.

strategic foresight

A planning-oriented practice based on the study of futures and statistics.

emotional intelligence

The capacity to be aware of, control, and express one's emotions, and to handle interpersonal relationships judiciously and empathetically.

land development

Changing the landscape to alter landforms, subdivide existing property, or changing current property usage for new purposes.

land entitlement

The legal process of obtaining approvals from a governing municipality to allow for the development of a certain building type.

NOTE

If there is one thing that I think a person could work on to transition from being a traditional construction manager to an integrated project leader, it would be to improve their EQ or Emotional (intelligence) Quotient. EQ, unlike our Intelligence Quotient (IQ), can be improved. Our IQ is something we are born with and it doesn't change over time. But we can work to improve our Emotional Intelligence. There are four basic skills associated with Emotional Intelligence. Two are related to Personal Competence. They are self-awareness and self-management. The other two are social awareness and relationship management, which relate to our Social Competence. You can also learn more about what Emotional Intelligence is and how you can enhance it by reading *Emotional Intelligence 2.0* by Travis Bradberry and Jean Greaves (Talent Smart, 2009). You can also benchmark your current EQ by accessing Talent Smart's EQ assessment at:
<http://www.talentsmart.com/products/emotional-intelligence-appraisal.php>.

As the industry continues to transform, I hope we will begin to see more cross-disciplinary education in the typical construction management curriculum. I also find that business and finance acumen is becoming more and more relevant to a construction professional's career path—especially if you have the desire to rise above the ranks of project manager, to business development or executive leadership. It is my belief, that if the only thing a person can bring to the project today is construction management, or architecture, or engineering for that matter—that it's simply not enough. Owners are expecting more from their project teams, and the segregated services model that has been the cornerstone of the traditional design-bid-build project delivery approach, just doesn't work anymore. It is too inefficient, too wasteful, and doesn't generate the added value that our clients expect and need. I don't think it will be too many more years before we begin to distinguish between

traditional construction managers and distinctly identifiable design-build project managers and even IPLs.

Terms to Know

commitment management	land entitlement
committed listening	open book philosophy
committed speaking	procurement
emotional intelligence	reliable promising
	strategic foresight
integrated project leaders	teaming enterprise
integrative thinking	vulnerability-based trust
land development	

Review Questions

1. Name three key members of the project team.
2. List at least three common factors that will influence your ability to trust or not trust members of your team.
3. How is vulnerability-based trust related to accountability within the team?
4. According to Fernando Flores, what are the five basic speech acts?
5. Define committed listening and committed speaking.
6. Give three examples of effective listening.
7. Give three examples of effective speaking.
8. How does low-bid mentality challenge the ability for the AEC industry to make cultural shifts?
9. What is the basic difference between management and leadership?
10. Define the role of the Integrated Project Leader (IPL).

Chapter 7

Performing Pre-construction Services

In This Chapter

- ◆ What pre-construction is and why is it needed
- ◆ The standard pre-construction services
- ◆ Why constructability is important
- ◆ How conceptual estimating helps manage scope
- ◆ How value in construction is defined
- ◆ When value engineering is performed
- ◆ Defining a life-cycle cost analysis

There are many factors that need to be analyzed long before the actual building process begins. This stage of construction is referred to as pre-construction services—often shortened to “pre-con” services. As you learned in [Chapter 2](#), the project owner is the party who sets the stage for any construction endeavor. And even though the owner will generally work with an architect early on in the project planning stages to develop a preliminary design program, they also solicit the services of general contractors and/or construction managers to help flesh out additional information related to project feasibility, risk identification and mitigation, design and construction challenges, cost information, schedule issues, and overall coordination and optimization of all of the project elements considered together as a whole. This is really one of the great benefits of bringing on the contractor at the earliest stages of design, and the reason that several of the newer alternative project delivery approaches such as at-risk CM, design-assist and design-build have become so popular. This upfront analysis and early involvement and coordination between the owner, architect, and contractor through the pre-construction and design phases often results in both cost and time savings, as well as risk mitigation and value generation that not only benefits the owner,

but can also prevent surprises down the road for all members of the project team. That's why pre-construction has become a stand-alone set of services that many general contracting or construction management firms provide, even if they aren't ultimately involved in the construction of the project.

The Evolution of Pre-construction Services

At one time, pre-construction was a set of activities that was undistinguishable from the building process and as such was basically given away for free. In other words, pre-construction services were just part of the preliminary work associated with ensuring success of the project. Its value was not independently recognized as distinct and separate from the building process. But today, that is not the case. In addition to consisting of activities that support the planning stages of construction, pre-construction is recognized as a distinct set of services that supports owners, architects, and engineers in their decision making.

As various alternative project delivery methods gained popularity, these preliminary activities began to be recognized for the value adding bonus that they are, and became, for many companies, stand-alone profit centers. Just a few decades ago, the pre-construction services component of many companies consisted of 1 or 2 persons. Today, most large construction companies have entire pre-construction departments with staffs of 10, 15, 20, and 30+ people on board. The work that these individuals and departments deliver is of great value and benefit to the entire team. It is the stage of the process where the diverse expertise and knowledge of the various team members can be brought to bear to help flesh out potential challenges and opportunities associated with the project before the design is complete or the construction has begun. The pre-construction phase of a project is the best opportunity to define, analyze, and manage the scope of the project such that the efforts put into design and construction can be optimized and remain within the bounds of an owner's budget, schedule, and other goals. Pre-construction allows the entire project team to anticipate surprises before they happen, and thus mitigate their impacts.

Alternative Project Delivery Approaches

As construction projects became more and more complex, the need for alternative approaches to project delivery became more and more prevalent. As you learned in [Chapter 2](#), the most common of the alternative project delivery methods used today are at-risk CM and design-build. Both of these methods overlap design and construction

efforts to better manage risks, generate greater value, and eliminate waste. Because of this overlap, owners often benefit from lower project costs, improved schedules, greater value, higher quality, less waste, greater efficiencies, and more innovation. The work that takes place between the owners, architects, engineers, contractors, and subcontractors during this overlap period is where many of the pre-construction activities occur. They occur while the design is in progress. The contractors, trades people, and material and equipment suppliers provide valuable information to the design team, and the owner, so they can be better informed as they make design decisions that will have impacts on the entire life cycle of the project's performance, and not just the initial first cost of the project.

Because design has a great impact on just about every aspect of a project's overall success, it is imperative that multiple discipline perspectives are considered during the design phase so the best overall design decisions can be made to support all of the owner's goals—including budget, schedule, quality, durability, sustainability, operations, and others. This is one of the greatest benefits of using an alternative project delivery approach that allows the various design and construction parties to work together as an integrated team at the very onset of the project feasibility and planning. The days of trying to address all of these various considerations in isolation through the design process, without engaging and talking with the various engineers, contractors, and subcontractors, who are expert in the numerous systems that make up the building design, just seems unthinkable today. No project can benefit from the newest technologies and advancements in materials and methods without the collaboration, coordination, and communication of the project team, consisting of owners, designers, contractors, material and equipment vendors, facilities and operations personnel, and other specialists of numerous kinds.

As you learned in [Chapter 6](#), the teaming aspect of the project delivery process has a great impact on the success of a project and the owner achieving all of her goals. So often in the past, under the design-bid-build approach, the architects and engineers often worked in isolation from the construction experts who could provide much of the information that had to do with overall feasibility, procurement, constructability, or cost issues associated with particular materials or

methods that were being considered. That meant that many of the resulting challenges and issues weren't discovered until the bidding process, or even worse, during construction. Such surprises often resulted in busted budgets, delayed schedules, or cost overruns. That's why we have seen such an increase in the use of alternative project delivery methods, and how the application of pre-construction services has become an expected part of the overall project delivery process. Its value to the client and the entire team cannot be emphasized enough.

NOTE

Just like a surgeon is supported by many experts in order to perform surgery, we need a team of multidiscipline experts to support the building of a project. Before a team of doctors go into the operating room, they huddle to discuss the various approaches to the surgery, and try to anticipate what might go wrong, and what their response would be if it did. It's the same for a pre-construction team. They too huddle on several occasions during design and before construction begins, often with the use of technology, to better plan their overall strategy and approach to the project, and try to anticipate the many scenarios that may play out as they execute the project delivery. The best teams often take a “plan for the worst and hope for the best” approach to risk assessment and management during the pre-construction phase of the project, trying to anticipate any surprises that might de-rail their plan. Although it is not possible to anticipate all such surprises, these pre-construction efforts certainly mitigate many of the risks associated with design and construction execution.

What Are Pre-construction Services?

Pre-construction services are just that—anticipatory planning, analytical, and evaluation activities that occur before construction begins, often during the design phase when at-risk CM, or design-build is employed as the project delivery method. The primary goal for these activities is to eliminate inefficiencies associated with the building process, supply chain, inspection and approval process. These services may or may not be employed as a separate fee generator for construction firms. When they are employed with at-risk CM for example, many of the pre-design oriented services are usually identified as activities warranting their own fee, independent of the construction contract. At other times, pre-construction services focused more on the building process, are just part of standard practice for contractors who want their projects to go as smoothly as possible.

pre-construction services

Anticipatory planning, analytical, and evaluation activities that occur before construction begins, often during the design phase when at-risk CM, or design-build is employed as the project delivery method.

If you check out the websites of general contractors of all types you will see that most list pre-construction services as a stand-alone set of tasks. Here is just a sampling of the types of services that you will find listed:

- ◆ Feasibility studies
- ◆ Design analysis and review
- ◆ Estimates and budgets—conceptual and detailed
- ◆ Target value design
- ◆ BIM management and execution
- ◆ Value engineering
- ◆ Constructability analysis

- ◆ Bidding and subcontract analysis
- ◆ Schedule creation
- ◆ Schedule management
- ◆ Resource loading and analysis
- ◆ Logistics phasing and planning
- ◆ Life-cycle analysis
- ◆ Design management

When and How Do They Occur?

As the project design develops, the construction team can provide valuable information relative to cost, schedule, construction approaches and efficiencies, material availability, labor availability, site planning and logistics, building codes, environmental issues, etc. to the architects and engineers designing the project. Such anticipatory analysis during the design phase helps eliminate costly redesign efforts later, resulting from design errors, omissions, missed value enhancement opportunities, or constructability issues; while at the same time increase efficiencies, save money, improve completion times, enhance quality, and add overall value by eliminating waste of all types. When and how pre-construction services are provided depends on when the contractor is engaged.

Under the design-bid-build project delivery approach, which most often employs a low-bid procurement approach, the contractor will not be engaged until after the design is complete. And no additional fees are added to the construction contract to apply value enhancement type reviews or analyses. In this scenario, the pre-construction services employed will primarily be limited to the planning and management of the construction execution. BIM coordination, logistics and phasing, resource loading and analysis, and schedule management are examples of the typical pre-con activities applied when the design-bid-build project delivery method is used. The contractor applies these techniques to add efficiency to their own operations.

However, when project delivery methods such as at-risk CM and design-build are used, pre-construction services may be applied

earlier because the design is not completed at the time the contractor is brought on board. Therefore, activities such as design reviews, constructability analysis, and life-cycle cost studies may be applied—adding much greater value to the project at the design stage, which in turn adds greater efficiency to the construction stage.

Although not all project delivery methods lend themselves to the full utilization and optimization of pre-construction services, there are always benefits to applying them on any project—whether during the design phase when they are most effective, or as a preparatory check and review process applied before mobilization and construction begins.

Common Pre-construction Services

Although different types and sizes of companies will offer different types of pre-construction services, the most common pre-construction services are:

- ◆ Feasibility studies
- ◆ Constructability reviews
- ◆ Conceptual estimating
- ◆ Value engineering
- ◆ Life-cycle cost analysis

We will consider each of these common services one at a time.

Feasibility Studies

One of the greatest expenditures that owners and companies make is on their *capital projects* and improvements. According to the 2017 Capital Spending Report published by the U.S. Census Bureau, *capital expenditures* for new and used structures by all U.S. nonfarm businesses reached just under \$646 billion in 2015—a 32 percent increase from 2006 spending. So, it is easy to understand why an owner might want to have some help from experts regarding the feasibility of their capital projects decisions. Contactors, and specifically construction managers, are one of the experts that an owner engages to help them with this early *due diligence* activity.

capital project

A long-term investment project to build upon, add to, or improve a capital asset.

capital expenditure

Funds used by a company to acquire, upgrade, build, and maintain physical assets such as property, buildings, or equipment. Capital expenditures can include everything from repairing an air conditioning system, to putting on a new roof, to purchasing a piece of equipment, to adding onto an existing building, or constructing a brand-new facility.

due diligence

Obligation of the contractor, usually written into the contract, to complete the construction project with reasonable care and avoid harm.

feasibility study

An analysis conducted at the very early stages of a project to help the owner determine if it is a good idea to invest their time and money to follow-through with the project or whether an alternative solution should be pursued.

What Is a Feasibility Study?

A *feasibility study* is an analysis undertaken in the very early stages of a project—long before any thought regarding the details of design or construction are even considered. The reason for completing such a study at this very early stage is to consider how successful the project will be in meeting the owner's intended purpose for the project. In addition, the construction manager will help the owner uncover both the positive and the negative outcomes of the project before they proceed with the investment and capital expenditure. There are many factors which come into play when analyzing the feasibility of a project. The more complex the project, usually, the more factors that will need to be considered. The feasibility study will help the owner

determine if it is a good idea to invest their time and money to follow-through with the project, or whether an alternative solution should be pursued.

Components of a Feasibility Study

A feasibility study can address any number of issues and concerns associated with a project and its impact on an organization's mission and goals. But generally, the study will focus on the most likely threats to the project and the overall business or operations. Some of the more common items presented in a feasibility study include:

- ◆ Full project description and rationale for its consideration
- ◆ Business case for the project
- ◆ Operational efficiencies
- ◆ Budget and schedule constraints
- ◆ Capital and life-cycle costs
- ◆ Financing availability and sources
- ◆ Operational and maintenance issues
- ◆ Project delivery and procurement options
- ◆ Design and construction considerations
- ◆ Environmental impacts
- ◆ Traffic and parking issues
- ◆ Site conditions and geotechnical considerations
- ◆ Adjoining lands, easements, covenants
- ◆ Market conditions and competition
- ◆ Legal constraints and regulatory environment
- ◆ Entitlement and permitting processes
- ◆ Political environment

Although some owners may not need to have a feasibility study completed to proceed with their capital projects, others have much more at stake, and need a thorough investigation and analysis of the

strengths, weaknesses, opportunities, and threats associated with their project. This pre-construction service explores various scenarios that may impose risks on much more than the physical building project itself—but rather, also considers risks that may threaten the entire business or institutional entity and its mission overall.

The Importance of a Feasibility Study

Not all construction companies will perform this particular pre-construction service. It is an intensive investigation that often considers factors beyond a contractor's usual scope of services. However, more and more contractors are beginning to hire personnel who can perform the types of analytical investigations needed to assess all risks associated with an owner's business and operations relative to their capital projects investment—particularly those full-service companies who are involved in all or multiple aspects of the built environment—planning, design, pre-construction, construction, commissioning, interiors, and facilities management.

Feasibility studies help owners identify both the upside and the downside of proceeding with a project by exploring various scenarios and considering the pros and cons of each outcome in-depth. They use the study to evaluate and analyze all of the issues and impacts that the project may have on every aspect of their business or operations, and help alleviate them. Or, the report may result in an owner determining that the project is not worth the risk, or the consequential impacts too disruptive, and therefore he does not proceed beyond the pre-construction and feasibility stage. The project may actually be tabled after a thorough feasibility analysis is completed. Either way, it's money well-spent, and a very valuable service that helps ensure that the decision-makers have the information and data they need to make informed, reliable, go/no-go determinations about their project.

Constructability Reviews

As stated in [Chapter 1](#), “It's not architecture until somebody builds it.” And in order for someone to build a designed project, it must be “buildable.” And the more “buildable” the project is, generally, the more economical it will be to construct. However, performing a constructability review during the pre-construction phase isn't just

about ease of construction and economics—it's also about quality, value, code compliance, schedule, sustainability, energy efficiency, and any other criteria an owner deems important to achieve their ultimate goals.

Architects and engineers know how to design, and contractors know how to build. The primary goal of constructability is to merge these areas of expertise such that one discipline's knowledge and work, may benefit from the other discipline's knowledge and work. Thus, evaluating a project's constructability is an effort to optimize both the design and the construction to achieve the desired outcomes for the project. It's one of the great benefits of engaging this particular pre-construction service. Alternative project delivery approaches that engage the contractor early during design, take advantage of this multidiscipline array of knowledge and work to coordinate the design development efforts with the construction efforts to leverage the efficiencies and value enhancements that are discovered. In the past, what so often happened is that details were designed without any input from the construction professionals, resulting in elements of the project that were very costly or difficult to build, or not constructible due to any number of factors—often leading to change orders, rework, cost overruns, schedule delays, missed opportunities to enhance the project, and a lot of frustration on everyone's part, but especially the owner.

Benefitting from Constructability Reviews

A project's design impacts far more than the cost, schedule, and quality of a project. Even though these are the more common reasons for owners wanting to have a constructability review done, they are not the only reasons. If the owner has other design intentions, they most likely will also have constructability implications. For example, if an owner is trying to achieve LEED certification for its building, then it will matter how and where the contractor disposes of the debris resulting from construction operations. That's why it's so important that the owner communicate all of their concerns and goals for the project so the pre-construction team can assist in the avoidance of construction issues that could jeopardize the project outcomes. Here is a list of items that may be considered during a constructability review:

- ◆ Ease of construction
- ◆ Labor intensity and specialization
- ◆ Phasing and sequencing
- ◆ Material selection and availability
- ◆ Design standards
- ◆ Quality standards
- ◆ Staging and site logistics
- ◆ Permitting, entitlements, and code compliance
- ◆ Accessibility and ADA compliance
- ◆ Subcontractor coordination and work flow
- ◆ Value enhancement
- ◆ Environmental issues
- ◆ Water tightness
- ◆ Energy efficiency
- ◆ Sustainability goals
- ◆ WELL-building standards
- ◆ Durability, maintenance, and upkeep
- ◆ Facility management
- ◆ Life-cycle costs
- ◆ Safety

Constructability, and its impacts, is primarily influenced by the design. Taking the time to align the details of the design, with the elements of the construction process, leads to successful projects. This pre-construction activity is well worth the cost and is highly recommended, regardless of the project delivery method.

When Are Constructability Reviews Performed?

Although a constructability review may occur after the design is complete, it is much more beneficial and efficient to have it occur as

the design develops. As a matter of fact, it is best if the architects and engineers consult with construction experts before they begin designing if at all possible. Once again it depends on the project delivery method being employed, but the opportunity for constructability reviews is the predominant reason that owners have opted to use at-risk CM or design-build in the first place. This up front, coordinated effort between the designers and the constructors, to designs systems and assemblies that they know will work, is simple common sense. Unfortunately, such common sense often still takes a back seat to the desire to use the traditional low-bid, design-bid-build approach, even when we know it often results in significant change orders, delays, and cost overruns—precisely because there wasn't a thorough constructability review and coordinated effort to align and coordinate the needs of the design with the needs of the construction. Performing a constructability review and analysis as the design is being developed is the single smartest step that an owner can take to ensure that they will have a smooth-running project and a facility that functions and operates as they intended.

NOTE

I asked a very successful design-build contractor one time how it was that he seemed to have so few Requests for Information (RFIs) from his subcontractors to the architect on his projects. He told me that he had one hard and fast rule when it came to performing constructability reviews. He said that he required all of his architects and engineers to sit down and talk with the subcontractors who were going to be involved in doing the work of the project BEFORE they designed anything. The rule was “talk first, and draw second” or what he called pre-design constructability conversations. This rule made the constructability reviews much more effective because the designs had already been informed in advance of the review, and thus it was almost like having two opportunities to catch things that might cause a problem during construction. It should be noted that this same contractor had a track record of almost always beating the projected project schedule—and he attributed that to the talk first, draw second rule. He insisted, that when time is of the essence, no designer should be allowed to draw or plot a single line until AFTER they spoke with the folks who would actually install the materials, systems, and assemblies. It eliminated any redesign work as well.

Who Should Perform the Constructability Review?

Obviously, those persons who are most familiar with the means and methods of construction are most qualified to perform constructability reviews. So it's important not to just leave this to the project managers and the more senior personnel within a construction organization. Those individuals who have the most experience in constructability issues are those who actually construct or build projects. That means superintendents, job foremen, trades personnel, subcontractors, facility and maintenance personnel, and

specialty contractors should definitely be involved when it comes to providing feedback and suggestions associated with constructability.

It is truly remarkable how much knowledge these individuals have about how all of the parts and pieces go together and how to avoid problems in the function and operation of systems. They can, and often do, help avoid costly malfunctions and delays down the road when consulted during the constructability reviews. And, they can help find ways to save money and time when given a chance to contribute to the design process. Likewise, if they are not consulted during the design phase, it is a missed opportunity to find efficiencies and value-adding ideas. More than any other pre-construction service, constructability reviews make the most sense and are the most beneficial in terms of saving money, and headaches, both during and after construction.

Conceptual Estimating

You will learn more about conceptual estimating in [Chapter 8](#), but in this section I am going to share how this predesign activity is expanded to deliver one of the most valuable pre-construction services. Conceptual estimating is one of the primary activities employed when pre-construction services are provided, and is widely used with any project delivery method where the contractor is hired by the owner before the design is complete. Cost certainty is a major driver for owners, and conceptual estimating through the design process can ensure that the completed design is in line with the budget that the owner anticipates. However, in traditional project delivery, known as design-bid-build, where the owner does not hire the contractor until the design is complete, it is quite common for the estimates of the completed designs to be in excess of an owner's budget. This is generally quite upsetting for the owner and often comes as a surprise—a surprise that the owner doesn't appreciate. If this is the case, then the owner has a couple of options:

1. The owner can increase the budget to align with the design, or
2. The owner can send the design back to the design team and ask them to redesign the project, which in turn increases design costs and delays completion of the design, and thus the construction, or

3. The owner can ask the construction team to “value engineer” the project and find ways of cutting costs from the project. However, at this stage, the cost cutting that takes place is not really associated with value generation at all, and to call this option value engineering is a misnomer.

NOTE

Unfortunately, it is common for owners who use design-bid-build project delivery to discover that their project is over budget only after the design is completed. Because they did not have the benefit of cost monitoring while the design was developing, this budget bust usually comes as a surprise—and not a welcoming one! Trying to cut costs after the design is complete is really just looking for the largest-dollar items that are easy to modify or remove, and doing so without much thought about the multiple impacts that making such a decision without proper coordination can have. In fact, when value engineering is approached at such a late stage, it is more likely that the cost-cutting actions may actually decrease value—especially in the long run.

Design has a major impact on the cost of construction. The project's shape, size, quality of finishes, and other design variables directly affect where the final estimate will end up. That's why the conceptual estimating function is so critical and valuable to the client.

Conceptual estimating is a major, and common, pre-construction service that often helps clients and architects track the impacts of the design, as the design develops. It also gives the owner cost certainty much earlier in the design process.

The Cost Model

The best way to employ conceptual estimating is to develop a cost model even before the detailed design process has begun, and then use the cost model to guide the design. In this fashion, cost actually becomes a function of the design. Cost models are developed from

previously built projects where actual costs are known and archived to create a “historical cost, or model cost database,” which can then be used to extrapolate estimates for similar projects. For example, if a client is interested in building a new elementary school, the contractor can access either their own historical model database or a published database resource.

How the cost model is used The cost model creates the working budget to guide the design process by allocating budget limits to the various elements or systems of the design. The challenge for the architects and engineers is to then design to the allocated budget.

Developing the cost model The process of developing a *cost model* begins with the project program. As you recall from [Chapter 5](#), programming establishes the overall building parameters—size, shape, function, number of floors, number of rooms, etc. These preliminary pieces of information are all that the contractor needs to start building a cost model. Once the contractor has information on the gross overall quantities for the proposed new building (square feet, linear feet of perimeter, number of floors, etc.), establishes the quality standard desired by the owner, and has current unit prices based on previous projects, she can build a cost model.

cost model

The working budget to guide the design process by allocating budget limits to the various elements or systems of the design.

**University Classroom Buildings
Systems Cost Model Comps**

	249,610	S.F.	222,166	S.F.	250,000	S.F.	
	COMP PROJECT A		COMP PROJECT B		NEW PROJECT COST RANGE		
CONSTRUCTION SYSTEM	TOTAL	CST/SF	TOTAL	CST/SF	Low	CST/SF	High
DIRECT JOB EXPENSE	2,069,916	8.29	1,699,570	7.65	1,937,500	7.75	2,125,000
SITE WORK	2,029,329	8.13	4,292,866	19.32	2,250,000	9.00	5,000,000
SUBSTRUCTURE	1,647,815	6.60	1,805,884	8.13	1,687,500	6.75	2,125,000
SUPERSTRUCTURE	11,396,713	45.66	7,881,295	35.47	8,875,000	35.50	12,000,000
EXTERIOR WALL	4,570,050	18.31	4,690,303	21.11	4,625,000	18.50	5,500,000
ROOFING	324,693	1.30	500,511	2.25	325,000	1.30	562,500
INTERIOR CONSTRUCTION	6,269,275	25.12	3,983,884	17.93	4,500,000	18.00	6,250,000
INTERIOR FINISHES	2,148,383	8.61	2,567,962	11.56	2,250,000	9.00	3,000,000
BUILDING SPECIALTIES	257,048	1.03	191,789	0.86	250,000	1.00	275,000
EQUIPMENT AND FURNISHINGS	91,996	0.37	45,938	0.21	62,500	0.25	125,000
SPECIAL CONSTRUCTION	43,292	0.17	438,035	1.97	62,500	0.25	500,000
CONVEYING SYSTEM	1,853,454	7.43	794,063	3.57	1,250,000	5.00	2,000,000
FIRE PROTECTION SYSTEM	781,968	3.13	516,141	2.32	625,000	2.50	812,500
PLUMBING	1,168,894	4.68	887,526	3.99	1,000,000	4.00	1,250,000
H.V.A.C.	9,591,963	38.43	5,264,680	23.70	6,250,000	25.00	10,000,000
ELECTRICAL	8,109,200	32.49	6,385,760	28.74	7,250,000	29.00	8,750,000
SUBTOTAL	52,353,990	209.74	41,946,209	188.81	43,200,000	172.80	60,275,000
DESIGN COSTS	7,900,000	31.65	0	0.00	6,000,000	24.00	8,500,000
INDIRECT COSTS	15,249,733	61.09	12,342,047	55.55	12,960,000	51.84	18,082,500
GRAND TOTAL	\$75,503,723	302.49	\$54,288,257	244.36	\$62,160,000	248.64	\$86,857,500

Note - Indirect Costs Include:
General Conditions, Sales Tax,
Bonds, Insurance, Contingency,
and Fee.

University Classroom Buildings
New Classroom - Reconciled Cost Model

RECONCILED COST MODEL	250,000	S.F.
	New Class Room Cost Model	
CONSTRUCTION SYSTEM	TOTAL	CST/SF
DIRECT JOB EXPENSE	2,000,000	8.00
SITE WORK	3,750,000	15.00
SUBSTRUCTURE	1,750,000	7.00
SUPERSTRUCTURE	10,000,000	40.00
EXTERIOR WALL	5,500,000	22.00
ROOFING	500,000	2.00
INTERIOR CONSTRUCTION	5,000,000	20.00
INTERIOR FINISHES	2,500,000	10.00
BUILDING SPECIALTIES	250,000	1.00
EQUIPMENT AND FURNISHINGS	62,500	0.25
SPECIAL CONSTRUCTION	125,000	0.50
CONVEYING SYSTEM	1,500,000	6.00
FIRE PROTECTION SYSTEM	687,500	2.75
PLUMBING	1,125,000	4.50
H.V.A.C.	8,750,000	35.00
ELECTRICAL	8,000,000	32.00
SUBTOTAL	51,500,000	206.00
DESIGN COSTS	8,000,000	32.00
INDIRECT COSTS	15,273,560	61.09
GRAND TOTAL	\$74,773,560	299.09

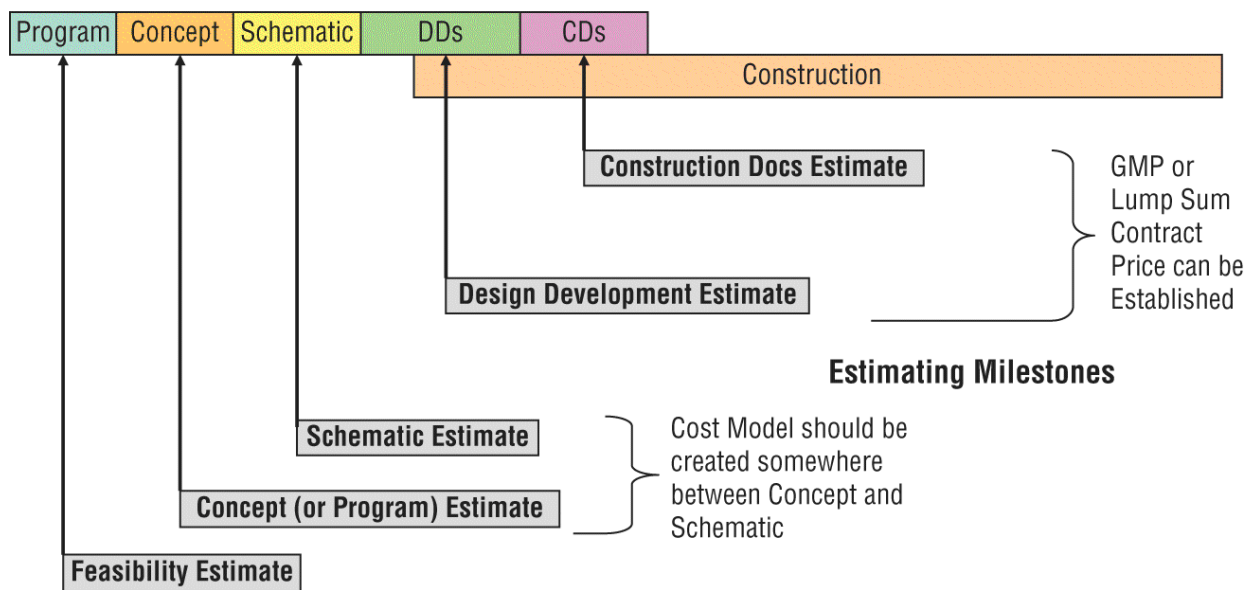
Note - Indirect Costs Include:
 General Conditions, Sales Tax,
 Bonds, Insurance, Contingency,
 and Fee.

The Estimating Churn

Contractors who are only accustomed to doing design-bid-build and detailed estimating may have a hard time understanding the rationale

behind the conceptual estimating process. In traditional detailed estimating, the design is usually 100 percent complete and the cost engineers or estimators will perform the estimating function only once to arrive at the bid or budget. However, in conceptual estimating the contractor will perform the estimating function several times at different stages of design completion. Some contractors have referred to this as the “estimating churn.” Initially traditional estimators might ask, “Why are we doing an estimate again, and again? We already did this.” But the goal in conceptual estimating is to maintain the overall budget number established in the cost model, and to do that they need to track the design as it is being developed and note any impacts to the project cost—thus the need for the “churn.” And, just as the details of the design become more refined as the design stages progress, so too should the cost budget numbers become more refined, or detailed as the design progresses through the various milestone design stages. The cost model might be referred to as the anchor estimate, establishing the project budget, which guides the design and project scope to stay on track. The goal in conceptual estimating is to have the designers and the contractors work as a team to maintain overall costs while making adjustments and tradeoffs in the finer details of the design, and estimate, to align with the cost model, so in the end, when the design is finally complete, there are no surprises in regard to the final project cost.

Design Stages



Value Engineering

You were first introduced to value engineering in [Chapter 2](#). You will find many definitions describing Value Engineering because the process is applied to the design effort of just about every type of project or product, from running shoes to rockets. Some are more scientific than others but I really like the one crafted by the National Institute of Building Sciences in their “Whole Building Design Guide (WBDG)” because it specifically relates to the design of buildings (<https://www.wbdg.org/resources/value-engineering>).

Value Engineering is a conscious and explicit set of disciplined procedures designed to seek out optimum value for both initial and long-term investment. First utilized in the manufacturing industry during World War II, it has been widely used in the construction industry for many years. Value Engineering (VE) is not a design/peer review or a cost-cutting exercise. VE is a creative, organized effort, which analyzes the requirements of a project for the purpose of achieving the essential functions at the lowest total costs (capital, staffing, energy, maintenance) over the life of the project. Through a group investigation, using experienced, multi-disciplinary teams, value and economy are improved through the study of alternate design concepts, materials, and methods without compromising the functional and value objectives of the client.

Value engineering, when properly applied, is a tremendously beneficial pre-construction service that every owner should take advantage of. It allows for the multidisciplinary teams to engage for the sole purpose of enhancing the objectives an owner is pursuing—whether they be associated with aesthetics, cost, quality, durability, functionality, sustainability, or any number of other aspects of a project.

The Benefits of Value Engineering

As noted previously in the conceptual estimating section, value engineering is a term that has gotten kind of a bad rap in the construction industry because of its misuse by some owners who are

not aware of its proper application. The point of value engineering is to increase a project's value, and this can only be done during the design phase of the project. But unfortunately, some owners apply it after the design is complete to cut cost when they find out that their project is over budget. At this stage, the only thing that can be done is to look for ways to delete high-dollar elements of the project that are easiest to remove without redesigning the project. Regrettably, this approach is haphazard and often results in leaving all parties disappointed and, in fact, when value engineering is misused in this fashion, there is often a reduction of value in order to bring the project back into budget. However, when value engineering is properly applied, the benefits can be significant and often produce enhanced results, no matter what kind of project.

NOTE

Subcontractors are often one of the best sources of value engineering ideas. It's important that these highly knowledgeable individuals are consulted during any VE effort. Their practical experience and familiarity often leads to unlocking cost savings, improved schedules, increased performance, and greater efficiencies, especially in many of the high-dollar systems such as HVAC, electrical, plumbing, structural, and others. If anyone knows how to do things smarter, faster, and cheaper, it's those boots-on-the-ground workers who build, install, and assemble our buildings.

What's the Difference between Cost, Price, and Value?

It is quite easy to quantify cost but it is more difficult to quantify value. Even though cost, price, and value are terms that are often used interchangeably, they each have distinct meanings. Before we can fully understand the benefits of value engineering, we must first be clear that cost and price are independent factors when it comes to gauging value.

Cost The cost of a construction project represents the actual dollars paid for the materials, labor, equipment, supplies, subcontracts, services, and any other item needed to build the project, whether identified as a direct or indirect cost. Cost also includes taxes, delivery charges, insurance, and other add-on variables such as overhead and profit. Project costs are communicated to an owner as a construction estimate. The actual cost won't be known until the project is complete and all items have been paid for. (Refer back to [Chapter 6](#) for information about direct and indirect costs.)

Price The price of a construction project is related to what the market will bear. In construction, the price is often communicated or delivered as a bid and represents what the owner will pay the contractor to build their project. The bid or price of the project given to an owner may or may not be equal to the project cost. For example, if the cost is \$1.25 million, the price charged to the owner will most likely be higher. The additional dollars added to the cost represents other justifiable risks or factors that may be quantified even if they aren't related to the actual building project. Factors such as anticipated inflation, increasing material prices, labor shortages, weather delays, or other factors may be calculated into a project's price. Some of those factors may also be intangibles, such as subjective value.

Value A construction project's value consists of a combination of its design, quality, usefulness, character, style, location, amenities, functionality, desirability, and other factors that are more subjective—and thus difficult to quantify. For example, if you have a major leak in your plumbing in the middle of the night, the cost to repair that leak could be relatively inexpensive—let's say \$200. But the value of getting that plumbing repaired expediently may be worth a great deal more to you than \$200. So, if the plumber charges you \$450, you may perceive that price as a good value given the circumstances, even though it's more than double the actual cost.

Bottom line, value equals the amount of benefit you get for amount of money you give or spend. However, the benefit that you get may have

nothing to do with square footage, or materials, or finishes. Instead, it may be intangibles such as ease of mind, convenience, prestige, location, sense of place, and aesthetics. For some owners, these intangibles will add value, for others, they will add no value at all. Value, like beauty, is in the eyes (or mind) of the beholder.

$$\text{Value} = \frac{\text{What you Get}}{\text{What you Give}} \text{ for } \frac{\text{What you Get}}{\text{What you Give}}$$

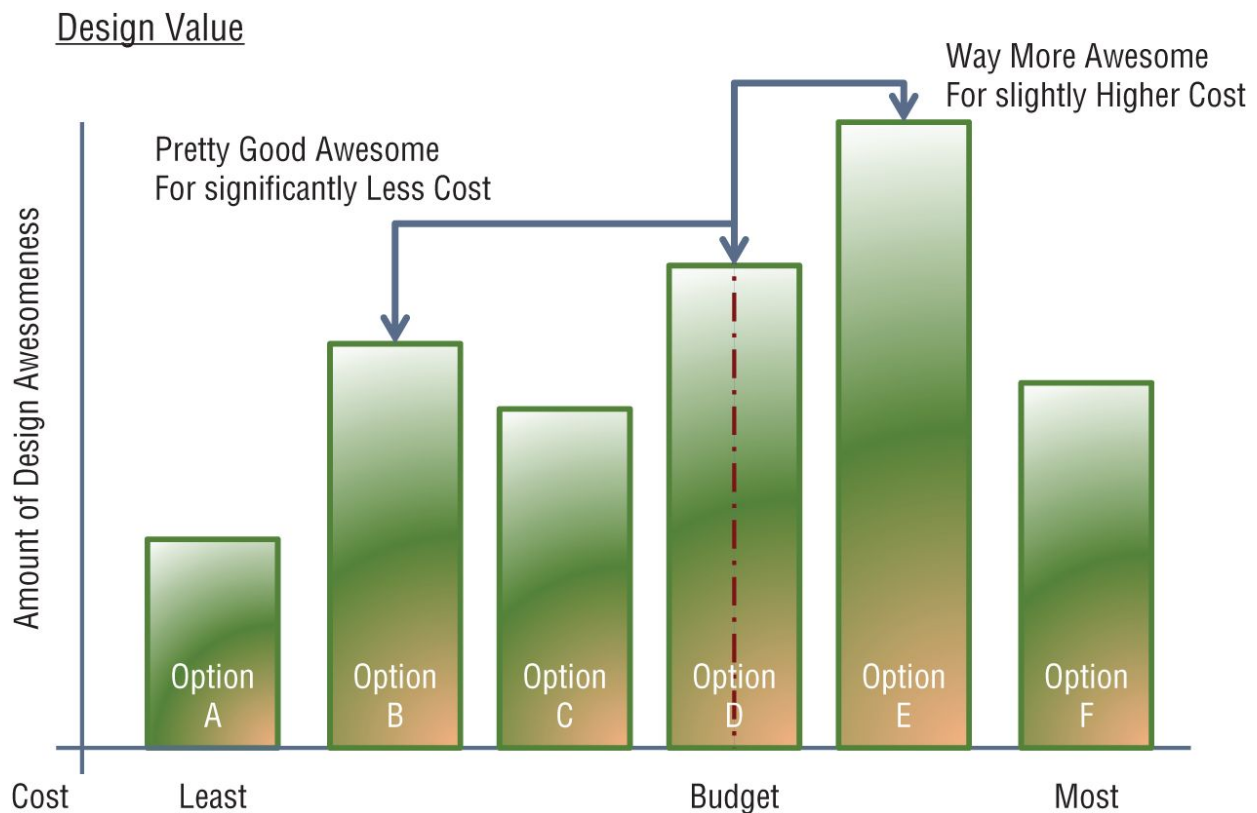
Generating Value from Multiple Perspectives

One of the most fundamental ways to think about value is that it represents what you get for what you give. In other words, value refers to an amount of benefit one can get, for the amount of cost invested to get it. However, value doesn't always mean reducing cost although that's often how we think of it in construction. In fact, there are several ways that we might look at value, and in some cases, it may mean that we actually add cost to the project. Let's consider a few different ways that we might add value to a project:

- ◆ Improve benefits and reduce cost
- ◆ Maintain benefits and reduce the cost
- ◆ Improve benefits and maintain the cost
- ◆ Increase benefits and increase cost (if added benefits are perceived to be worth more than the additional investment)
- ◆ Reduce benefits and reduce cost (if benefits still meet the owner's needs)

It's pretty easy to understand value from the standpoint of adding benefit at the same cost, or at a reduced cost. But how do we add value by adding cost? Or by reducing benefits while reducing cost? That's why value engineering is as much an art as it is a science. It's also why it is really important that the contractors understand what is

most important to their client—and what the desired “wow” factors are. Because contractors and subcontractors know better than anyone else how much things cost, they can better assess how much “wow” can be gained per dollar invested. If they know the client is looking for the greatest amount of “wow” in an element or feature, for the least amount of money, they can offer up the scenario that provides the maximum benefit per dollar spent. Or in the reverse, an owner might be spending excess dollars for gaining very little value. Contractors often know where the point of diminishing return is, and can add value by not letting an owner spend money in an area where the benefits gained aren't worth the dollars spent. In either case, the assistance that an experienced contractor can bring to the project when it comes to optimizing value is a great reason for applying this pre-construction service.



In addition to the different ways that you can generate value, there are also fundamentally two perspectives by which to view value. One way is to consider value from a product-oriented perspective. In this perspective, you might focus on a product or building element and see if you can provide it for less money. A simple example would be utilizing prefabricated roof trusses instead of stick framing the ceiling

joists and rafters. They are both roof system products or elements serving the same purpose, but one is definitely less labor intensive, and utilizes less lumber, and therefore is less expensive. (That's why it is very rare to see anyone stick framing a roof anymore.) Or you might consider a function-oriented perspective and focus on the needed function or performance instead of the product. In this perspective, you look for alternative products that can provide the same, or even better, function or performance. For example, if a client needs vertical transportation from floor-to-floor for its building occupants, they have several options they could consider. They could use an escalator, an elevator, or stairs. There are value factors that influence why, or why not, one of these options might be used over the others. Factors such as cost, installation ease, square footage required, number of people being moved, and of course building codes will all come into play when making this decision. Each option will serve the function, but it takes some consideration as to which offers the best value.

NOTE

For transporting people up and down two or three floors, escalators are more expensive than elevators, but they can move many more people, faster. That's why you see escalators at airports and shopping malls, but elevators in office buildings. The number of people who occupy an office building, and the frequency of use, is much less in an office setting than in an airport.

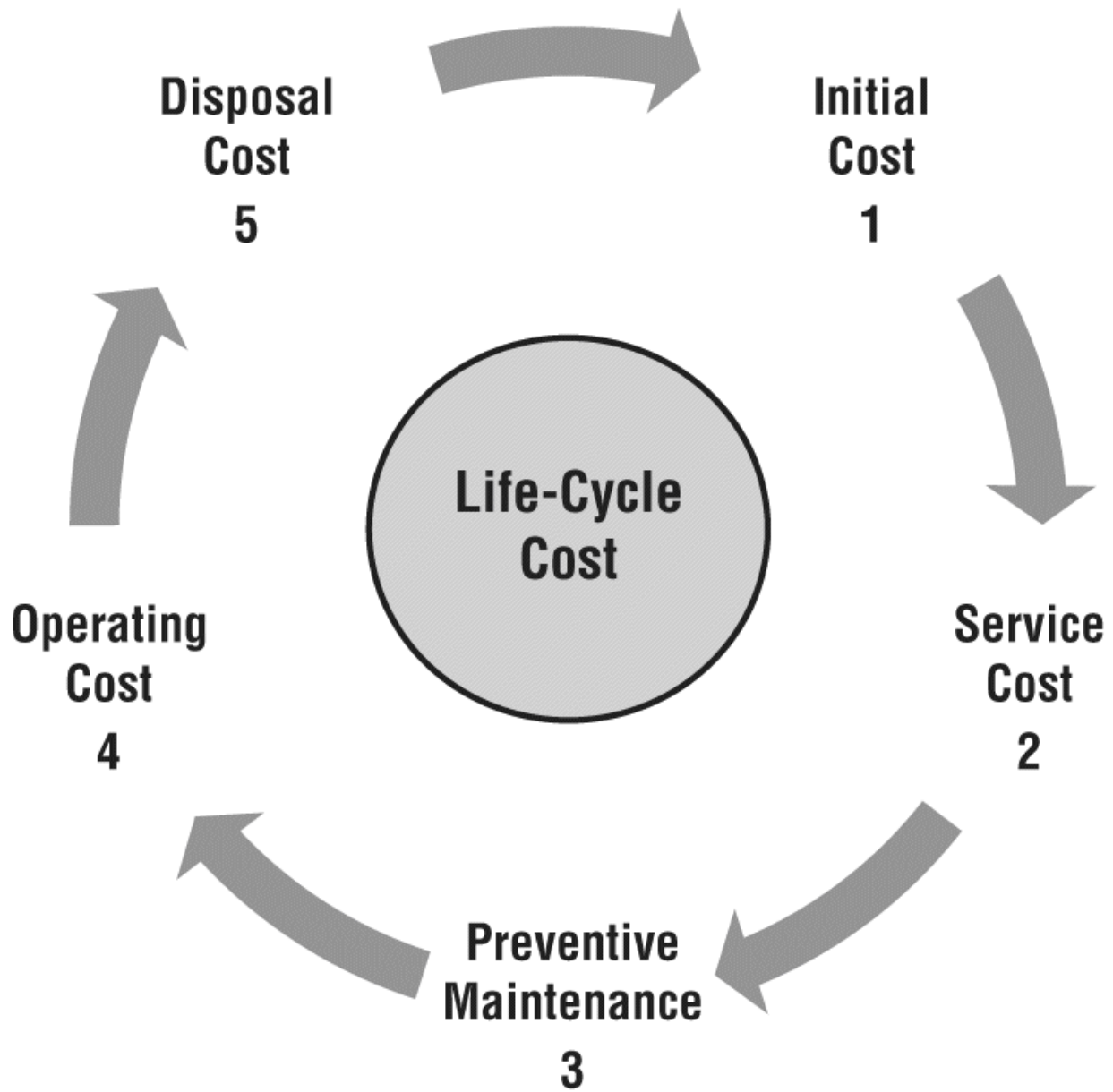
Life-cycle Cost Analysis

Value engineering and life-cycle cost analysis (LCCA) go hand-in-hand as highly useful tools for sound decision making at the earliest stages of design. Whereas value engineering generally focuses on the immediate, short-term impacts to the initial budget, the life-cycle cost analysis provides long-term cost projections for a particular building investment over its useful life cycle. LCCA is a formal process for calculating the ROI (return on investment) you can expect after considering all factors of cost and payoff associated with the:

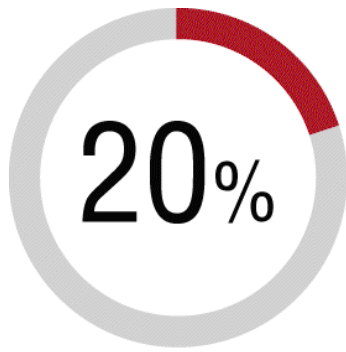
return on investment

A financial ratio used to calculate the benefit an investor will receive in relation to their investment cost.

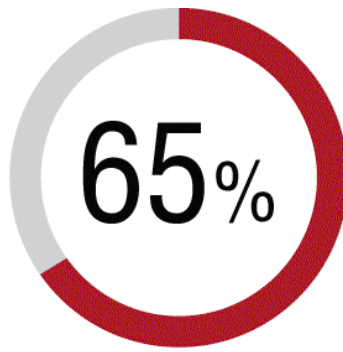
- ◆ Initial first cost
- ◆ Service cost
- ◆ Maintenance cost
- ◆ Operating cost
- ◆ Disposal cost



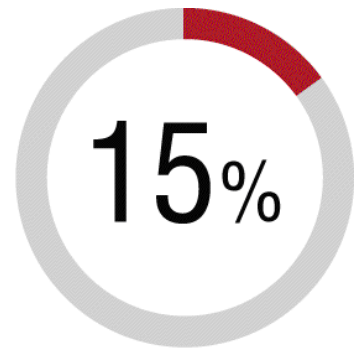
In some cases, this long-view perspective justifies spending more money upfront, to save service, operational, or maintenance dollars later down the road. The fact is, initial design and construction cost only makes up about 20 percent of the *life-cycle cost*, whereas operations and maintenance of a building make up around 65, and *decommissioning* and disposal cost equals about 15 percent. You can understand why applying both VE and LCCA techniques at the pre-construction stage would be so beneficial.



Design &
Construction Costs



Operating
Costs



Disposal
Costs

life-cycle cost

Long-term cost projections for a particular building investment over its useful life cycle.

decommissioning

The process of shutting down a building and removing it safely from operational use.

It's really important that owners think through their overall project and business goals before taking on a construction project—and not just their short-term goals but also their long-term goals. What some owners don't realize is just how much assistance and value that a contractor can bring to a project at the early planning stages because of their knowledge and expertise associated with building systems, construction materials and methods, and construction costs. That's why pre-construction services have become stand-alone, fee-generating departments within so many construction companies and not just ancillary components of the construction process.

Terms to Know

capital expenditure	capital project
cost model	decommissioning
due diligence	feasibility study
life-cycle cost	pre-construction services
return on investment	

Review Questions

1. When does the pre-construction phase take place?
2. What are three ways owners can benefit from alternative project delivery methods?
3. Define pre-construction services.
4. List the five most common pre-construction services.
5. How do feasibility studies benefit the owner?
6. Who should perform the constructability review?
7. What are two benefits of using conceptual estimating?
8. How are cost models developed?
9. How can value be added to a project in terms of benefits and cost?
10. Define life-cycle cost.

Chapter 8

Estimating Project Costs

In This Chapter

- ◆ How estimates are used in construction
- ◆ What factors influence costs
- ◆ What components make up an estimate
- ◆ How costs are estimated
- ◆ Estimating techniques
- ◆ What constitutes a quality estimate

There are always two questions asked by a client considering an investment in construction: “How much?” and “How long?” Estimating responds to the first question. Very few projects can go forward before the cost of the construction has been determined.

Estimating is a distinct function in the construction management field, and unlike some other jobs in construction, the estimator's role is pretty specific. The estimator's primary focus is costs. They have the awesome responsibility of accurately determining the price of the project while maintaining a competitive edge in the marketplace. Projects are won or lost by the efforts of the estimator. However, no matter what your job or position is in the construction company, you need to understand the estimating process as well.

After reading this chapter, either you will decide that this is one position that you will avoid at all cost (no pun intended) or you will be drawn to it like a magnet. That is the response in the industry as well. Either way, you will understand the process and discover just how important estimating is to construction management.

Estimating project costs requires a methodical approach yet at the same time demands a certain finesse. This chapter introduces you to both aspects and walks you through the steps necessary to build a construction estimate from the ground up.

What Is an Estimate?

An estimate is an educated guess. We are all familiar with estimates. We have obtained estimates for work on our car, for getting our house painted, or for closing costs on a mortgage. And most of us have actually engaged in doing an estimate. We've guessed or estimated how many jelly beans were in a jar at the local county fair or calculated how many gallons of paint we needed to paint the living room. The main differences between these simple estimating activities and the estimates used to price construction are the complexity and what's at stake. When you estimate how many gallons of paint are needed to paint your living room and you are off by a gallon or two, the stakes are pretty small. But when you estimate the cost to build a nuclear plant or a superhighway or a hospital or even a house, the stakes are much, much higher.

The estimate is a summary, based on the best information available, of probable quantities and costs of materials, labor, equipment, and subcontracts to complete a project, including taxes, overhead, and profit. It is the number used to develop the project bid price. The bid price is what goes in the contract, and the contract obligates you to perform all work needed to complete the project in accordance with the plans and specifications.

The consequences of any errors or omissions in the estimate are borne by the contractor, and the contractor will not actually know what the true cost of the construction is until the project is complete. If the estimated cost is equal to or greater than the actual cost, the project makes money for the contractor. If the estimated cost is less than the actual cost, the contractor loses money on the project.

As you can see, estimators have an awesome responsibility. First, they must come up with an accurate but competitive estimate that will win the job. Second, their planning and calculations set the stage for the overall management targets for the entire project. Once the estimator turns the project over to the project manager and the on-site team, the estimator shifts to a support role and really has no direct management duties associated with the day-to-day operations.

Every time contractors estimate a job and submit a bid, they are taking a risk. It is a high-stakes gamble, and many factors may influence the outcome. The construction management team is on the front lines of managing this risk to a successful outcome.

NOTE

When a job goes bust for the contractor with significant cost overruns, there is often an internal argument regarding who is to blame. The project manager may point to a bad estimate as the source of the failure. But the estimator may turn around and accuse the on-site team of poor management resulting in the overruns. This finger-pointing is usually a futile effort; the time would be better spent looking at specific areas of overrun and analyzing them, line item by line item, to see what mistakes should be avoided on the next project or estimate.

Every person in construction management must be familiar with the estimating process, but not everyone in construction is suited to be an estimator. It takes special skills and aptitude to be successful at this very important role in construction management. Let's consider exactly what it takes to be good at this job.



Real World Scenario

A Simple Estimate: How Many Gallons of Paint?

You have decided to repaint your living room. You want to go buy the paint, but you must first figure out how much you need. What types of information will be required to make this determination? Based on that information, how many gallons will you need, and how much will it cost?

Basic Information

A gallon of paint covers 350 square feet. Each gallon of paint costs \$27. The room is $16' \times 14'$ with an 8' ceiling, one door ($3' \times 7'$), and three windows (each $3' \times 4'$).

Specification

Paint all walls and ceiling with two coats of paint, one color only. Do not paint door, windows, or trim.

Process

Ceiling area = $16' \times 14' = 224$ square feet

Wall area = $[16' + 14' + 16' + 14']8' = 480$ square feet

Deduct openings: Door = $3' \times 7' = 21$ square feet and $[3]3' \times 4' = 36$ square feet

Total square feet: $224 + 480 - [21 + 36] = 647$ square feet

Total gallons of paint:

647 square feet $\times$ 2 coats of paint = 1,294 square feet

$1,294$ square feet $\div$ 350 square feet per gallon = 3.70 gallons

You must purchase 4 gallons $\times$ \$27 = \$108 plus tax.

Note: Labor, preparation materials, and equipment are not included (ladders, brushes, rollers, masking tape, drop cloths, cleanup).

The Characteristics of a Good Estimator

I started my career as an estimator, and I think that it is one of the best ways to really learn the business. As an estimator, you have to learn to “build” the project mentally before you can price it. You must decide upon the construction approach and make decisions all along the way as to how the facility will be built. As an estimator, you develop a tremendous understanding and knowledge of construction products, productivity, and process. In my opinion, no one knows the project as well as the estimator. I used to walk onto the site and be able to tell in an instant if something was off in the layout or missing altogether. After all, I had already built the project in my mind and was aware of every detail associated with the construction.

People in the business either love estimating or hate it. I love estimating. Once you are an estimator, it sort of gets in your blood, and you end up having the capacity to estimate anything. You begin to think in terms of chunks of time and cost. You walk into a room and can immediately estimate the size of it without any measuring device because of what you know about products and dimensions. The acoustic tiles, the floor tiles, the wall panels, the doors, the windows—all of these items provide hints for you to use to ascertain dimensions without having a measuring tape.

The estimator is probably one of the most important people in construction management. Without the estimator, the rest of the team wouldn't have much to do because they wouldn't have any jobs. The following specific skills and characteristics are common among estimators:

- ◆ Reads contract documents well
- ◆ Is knowledgeable about construction techniques
- ◆ Is familiar with typical job conditions
- ◆ Is familiar with construction products
- ◆ Has good visualization skills
- ◆ Follows instructions explicitly
- ◆ Is creative, yet practical
- ◆ Is detail-oriented and thorough
- ◆ Can meet deadlines and work under pressure
- ◆ Is familiar with purchasing
- ◆ Is familiar with computer applications
- ◆ Works well with numbers and statistics
- ◆ Is a perfectionist at the task level
- ◆ Has very good organization skills

Keep in mind that there is as much art as science to estimating, and therefore the need for seemingly dichotomous traits is essential. Throughout the estimating

process, estimators must make judgment calls regarding techniques, pricing, and people, and they often put their reputations on the line. They are risk takers—calculated risk takers but risk takers, nonetheless. For this reason, senior or chief estimators are among the most respected and highest paid individuals in the industry.

Factors Impacting Project Cost

All projects are not the same. Even if you are in the business of building the same facility (such as a Walmart store) over and over, the price of each project will differ. Many specific factors will always influence the pricing of the project, and the estimator must be able to discern the level of impact for each. Many of these factors call for the art of estimating, and the more experienced the estimator, the more accurate the “gut feel” for some of these impacts will be. Let's consider several of these factors and see just how they might influence the pricing of the project.

Project Size

Obviously, the larger the project, the more it is going to cost, simply because of the square footage involved. But the concept of “economy of scale” often comes into play with construction projects. The larger the project, the more opportunity there is to increase efficiencies around any particular activity. For example, if the cost to mobilize a project (bring in equipment, set it up, and prepare the area) for a particular trade such as masonry is \$5,000, then it would be more economical to set up to construct a 20,000-square-foot building than it would be for a 4,000-square-foot building because the mobilization will cost the same either way. Economy of scale also applies to labor. If there is 900 square feet of floor tiles to lay, the first 100 square feet of the installation is going to cost more per unit than the last 100 square feet of the same operation or activity simply because repetition breeds efficiency and speed. So, size often impacts the estimated cost of a project.

NOTE

There is always more to any operation or installation than the work activity itself. There are always preparation, mobilization, and setup and always knockdown, cleanup, and demobilization. That's why a painter will quote you a higher price to paint the interior of your house if you want different colors in every room rather than one color for all walls. It may be exactly the same square footage, but every time you have to open up, close up, and clean up a new color, it takes time. You have to clean out the paint tray or paint sprayer and clean or replace brushes and rollers every time you start with a new color.

Complexity of the Project

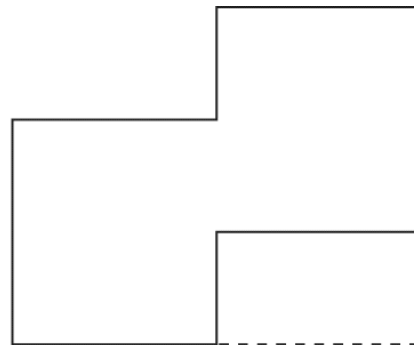
The complexity of the project and project details impacts productivity. So even if you are pricing a relatively simple material application such as a brick veneer or stucco finish, once the shape becomes anything but a box or the height goes beyond 8 feet, for example, it will be more difficult to build. It will take greater skill and/or more time. Let me share with you some of the fundamental elements that estimators consider when pricing a project:

Shape of the facility The rule of thumb that I used to share with my clients was that every time you turn a corner, it is going to cost you more money. The facility can be exactly the same square footage, but if the shape moves from a square or rectangle and the number of corners increases, the price is going to go up. Shape impacts the price of all elements of the building: the ceiling, the roof, the doors, the windows, the staircases, and so on. A flat ceiling is easier to construct than a vaulted ceiling. A gable roof is easier to build than a hip roof. A rectangular window costs less than a circlehead window. A rectangular door costs less than an archtop door. And a straight stair costs a lot less than a winding stair. Shape clearly impacts cost.

Same size – Different shape



2000 SF — 4 corners. This facility will cost less to build.



2000 SF — 8 corners. This facility will cost more to build.

Height of the facility Anything a worker cannot reach by standing on the ground will increase the cost of construction. Whenever you have to employ ladders, scaffolding, manlifts, and cranes, the price goes up. It takes additional time to set up, take down, and move this equipment around, and it also takes time to move manpower and materials up and down the equipment. The expected productivity by a craftsperson working on scaffolding is always less than the expected productivity of the same craftsperson standing on the ground. For example, two carpenters experienced in drywall installation should place about 1,700 square feet of wallboard in an eight-hour day. For walls and ceilings higher than 12 feet, the same crew would be able to place only 1,445 to 1,530 square feet of wallboard in a day. That's a decrease of 10 to 15 percent. Height makes a difference regardless of the building element.

lead time

The amount of time it takes for a product or equipment to be delivered to the job site. Products that have a long delivery time are called *long lead-time items* and require special planning considerations.

Unique materials or applications Most of us have tastes beyond our budgets. This is a common phenomenon in design and construction as well. The use of unique materials or unique applications of materials always adds to the

construction costs. Knowing this will give the estimator a heads-up when first reviewing the plans and specs. The estimator can also count on the fact that a unique material is almost always going to require a longer *lead time* for delivery. If that delayed delivery is not anticipated by the management team in scheduling the work, this misstep can cause a delayed completion of the project overall and be very costly. Even a unique application of a common material will require special skill and take longer to install and therefore cost more money. Common ceramic tiles applied in a special geometric or artistic pattern, for instance, will always cost more to install than the same tiles installed in a standard pattern.

liquidated damages

A daily amount of money paid by the contractor to the owner for each day that the project fails to meet the completion date specified in the contract. Not all contracts contain a liquidated damages clause.



Real World Scenario

Red Flagging Long Lead Time Items

There was a project where the architect had specified a special Italian marble tile for the lobby of a high-rise office building. Unfortunately, the estimator on the job was somewhat inexperienced and did not red flag the material for early purchase and instead waited to order the tile with all of the common or stock tiles being utilized. It turned out that the lead time on the special marble tile was six months. There were only 90 days left in the contract for completion. The contractor made an attempt to talk the owner into a marble tile that was readily obtainable. The owner would not budge. To avoid a delayed opening of the project and having to pay *liquidated damages*, the contractor ended up installing a stock marble tile in the lobby temporarily so the facility could open on time. When the specified Italian tile finally arrived (approximately three months later), the contractor had to remove the stock tile and install the correct tile, all done during evening hours, resulting in overtime pay for the tile setters. The entire cost of installing the first tile and removing it was chalked up as a loss. (You will learn much more about liquidated damages in [Chapter 9](#), “Contract Administration.”)

This scenario illustrates the importance of the handoff of the project from the estimator to the project manager. Although the estimator picked up the added cost for the Italian tile in the estimate, he did not red flag the material when he passed the project on to the project manager. The team did not pick it up, and the mistake was very costly—not just in dollars but also in the loss of goodwill because of the irritation and disappointment experienced by the owner.

The Site Location

The location of the project impacts the ease of procurement and delivery of materials, labor, and equipment, and therefore it affects the overall pricing of the project. Certain locations are simply more accessible than others for different reasons. For example, it is very difficult and very costly to get materials and equipment into a remote location such as the Alaskan pipeline. But at the same time, the logistics associated with getting materials delivered to a busy downtown metropolitan area such as San Francisco or New York can be just as difficult. Either way, the site location becomes a primary factor in preparing the estimate.

Location also impacts the availability and cost of labor. For example, when trying to construct a new facility in a small community, the contractor may run up against a shortage of skilled labor to perform the work. In a case like this, the contractor would have to import the needed labor from outside locations. When this occurs, the contractor usually has to provide housing and meals for the workers, adding to the costs of the overall project. If the estimator does not anticipate this added expense up front, there will be labor cost overruns. On the other hand, another location may have an abundance of skilled labor, and the estimator can anticipate fairly competitive pricing in the area and estimate the job accordingly.

Pricing can also vary from city to city, even in the same state. For example, in California, the cost of installing 400 square feet of standard acoustic ceiling in Bakersfield, CA, is less than the price of the same work in San Francisco. According to R.S. Means (2019), which is probably the largest publisher of construction cost information in the United States, the cost in Bakersfield would be approximately \$6,000. But in San Francisco, the same ceiling would cost about \$7,200. That's 20 percent more. At the same time, according to Means, it would cost only \$3,600 to install 400 square feet of standard acoustic ceiling in Huntsville, AL. So, you can see how important it is for the estimator to know about local costs in the area where the company will be building.

NOTE

In addition to providing location cost factors, R.S. Means publishes numerous annual construction cost guides and construction reference books. They are a great resource to novice and experienced estimators alike. You can access R.S. Means online at www.rsmeans.com.

Time of Construction

Time is one of the factors that every estimator must be very aware of when putting together the numbers for the project. There is always a time period between when a project bids and when the construction actually starts. There is also the time between when a project starts and when it is anticipated to end—sometimes several years. The estimator must be careful to anticipate fluctuations in prices and availability of labor during these stretches of time.

Time of year is another time factor that often comes into play when estimating project costs. Construction is often thought of as seasonal. However, the truth is that construction can take place any time of year, but certain considerations must be factored into the pricing. For example, if a contractor anticipates receiving the notice to proceed in mid-December, the estimator would factor certain cold weather preparations for the concrete work into the price. In addition to forming, placing, and finishing costs, the estimator would also have to consider the cost of heaters, special concrete blankets, and insulating materials to keep the concrete from freezing after it is placed. If the concrete pour were happening in July, none of these items would be included in the price.

Other time factors may not seem so obvious but must also be taken into consideration by the savvy estimator. For example, I was in the construction business in a part of the country where deer hunting was a very popular sport and most of the subcontractors in the area were avid hunters. I know it may seem very strange, but I would have to take “deer season” into account whenever estimating a project. It would take longer to complete the work during this time of year simply because many of the trades would not be as readily available, and this would definitely impact my price.

Not only that, think of the challenge I faced trying to explain deer season delays to clients itching to move into their new home.

Quality of the Work

The quality of the project is defined by the standards set forth in the specifications. Quality clearly impacts project cost. The specifications stipulate what materials to use and equipment to install. There are grades of performance, durability, and aesthetics associated with every construction product. A project that specifies minimum standards for the products and equipment to be installed will cost less than a project that includes several high-end materials and installations. Obviously, marble or granite tiles are going to cost more than ceramic tiles. Stainless-steel toilet partitions are going to cost more than painted metal partitions. Although both of them serve the same purpose, the degree of performance, durability, or appearance varies—the higher the quality standard, the higher the cost. An experienced estimator gets a good idea of just how much impact quality will have on the overall cost of the project after just a quick review of the plans and specs.

Market Conditions

Market conditions always have an impact on the estimate. The basic laws of supply and demand go to work here. In very tight markets where construction contracts are scarce, the cost of construction becomes very competitive, and the estimates will reflect this condition. In an effort to keep good employees working, some contractors are even willing to take a job at cost with little or no profit on the project. However, when there is a lot of construction work going on, the market becomes very selective. General contractors and subcontractors alike become much pickier about which jobs they are willing to go after, and their pricing will reflect a more conservative approach to risk. The estimating team takes all of this into consideration when pricing the project.

Management Factors

Management factors are those considerations that once again have more to do with the art of estimating than the science of estimating. Management factors include such things as knowing that a particular owner or architect is more difficult to deal with than another, sensing that you are going to have to watch things more carefully with an inexperienced subcontractor, or knowing that the owner is very slow at making decisions.

Some management factors are much more predictable, such as dealing with a public project versus a private project. With a military project, for example, the paperwork and reporting required for standard contract administration tasks such as a submittal or an application for payment are at least twofold. All of that extra work takes extra time, and extra time means extra cost. Once again, an experienced estimator takes all of these factors into account before submitting a bid.

Types of Estimates

The amount of information available regarding the project will dictate the type of estimate that can be prepared. However, you must keep in mind that all estimates are not equal—the less information available, the less accurate the estimate. But sometimes owners don't need a high level of accuracy. They simply need a rough idea about their building cost. At other times—for example, when preparing a competitive bid or approaching a financial institution for a mortgage—accuracy is of vital importance. Let's take a quick look at the various types of estimates.

Conceptual Estimates

Conceptual estimates are often called *ballpark estimates*. Typically there are no drawings available at all. You can use conceptual estimates when you are in the idea or concept stage of a project. Often an owner doesn't really know whether their idea is economically feasible, and they don't want to start spending money on design until they know that the project is at least possible. An experienced estimator can help out in a situation like this by offering a rough order of magnitude (ROM) estimate. These estimates are based upon a cost per primary unit for the facility. For example, for hospitals, the primary unit of measure would be beds, and you would multiply the proposed number of beds by the appropriate unit cost. For a school, the calculation would be cost per pupil; for a highway, the estimate would be based on a cost per mile. Once the owner suggests how many primary units they would like to build, an estimator can whip out a rough order of magnitude estimate within minutes; however, the accuracy is limited.

Preliminary Estimates

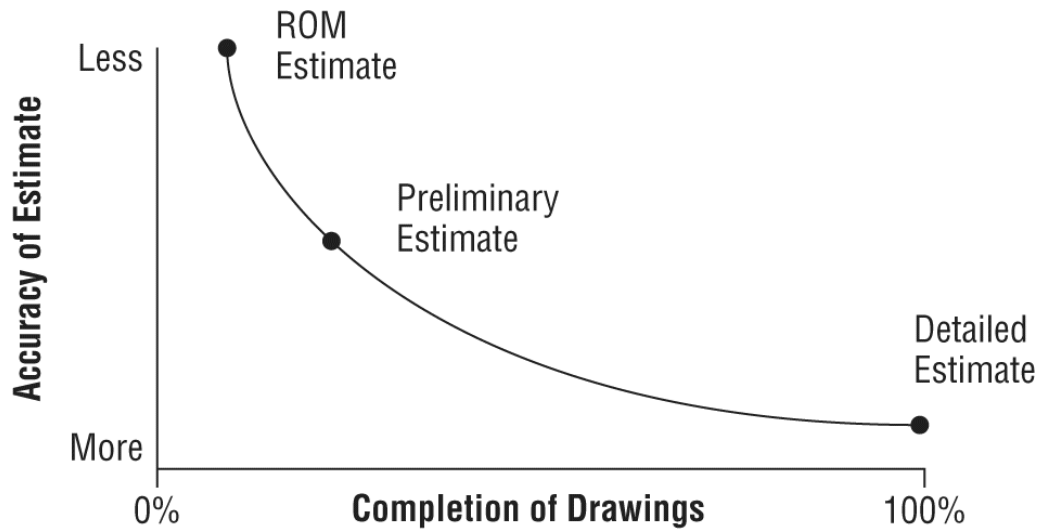
If you have a preliminary set of drawings with overall dimensions, you can move to the next level of estimating. Preliminary estimates provide a somewhat higher level of accuracy and may be used to establish initial budgets and preliminary financing scenarios. However, these estimates should never be used to commit to a contract price because too many factors can influence the reliability of the numbers.

Although there are numerous preliminary estimate methodologies, the most common is probably the square foot method. In its simplest form, the estimator calculates the area of the floor plan and multiplies that number by a unit price. There are various levels of skill and detail that can be applied to the square foot estimating method, and the degree of accuracy increases with each step up, as will the time it takes to calculate the price.

Detailed Estimates

Whenever you have a complete set of plans and specs, you should do a detailed estimate. This is where you count every brick and stick, so to speak. Quantities and costs are calculated for every aspect of the project, and this is by far the most reliable estimate if the contractor is being asked to give a firm bid on a project. Detailed estimates are the most accurate. But keep in mind that as the accuracy increases, so does the time, effort, and skill required to complete the estimate. Although

computerized estimating has reduced the time needed to compile project costs, it can still take two to three weeks and a team of estimators to put together a detailed estimate for a large, multistory commercial building such as an office or retail complex. The estimators still have to put the bid packages together and spend time soliciting subcontractor and vendor pricing. Throughout the rest of this chapter, I will be talking about detailed estimates.



Understanding Project Costs

Before I can really get into the estimating process, it's important to distinguish the types of costs that are included in the construction estimate. It takes a lot more than just materials and labor to build a project. A whole host of costs are associated with construction that have nothing to do with the actual structure of the facility. For example, building permits, supervision, job trailers, portable toilets, scaffolding, freight charges, bonds, insurance, sales tax, and many other costs could be easily overlooked by an inexperienced estimator. If the estimator fails to recognize and include all costs in the project estimate, then the bid number will be off significantly. In making such a mistake, the estimator may indeed win the job by being the lowest bidder but unfortunately will end up losing money on the project. These are hard lessons to learn, but, as costly as they are, you rarely ever make the same mistake twice.

Direct Costs

Direct costs are those items that actually go into building the facility. An item is considered a direct cost if it can be linked to a specific item of work on a project. Direct costs make up the bulk of any construction estimate. These are the obvious direct costs associated with any project:

- ◆ Materials
- ◆ Labor
- ◆ Equipment
- ◆ Subcontracts

Indirect Costs

Indirect costs are the expenses incurred in order to manage and deliver the materials, labor, equipment, and subcontracts employed on any given job. They are often referred to as *job-specific overhead* or *general conditions*. The list of indirect costs for any given project will vary, but some of the common items include the following:

- ◆ Supervision
- ◆ Job trailer expense
- ◆ Temporary utilities
- ◆ Testing and inspections
- ◆ Job photographs
- ◆ Safety supplies
- ◆ Chemical toilets
- ◆ Security fencing and barricades

- ◆ Trash and debris removal
- ◆ Cleanup
- ◆ Bonds and insurance

NOTE

Contractors are starting to direct their trash and debris to recycling centers rather than to the landfills. This operation takes a little more effort on the contractor's part and can actually be more expensive, but as the industry is slowly becoming more sensitive to environmental issues, recycling operations are showing up more and more in construction estimates.

The Estimating Process

Accuracy and completeness are the fundamental objectives of the construction estimate. The ultimate goal is to have the estimated cost be greater than or equal to the actual cost of the project. When you do a construction estimate, you are concerned with three things:

- ◆ How many (quantities)
- ◆ How much (pricing)
- ◆ How long (productivity)

These three components make up the construction estimate and establish the management targets for the project team. You will discover that the estimate sets the parameters for the project budget and schedule and will be used throughout the construction process to monitor success. Now let's look at what it actually takes to put an estimate together.

Getting Started

Although an estimator can work alone in developing an estimate, the quality of an estimate improves when there is input from other members of the team. Fellow estimators, project managers, superintendents, subcontractors, material suppliers, and others can all add to the resource base when trying to make decisions during the estimating phase. The team works together to develop a unique strategy that might provide an edge in the bidding process. In preparation for the estimating task, the team becomes completely familiar with the requirements of the project by doing the following:

- ◆ Thoroughly reviewing the plans and specs
- ◆ Developing a list of questions and needed clarifications
- ◆ Attending the prebid meeting
- ◆ Visiting the project site

Reviewing the Plans and Specs

It is important to get a “big picture” perspective of the project before you get into the details of the work. Having an overall understanding of the difficulty of the construction will assist the estimator when making judgment calls that inevitably affect the accuracy of the estimate.

Ideally, the plans and specs are reviewed in detail before any estimating takes place. Among the first things to look for when making the initial review are any special conditions, clauses, or criteria that could adversely affect the project schedule or cause unusual risks to be taken. Such items should be highlighted during this process and red flagged for the project team when the job is passed from the estimator to the project manager. (Remember the earlier example regarding the imported Italian marble tile.) Many of these red flag clauses are found at the front

end of the project manual in the instructions to bidders and supplemental conditions.

NOTE

One of the most costly red flag clauses commonly found in the project manual is a liquidated damages clause. Liquidated damages are a financial penalty applied to the contract resulting from a failure to meet a specific completion date for the project. For example, the supplemental conditions could stipulate that a penalty of \$1,000 to \$10,000 a day be paid by the contractor to the owner for failing to meet a completion deadline. Liquidated damages pose a significant risk to the contractor and must be taken into account during the estimating process.

query list

A list of questions and needed clarifications compiled by an estimator as they review the plans and specs during the estimating process.

In addition to discovering red flag issues, the plan and spec review provides an opportunity for the estimator to uncover details that require clarification or questions about the project that are not addressed in the contract documents. As the estimator thumbs through the drawings, they will prepare a *query list* in anticipation of the prebid meeting, site visit, or phone conference with the designer. The designer typically responds to each of the questions in writing. Those responses that result in a change to the original plans and specifications become official addendum to the contract.

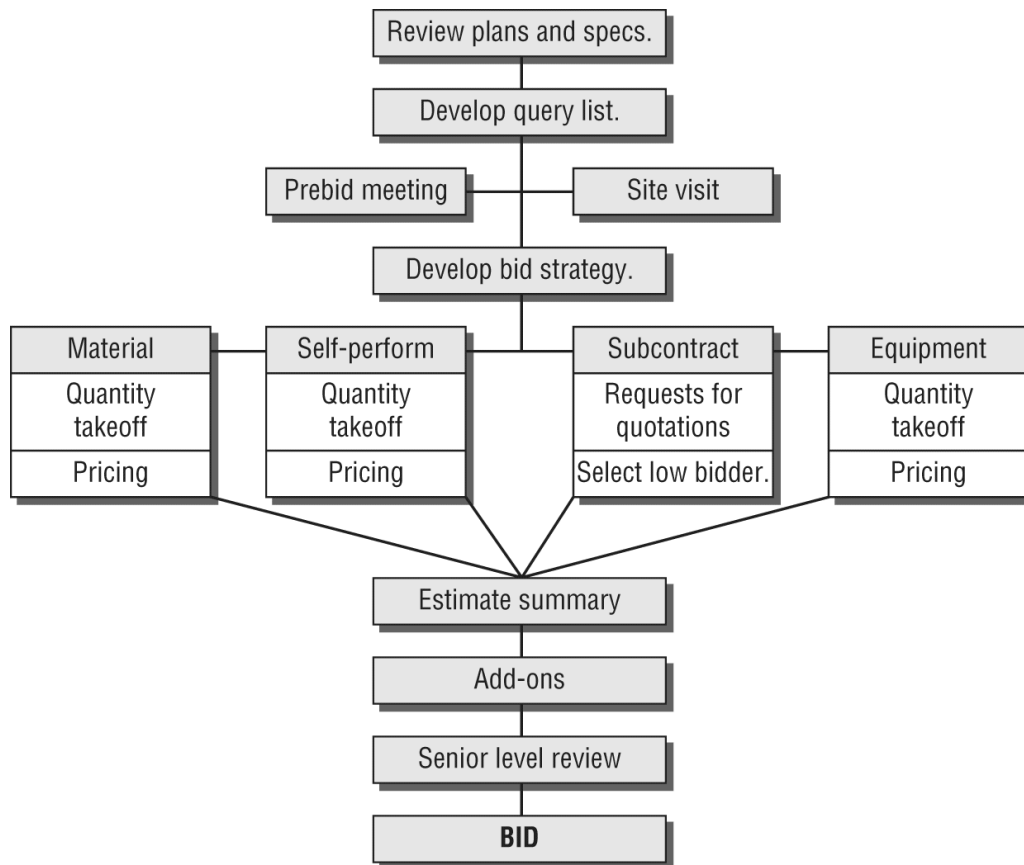
Checklists are a common tool used to make sure that nothing gets left out or overlooked.

The Prebid Meeting

Prior to bidding, it is common for the owner and/or designer to conduct a prebid meeting. This meeting often occurs at the project site and provides an opportunity for the bidding contractors to get many of their questions answered. It is very important that each of the bidding contractors sends a representative to this meeting. The estimator is often the representative sent, simply because that is the person who is the one most familiar with the project at this stage and who has developed a query list after a thorough review of the plans and specs. Some projects require attendance at this meeting, and contractors who fail to attend are not allowed to bid.

The Site Visit

No one should ever estimate a job without first visiting the job site. There are site conditions that just cannot be understood by merely looking at the plans and specs. Only by walking around will you get a good sense of the lay of the land, which will help you make the necessary judgment calls that ultimately affect your pricing. Even if the site visit is not part of the prebid meeting, it is your obligation to make every effort to mitigate risks associated with the bid. Visiting the site is one way in which you can mitigate those risks.



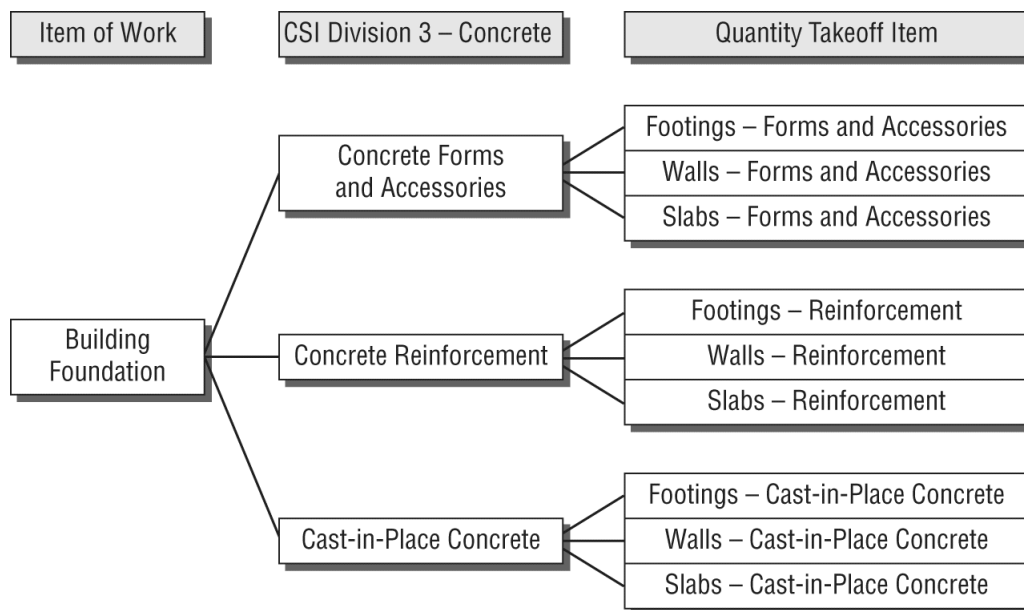
Estimators should consider the following when visiting the site:

- ◆ Distance from office
- ◆ Site conditions
- ◆ Site access
- ◆ Soil data
- ◆ Groundwater
- ◆ Security needs
- ◆ Traffic considerations
- ◆ Adjacent structures
- ◆ Possible contamination

- ◆ Water, electricity, and telephone service
- ◆ Obstructions
- ◆ Parking and storage
- ◆ Debris disposal
- ◆ Local weather patterns
- ◆ Local labor and subtrades
- ◆ Local regulations

How You Build the Estimate

You build an estimate in very much the same order that you build the actual facility. Generally, you start from the ground up and work through the 50 divisions of the CSI MasterFormat outline. (Refer to [Chapter 4](#), “The Construction Contract,” for information about these divisions.) Each CSI division is broken down into detailed items of work. This format is one of the most common ways to organize the estimate. However you decide to organize the estimate, it is very important to stick with a consistent format, even if some divisions are not applicable to every project. In this way, the estimate outline acts as a master checklist that should be consulted for every project to make sure that nothing gets left out of the estimate.



Organizing the Work of the Estimate

Estimating the cost of a multistory office building, high-tech manufacturing facility, or state-of-the-art concert hall is no easy task. It is a big job and takes a great deal of planning and organization. So, how do you conquer this challenge? Well, the same way you eat an elephant—one bite at a time! Although the CSI MasterFormat gives us an overall outline to follow, thousands of activities and materials must be considered before you can begin to price the project. As large as the task may seem,

there actually is a logical method for organizing all of the work activities, materials, and labor associated with a project. Let's take a look at just how you eat this elephant!

The Work Breakdown Structure

The primary organizational tool utilized by the construction estimator is the *work breakdown structure (WBS)*. The work breakdown structure establishes the basic building blocks of both the estimate and the schedule. (I will explain how it is applied to the schedule in [Chapter 11](#), “Project Planning and Scheduling.”)

work breakdown structure (WBS)

A tool used by estimators to organize the work of a contract in a hierarchical fashion.

work package

Detailed items of work bundled together under a particular trade. This is also called a bid package.

The purpose of the work breakdown structure as it applies to the estimate is to organize and identify the work of the project by breaking each division of work into a separate *work package* or bid package. The work package identifies each step in the process of that work item. Work packages are usually assembled around the work activities typically performed by a single subcontractor or work group. Obviously, being familiar with construction materials and methods is pretty important here. One of the primary goals in creating a work package is to not overlook any of the steps needed to complete the work.

A sample work package looks something like this:

Work Package—Concrete Floor Slab

- ◆ Excavate the footings
- ◆ Install the edge forms
- ◆ Install under slab fill
- ◆ Install vapor barrier
- ◆ Install the reinforcing
- ◆ Place anchor bolts
- ◆ Place the concrete
- ◆ Finish the concrete
- ◆ Strip the formwork

Once each step associated with a particular item of work is identified, it can be quantified and priced. But let me stop here and back up a minute to make sure that you remember how the work of the project is actually accomplished. The contractor has two options: to self-perform the work with their own forces or to subcontract the work to various trade contractors. The contractor will have to do all of the quantifying and pricing of each step of the work if the contractor decides to self-perform a particular section of work. If the contractor decides to subcontract out some of the work, then the subcontractor will quantify and price the work and submit a bid to the general contractor. The greatest challenge either way is to make sure that nothing gets overlooked or left out of the estimate.

NOTE

Sometimes the general contractor calculates their own quantities and estimates for subcontracted work even though the subcontractor will be submitting a bid. This is called a *fair value estimate*; it's done as a check to guard against inaccurate quantity surveying by the subcontractor and unreasonable pricing.

Calculating Quantities

Now that you have assembled all of your work packages and identified all of the steps necessary to do the work, you can start doing your quantity *takeoff*. You must quantify all of your materials, labor, and general conditions before you can price any of the work. You need to calculate “how many” before you can calculate “how much.” Once you determine the quantities, you can apply a unit price factor to the equation. Junior estimators often start off as *quantity surveyors*. The primary attributes of a good quantity surveyor are the ability to read and interpret plans, knowledge of common units of measure for construction materials and labor, and basic estimating mathematics.

takeoff

A term commonly used in the construction industry to describe the process of measuring the plans to quantify materials, labor, and equipment.

quantity surveyors

Individuals who are responsible for counting up and calculating all of the quantities of materials, labor, and equipment necessary to build a construction project.

You will use algebra to measure ratio and proportion, plane geometry for lineal and area measurements, solid geometry for cubic measurements, and plane trigonometry for lineal, area, and cubic measurements. The following table shows some of the mathematical functions and their applications:

Mathematical Function	Measurement	Sample Estimating Application	Unit of Measure
Basic math	Counting	To calculate the quantity of interior doors	Each
Algebra	Perimeter	To calculate the quantity of rebar in the footing	Lineal feet
Plane geometry	Area	To calculate the quantity of stucco siding	Square feet
Plane geometry	Area	To calculate the quantity of carpet	Square yard
Solid geometry	Volume	To calculate the quantity of concrete in the footing	Cubic yard

There are also a number of common estimating formulas that can be found in any estimating manual or textbook. Here are a couple of samples:

Work Item	Common Formula	Sample Calculation
Standard brick	6.67 bricks per square foot of wall area with 5% waste	$1,260 \text{ square feet} \times 6.67 = 8,404 \text{ bricks}$ $8,404 \text{ bricks} + 5\% \text{ waste} = 8,824 \text{ bricks}$
Mortar for 3/8" joints	7.2 cubic feet per 100 square feet of wall area with 40% waste	$1,260 \text{ square feet} \div 100 = 12.6 \text{ square feet}$ $12.6 \times 7.2 \text{ cubic feet} = 90.72 \text{ cubic feet}$ $90.72 + 40\% \text{ waste} = 127 \text{ cubic feet mortar}$

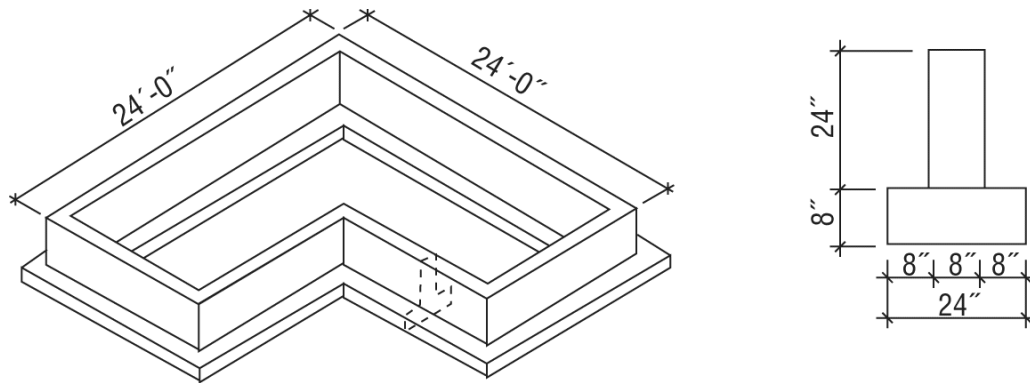
There is an increasing trend to use a digitizer when performing quantity takeoffs. You'll learn about these time-saving devices in more detail later in this chapter.

Quantifying Materials

Quantifying materials is the least risky of all the estimating activities. You are simply counting and calculating all of the parts and pieces that will go into the project. Quantity surveying represents more of the science of estimating. That's because you are working with known sizes and dimensions depicted in the drawings. If the plans are drawn correctly and include all of the information needed to do the takeoff, the estimator should be able to come up with very accurate quantities, assuming the estimator doesn't overlook anything and doesn't make mathematical errors. The estimator reviews the plans, the elevations, the sections, and the details; pulls the dimensions needed to make the appropriate calculations; and comes up with the lengths, areas, and volumes of work and material required for the project.

Probably the most difficult part of the quantity survey is making sure that the quantity is taken off in the proper unit of measure. The unit of measure for takeoff must be the same as the unit of measure for pricing. For example, concrete is priced by the cubic yard. The quantity surveyor must takeoff all concrete by the cubic foot (length $\times$ width $\times$ depth) and then convert to cubic yards to match the pricing unit. It takes a little time to learn all of the pricing units for the various materials and labor, but this knowledge is an absolute necessity if you are an estimator.

In this typical quantity surveying exercise, you will estimate the cubic yards of concrete needed for this foundation. All inches are converted to decimals of a foot. Here are the steps:



◆ Section area of foundation:

$$\text{Footing} = 2.0 \text{ feet} \times .66 \text{ feet} = 1.32 \text{ square feet}$$

$$\text{Wall} = .66 \text{ feet} \times 2.0 \text{ feet} = 1.32 \text{ square feet}$$

$$\text{Total section area} = 1.32 \text{ square feet} + 1.32 \text{ square feet} = 2.64 \text{ square feet}$$

◆ Perimeter of building:

$$24.0 \text{ feet} + 24.0 \text{ feet} + 24.0 \text{ feet} + 24.0 \text{ feet} = 96 \text{ feet}$$

◆ Section area $\times$ perimeter = cubic feet

$$2.64 \text{ square feet} \times 96 \text{ feet} = 253.44 \text{ cubic feet}$$

◆ Convert to cubic yards (unit of measure for concrete):

$$253.44 \text{ cubic feet} \div 27 \text{ cubic feet} = 9.39 \text{ cubic yards}$$

The answer is 9.39 cubic yards of concrete in foundation.

Quantifying Labor and Equipment

Quantifying labor and equipment is a little riskier. That's because you must deal with crew sizes and productivity rates. In other words, working with the human factors of construction is not quite the same as working with hard and fast dimensions on a set of drawings. Productivity is the amount of work that can be placed or installed in a specified unit of time. Productivity varies because of site conditions, weather, crew makeup, crew skill level, complexity of the project, and several other factors discussed earlier in the chapter.

This is where estimating moves way over on the art side of the equation. It's all about judgment. The individual estimator will determine the productivity for any given crew regarding any given item of work. Fortunately, productivity is something that is studied quite extensively in the construction industry, and there are databases and references available that can help the estimator make sensible judgments regarding labor and equipment quantity takeoffs. In the following, I show some average crew sizes and productivity rates for concrete work:

Item of Work	Crew and Equipment	Estimating Unit	Productivity Output
Forming slab	3 carpenters 1 laborer 3 power tools	Lineal foot	600 lineal feet per day 75 lineal feet per hour
Reinforcing slab	2 rodmen	Square feet	2,700 square feet per day 338 square feet per hour
Placing concrete	1 foreman 5 laborers 2 gas engine vibrators 1 concrete pump	Cubic yard	120 cubic yards per day 15 cubic yards per hour
Finishing slab	1 concrete finisher 1 gas finishing machine	Square feet	625 square feet per day 78 square feet per hour

NOTE

I've already referenced R.S. Means as a very valuable resource for construction estimating data. Another excellent source of information, especially regarding productivity, is *Walker's Building Estimator's Reference Book*. This handbook was originally published in 1915 and is updated every two years. If you are serious about construction estimating, *Walker's* is a must-have reference.

Quantifying General Conditions

Also called *job overhead*, general conditions make up the indirect costs associated with any given project. Time, not productivity, is the normal unit of measure for general conditions. Therefore, the primary task of the estimator is to come up with a time estimate for the overall job duration. The estimator must make an educated guess as to how many days, weeks, months, or years the construction will take to complete. Here's a sampling of general condition items and their respective units of measure:

General Condition Item	Common Unit of Measure
Supervision (salary)	Week

General Condition Item	Common Unit of Measure
Job trailer (rent)	Month
Material storage trailers (rent)	Month
Temporary utilities (usage)	Month
Portable toilets (rent)	Month
Dumpsters (rent)	Month
Job photographs	Lump sum
On-site webcam	Lump sum
Job office supplies	Lump sum

Pricing the Work

Once all of your quantities are calculated, you are halfway there. Now all you have to do is plug in the unit cost for each item of material, labor, equipment, and general conditions in your estimate. You can see the price extensions displayed in [Table 8.1](#). As an estimator, your primary concern is where the costs will come from and their reliability.

NOTE

Sometimes it is not possible to accurately determine the costs of items at the time of the estimate because there are decisions regarding quantities and quality that simply can't be made until the project is under construction. When this happens, it is a common practice for estimators to plug in an “allowance” number, fully disclosed to the client, based on a best guess at the time. Once the information needed is available, the allowance is adjusted up or down to reflect the actual cost of the item. If the actual cost is less than the allowance, the estimator returns the surplus funds to the client. If the cost is greater than the allowance, the client pays the difference. Allowances are often used for finish items that require owner involvement regarding style, color, or quality such as carpet, tile, or light fixtures. They may also be used when there are simply too many unknown variables to be able to accurately quantify the cost of the work, such as rock excavation or drilling.

Sources of Information

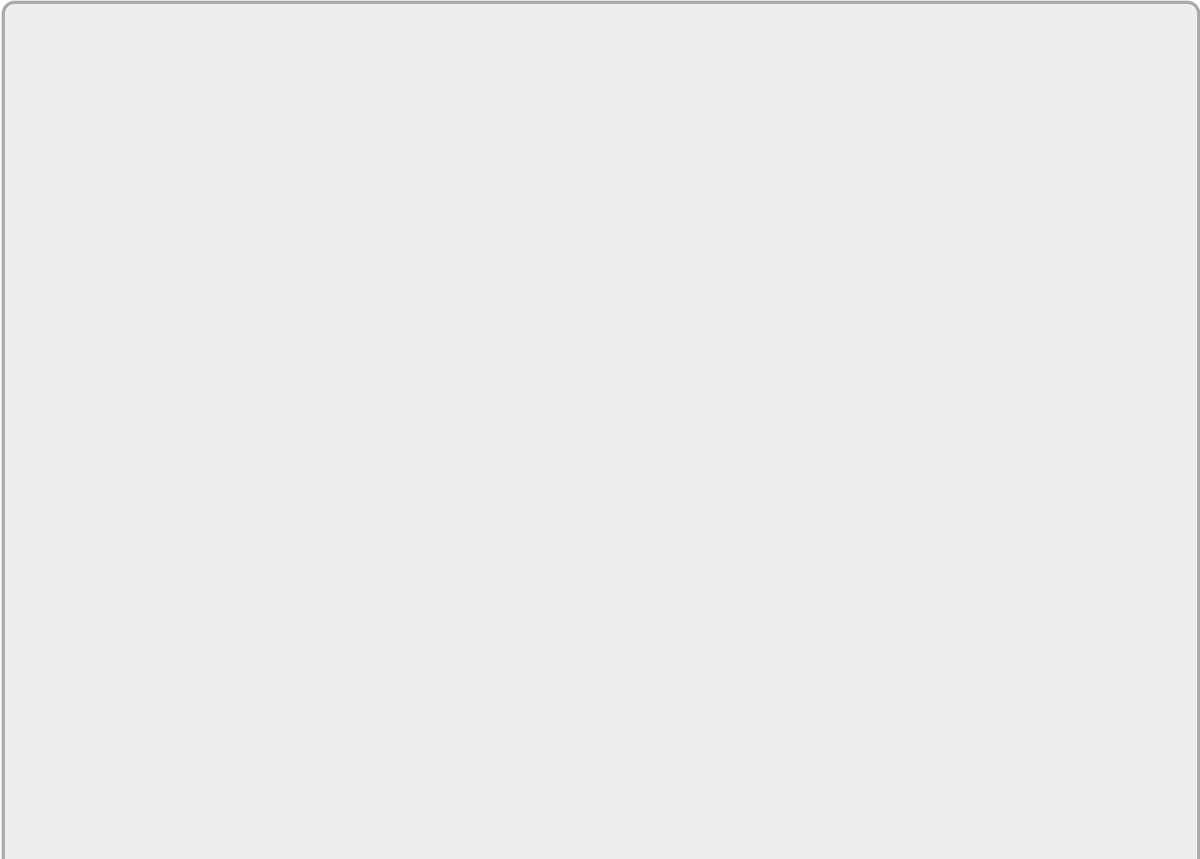
Pricing information comes from a variety of sources. When it comes to materials, you can obviously get prices directly from your vendors and retail building suppliers. Or you can check the various construction cost guides such as R.S. Means. They list unit costs for every section of work for labor, material, and equipment. Many construction companies create their own cost databases based on historical performance. They track actual job costs from various projects over a number of

years and come up with average unit prices for their self-performed work. If a company has an excellent cost reporting system in place, then this may be the best way to go. However, not all companies have such a system in place, and many rely on published cost data for their pricing.

There is one more alternative when it comes to pricing labor. Some estimators choose to use the productivity data from the various guides but then calculate their own unit prices by using local wage rates in the formula. See the sidebar “Calculating Crew Unit Cost” for an example.

Table 8.1 Calculating the Estimate

Description of Work	Quantity	Mat. Unit Price	Total Mat.	Labor Unit Price	Total Labor	Equip. Unit Price	Total Equip.	Total Cost
Form slab	390 LF	\$0.31	\$121	\$1.25	\$488	\$0.05	\$20	\$625
Reinforce slab	9,500 SF	\$0.18	\$1,710	\$0.16	\$1,525	—	—	\$3,235
Place concrete	120 CY	\$63.00	\$7,560	\$11.15	\$1,338	\$5.35	\$642	\$9,540
Finish slab	9,500 SF	—	—	\$0.31	\$2,945	\$0.06	\$570	\$3,515
TOTAL SLAB CONCRETE			\$9,391		\$6,292		\$1,232	\$16,915



Calculating Crew Unit Cost

According to *Walker's Building Estimator's Reference Book*, one tile setter with one helper can install approximately 90 square feet of mortar set, glazed wall tile in an eight-hour day. If I pay my tile setter \$22 per hour and the helper \$10 per hour, then my unit price for glazed wall tile labor will be \$2.84 per square foot based on *Walker's* productivity rate and my wage scale. The unit price would vary as my wage rate varies.

$\$22 \text{ (tile setter)} + \$10 \text{ (laborer)} = \$32 \text{ per crew hour}$

$\text{Crew rate of } \$32 \times 8 \text{ hour day} = \$256 \text{ per day}$

Crew can set 90 square feet of tile per day

$\$256 \div 90 = \$2.84 \text{ per square foot for this particular crew}$

Obtaining Subcontractor and Vendor Bids

The final components of your estimate are subcontractor and vendor bids. Today, subcontractor and vendor bids make up the bulk of the construction estimate. While the estimating team is putting together their own pricing for self-performed work, they must also be gathering prices from subcontractors for the work they are not going to self-perform. The team must also be soliciting vendor pricing for all of the materials and equipment associated with the work. The management of this process is very important. If one of the trades needed to complete the project is not covered, there will be a big hole in the estimate, which will lead to a big problem on bid day. There are four steps to ensure that the solicitation of the subcontracted work and vendor pricing are complete and thorough:

1. Solicit the bids
2. Receive the bids
3. Analyze the bids
4. Choose the bids

Soliciting the Bids

After a complete review of the plans and specs, the estimator will create a list or chart representing all the work of the contract, showing which areas of work or trades will be self-performed, which will require subcontractor or vendor quotes, and which will require both. [Table 8.2](#) shows a sample subcontractor/vendor list.

Table 8.2 Subcontractor/Vendor List

Div	Item Of Work	Self-Perform	Sub	Vendor
03	Concrete forming	X		
	Concrete reinforcing	X		
	Concrete placing	X	X	
	Concrete finishing	X	X	
04	Masonry—CMU block		X	X
	Masonry—stone work		X	X
05	Metal railings	X		X
06	Rough carpentry	X		X
	Finish carpentry	X	X	X
07	Roofing		X	
	Waterproofing	X		
08	Doors and windows	X		X
	Skylights	X		X
09	Drywall		X	
	Painting		X	
	Tile		X	
	Carpet		X	
10	Specialties		X	
14	Elevator		X	
23	Mechanical		X	
26	Electrical		X	
31	Earthwork		X	

After it is determined which areas of work will require a price quote from a vendor or a subcontractor, a formal solicitation process gets underway. Although subcontractors and vendors watch the trade journals and construction news services for bid notices as closely as the general contractors do, most estimators choose to send out their own requests for quotation to a selected list of subcontractors and vendors with whom they have a past history. They usually send out requests to several companies representing the same trade.

It is important that these requests go out very early in the estimating process to give the subcontractors enough time to put together a price or notify you of their decision not to bid on the project. It is crucial that the estimator be aware of whom they can expect to receive quotes from on bid day. Trust me, you do not want to be left hanging on bid day waiting for an expected subcontractor quote that doesn't arrive. At the last minute, you will be left to guess what the estimated cost of the work in question might be. Estimators do everything they can to avoid this situation. And

even though it takes a lot of time to solicit all of the bids, it is far better to play it safe than to be left standing without a trade covered by a reliable price.

NOTE

One of the most precious possessions of the estimator is their personal directory of subcontractor and vendor names, addresses, and phone numbers. It can take years to develop reliable relationships with a substantial list of steadfast trade contractors and material suppliers. When trying to win a job, this database can become one of the estimator's most powerful resources.

Receiving the Bids

The request for quotation includes all of the pertinent information relative to the project including project name and location, who the architect is, where the plans may be obtained, when the bid is due, and how the bid may be received by the general contractor. Although some subcontractors and vendors send their initial quotes ahead of time, most bids are called in by phone on bid day—many at the last minute. I have already described to you the chaotic environment that ensues on a typical bid day in [Chapter 3](#), “How We Get the Work.”

Whether the bid is received ahead of time or at the last minute, it is very important that each one be recorded accurately and analyzed thoroughly to determine whether it covers all of the work detailed in the plans and specs for that particular section of work. Estimators typically use a standard telephone bid form as a checklist for vital information when they are receiving prices by phone.

Telephone Bid	
Project: A.J. Coffee House	Date: July 18, 2020
Company: Wayne's House of Tile	
Address: 432 Rocky Blvd., Rimrock, AZ 97660	
Phone: 734-555-1212	Fax: 734-555-1212
Division of Work: FINISHES	
Work Included: TILE	
Scope: Work includes all surface preparation, layout, mastic, tile, grout, and clean-up for kitchen area, storage area, customer area, and restrooms.	
Exclusions: Outside tile work	
Quoted per plans and specs:	YES
Acknowledged Addendum:	No. 1 and No. 2
Includes Sales Tax:	YES
Bond:	YES

Analyzing the Bids

Although this is one of the more stressful tasks associated with the estimating process, especially when bids are arriving at the last minute, it is a crucial one. This is where we attempt to find any holes or overlap in our estimate. The estimator looks to make sure that every little detail associated with an item of work is covered in the bid. For example, with a painting bid, sometimes caulking is overlooked. The caulking must be covered somewhere. And if it is not part of the painting bid package, then where is it? Is it covered in the siding subcontractor's bid? Will it be done by the contractor's own forces? The estimating team must make sure that it is priced somewhere in the estimate.

scope sheet

Similar to a work package, a scope sheet describes the items of work to be performed under a particular trade heading. It often accompanies a subcontractor's bid or a request for quotation.

One of the tools that the estimator uses to assist this analysis is a *scope sheet*. These sheets go out with the requests for quotation and list all the items associated with that bid package, including any miscellaneous bits and pieces such as hardware, flashing, caulk, inserts, moldings, or trim. The following are some other common cost items checked during the bid analysis:

- ◆ Sales tax
- ◆ Performance bond
- ◆ Shipping costs
- ◆ Delivery charges

Choosing the Bids

Once all of the bids have been received and analyzed, the estimator chooses which price to use. Under the traditional design-bid-build project delivery method, the low bid usually gets plugged into the estimate. However, it is always important that all bids be looked at as a group before choosing, because a situation may arise where one of the bids is actually too low. Yes, there is such a thing, and when you receive one, you should be very wary. A bid that appears to be significantly lower than the rest of the quotes should activate an immediate red flag to the estimator. When this occurs, a thorough review must take place. The estimator must determine whether the low quote is a result of an error or miscalculation on the subcontractor's part or whether the subcontractor actually has come up with a legitimate price based on a creative approach or strategic buying advantage. Making this determination is tricky business, and if the estimator makes the wrong call, it could be quite costly. If the contractor uses the exceptionally low price in the bid and then gets the job, the contractor will expect the subcontractor to perform the work at the quoted price. However, if the subcontractor later discovers that they cannot actually do the work for the quoted price (because of an error or for some other reason), then the contractor is left with this huge gap between the low bidder's price and the next lowest bidder. The contractor will have to make up the difference.

NOTE

Subcontractors have no contractual obligations to the contractor regarding their prices at the time of bidding. Subcontractor agreements are not executed until after the contractor has signed the contract for construction with the owner.

Once all of the self-performed work has been quantified and priced and all of the appropriate subcontractor and vendor bids have been chosen, it is time to pull all the numbers together to prepare the final estimate.

Putting It All Together

It's time to compile all of your self-performed work and subcontracted work into one estimate summary. All of the subtotals calculated on the material takeoff sheets are transferred to the estimate summary sheet as well. The estimator must be very careful to accurately transfer all of the numbers. As you can see in [Table 8.3](#), the estimate summary follows the CSI MasterFormat discussed earlier in the chapter. However, a few very important numbers have been added down at the bottom. Once you calculate the cost of the project, you must also apply taxes, general overhead, and profit to come up with your final bid. These last few items are often referred to as project *add-ons*.

add-ons

A term commonly used in construction estimating to describe the taxes, overhead, and profit added to the estimate after all other costs have been calculated.

Table 8.3 Estimate Summary for Office Building

	Division of Work	Total Material	Total Labor	Total Equipment	Subcontracts	TOTAL
1	General requirements	\$112,400	\$64,100	\$1,040	0	\$177,540
2	Site conditions	0	0	0	\$7,800	\$7,800
3	Concrete	\$83,900	\$54,340	\$4,110	0	\$142,350
4	Masonry	0	0	0	\$46,300	\$46,300
5	Metals	\$5,100	\$1,800	0	0	\$6,900
6	Wood, plastics, and composites	\$243,500	\$191,250	0	0	\$434,750
7	Thermal and moisture protection	0	0	0	\$86,000	\$86,000
8	Openings	\$43,970	\$15,120	0	\$1,775	\$60,865
9	Finishes	0	0	0	\$102,200	\$102,200
10	Specialties	\$7,950	\$2,790	0	0	\$10,740
11	Equipment	\$5,400	\$1,300	0	\$3,600	\$10,300
12	Furnishings	0	0	0	0	0
13	Special construction	\$1,345	\$890	\$950	0	\$3,185
14	Conveying systems	0	0	0	\$60,000	\$60,000
21	Fire suppression	0	0	0	\$50,000	\$50,000
22	Plumbing	0	0	0	\$114,000	\$114,000
23	HVAC	0	0	0	\$97,600	\$97,600
25	Integrated automation	0	0	0	\$19,400	\$19,400
26	Electrical	0	0	0	\$160,000	\$160,000
27	Communications	\$9,400	\$2,790	\$10,000	\$30,000	\$52,190
28	Electronic safety and security	0	0	0	\$14,900	\$14,900
31	Earthwork	\$4,600	\$3,500	\$2,300	\$116,800	\$127,200
32	Exterior improvements	\$9,780	\$4,900	\$3,500	\$29,400	\$47,580
33	Utilities	0	0	0	\$37,750	\$37,750
	TOTALS	\$527,345	\$342,780	\$21,900	\$977,525	\$1,869,550
	Sales tax (7.5%)	\$39,551	0	0	0	\$39,551

	Division of Work	Total Material	Total Labor	Total Equipment	Subcontracts	TOTAL
	Payroll tax (31%)	0	\$106,262	0	0	\$106,262
	<i>SUBTOTAL</i>	<i>\$566,896</i>	<i>\$449,042</i>	<i>\$21,900</i>	<i>\$977,525</i>	<i>\$2,015,363</i>
	Overhead (6.5%)	—	—	—	—	\$130,998
	<i>SUBTOTAL</i>	—	—	—	—	<i>\$2,146,361</i>
	Profit (3.5%)	—	—	—	—	\$75,123
	TOTAL ESTIMATE	—	—	—	—	\$2,221,485

Taxes

You include two types of taxes in your construction estimate: sales tax and payroll taxes. That's why it is important to divide your summary into four columns: material, labor, equipment, and subcontracts. The subcontracted work and equipment bids will already have taxes included, but sales tax must be added to the material column, and payroll taxes must be added to the labor column. We all know what sales taxes are, but you may not be as familiar with payroll taxes (also referred to as *labor burden*). Some of the payroll add-ons are not taxes at all, but you merely refer to them as taxes to keep it simple.

When I was running my own construction company, employing approximately 14 to 20 people, it really surprised me to learn just how much “burden” labor really did put on the payroll. Sometimes this factor alone will cause a general contractor to subcontract work that otherwise they might self-perform. The percentage is significant. Those costs that I am classifying as payroll taxes include the following:

- ◆ Employer's portion of Social Security tax
- ◆ Workers' compensation
- ◆ Unemployment tax
- ◆ Employee benefits (health insurance, life insurance, vacation, paid holidays, and so on)

General Overhead

I've already mentioned job-specific overhead. These costs include such things as the job site office trailer, portable toilets, and job photographs. They are estimated item by item relative to a specific job. General overhead is a different story. Basically, general overhead represents the cost of doing business. These are expenses that would be incurred by the company whether they had a job to build or not, such as office expenses, executive salaries, and automobile insurance. General overhead is applied to the estimate as a percentage of total cost. This percentage will vary from company to company.

Profit

The goal for every project is to make a profit. Profit is what's left after all costs and expenses associated with the job have been paid. The estimate represents the contractor's best guess as to what those costs and expenses are going to be.

Profit is expressed as a percentage of the total estimated cost. Profit is rarely a fixed percentage in construction. The estimating team will make a determination as to how much that percentage should be for any given job. As previously stated, when times are tight in construction and there is very little work to bid, profit margins may be quite small. On the other hand, when there is a lot of construction going on in a particular market and demand is high, profit margins will be adjusted upward. Either way, profit is an estimated number just like every other number in the bid.

It is highly unusual for the actual cost of the project to exactly match the estimated cost of the project. If we consider each division of our estimate summary, and each of our add-ons, the most likely scenario will be that some divisions (and add-ons) will be over the individual division estimates and some will be under the individual estimates. However, it's the final number that you are most concerned with. The goal is to have the actual overall cost of the project at the estimate or under.

Completing the Estimate

Once the estimate is complete, the contractor prepares and submits their bid and delivers it to the owner. (Remember [Chapter 3](#)?) The particular bid procedure will specify when and how the contractors will be notified as to whether they have been awarded the contract. Winning or losing depends on the quality of the estimate—and of course, a little luck. High-quality estimates display the same characteristics:

- ◆ Organization
- ◆ Correct quantities
- ◆ Accurate labor hours
- ◆ Correct pricing
- ◆ Accurate calculations
- ◆ Completeness
- ◆ Proper overhead
- ◆ Proper profit

If the estimator was successful, they will gather together all of the documents and label or tag them as “original bid documents.” It is very important that there is a clear paper trail detailing exactly how the final bid was compiled. Eventually a clean set of drawings and specs will be issued to the builder to formally execute the contract. The estimator will want to check these documents against the original bid documents to make sure nothing has changed. All of the calculations, price quotes, subcontractor bids, and any other pertinent documentation that could track the estimate logic will be organized and bundled into a package that will be passed on to the project manager charged with running the job. And although the estimator's primary job is complete once the bid is finished, they will provide support to the project team as the job moves forward, often clarifying information and pricing change orders.

If the estimator was unsuccessful, they will gather all of the bidding documents (plans and specs) and return them for deposit refunds. All of the paperwork associated with the estimate will be filed for possible future reference.

Applying Technology

Today, whether you are a small remodeling contractor or a large national construction firm, technology and software associated with the estimating function in construction management will be in play at some level. Because estimating is fundamentally a mathematical application, it is quite easy to utilize software to put together your estimate even if it is only a simple spreadsheet application. Although estimating software cannot guarantee that you will win every contract that you bid on, it will help you manage the day-to-day estimating tasks, increase the accuracy of your calculations, and significantly reduce the time it takes to put together an estimate.

All estimating programs, regardless of their level of sophistication, are usually comprised of some type of an electronic spreadsheet to organize the estimate format and automate calculations. Most programs will accept the insertion of customized formulas and calculations as well. Estimating programs also contain a unit cost database for pricing. Some estimating programs are designed for a specific industry sector and, therefore, their cost data includes the common construction categories and materials associated with that sector only. Other programs include a comprehensive, multisector cost database with extensive pricing information across all divisions of work, including everything from general conditions to concrete and carpentry and even plumbing, mechanical, and electrical work. Regardless of the depth and details of the cost information, most programs allow the option of customizing the database by adding, deleting, or changing unit costs, line item entries, and the database itself. This feature is what really makes any of the estimating programs viable because no matter how comprehensive the generic data is, there are always some adjustments that most users will make to fit their company's unique pricing resources and productivity factors.

Most estimating programs provide various types of estimate reports and can import national cost indexes to adjust bids for location, quality, and other factors. Many also have the ability to organize and compare subcontractor and vendor quotes and other types of bidding process support. Some will go several steps further by performing other common construction management tasks such as creating contracts and change order documentation, tracking purchase orders, subcontracts, and job cost accounting, as well as handling customer billing, accounts payable, and even payroll.

Many estimating programs are available on the market today within a wide range of prices. I have listed just a few here. Of course, the key in the selection of any software is to first know what your needs are and then to find a program that matches them:

- ◆ Sage Timberline (commercial construction)
- ◆ WinEst (commercial construction)
- ◆ Bid 4 Build (heavy/highway contracting)
- ◆ ProEst Estimating (commercial construction)
- ◆ Accubid (electrical contracting)
- ◆ Buildsoft (residential construction)
- ◆ Planswift (residential construction)
- ◆ GiddyUp (remodeler and specialty contractor)
- ◆ QuoteSoft (piping, plumbing, and ductwork)
- ◆ Plumbing Bid Manager (plumbing contracting)

Other construction management tools are integrated into many of these software programs, and it is not unusual to see overlaps between estimating software and cost control software. In some cases, even the scheduling task and estimating tasks are

integrated into a single software application. And today with the growth of the use of building information modeling (BIM), both the estimating and scheduling functions may be integrated into the 3D model as the design develops.

Automating the Quantity Takeoff Task

Although most firms today, big or small, employ estimating programs, not all have incorporated the technology to make the quantity takeoff procedure much easier. That's where a construction *digitizer* comes in. Digitizers are devices that automate the takeoff process of construction estimating.

digitizer

An electronic pen-shaped stylus or mouse curser used in conjunction with software to assist in the quantity takeoff task in estimating.

Digitizers are used to measure areas and lengths and to count items. They are generally comprised of an electronic roll-up matt or hardboard tablet, software, and some type of pointing device such as a pen-shaped stylus or a mouse/cursor device for outlining parts of the drawings. Instead of manually pulling off dimensions from a set of plans and specs and then entering them into a spreadsheet, a digitizer allows the estimator to take the pen or cursor, put it on a point, hold the button down, and trace around an area until you come back to the beginning. The software calculates the square footage for you in a matter of seconds, saving a great deal of time and providing more accuracy. Digitizer software can be applied to do quantity takeoffs from either paper plans or digital drawings.

Even though technology has made the estimating process less time-consuming, it is still *very* important for construction managers to learn how to estimate manually. Just remember, knowing how to use estimating software does not make you an estimator. Understanding the building process and all of the materials, labor, and equipment needed is crucial in order to become a top-notch estimator. The software tools just help facilitate you getting the estimating task done more quickly and with less error in the calculations. You still must know how to read a set of plans and specs and understand how the building goes together in order to enter the right kinds of information into the estimate to come up with an accurate and competitive bid that wins you the job.

Remember, It's All a Game

Bidding is a competition, and just as in any other competitive sport, there's emotion involved. Sometimes you win, and sometimes you lose. When you win, you feel really good. Winning a contract is a *big* deal! Getting jobs for your firm is what keeps the business going, and it is no small achievement. Some companies actually instigate a formal celebratory event each time a project is won, such as ringing a bell or sounding a horn. Other companies, such as my own, would simply execute high fives around the room and go out to dinner. But either way, it is definitely a time for celebration.

On the other hand, when you lose a job after all that work, you feel really bad. You go over and over in your head what you could have done differently. You check your calculations, you review the subcontractor bids, and you consider your add-ons. However, it is usually to no avail. As hard as you try, you will probably never figure out why someone else won and you lost. Every company is different, with different personnel, project approach, overhead, and logic, and no two estimates will ever be the same. And the truth is that no one will know the final outcome until the job is complete and the last numbers are added up. Only then can one declare the estimate a winner or a loser.

Terms to Know

add-ons	query list
digitizer	scope sheet
lead time	takeoff
liquidated damages	work breakdown structure (WBS)
quantity surveyors	work packages

Review Questions

1. What is a construction estimate?
2. Name the four primary categories of costs in the construction estimate.
3. How are construction estimates typically organized?
4. What type of estimate would we probably do if we were meeting with a client for the first time and they wanted to get a rough idea about their project cost?
5. Identify the four preparation steps taken to start the estimating process.
6. What are general conditions?
7. What unit of measure is typically employed for pricing general conditions?
8. What is a scope sheet?
9. Identify at least four characteristics exhibited in a quality estimate.
10. When will you know the true accuracy of your estimate?

Chapter 9

Contract Administration

In This Chapter

- ◆ How you get questions answered
- ◆ How you make changes to the contract
- ◆ How to maintain a reliable paper trail
- ◆ How the contractor gets paid
- ◆ What to do when things go wrong

Contract administration is all about managing the business details and relationships. When you consider all of the general conditions, supplemental conditions, and specifications associated with the contract, you can understand what a challenge this is. Every statement and every clause in the contract sets forth rules, regulations, and procedures for every aspect of the construction process. Nothing goes forward without some paperwork leading the way: written requests for information, change orders, submittal logs, shop drawings, pay requests, lien waivers, progress reports, and on and on. Staying on top of it all is a huge task and a critical one.

It is virtually impossible for one person to accomplish the job; support from the main office and the job site is required. Although one person may be the contract administrator, it takes the efforts of the entire project team to accomplish the task. From the notice to proceed to the certificate of completion, every notification, clarification, correction, approval, request, change, letter, e-mail, phone call, and administrative transaction must be tracked. Without proper attention to the contract details, the whole job could end up in one big lawsuit. No matter how good your concrete finishers or carpenters might be, you can't really fulfill the requirements of the project without strong contract administration.

Starting Off Right

By now, you are well aware that the owner of the project really sets the stage for how the construction game is going to be played. The owner establishes the project program (along with the architect), decides which project delivery method to use, and selects a contract form. Each of these decisions has an influence on how the players relate to one another in general terms. However, once everyone—architect, contractor, subcontractors, and vendors—is on board for the project, it is time to flesh out the details about how the team is going to work together for the duration of the project. It is very important that the owner takes a leadership role in directing the team and makes sure that everyone gets started on the right foot. Virtually all construction projects start with a formal preconstruction meeting led by the owner.

The Pre-construction Conference

The purpose of this initial meeting is to establish the rules by which the game is to be played and to clarify the lines of authority and communication. It is critically important that the owner's representatives, the architect, the primary engineers, and the contractor's project manager and supervisory staff be present at this first meeting. It is important to have the major subcontractors and vendors attend as well. There may even be some outside agencies that should be called in, especially if they have a substantial influence on the project, which they often do. Public utility personnel, fire marshals, and highway department representatives are some of the more common public agency players brought in on the initial discussions.

The agenda for this meeting usually covers all of the items listed in the general conditions and supplemental conditions of the contract (think back to [Chapter 4](#), “The Construction Contract”) but in much greater detail. This initial preconstruction meeting is an opportunity for the parties to be introduced and primary relationships to be established. The agenda covers the fundamental administrative and coordination issues associated with the construction project. A number of common discussion items are listed next:

- ◆ Introductions and accountabilities
- ◆ Mobilization and site logistics

- ◆ Site access
- ◆ Temporary utilities
- ◆ Temporary facilities
- ◆ Site security
- ◆ Traffic and pedestrian issues
- ◆ Construction coordination issues
 - ◆ Subcontracts
 - ◆ Submittals
 - ◆ Shop drawings
 - ◆ Requests for information
- ◆ Schedule issues
 - ◆ Notice to proceed
 - ◆ Sequence of work
 - ◆ Work hours
 - ◆ Liquidated damages
- ◆ Payment issues
 - ◆ Schedules of value
 - ◆ Applications for payment
- ◆ Change orders and extra work
- ◆ Dispute issues
 - ◆ Claims
 - ◆ Alternative dispute resolution
- ◆ Completion procedures
 - ◆ Substantial completion
 - ◆ Final inspection
 - ◆ Final payment

The Contract Administration Function

Contract administration has to do with the management of the details and information presented in the general and supplemental conditions of the contract and at the pre-construction meeting. Sometimes this role is handled by an individual identified as a contract administrator, and sometimes the function is handled by numerous individuals associated with the project team. For example, applications for payment are often handled by a contract administrator back at the main office, but requests for information and submittals are handled by field engineers located on the job site.

The need for a clear and accurate paper trail in construction is paramount, and the individuals charged with the contract administration duties must be particularly dedicated to the chore if the job is to move along smoothly. Poor performance here can be devastating. For example, inaccurate payment applications or delayed information attainment will cause havoc with the entire construction process. The workflow will suffer and affect both the schedule and the budget. That of course puts the entire project at risk. So, you can see how important the contract administration function is to the overall project success even though it has very little to do with the actual bricks and sticks of building. You will get an even better sense of how these administrative and organizational issues impact the job in [Chapter 10](#), “Construction Operations and Job Site Management.”

NOTE

Keeping up with all of the paperwork and red tape of the contract is a real challenge, and it cannot be taken lightly. Poor contract administration procedures are one of the main reasons that projects get into trouble. And if the project should go to court, the party with the most organized managerial procedures will win the majority of the time. The contractor must train all of his management personnel in good administrative practices.

Setting the Tone

The tone expressed by the owner and their representatives at the initial pre-construction meeting will set the tone for the entire project. I

cannot stress enough how very important it is for this meeting to be conducted in a spirit of trust, cooperation, and fairness. Any hints of heavy-handedness on the part of the owner or the architect will only cause distrust and apprehension on the part of the workforce. This is not the way to start off the job. Owners who understand the importance of setting a positive tone up front sometimes employ a team-building technique called *partnering*. Partnering has been used successfully to build cooperative relationships between the owner, the design team, and the construction team on numerous projects of every size and type, resulting in improved communication, speedier decision making, fewer change orders, improved quality, shorter schedules, lower costs, fewer disputes, less litigation, and higher satisfaction all around. Let me give you a brief synopsis of what partnering is and how it works.

partnering

A team-building technique, calling upon the parties to the construction contract to establish a common set of project goals and objectives and develop a mutually acceptable protocol for communication and conflict resolution through a formal agreement.

Partnering

The concept of partnering is not new, but it really didn't start showing up in the construction arena until the Army Corps of Engineers embraced it in 1988 on a project in Alabama. Then in January 1991, the Associated General Contractors of America (AGC) took hold of the Corps of Engineers' concepts and started promoting the technique on a regular basis.

The reality of the traditional owner-designer-contractor relationship is this: the environment can often turn antagonistic and adversarial. The intent of partnering is to gather together all stakeholders—owner, contractor, designers, subcontractors, and material suppliers—early in the project to establish a mutually acceptable protocol for communication and conflict resolution through a formal agreement. The goal of partnering is to create a win-win situation for all involved.

The partnering process itself starts with a few intensive planning meetings before the construction ever gets started. Led by a qualified

facilitator, the team first develops a mission statement for the project. Then they knock out a charter identifying specific goals and objectives for the project. They continue by developing an effective communication system, a reliable method for monitoring and evaluating the system, and, finally, an effective conflict resolution system. Once this structure is in place, all members of the team confirm their commitment by signing a formal agreement.

The key to partnering is to embrace it as a process, not just a one- or two-day event. It is an everyday practice that needs to be maintained and monitored throughout the duration of the project. For the partnering agreement to have meaning and merit, the leadership of the team must be steadfast in their commitment to the process. AGC defines seven essential elements of partnering for it to be successful:

- ◆ Commitment to partnering by the top management of every organization involved in the project
- ◆ Equity in considering all stakeholders' interests to create shared goals and commitment by all stakeholders
- ◆ Trust among all parties through personal relationships and open communication, with mutual sharing and understanding of each party's risks and goals
- ◆ A partnering charter developed jointly by all parties that identifies specific mutual goals and objectives
- ◆ Implementation of mutual goals and a mechanism for problem solving
- ◆ Continuous evaluation based on the goals to ensure that the plan is proceeding as intended and all stakeholders are carrying their share of responsibilities
- ◆ Timely resolution of all disputes at the lowest level possible during the project

I will be the first to tell you that carrying a complex project from start to finish, while working with a wide array of personalities and diverse agendas, is no easy task. However, the proper implementation of partnering and other team-building efforts before the work begins can help in a big way. Several studies have shown that partnered projects

outperform nonpartnered projects in practically every category tested. Obviously, partnering is one way to set a tone that really works.

NOTE

To learn more about partnering in construction, I recommend checking out the book *Partnering in the Construction Industry* (Routledge, 2017), by John Bennett and Sarah Peace.

Who's on First?

In any game, not only do you need to know what the rules are but you also need to know who is playing what position. As stated earlier, construction presents new challenges every day, and as a construction manager, you must be prepared to take on these challenges. Well, you can't do that all by yourself. You must depend on your team. And you can't depend on your team unless you know who they are and how to get hold of them, fast.

The very first task in contract administration is to create a contact list for every single person associated with the project. That includes the owner of the project, the project architect, the project manager, the superintendent, the field engineer, every subcontractor, every vendor, every material supplier, the lumberyard foreman, and even the driver of the mobile lunch van. This list becomes the lifeline for the project; the communication chain is an integral part of the management plan. The contact list must contain all of the information needed to reach each person at any time, day or night. Office, cell, home, and fax numbers must be listed along with e-mail addresses and mailing addresses. I have found that it is also a good idea to list office assistant phone numbers as well.

Many issues come up on a project that require a fast response from exactly the right person in order to keep the work flowing. Solving problems doesn't happen in a vacuum, and you can't have too many contact numbers or too many people on your team. In addition to the contact list, it is important to know the specific accountabilities for the primary players on the list. Therefore, it is wise to also create a responsibility matrix as a quick reference for everyone on the project team. [Table 9.1](#) illustrates a sample responsibility matrix.

Table 9.1 Sample Responsibility Matrix

OWNER REPS (Peabody Industrial)	ARCHITECT (Keller & Hendricks)	UTILITIES (Various)	SUBCONTRACTORS (Various)
President Tom Peabody(805) 768-0674 (O) (805) 768-5220 (C)	Project Architect Sandra Keller(805) 891-1723 (O) (805) 891-4590 (C)	SO-CAL Electric Co. Diane Eppersen (805) 768-0674 (O) (805) 768-5220 (C)	Brian Hap Electric Brian Hap (805) 617-8944 (O) (805) 617-9332 (C)
Clerk of the Works Bob Stevens(805) 768-0098 (O) (805) 768-5411 (C)	Project Manager Ron Michaels(805) 891-2234 (O) (805) 891-1144 (C)	Cal State Gas Wayne Koppel (805) 268-0554 (O) (805) 268-1772 (C)	Thompson Mechanical Kyle Gibbons (805) 459-9008 (O) (805) 469-4571 (C)
Resident Manager Steve Bosco(805) 768-1134 (O) (805) 768-7604 (C)	Design Administrator George White(805) 891-8278 (O) (805) 891-7306 (C)	Beaumont Water/Sewer John Dirk (805) 445-0974 (O) (805) 445-0610 (C)	Vander Excavation Mike Shepard (805) 768-3331 (O) (805) 768-8200 (C)

NOTE

One of the things that new field engineers get nervous about when they first go to work on the job site is their inexperience in construction. All of a sudden they go from working summers cleaning up construction debris for their father's home-building business to being smack dab in the middle of a multimillion-dollar high-rise project somewhere. And on top of that, now they are actually accountable for something important. My advice to new recruits is always the same. “No one expects you to know everything there is to know about construction, but they do expect you to know where to go to get the information you need.”

The one sure thing about construction is that problems are going to arise every single day on the job site. Regardless of your position on the team, you must be able to respond quickly when the problems arise. In construction management, you don't need to have all of the answers, but you do need to know where to find them. So, probably the most valuable tool in your tool belt is the telephone. The second is the contact list and responsibility matrix that you create for the project, and the third is your own personal “special resource” list created over time. (See the real world scenario “Help Is Just a Phone Call Away.”)



Real World Scenario

Help Is Just a Phone Call Away

Some of the most valuable resources that I had when working as a construction manager were vendors and manufacturers of products. Many problems that arise on a project stem from not knowing exactly how a material or product is going to react to various conditions.

For example, one time we were trying to install a synthetic concrete topping compound to about 20,000 square feet of an existing manufacturing plant floor. Having never used the product before, we read the installation instructions very carefully and proceeded to apply the material exactly as stipulated. Well, it wasn't working. Even though we had scarified the floor, as directed, to give the product better “sticking” power, it would still just chip right off. We contacted the architect, the product manufacturer, and the owner. No one had a clue as to why it wasn't working.

Finally, I called a friend of mine, Charlie, who was a sales rep for another manufacturer (not of the product that I was using). Charlie was an expert when it came to anything to do with concrete and concrete products. As soon as I told him what I was trying to do, the product I was using, and what was happening, he immediately explained that the old concrete floor had probably been cleaned numerous times with a particular cleaning solution that had penetrated deep into the concrete. Therefore, I needed to spray the floor with a household vinegar and water solution before the topping compound would stick.

Sure enough, Charlie's suggestion fixed the problem. Thank goodness for Charlie, and thank goodness for my “special” contact list! Charlie knew more about concrete problems than any person I had ever met in construction, and I knew that he would always help me out when I ran up against a problem I couldn't solve. He always said, “All you need to do is ask.” It is a lesson that I learned early on in my career.

Spend time developing relationships with people who know more than you do and learn from them. There were a number of great people on my “special” contact list, and they helped me solve tough problems more than once in my career as a construction manager.



Coordinating Construction Details

You've probably heard the expression “The devil is in the details.” That couldn't be truer than it is in construction. The amount of information that must be processed on a construction project is tremendous. It is probably one of the biggest and most arduous challenges of the job and one of the primary contract administration functions.

There are literally thousands of bits of information and approvals pertaining to the construction that must be checked and rechecked, clarified, and confirmed. Just think for a minute about the details that you would have to consider if you were to build a new home. Even though you already have decided on the house design and have the plans in hand, there are still numerous decisions and approvals that you would have to make. (Those of you who have already built a home will know exactly what I am talking about!) For example, you would have to decide on and approve the color of the siding, color of the trim, color of the front door, door hardware style and finish, garage door style, type of garage door opener, type of windows, type of glass in the windows, roof shingle color, color of the gutters and downspouts, exterior lighting styles and finish, and so on. And we haven't even moved to the interior of the house yet, where we would have to approve dozens of details regarding each room and its features. Then, of course, there are all of the technical approvals associated with the heating, air conditioning, electrical, plumbing, and other equipment. Do you get my drift? Multiply this process about 100 to 1,000 times, and you will get a sense of what it takes to manage and coordinate all of the approvals and information associated with the details of construction.

This is no easy task. Keeping things straight is a real challenge, and it is vital that this job be handled in the most expeditious way to keep the work moving along smoothly. For that reason, there are two key process tools that are used to track all of the inquiries, decisions, and approvals that occur during the construction process. They are requests for information (RFIs) and submittals.

Requests for Information (RFI)

Getting questions answered fast is one of the biggest challenges of the construction process. I know that this may seem like a very basic thing, but believe me—it is no simple thing! In construction there is a formal document used for asking questions called the *request for information*

(RFI). There is also a formal procedure for processing and keeping up with these forms. It is critical that every single inquiry and every single response be tracked and documented. There *must* be a clear and accurate paper trail to reference and confirm all correspondence related to requests for information, especially if there is a dispute over specific directives.

request for information (RFI)

A written request for clarification regarding the details presented in the plans or specifications. The requests are usually made by subcontractors through the general contractor to the architect.

RFIs primarily stem from questions regarding the details of the design. They often originate from a craftsperson or subcontractor needing information or clarification from the designer to keep working. Most general contractors develop their own RFI forms and require their subcontractors to use the same form. This way, the information is consistent. A sample RFI is shown here.

ABC Construction Company

REQUEST FOR INFORMATION

Project: Spinnaker's Restaurant
RFI No. 042

Date: May 14, 2020

Required Response Date: May 20, 2020

To: Tony Parisi
Parisi & McDylan Architects
1650 First Street, Suite 2A
San Piatra, CA 96744
(701) 667-9871

From: A.L. Jackson
ABC Construction
1400 Elm Grove
Carpenter, CA 83347
(509) 711-8223

Subject: Grout color in men's & women's restrooms

Description of Request: The finish schedule shown on sheet #A-17 indicates that the grout color for the men's and women's restrooms is to be "Buff #032." The specifications call for all tile grout to be "Charcoal #016" throughout. The tile setters will be starting tile work on May 25, 2020. Please advise regarding correct grout color.

Support Documents Attached: Drawings A-17, Spec Section 09310

REPLY: The grout in the Men's and Women's restrooms is to be Charcoal # 016 as indicated in the specifications. Please correct the finish schedule to reflect this change.

We assume that this change is a non-cost item.

Signed: Tony Parisi

Parisi & McDylan Architects

Date: May 17, 2020

Many times, an RFI is of an urgent nature, meaning that the subcontractor needs the answer now! Unfortunately, the RFI process is cumbersome, slow, and a real source of frustration for everyone involved. And although technology has assisted with the actual tracking of the RFIs, we are still at the mercy of the "human response." In other words, you still have to track down the person who can actually answer the question. There are instances where some minor piece of information ends up holding up a major portion of work. The job can be delayed and even stopped because of a failure to expedite RFI responses. Real schedule and budget issues with serious consequences can result if the process isn't managed properly.

Some projects require few RFIs, as few as 10 or 15. And some projects are an RFI nightmare, requiring hundreds or even thousands of clarifications, corrections, or directions. It is usually the charge of an entry-level field engineer to keep up with the communications, track their progress, and coordinate the results with the subcontractors and field personnel as required. Most field offices make use of electronic tracking systems, and RFI logs will be kept on the job site. As tedious as the job may sound, it is a critical contract administration function, and if you work in construction management, you will indeed get a turn at processing RFIs. Of this you can be certain!

Good RFI tracking methods have saved more than one contractor in a claims dispute, and poor tracking has sunk many a contractor as well. Some RFIs result in extra work and changes in the contract cost, but we'll talk about this later in the chapter. When an RFI does result in a price adjustment, the process can take even longer because the estimators have to get involved.

Submittals

Submittals are similar to RFIs but are processed with a different purpose in mind. Submittals contain information concerning products and equipment that are to be used in the building of the project. Submittals provide a means by which the architect and owner can confirm the intent of the design. The architect checks for conformance with the plans and specs and confirms dimensions, colors, texture, sheen, pattern, details, and installation procedures. As a general rule, everything that will be installed in the facility requires a submittal.

submittals

Data, samples, details, colors, and product literature required by the terms of the contract to be presented to the architect by the contractor for approval prior to ordering and installing them.

Although many submittals consist of a simple catalog description, diagram, or data sheet, others are quite substantial. For example, if a building is to have brick as an exterior finish, a *mock-up* of the wall must be constructed for the architect's approval. Sometimes the contractor has to build several mock-ups with various colors and

textures before they develop one that satisfies the designer and the owner.

The submittal process requires the same tenacity as the RFI process and must be managed as competently. It is a big chore; the project team must stay on top of the process, or it will get away from them in a hurry.

mock-up

Physical models or small samples constructed to allow the architect and owner to review the appearance and function of materials, colors, textures, and other aesthetic features before incorporating them into the actual project.

Shop Drawings

Many items associated with construction cannot be ordered out of a product catalog or off the shelf. Many items have to be fabricated in a shop or manufactured specifically for the job. In these instances, a special type of submittal called a *shop drawing* is required. Shop drawings include details, dimensions, and configurations of the item to be fabricated. Shop drawings are typically prepared by a subcontractor or a vendor and then submitted to the general contractor for review. The general contractor sends them off to the architect for a final approval. The drawing moves back down the chain, eventually reaching the subcontractor or vendor, authorizing fabrication to begin. Steel rebar bends, steel beams, ornamental handrails, trusses, and architectural woodwork are all examples of construction products that require shop drawings.

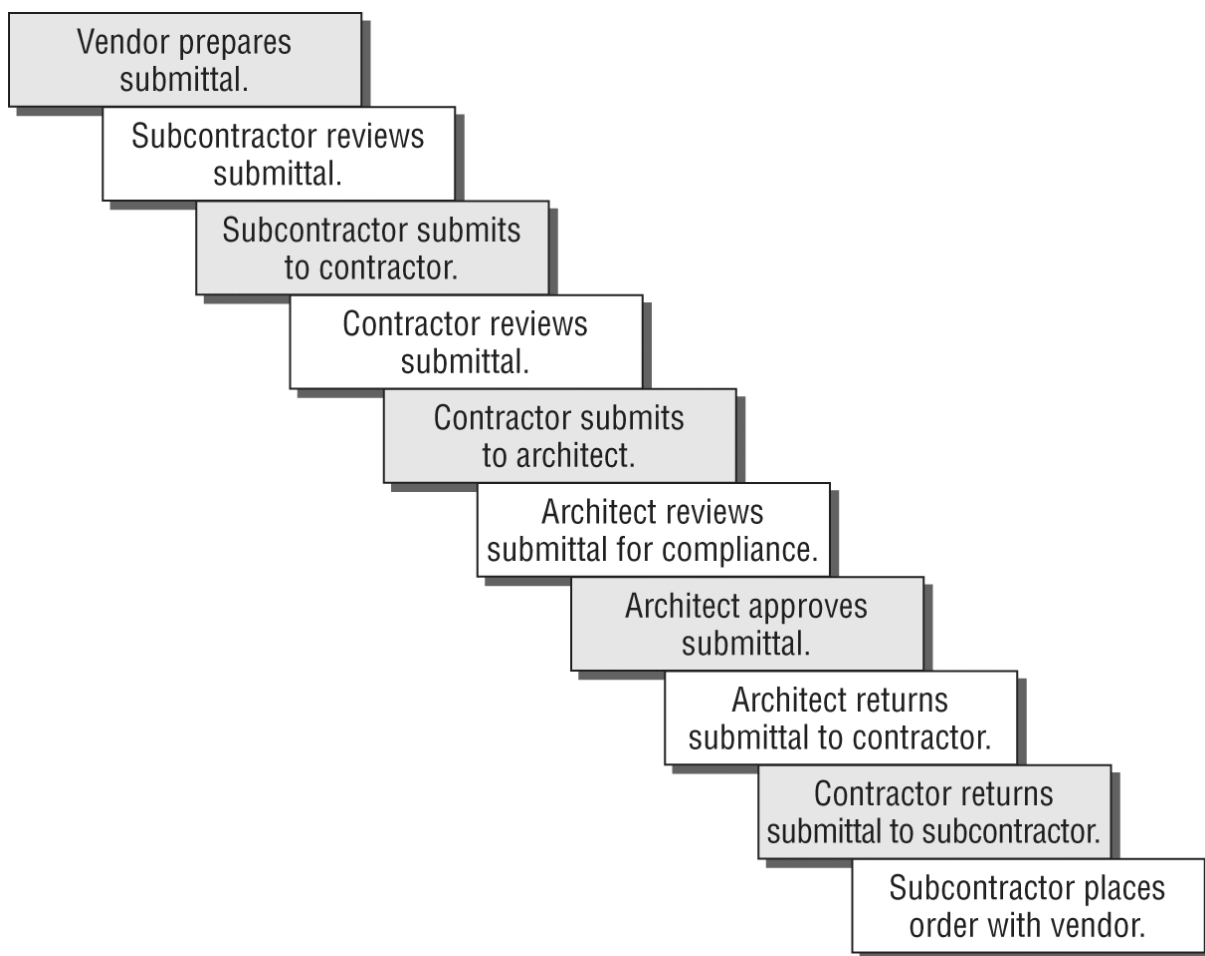
shop drawing

A supplemental drawing to the plans and specifications that details fabrication methods, materials, and models of a product or installation associated with the project.

Shop drawings require extra time to process, and this effort must be managed in a timely fashion. As a matter of fact, they are so important that they often show up on the construction schedule as a work item.

The Information Flow

RFIs, submittals, and shop drawings must all be routed up and down a similar approval chain. That approval chain is illustrated next. As with any associative process, the actions (or inactions) of one party clearly impact the actions of another. A bottleneck at any one of the stops along the way will most likely mean a delay in the work progress.



Bottlenecks in the RFI, submittal, and shop drawing process are the scourge of construction management. Trying to stay on top of the flow of information up and down the chain is a huge challenge but a manageable one. The ability to expedite the process will increase the overall reliability of both the schedule and the budget. That's why good contract administration is so important.

Nothing is more frustrating to the contractor than having to deal with paperwork that slows work progress. The temptation to bypass an approval or a change order is high. But whenever contractors decide to go forward without proper authorization, as they sometimes do, they are taking a risk that could backfire on them. On the other hand, if work is held up while they wait for authorization, the consequences could be even worse. It is a constant struggle between trying to maintain the schedule while dealing with administrative requirements that can drive you crazy. However, it is exactly the kind of struggle that the team has to face throughout the construction process.

Recently I was told by a large national contractor that they would no longer take on small school district projects because the owners were simply unable to manage the pace of the jobs and respond to RFIs in a timely fashion. This lack of management capability and decision-making expediency placed too high a risk on the contractor, and the contractor was no longer willing to take on that risk.

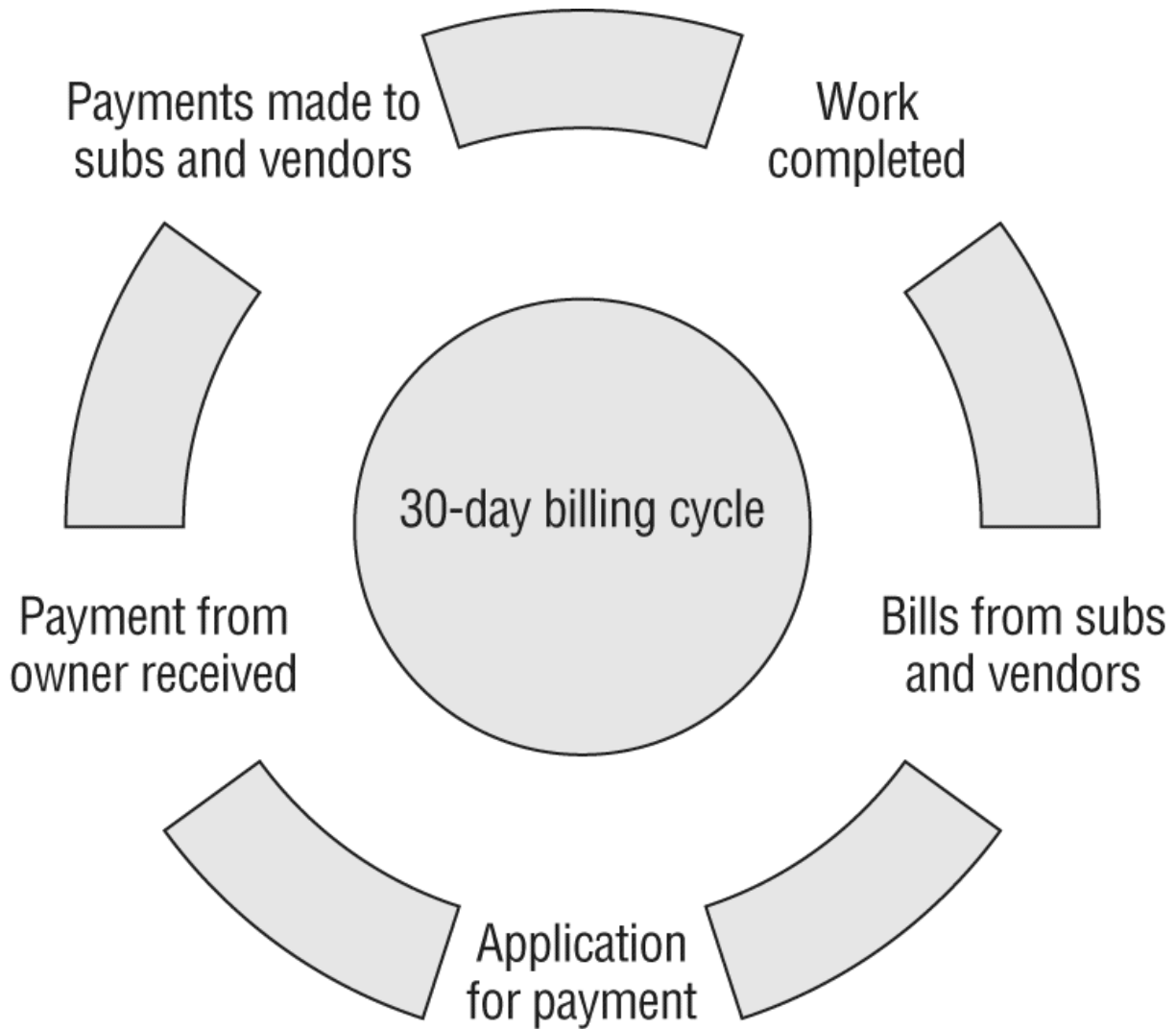
NOTE

In situations where an owner lacks the management experience and expertise to handle their own construction process, a professional construction management firm can be hired as an agent of the owner. The agency CM firm works with the general contractor on the owner's behalf. This arrangement mitigates risks for both the owner and the contractor.

Getting Paid

One of the most important contract administration functions from the contractor's perspective is getting paid on time. This doesn't just happen automatically. There is a formal payment request process involved that must be followed to the letter; otherwise, the payment request may be kicked back to the contractor, delaying receipt of the payment by a whole billing cycle. Missing even one payment cycle can cause severe cash flow problems, especially for smaller contractors or subcontractors, and can even jeopardize the solvency of a company.

Many construction projects are very, very large and represent millions and even hundreds of millions of dollars under a single contract with one general contractor. For this reason, the perception is that all of this money is collected month after month and just sits around somewhere in a special contractor account, adding to the company coffers—right? Wrong. The reality is that the money is just passing through the company accounts—coming in one end and going out the other. On a monthly basis, there is actually little or no revenue being retained during construction. The payments made by the owner to the contractor are being passed directly on to the subcontractors doing the work and to the vendors and suppliers providing the material on a monthly basis. Furthermore, the contractor gets paid only for work already completed. So in truth, most contractors are, in essence, fronting money to the owners, covering as much as 30 to 60 days of bills and expenses for work completed before receiving even one payment from the owner. This point is illustrated here.



I hope you can see how critical it is for payment requests to be handled correctly. Sloppy administrative work here means big trouble, especially on those multimillion-dollar jobs. The superintendent and project team have enough to worry about just keeping the work going. They sure don't need to be worrying about delayed payments or cash flow. Let's take a little closer look at exactly how the payment request process works.

The Payment Request Process

Requests for payment are made by the contractor to the owner via the architect on a monthly basis. The project manager or contract administrator is usually responsible for compiling the request. The

payment request is due by a certain day each month, usually at the end of the month (for example, the 25th day of each month). That means the project manager must determine a cutoff date (probably the 20th of each month) by which the project manager must receive all bills from subcontractors and vendors, and payroll data for self-performed work, in order to meet the submittal deadline.

After the payment request is submitted, the architect reviews the application and either recommends it for payment by the owner or sends it back to the contractor for revisions. You do not want a payment request returned. Even the simplest revision can result in a missed payment, and not many contractors can absorb the financial hit. However, if everything goes well, the contractor should receive payment by the 10th of the following month if the pay request is submitted by the end of the current month. Unfortunately, this is not always the case, and some owners are notoriously late with their payments. Consistently late payments not only put a financial strain on the contractor but also put a real strain on the contractor-owner relationship.

Once the payment is received from the owner, the contractor is obligated to promptly pay their subcontractors and vendors. Many subcontractors run relatively small operations and cannot afford to wait longer than just a few days before receiving payment. In instances where the owner's payment to the contractor is delayed, it is important that the contractor go ahead and pay their subcontractors and vendors anyway. Delaying payments to smaller subcontractors can add a significant burden to an already stretched payroll and end up damaging this very important working relationship.

NOTE

Owners who are slow payers get the attention of the construction community. Word gets around, and a slow-paying or cantankerous owner should not be surprised when there are few bidders on their future projects. This can be a real problem for owners because fewer bids usually mean less competition, and sometimes less competition results in higher bids. It's not a good thing for an owner with a strict budget.

The official payment request requires the assemblage of three specific documents: the schedule of values, the pay request continuation sheet, and the application for payment. Each of these documents is described next.

The Schedule of Values

The first step in the progress payment process is to complete a document called a *schedule of values*. This schedule represents the project budget derived from the original project estimate. (You will learn more about the project budget in [Chapter 12](#), “Monitoring Project Performance.”) The schedule of values is typically organized by CSI MasterFormat divisions. Each line item on the schedule represents a complete dollar amount, including overhead and profit, for each section of work. The schedule of values is one of the administrative submittals that must be approved by the architect very early on, before construction actually begins. The schedule provides the benchmark measure for each payment throughout the project duration. Every payment will be a reflection of the percentage complete for each section of work shown on the schedule. A sample schedule of values is shown here.

schedule of values

A budget template established early in the project against which progress payments are measured. The schedule summarizes the total project cost by the various divisions of work.

ABC Construction Company

1400 Elm Grove
Carpenter, CA 83347

Schedule of Values Spinnaker's Restaurant

March 17, 2019

Line Item	Description	Contract Value*	% of Total
1	General Conditions	\$175,550	9.08
2	Site Work	\$196,000	10.14
3	Concrete	\$137,000	7.08
4	Masonry	\$16,500	0.85
5	Metals	\$5,500	0.28
6	Carpentry	\$427,000	22.09
7	Thermal & Moisture Protection	\$76,400	3.95
8	Doors, Windows, Glass	\$58,600	3.04
9	Finishes	\$154,000	7.97
10	Specialties	\$49,500	2.56
11	Equipment	\$106,000	5.48
12	Furnishings	\$126,000	6.53
13	Special Construction	\$0	0.00
14	Conveying Systems	\$0	0.00
15	Mechanical Systems	\$243,000	12.57
16	Electrical Systems	\$162,000	8.38
TOTAL CONTRACT AMOUNT		\$1,933,050	100.00

* Includes overhead and profit

The Pay Request Continuation Sheet

This form is simply a continuation of the schedule of values, tracking previous payments and change orders as well as identifying the current payment due. The American Institute of Architects publishes a standard continuation sheet (AIA Form G703) as part of its application for payment form described in the next section. An updated continuation sheet must accompany the application for payment form each month. The form shown here is similar to the AIA G703 document.

ABC Construction Company 1400 Elm Grove Carpenter, CA 83347 Date: June 1, 2019 Billing Period: 05/01/19 – 05/31/19 Payment Request: No. 5							
Continuation Sheet Spinnaker's Restaurant							
A	B	C	D	E	F (D + E)	G (F/C)	H (C-F)
LINE ITEM	GENERAL DESCRIPTION	CONTRACT VALUE	PREVIOUS COMPLETION	COMPLETE THIS MONTH	COMPLETE TO DATE	PERCENT COMPLETE	CONTRACT BALANCE
1	General Requirements	\$175,550	\$89,600	\$23,600	\$113,200	64.48	\$62,350
2	Site Conditions	\$16,000	\$16,000	\$-	\$16,000	100.00	\$-
3	Concrete	\$137,000	\$137,000	\$-	\$137,000	100.00	\$-
4	Masonry	\$16,500	\$9,800	\$5,500	\$15,300	92.73	\$1,200
5	Metals	\$5,500	\$1,700	\$2,100	\$3,800	69.09	\$1,700
6	Wood, Plastics & Composites	\$427,000	\$207,500	\$67,800	\$275,300	64.47	\$151,700
7	Thermal & Moisture Protection	\$76,400	\$33,600	\$3,200	\$36,800	48.17	\$39,600
8	Openings	\$58,600	\$47,800	\$2,180	\$49,980	85.29	\$8,620
9	Finishes	\$224,000	\$-	\$-	\$-	0.00	\$224,000
10	Specialties	\$49,500	\$-	\$-	\$-	0.00	\$49,500
11	Equipment	\$106,000	\$33,600	\$7,945	\$41,545	39.19	\$64,455
12	Furnishings	\$126,000	\$-	\$-	\$-	0.00	\$126,000
13	Special Construction	\$9,500	\$650	\$-	\$650	6.84	\$8,850
14	Conveying Systems	\$16,700	\$4,100	\$1,290	\$5,390	32.28	\$11,310
21	Fire Suppression	\$44,000	\$18,000	\$3,300	\$21,300	48.41	\$22,700
22	Plumbing	\$129,000	\$31,000	\$36,000	\$67,000	51.94	\$62,000
23	HVAC	\$114,000	\$10,590	\$19,600	\$30,190	26.48	\$83,810
25	Integrated Automation	\$48,250	\$3,690	\$2,100	\$5,790	12.00	\$42,460
26	Electrical	\$162,000	\$54,900	\$27,444	\$82,344	50.83	\$79,656
27	Communications	\$55,000	\$10,590	\$12,766	\$23,356	42.47	\$31,644
28	Electronic Safety & Security	\$16,000	\$1,980	\$5,132	\$7,112	44.45	\$8,888
31	Earthwork	\$159,500	\$134,000	\$11,290	\$145,290	91.09	\$14,210
32	Exterior Improvements	\$90,500	\$34,000	\$-	\$34,000	37.57	\$56,500
33	Utilities	\$57,000	\$23,000	\$7,600	\$30,600	53.68	\$26,400
	CURRENT TOTALS	\$2,319,500	\$903,100	\$238,847	\$1,141,947	49.23	\$1,177,553

Application for Payment

The application for payment is the final document needed to process a payment request. This form summarizes the actual payment amounts and provides the official approvals required before the payment can be released. The American Institute of Architects also publishes a standard application for payment form called an *application and certificate for payment* (AIA Form G702). This standard form is commonly used across the industry, although some projects may provide their own customized form.

A document similar to the AIA Form G702 is shown here.

ABC Construction Company1400 Elm Grove
Carpenter, CA 83347**Application and Certificate for Payment****Project:** Spinnaker's Restaurant
Application Date: June 1, 2019**Billing Period:** 05/01/19 - 05/31/19
Payment Request: No. 5**Contractor's Application for Payment:**

Application is made for payment as shown below, in connection with the Contract Continuation Sheet attached.

1.	Original Contract Sum	\$ 2,319,500
2.	Net Change by Change Orders	\$0
3.	Contract Sum To Date (1 + 2)	\$ 2,319,500
4.	Total Completed to Date (Column F)	\$ 1,141,947
5.	Retainage:	
	5% of Completed Work	\$ 57,097
6.	Total Earned Less Retainage (4 - 5)	\$1,084,850
7.	Less Previous Payments (Column D)	\$903,100
8.	Current Payment Due	\$181,750
9.	Balance to Finish, Including Retainage (3 - 6)	\$1,234,650

CHANGE ORDER SUMMARY:	Additions	Subtractions
Total Changes Approved in Previous Month	\$0	\$0
Total Approved This Month	\$0	\$0
Totals	\$0	\$0
NET CHANGES by Change Order:	\$0.00	

The undersigned Contractor certifies that to the best of the Contractor's knowledge, the work covered by the Application for Payment has been completed in accordance with the Contract Documents.

CONTRACTOR:

By: _____ Date: _____

ARCHITECT'S CERTIFICATE FOR PAYMENT:

In accordance with the Contract Documents, based on on-site observations and the data comprising this application, the Architect certifies to the Owner that to the best of the Architect's knowledge, the Work has progressed as indicated, the quality of the Work is in accordance with the Contract Documents, and the Contractor is entitled to payment of the AMOUNT CERTIFIED.

AMOUNT CERTIFIED: \$ 181,750

ARCHITECT:

By: _____ Date: _____

retainage

A certain percentage of money owed to the contractor for work progress that is held back by the owner to encourage completion of the project.

You will notice a line item on the application for payment identified as *retainage*. Retainage is an amount of money that is commonly withheld from each payment as an incentive for the contractor to complete the project, including all of the final paperwork and submittals at the end of the job. The retainage amount is typically calculated as 10 percent of the contract payments for the duration of the job. Release of the retainage is tied to substantial completion, which you learned about in [Chapter 5](#), “Project Stages.” Once substantial completion is achieved, the entire amount of retainage is paid to the contractor.

NOTE

It is a common practice for the general contractor to impose retainage on their subcontractors as well. Once again, though, consideration is often given to the smaller contractors, especially the ones who complete their work very early in the construction. It seems quite unfair to withhold 10 percent of a subcontractor's money for the entire duration of the project when their work was completed in the first 30 days or so. Most general contractors try to work with their subcontractors as best they can to see to it that they receive all of their money upon completion of their work.

The Final Payment

I told you in [Chapter 5](#) that the job startup and job closeout are two of the most difficult stages to manage. I want to discuss the final payment as a separate issue because, administratively, it is indeed a real challenge. Once the job starts closing down, the punch list work is complete, and the trades start pulling off the job one after another, it is

really hard to stay focused. Like everyone else, the project team wants to move on to the next job. As a matter of fact, several members of the team have probably already been reassigned to the next job. However, the few remaining folks (probably the superintendent and a field engineer), along with contract administration support from the main office, still have plenty of work to do. The job is not complete until all of the paperwork and final submittals have been delivered to the architect. Only then is the final payment released. The typical contract documentation needed to wrap up the job includes the following:

- ◆ As-built drawings
- ◆ Operation and maintenance manuals
- ◆ Product and equipment warranties
- ◆ Test reports
- ◆ Surplus materials
- ◆ Permits
- ◆ Lien waivers

These final little details usually leave a lasting impression. In other words, no matter how well the rest of the job went, the owner has a tendency to remember only the latest event. If it goes smoothly and is completed in a timely fashion, the owner will remember how efficient and expeditious you were. However, if you drag this process out in an agonizingly delinquent fashion, they will only remember that. When I was running my construction firm, I regularly reminded my project teams that they always had to start strong and finish strong. No matter what happens in the middle, it is the first impression and the last impression that establish your reputation.

Schedule Issues

Remember the three-legged stool mentioned in [Chapter 2](#) (“What Is Construction Management?”)—time, cost, and quality? You already know that these three factors are at the heart of every project. However, on most projects, one of these factors shows up as more important than the other two. Time is often the one. You've heard the expression “Time is money,” right? Well, I'm sure you understand by now that when time becomes an issue in construction, it can mean *a lot of money!*

There are many scenarios where the construction schedule becomes the all-important issue in the process. For example, school projects must be completed by August or September, when the facility opens for the new academic year. There is typically little to no flexibility in these schedules, period. The work must be done! The completion dates are critical, and school buses will be arriving with children whether the contractor is ready or not. Another example is the opening of a new retail facility. Often these projects are designed around a pro forma that calculates a particular return on investment tied to the date when the operation opens for business. In some instances, even a single day's delay can cost the owner a significant amount of revenue. So, it is pretty easy to see why an owner might want to try to influence the contractor's performance relative to time of completion for their project, and they often do.

A Stick or a Carrot?

Owners can take one of two basic philosophical approaches in an attempt to influence contractor performance. They can threaten with a stick, or they can coax with a carrot—and, believe it or not, there are actually standard procedures for both actions in construction. The construction manager must be fully aware of how each works and plan accordingly. The stick approach calls for liquidated damages to be imposed if the contractor does not meet the completion date. The carrot approach gets more creative, providing performance incentives for work completed in advance of the completion date or for other criteria deemed important by the owner. Let's take a look at each of these techniques.

Liquidated Damages

Liquidated damages are an amount of money that is assessed to the contractor for a failure to meet a specified contract completion date. The theory behind this mechanism is that the payments would mitigate the losses that the owner would experience if the project is not completed on time. It is unlawful for them to be instigated in an amount in excess of actual damages to the owner.

The specific amount can be as little as a few hundred dollars a day or as much as several thousand dollars a day. When an owner opts to utilize this technique, it is presented in the contract documents right up front so the bidding contractors are well aware of it. For example, the liquidated damages clause may state that the contractor must pay \$1,000 per day in damages to the owner for each calendar day that the project is late.

Although liquidated damages cannot be legally used as a penalty, they sure show up that way for the contractor under the gun. This is not a position that contractors want to be in if they can avoid it. Liquidated damages are a risk that must be considered and managed just like any other risk in construction. But in most cases where a liquidated damages clause is imposed, the entire project management scheme will be designed around the avoidance of this action kicking in.

NOTE

When bidding on a job with liquidated damages, the estimating team tries to figure out how many days the project could possibly run past the completion deadline. Based on experience and a little research regarding the current industry conditions, they try to anticipate delivery delays, labor interruptions, weather conditions, and anything else that might cause a delay in the schedule. They make their best guess, multiply the number of days by the penalty, and add this amount to their bid, thus hedging their bets. This is a tricky thing to do, because the contractor must also remain competitive.

Project Incentives

I don't know about you, but incentives have a tendency to motivate me more than techniques that I might perceive as penalties. And by nature, contractors really like a good challenge and love a good game. That's why they are in the business in the first place. So if you want to influence positive behavior, why not come up with some positive incentives? Interestingly enough, the industry is starting to do just that.

One of the more common approaches is to reward contractors with a certain financial benefit if they complete the job before the dedicated completion date—sort of like reverse liquidated damages. For example, a contractor might receive \$500 per day for each day substantial completion is achieved ahead of the project completion date. Some contracts contain both clauses: a liquidated damages clause and an incentive clause. Furthermore, this same concept could be developed to create incentives around any number of factors, such as safety, workmanship, quality, or value engineering. And what really makes this concept powerful is that it has the potential to affect the performance of the entire project team, not just the superintendent or project manager. When you have the whole team committed to superior performance, you really have the potential for extraordinary results.

Making Changes

It is extremely rare to find a project that is built exactly as it was originally designed without any changes. It is virtually impossible to present every detail needed to construct a complex (or even simple) project in a standard set of plans and specifications. There are always errors or omissions in the documents that are discovered during the construction process. But remember, the contractor bids on the job per the plans and specs. Therefore, when the deficiencies are noticed, the contractor is entitled to extra compensation for correcting the errors or completing the missing details. Managing the many changes on a project is another one of the primary contract administration functions. The mechanism used to instigate these changes is called a *change order*, and there is a standard procedure for processing them. (Change orders were first discussed in [Chapter 4](#).) Change orders either add work to the contract or, in some cases, delete work from the contract, but either way the contract will be changed. Let's take a look at how this important process is handled.

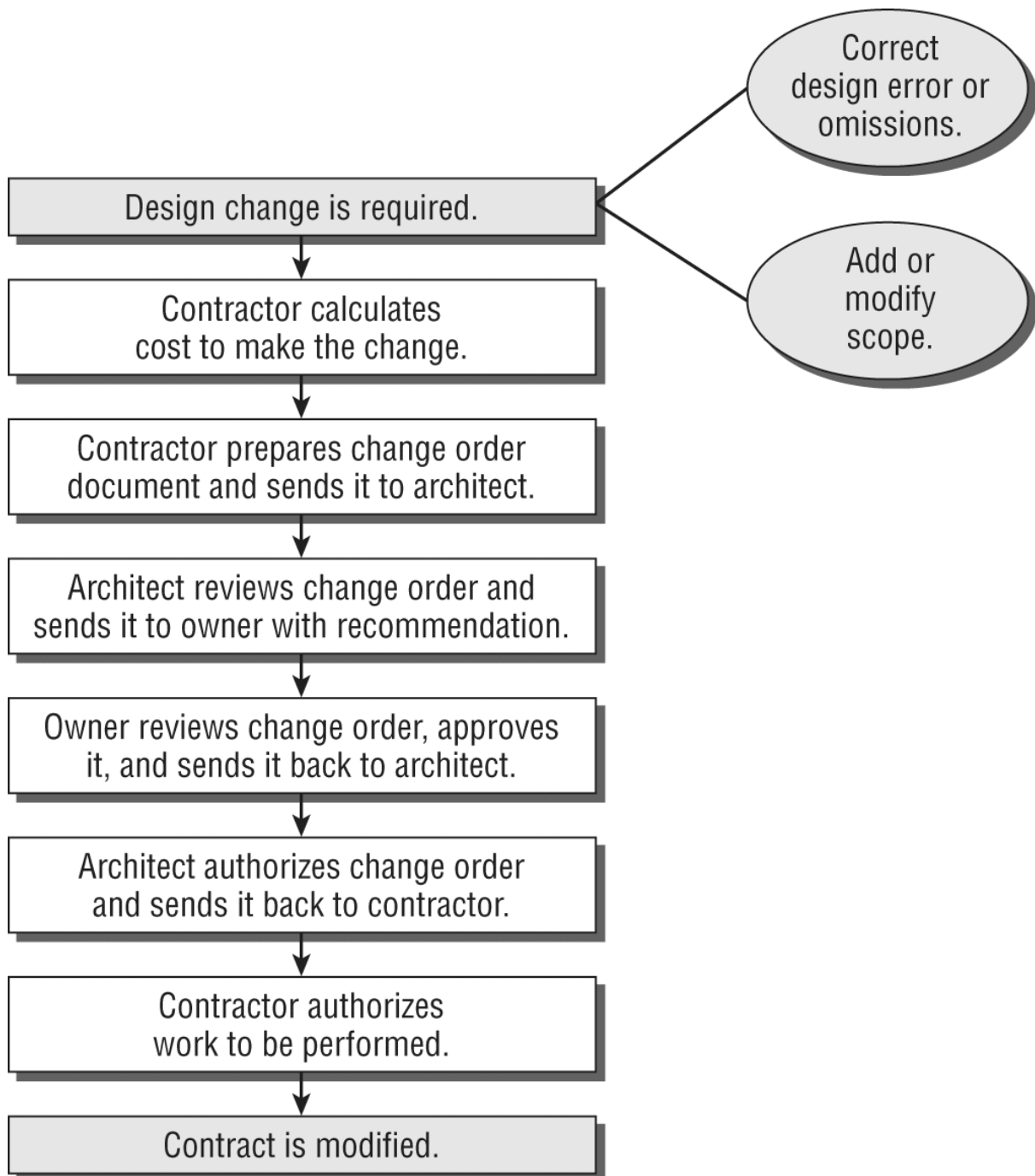
The Change Order Process

As a rule, owners don't like change orders very much; change orders often spawn many of the disputes that arise on a project. Therefore, it's important to handle the process correctly to avoid disagreements or discrepancies associated with these changes down the road. The change order process is one of the key issues discussed at the pre-construction meeting. Mishandling or misuse of this process can result in all kinds of costly disputes, and the construction team must be vigilant in administering the process correctly.

The main rule in construction is to *never* execute the extra work or change without first receiving a written order to do so by the architect or the owner. A verbal approval is not enough. I don't care if the project is as simple as a little storage building. The best way to ensure that you will be properly compensated for the extra work is to have a written change order in hand, signed by the proper authority. This can be harder to manage than you think. Remember, the building trades people are on-site to get the job done. They are not inclined to sit around and wait while the owner makes up their mind. The temptation is very strong to just go ahead with the fix on a verbal cue from the architect because you want to keep the work going. Change orders take

time to process, and whenever you decide to proceed without one in hand, the contractor is taking a chance that they may not get paid for doing the extra work. Therefore, as the construction manager, you must insist that none of your workers or subcontractors proceed with a change in the work until the change order has been properly authorized.

A change order may be instigated by the architect or by the contractor. Once the deficiency is discovered, an estimate is computed to determine what the cost of the change will be. These estimates may require a simple computation that can be handled on-site, or they may need to be sent to the main office where the estimator can perform the quantity takeoff and pricing necessary to come up with the price for the change. The estimate total, including overhead and profit, is presented in a standard change order form that gets submitted to the architect. Some change orders also require that additional time be added to the contract. This request is made right along with the request for extra compensation. The architect presents the change order to the owner, and a decision is made to authorize the change. The change order document is then rerouted back to the contractor, and the contractor orders the workforce to proceed with the work.



Every change order changes the contract amount and becomes a binding, legal document. Sometimes the change increases the contract total, and sometimes the change actually reduces the amount. For example, an owner may choose to change a room full of floor tile to carpet. Carpet is usually less expensive than tile, and therefore the result would be a reduction in the contract amount. The contractor

would go ahead and calculate the cost and process a change order accordingly.

Changes in Scope

Scope changes are some of the easiest change orders to process because they are normally instigated by the owner. Examples may range from upgrading the floor covering in the lobby to requesting more cabinets in the kitchen to adding more square footage to the whole facility.

This type of change typically starts with a request from the owner or architect for a cost estimate of the new work. The estimator comes up with a price based on the sketches and specifications provided. There may be some negotiation involved, but generally the owner simply decides whether they want to go forward with the additional work. If they do, a change order is processed, and the work is added to the contract. Depending on the size and complexity of the change, there may be a time extension associated with these change orders as well.

Time Extensions

There are occasions when the contractor is compelled to request a time extension to the contract. Time extensions are processed just like any other change order but are often more difficult to get approved. There are many reasons why a time extension might be appropriate:

- ◆ Delays resulting from severe weather
- ◆ Delays caused by slow responses to RFIs
- ◆ Delays caused by slow processing of submittals or shop drawings
- ◆ Delays caused by delinquent deliveries
- ◆ Delays caused by labor strikes
- ◆ Delays caused by slow permit processing
- ◆ Delays caused by the architect (poor-quality contract documents, work interference)
- ◆ Delays caused by the owner (slow decision making, work interference)
- ◆ Delays caused by outside protests (political groups, environmental groups, others)

Time extension change orders may consist of a simple request for extra time, or they may be more complex and include a request for cost reimbursement associated with the extra time. Simple time extension requests are relatively easy to process. For example, severe weather (especially unexpected) often results in a time extension change order with little or no objection from the owner, as long as the bad weather days are properly documented and the owner has some schedule flexibility. On the other hand, the time extensions that include additional costs are usually quite difficult to negotiate and unfortunately often end up as disputed items at the end of the project. For example, it can be hard to prove that the owner or architect interfered with construction operations and therefore delayed work progress, resulting in extra costs to the contractor and creating a need for extra time. But it is very important that the construction manager be alert to circumstances where delays beyond their control result in extra costs, especially if liquidated damages are at stake. Once again, this is a situation where having strong contract administration skills and the right paperwork makes all the difference.

I told you there was a lot more to this construction management job than just bricks and sticks!

NOTE

Police officers, firefighters, and pilots are often exposed to something called *awareness training*. This training teaches a supersensitivity to circumstances that may pose a danger in a given situation. When I was running my construction business, I actually created a type of awareness training for my project managers and site personnel. A lot of it focused on job site safety, but it also addressed risk points relative to the conditions of the contract, including change orders.

When Things Go Wrong

As hard as we may try to prevent it, the likelihood is high that there will be disagreements among the parties associated with the construction contract. As it turns out, construction is one of the most litigious industries out there. That is one of the reasons that alternative project delivery methods such as at-risk CM and design-build have become so popular—there tends to be less litigation with those methods.

claim

An issue that occurs during construction and remains unresolved after the job is complete.

As you might imagine, most of the disagreements that arise in construction have to do with money. When one of these disagreements reaches an impasse and cannot be resolved through the standard change order process during construction, the contractor must file a *claim* after the job is complete. The rules regarding the submission of a claim are spelled out in the general conditions of the contract. There is a specified time during which the contractor must inform the architect and owner of their intentions to file the claim. Construction claims typically result from one of the following causes:

- ◆ Disagreements regarding the terms of the contract
- ◆ Defective or deficient contract documents
- ◆ Denied and unresolved change orders
- ◆ Denied time extensions resulting from delays beyond the contractor's control
- ◆ Differing site conditions that resulted in extra cost to the contractor

The owner or architect must formally respond to the contractor's claim. If they reject the contractor's claim for additional compensation, the matter becomes a formal contract dispute. Some form of dispute resolution must be implemented; most construction contracts today call for methods other than traditional litigation.

Dispute Resolution

Earlier in this chapter, I indicated how important it is for the owner to kick off the construction project with a positive tone of trust and collaboration. I made reference to a formal management and communication technique called partnering. The whole premise behind partnering is to avoid the need for time-consuming and expensive dispute resolution at the end of the project. The idea behind partnering is to resolve issues along the way as they occur. Whether we employ partnering or not, once we get to the end of the project and are left with unresolved issues, we must find a way to resolve them. Several options are available to us short of going through the full litigation process. Let's consider a few of these options.

Mediation

In mediation, an impartial third party (the mediator) facilitates the negotiation between the disputing parties. Sometimes it just takes a new set of eyes and ears in the room to be able to move the disagreement to a settlement. The objective is to assist the parties in coming to a mutually acceptable agreement. Obviously, this methodology is going to be less time-consuming and less expensive than going to court. There are no attorneys involved, and the basis of resolution is still negotiation between the parties who are most familiar with the matter at hand.

Minitrial

Minitrials are one step up from mediation in terms of the amount of time and cost invested. A minitrial is conducted as an informal private process that combines aspects of both mediation and litigation. As in mediation, a neutral outside advisor is engaged; as in litigation, an attorney is employed to represent each of the parties. The unique element in the process is that an executive from each of the firms involved in the dispute is brought into the mix.

Basically, the attorneys are charged with making an abbreviated case for each argument to the executives of the firms. In the best scenario, the executives are expected to come to a settlement after seeing all of the exhibits and hearing the evidence. If they can do that, fine; everyone shakes hands and goes home. If they are unable to come to an agreement, the third-party neutral advisor may offer an opinion upon

which the parties may or may not settle. The outcome of a minitrial is nonbinding, and therefore the dispute could still end up in litigation, although every effort should be made to avoid that.

Arbitration

The use of binding arbitration in lieu of litigation is often stipulated in the general conditions of the contract for construction. Arbitration is a more formal process and is generally more costly and time-consuming than either a mediation or a minitrial, but it is less expensive than litigation. (Having participated in three arbitration cases, I can tell you that they are *very* costly and *very* time-consuming indeed.) Although the arbitration method employs a neutral third party to preside over the proceedings, everything else about the process is quite similar to a traditional trial. Each party is represented by an attorney, witnesses are called, and exhibits and evidence are presented. The preparation involved can take months, and the hearings themselves can go on for days. In the end, the arbitrator makes a ruling, and the decision is final. Although the process is indeed less demanding than a full-blown trial, it is still an arduous exercise, and my recommendation would be to do whatever is necessary to settle the dispute before it ever gets to arbitration.

It's All About the Relationships

It has been my experience that anything the contractor can do to avoid legal action and settle disagreements before they become disputes should be the first line of action. That's why the contract administration function is so important. Although there will always be differences in the interpretation of the contract documents, adherence to the protocol spelled out in the general conditions and the rules set forth in the preconstruction meeting will at least explicate the argument for the contractor.

One of the most important management tasks associated with construction is the management of good relations with the owner, the architects, the subcontractors, the vendors, and all other vested parties associated with the project. I cannot stress enough how vital it is to maintain clear and direct lines of communication with everyone on the team. Communication is the key to any relationship, and construction is no different. As a matter of fact, construction may call for

extraordinary measures of communication, given the level of detail that must be coordinated.

Every project has its share of problems; they cannot be avoided. However, if the parties can establish a firm trust through open communication and a cooperative attitude, many difficulties can be immediately defused. Otherwise, disagreements can escalate to a crisis level and end up being addressed in an arbitration hearing. However, I believe that architecture, engineering, and construction management education is beginning to shed much more light on the relationship side of our industry, which should result in a much less adversarial environment in the future. Although we still have a way to go, progress is definitely being made.

Applying Technology

After reading this chapter I'm sure it is clear to you by now that there are a lot of details to keep track of when it comes to construction. It is vital to keep a record of the various contract and project interactions and activities that occur each day. It can be an overwhelming task to log, track, route, and review the thousands of documents associated with even a moderate-size project. Quite frankly, if left to only rudimentary tools such as spreadsheets, log books, and paper forms, the contract administration task can easily overcome any project manager, even if they are managing only one project at a time—which is rare.

Before contract administration software programs were available, the tracking and monitoring of these various interactions, obligations, and management tasks were not always performed as often or as effectively as they should have been—leaving companies and projects at risk. However, today this very important task is aided greatly by software tools designed specifically for the construction industry.

Contract administration (CA) software saves time and paper by managing the contract administration phase of a project electronically. All files, communications, daily log entries, RFIs, and submittals can be organized, tracked, and processed electronically. And because many CA programs are now web-based, data files, project plans, and process information can easily be shared with all appropriate parties associated with the project while still providing the necessary level of security for any given project. Furthermore, with built-in email capabilities,

contract administration software can remind the construction manager and other project participants of actionable dates when reviews, renewals, reports, or special filings are required to keep a project on track to a successful completion.

There are many CA software programs on the market today. Here are some of the more popular ones:

- ◆ ProCore
- ◆ Primavera Expedition
- ◆ Prolog
- ◆ CMiC
- ◆ Newforma
- ◆ ConstructJob
- ◆ e-Builder
- ◆ StatsLOG

Construction administration software applications are common in midsize to large commercial construction companies. Small residential contractors and subcontractors may not yet have employed these methods. But this is exactly where tech-savvy entry-level employees can add real value to the smaller firms that they go to work for. You don't have to know every aspect of construction to understand that recording, monitoring, and tracking these important contract administration tasks in a more efficient and effective way will add value to the construction management process regardless of the project or firm size.

Terms to Know

claim

retainage

mock-up

schedule of values

partnering

shop drawing

request for information submittals

Review Questions

1. What is partnering?
2. How does the contractor receive clarification from the architect regarding details of the design?
3. What is the purpose of a submittal?
4. What is a shop drawing?
5. What is the name of the document that establishes the template for measuring work progress as it relates to requests for payment?
6. What is the name of the document that formally and officially authorizes a payment to the contractor?
7. What are liquidated damages?
8. What is retainage?
9. Identify two instances when a change order might need to be initiated.
10. Name three alternatives to traditional litigation for resolving construction contract disputes.

Chapter 10

Construction Operations and Job Site Management

In This Chapter

- ◆ The challenges associated with managing the construction
- ◆ What factors influence productivity
- ◆ How to manage environmental impacts of construction
- ◆ The role of the superintendent
- ◆ Factors to consider when organizing the job site
- ◆ The importance of documenting construction activity
- ◆ How to maintain positive employee and community relationships

Construction operations is where the action is! This is where the ideas presented on paper by the designers become the reality of a new facility—a new office building or hospital—or some magnificent bridge or highway.

What may appear as absolute chaos at first glance—with all kinds of people running around, delivery trucks coming and going, and lots of noise and banging and dirt and dust flying—is actually a well-orchestrated effort typically directed by one person, the superintendent, with support from an on-site project team.

After setting up the temporary field office, the superintendent sets out to organize the job site in a systematic, logical fashion so that it provides the greatest efficiency for getting the work done as quickly and as safely as possible. The superintendent must figure out the best way to manage, control, and coordinate all of the subcontractors, labor, materials, tools, equipment, deliveries, inspections, noise, dust, security, safety, quality, cleanup, and even visitors to the site—all the while trying to keep the project within budget and on schedule.

In this chapter, you will learn that there is a lot more to construction operations than labor and materials. When you get done reading this chapter, you might have a whole new understanding of the word *super* as it applies to superintendent!

Building the Project

Construction operations are the actual work that it takes to build the project. This includes laying out the foundation, placing the concrete, laying the block, setting the steel, framing the walls, installing the roof, installing the electrical, running the plumbing, and doing every other construction activity needed to complete the facility. It is these activities that most clearly define construction from a practical standpoint. An owner needs a facility, and the contractor puts together a package of materials, labor, and equipment to construct that facility. As the construction moves forward, the ultimate goal is to keep the project on schedule, within budget, and of high quality. To do this, the on-site construction management team must concern itself with several issues:

- ◆ Subcontractor coordination
- ◆ Material and equipment deliveries
- ◆ Productivity
- ◆ Coordination with outside agencies
- ◆ Job site safety
- ◆ Quality control

How well each of these issues is handled determines how successful the team will be at controlling the project schedule and costs. Let me explain how each of these items can impact the overall project goals.

Subcontractor Coordination

You may have heard the expression “jack-of-all-trades, master of none” to describe an individual craftsman who, while capable of performing a number of trade skills, is not quite talented enough to be considered an expert in any one of them. A jack-of-all-trades may work perfectly well for a handyman operation, but the skills needed to construct complex facilities today require an expertise that can only be classified as “mastery.” For this reason, most construction firms subcontract the bulk of the construction work on their projects to various specialty trade contractors. In other words, they hire experts to perform the work—plumbers do plumbing, electricians do electrical, carpenters do

framing, and painters do painting. This way, the work is done much more efficiently and expertly, increasing project quality, decreasing project cost, and reducing contractor risk.

However, as the construction manager, you must keep in mind that each of these subcontractors is an independent operator, and they all typically have several projects that they must attend to in addition to yours. This is where subcontractor coordination gets a little tricky. Just because your schedule requires the subcontractor on a specific date doesn't necessarily mean that they will be available.

It's very important to develop reliable and realistic schedules when planning the work, especially when it comes to subcontractor coordination. Nothing frustrates subcontractors more than being called to a job before it is ready for them. There is often interdependency between the various divisions of work. With most trades, certain items of work must be completed before they are able to proceed with their work. Sometimes the general contractor tries to keep things moving along by bringing in a subcontractor before the preceding subcontractor is 100 percent complete. For example, a trim carpenter may be brought in to install a wood baseboard before all of the floor tile work is completed. This means that you are going to have two different subcontractors trying to work in the same space; more than likely, one of them is going to be holding up the work of the other. This does nothing to aid progress; instead, it totally frustrates the process.

NOTE

Project scheduling is covered in depth in [Chapter 11](#), “Project Planning and Scheduling.”

Proper scheduling, preparation, and planning are the keys to successful subcontractor coordination. And successful subcontractor coordination is at the heart of successful construction management. The construction manager must have a keen sense of work sequencing and project planning in order to organize the schedule in such a way that the subcontractors can perform their work in the most efficient manner possible. When I was in business and scheduling subcontractors on a regular basis, I tried to remember three fundamental axioms:

- ◆ Resist bringing subcontractors onto the job until you are 100 percent ready for them.
- ◆ Once you bring them onto the job, make sure that they have everything they need to proceed.
- ◆ Pay all subs promptly upon completion of their work.

Coordination Meetings

Open and honest communication goes a long way in helping coordinate all of the subcontractors involved in building any type of facility. One of the strategies used to improve coordination efforts is the weekly subcontractor meeting. The primary focus of these meetings is to review work progress, update changes in the schedule, discuss potential interface conflicts, share information regarding equipment and personnel requirements, address any discrepancies in the plans and specs, and clarify any procedural questions. It is important that all appropriate subcontractors be encouraged to attend each of these meetings so that everyone hears the same information. The superintendent should direct the meetings and facilitate the group's interaction to best serve both the project and each individual subcontractor.

Material and Equipment Deliveries

Scheduling and coordinating material deliveries can be as tricky as scheduling subcontractors. There are literally hundreds, if not thousands, of materials and pieces of equipment that get incorporated into a construction project. Many of these items originate by way of a purchase order issued through the main office by estimators or contract administrators. However, once the order is placed, the tracking and delivery of those orders must be handled by the field personnel on the job site, because they are the ones most familiar with the day-to-day operations. The goal is to make sure that the material is on-site when it is needed and preferably not before. And although an order may be scheduled for delivery days, or even weeks in advance, the final *will-call* order and delivery confirmation should be left up to the job superintendent.

will-call

A will-call acts as a verbal confirmation of an order that has been placed prior to the date it is actually due for delivery. The will-call, generally made by the superintendent, occurs just before the scheduled delivery date.

Once the product or piece of equipment arrives at the job site, it is very important to make sure that someone is there to receive the order and direct the driver to place the material as close to the work site as possible. Whoever receives the merchandise should thoroughly inspect it and make sure that it is correct as ordered and free from defects or damage. If the material passes inspection, the on-site representative can sign off and log the delivery. If the order is not as it should be, the delivery should be refused and returned to the supplier immediately. Proper inspection at the time of delivery will prevent the problem of arguing with suppliers later.

The worst-case scenario is when the proper inspections have not been made and the product error or defect is discovered as you are ready to install the material. Obviously this is way too late in the process, and a lot of costly time and energy will be wasted because of poor material management.

Productivity

Productivity is all about expectations. When the estimators put together the price for the project, they based their labor calculations on an expected output of work per unit of time. In most instances, the productivity rates are calculated from past performance and historical databases. To meet the cost and schedule goals for the project, the productivity goals must also be met. That means that the construction manager must keep a close watch on productivity and do everything possible to optimize the conditions that contribute to enhanced productivity.

Whenever a job is taking longer than expected, the construction manager must step in and take a look at exactly what is going on that might be interfering with the productivity for that task. Many factors

can negatively influence the flow of work. Here are just a few that commonly cause lower productivity regardless of the trade involved:

- ◆ Crowded work spaces
- ◆ Poor coordination of work activities
- ◆ Poor supervision or lack of supervision
- ◆ Inexperienced or poorly trained workforce
- ◆ Not having the proper tools and equipment
- ◆ Adverse weather conditions
- ◆ Confusing plans and specs
- ◆ Changes in the work plan
- ◆ Inefficient job site layout

The construction manager's objective is to see to it that the job conditions support maximum productivity. The ability to organize the job site and schedule the workforce in the most efficient manner possible is critical to meeting productivity goals. It takes keen planning, excellent organization skills, and effective communication to pull this off.



Real World Scenario

When to Will-Call

Will-calls are a mechanism developed to allow the contractor to tentatively schedule deliveries while still maintaining flexibility should an unexpected circumstance thwart the plan. Concrete is one of the material deliveries that works best when placed as a will-call. There are so many things that can go wrong in preparing for a concrete pour that it would really be ludicrous to try to pinpoint the exact date, time, and quantity too far in advance. For example, the night before the pour it might rain, the forming subcontractor might not complete on time, or the inspector may not pass the rebar layout.

And yet at the same time, it is very important to get on the concrete supplier's delivery schedule in advance of your need. So, for example, if I am planning to pour concrete on Friday, I would typically call the concrete company on the preceding Monday morning to inform them of my intentions. This way, I am tentatively scheduled for a delivery but under no obligation to take it unless my superintendent confirms it. I would give the supplier the estimated number of cubic yards needed but remind him that my job superintendent will confirm the quantity and the order with a will-call late Thursday afternoon. If we aren't ready for the pour, the superintendent informs the supplier that the delivery is a “no go,” and the supplier will bump us off the list. If we are ready, the super calls Thursday evening, confirming the exact number of cubic yards needed and the exact time she wants to start receiving concrete trucks on the job site. Sometimes it really does take right up to the last minute to determine whether a delivery is needed, so contractors and suppliers are accustomed to this “will-call” dance.

I told you it was tricky business trying to schedule and arrange material deliveries for construction!

Coordination with Local Agents

Way back in [Chapter 1](#), “The Construction Industry,” I talked about a number of secondary players in the construction game that have a great influence over the process. One of the major challenges associated with

managing construction operations is coordinating building activities with these agencies.

For example, the building department that issues the building permit for the project is one of the agencies that you have to work with throughout the process. There are several building inspections that must be scheduled as the work progresses. For instance, referring to the example given in the previous section, the contractor can't pour concrete unless the building inspector approves the excavation, the formwork, and the reinforcing.

Some of these agencies are more responsive to scheduling needs than others. Building inspectors generally try to be responsive within a few days of a request for their services. They realize that the contractors and subcontractors are depending on them to be quick in their response so the project can move forward. However, other agencies are not so predictable. In my own experience, I have been delayed by weeks and even months on a project waiting for a public utility to respond to an inspection request, authorization, or approval. When this happens, there really isn't a lot that you can do other than try to schedule around them and keep the pressure on the agency to respond as quickly as they can. These are some of the agencies that you have to deal with throughout the construction process:

- ◆ Building and zoning departments
- ◆ Planning commissions
- ◆ Independent testing agencies
- ◆ Utility companies (electric, telephone, water, sewer, and natural gas)
- ◆ Fire marshals

Although these agencies have no contractual agreement with you, the architect, or the owner, they do have a lot of power. The reality is that they can bring your job to a standstill. Coordinating inspections and agency approvals is one of the most critical components of managing construction operations. If someone is not on top of this task right from the beginning, the consequences can be disastrous, and there will be very little that you can do about it. You've heard the expression "You can't fight city hall," right? Well, not only can you not fight them, but it's also very hard to move them any faster than they are willing to go.

Job Site Safety

Although poorly managed subcontractor coordination, low productivity, or delayed material deliveries can result in cost overruns and scheduling fiascos, serious job site accidents can prove catastrophic in terms of loss of life and personal injury.

Construction sites are noisy, dirty, and dusty places to work, and the likelihood of being struck, crushed, or injured in some other way by falling materials, moving equipment, or hazardous materials is quite high. It is very important that the construction manager make every effort to prevent such accidents from happening and protect all workers and the public from these potential hazards. Job site safety must be the number-one priority when it comes to managing construction operations.

Safety management will be addressed as a separate issue in [Chapter 13](#) (“Managing Quality and Safety”). For now, to give you a sense of the kinds of details associated with safety planning, here are some ways to help ensure a safe work environment:

- ◆ A fully equipped first-aid kit should be on-site at all times.
- ◆ “No Trespassing” signs should be posted and maintained around the site for the duration of construction.
- ◆ Emergency phone numbers for ambulance, fire, hazmat, police, and hospital should be posted at every telephone.
- ◆ A list of hazardous materials used on the project should be readily available.
- ◆ Hard hats, safety glasses, hearing protection, and other personal safety equipment must be worn by all workers and visitors.
- ◆ Trash and debris must be removed from the construction site on a regular basis.
- ◆ All heavy equipment and job vehicles must have backing-up alarm signals.
- ◆ All open excavations must be properly protected by barricades and security tape.
- ◆ Flagmen, wearing orange safety vests, should be used for traffic control as needed.

- ◆ Fire extinguishers and required fire equipment should be certified and maintained.
- ◆ Safety meetings should be held on a regular basis with all subcontractors and workers.
- ◆ Power tools should be inspected regularly for defects or unsafe conditions.
- ◆ Only qualified personnel should be allowed to operate cranes, forklifts, and other equipment requiring special training.
- ◆ Scaffolding should always be erected correctly and inspected to ensure that it is in good condition.
- ◆ Trench shoring should be used to support walls and faces of excavations exceeding 5 feet.

Quality Control

Of all the construction management responsibilities associated with operations, quality control has the greatest influence on long-term project success. Poor work performance and quality not only impact the immediate schedule and budget but can also contribute to additional damage and liability down the road, resulting in even higher losses.

The best way to control quality during construction is to develop a comprehensive plan to avoid defects, deficiencies, and problems from the start. However, getting the work done right the first time is no easy task. With so many different companies and people working on the project and so many different materials, products, and equipment to keep track of, it can be a real challenge.

In [Chapter 13](#), I go into much more detail about this very important aspect of construction operations. For now, keep in mind that it is critical that the superintendent and entire on-site management team pursue quality control from the outset of the project. They should, at a minimum, do the following:

- ◆ Be fully aware of the quality standards specified for the project.
- ◆ Understand the quality of workmanship expected to be performed on the project.

- ◆ Be able to recognize and reconcile actual performance with the quality expectations.
- ◆ Establish and implement a quality control plan that ensures that expectations are being met.

If the team is able to meet these qualifications, then the odds of a negative impact to the project as a result of poor quality, customer callbacks, or defective work are minimized.

Construction Impacts

In addition to the more obvious management tasks such as coordinating subcontractors and tracking material deliveries, certain management issues arise from the construction activity itself. For example, construction can create a lot of noise and stir up a lot of dirt and dust; depending on where your building site is located, controlling these aspects can become a major management challenge.

Not every project encounters the same construction impact issues. It all depends on the particular project location, project owner, weather conditions, proximity to other activities, and so on. Obviously, projects that are out in the middle of nowhere are less burdened with some of these issues. But if your project is smack dab in the middle of an urban area, you'd better be ready for a possible onslaught of issues, crises, and complaints—some of which can be quite controversial, and all of which you, as a construction manager, are responsible for controlling. Let's consider a few of these issues.

Noise Control

Construction is inherently a noisy business—the sound of tools and equipment running, the noise of big trucks moving about the site, and the clanging of steel on steel are expected. But noise is becoming a bigger and bigger problem, especially on sites that are close to schools, neighborhoods, and other work environments, and contractors are being challenged more than ever to find ways to mitigate the noise.

Owners will often communicate their restrictions regarding noise in the supplemental conditions to the contract, and the project manager can plan accordingly right from the start. For example, today it is not uncommon to find clauses in the contract restricting work hours to starting later in the day or prohibiting the use of radios on the work site.

However, sometimes the extent of the noise effects are not known until the project has already started. Under these circumstances, the contractor is usually confronted with a statement like, “I knew it would be noisy, but I didn't know it would be *this* noisy!” In these instances, the contractor must be willing to take reasonable steps to mitigate the nuisance and satisfy the wishes of the client or an unhappy neighbor. But sometimes these steps can add significant expense to the job, and

an agreement must be reached between the owner and the contractor as to who shall bear the brunt of the mitigation costs.



Real World Scenario

Intolerable Noise Impacts

Several years ago there was a project in downtown Sacramento where the architect and contractor had to redesign the foundation system on a building because of the noise factor. The original foundation on this high-rise building was designed (and bid) as a pile foundation. A pile foundation consists of tall concrete, wood, or steel columns driven deeply into the ground to support the structure of the building. These piles are driven into the ground by a very large hammer called a pile driver, and it is quite a noisy operation. Sacramento is the capital of California, and this new office complex was downtown in the heart of the governmental hub. The noise caused by the pile driving was so disturbing to the surrounding work environment that the project was temporarily halted while the foundation system could be redesigned from a pile foundation to a spread foundation, therefore eliminating the need for the pile driver. Although the owner picked up the tab on this one, it delayed the job nonetheless and caused a significant amount of wasted time and energy.

Dust and Mud Control

Everybody knows that construction is a dirty business. Once you clear the building site and start laying out the foundation, you are into the dirt. There's no way around it. However, once that dirt gets stirred up or rained upon, you have dust or mud—both of which can become site management challenges.

The supplemental conditions to the contract usually address the issue of dust control. Contractors are required to use whatever means are necessary to control dust on a daily basis. I'm sure you have seen water trucks sprinkling dusty building sites or access roads on a construction project. This is a common practice that is repeated numerous times per day and is typically anticipated as an overhead expense item by experienced estimators.

However, on-site mud control is not always addressed in the contract documents, and it can become a management headache in a hurry. Mud can cause all kinds of problems on the construction site. First,

mud makes it very difficult to move vehicles in and out of the job site, which can slow down operations significantly. In an effort to keep things moving along, the contractor will often spend extra money to bring in gravel and temporary road-base material just to keep expensive equipment, trucks, and trailers from getting stuck.

Second, mud makes things look very dirty. For example, a freshly poured concrete slab, a newly laid brick wall, or attractive wood siding will appear distressed and blemished once mud gets tracked or smeared onto it. And even though the contractor will take steps to protect these surfaces by covering them with plastic film or tarps, it's almost impossible not to track or smear the mud. The mud must be removed and the surfaces cleaned, and unfortunately, this extra work is often not anticipated, adding extra cost and slowing the project down.

NOTE

The fact that construction is naturally noisy and naturally dirty doesn't keep the public from complaining about the noise and the dust. Owners and contractors alike must be aware that these complaints can pose serious risks to project efficiencies, progress, and cost. The industry is quite able to ease these nuisances, but I'm not sure that the public at large understands that the costs associated with the mitigation are ultimately passed on to the consumer. It is just one more reason why construction management has become such a high-demand profession. Building is no longer just about putting together a package of materials, equipment, and labor. All of the risks associated with the construction must be anticipated and managed while still maintaining strict budgetary targets, on-time project delivery, and high quality.

But the problems associated with controlling dust and mud can go even further than that. Sometimes they can impact much more than operations on the site itself. Let me explain with another real-life scenario.



Real World Scenario

Keep My Streets Clean!

Several years ago, I was managing a residential development project in Virginia. In addition to being in charge of building approximately 20 new homes, I was responsible for building all of the new streets, water, sewer, and utilities needed for the community. Everything was going quite well until spring when the rains started. Although I had implemented the usual erosion control measures on-site and all of my streets were graded with the initial road base (gravel) down, we had not yet paved the streets; we still had a number of construction activities going on with the building of the homes, and we did not want to risk damaging any new pavement. During this rainy season, the gravel on our roads allowed us to continue moving in and out of the site. However, as the trucks were moving in and out of the site, they were picking up a significant amount of mud on their tires. Still, as long as they were able to keep moving, I was not concerned—until one afternoon when I got a visit from the town manager.

The town manager presented me with a stop work notice and basically read me the riot act, threatening severe fines for getting *his* streets dirty. Once the trucks left my site, they were apparently dropping and smearing mud all over the clean (paved) streets of the town, and the manager was not happy. Well, I was in a real pickle. I couldn't prevent the rain or the mud, and I couldn't very well put the project on hold waiting for it to dry up. Fortunately, the town manager was willing to consider a proposal I presented that would eliminate the tracking of mud on his streets and allow me to continue working.

I had to start by sending a crew of workers to sweep up and clean all of the mud on the streets that could be traced back to my site. This took several days. I had argued that the next rain would just wash the mud away, but the manager did not buy my argument. I learned a long time ago *not* to argue with the people who basically hold the future of your project in their hands by their power to shut you down, right or wrong! It is much better to apologetically acknowledge their concerns and do everything you can to mitigate the situation.

I then built a temporary tire-washing station (concrete slab, floor drain, and high-pressure water hoses) at the entrance/exit of my building site. There we would wash the tires of every pickup truck, delivery truck, and concrete truck leaving the job site before it entered the public street. I also stationed two laborers at the site entrance full time to sweep the street clean of any mud or debris that still dropped from the truck tires. Keep in mind that none of these remedies was figured into my initial estimate because the severity of the problem was never anticipated. The developer and I split the cost of this lesson learned.

This went on for most of the spring until I was able to complete my own street paving, thereby eliminating the encounters with the mud. The town manager and I actually became pretty good friends, and at the grand opening of the project, he readily acknowledged the quality of the construction and the professionalism of the construction team.

Apparently I am not the only contractor who has had to deal with this type of muddy street problem. I have since visited several building sites that post signs warning subcontractors that they will be fined by the contractor for tracking any dirt or mud onto the public streets. These contractors have decided to shift the risk of the potential penalty to the subcontractors working on the project. By the way, in most of these instances, I noticed that the subcontractors opted to park off-site and carry their tools and equipment in by hand or on dollies—inefficient, yes, but probably less risky.

Environmental Protections

Today, the need for some type of environmental protections during construction is a given. In many instances, the contractor is well aware of the special care that must be taken regarding some of these environmental issues. For example, soil erosion is always a concern during construction, and the measures needed to control that erosion should not come as a surprise to any contractor. However, sometimes an environmental issue does show up as a surprise, and that's when construction managers become concerned. They did not anticipate making special provisions, and their project budgets and schedules will

be at risk without some concession from the owner. I have listed just a few of the possible environmental issues that may arise during construction.

Storm water pollution Erosion is always a consideration on a newly graded construction site. Once you disturb the natural vegetation of the building area, you are at risk of causing unwanted damage on or off the site from excessive water runoff and the accompanying sedimentation transfer that occurs. In addition, harmful pollutants in the runoff water can have a negative impact on nearby rivers, lakes, wetlands, and coastal waters.

For this reason, many states require the contractor to prepare a storm water pollution prevention plan (SWPPP) that will be instituted at the beginning of the project and maintained throughout the duration of the construction. The purpose of the SWPPP is to identify potential sources of storm water pollution and to outline and describe the measures that the contractor will take to prevent erosion and contain sediment on-site.

concrete washout station

A temporary container installed on a construction site to collect all water runoff from the washing of trucks, tools, and equipment associated with concrete. The container may be prefabricated and delivered or built on-site.

straw wattles

An erosion control product made of compacted straw or other materials such as geotextile fibers, bound into a tight, tubular roll that comes in 10- to 25- foot lengths.

All types of pollutants are associated with construction materials and operations, but one of the biggest culprits is runoff associated with concrete. On most construction sites you will see a *concrete washout station*. These stations can be built on-site by the contractor out of straw bale walls and a polyethylene plastic liner,

or they can be prefabricated out of metal. In addition to the concrete washout stations, this plan includes temporary installations such as silt fences, filter fabrics, and *straw wattles* intended to hold soil in place.

SWPPPs are usually quite detailed and must address all regulatory requirements imposed by the governing agency. (Requirements may vary from state to state.) Poor management here on the part of the contractor can result in significant fines and even lawsuits, both of which can and should be avoided. The Environmental Protection Agency (EPA) offers the following 10 keys to effective erosion and sediment control:

- ◆ Disturb as little area as possible
- ◆ Phase construction activities to better manage the site
- ◆ Control storm water from flowing through the project
- ◆ Stabilize soils as soon as they are disturbed
- ◆ Protect all slopes with appropriate erosion controls
- ◆ Protect storm drain inlets
- ◆ Establish perimeter barriers that control runoff
- ◆ Prevent sediment from leaving the site
- ◆ Stabilize and manage construction exits
- ◆ Inspect protection measures often

Endangered species Although it doesn't happen often, your project may be in a location where you have to contend with an endangered species. Maybe you have heard stories about some little frog, bird, or rodent holding up progress on a construction site and thought at first that the story was somewhat humorous. But if the incident happens on your job, you will soon learn that it is no laughing matter.

The discovery of an endangered species on the building site usually shuts down construction operations while proper authorities evaluate the situation and decide what to do. In a very recent incident, an endangered beetle was discovered during excavation on a \$40 million college dormitory project, and the foundation work was completely halted for two months. In the

end, the foundation was redesigned and reconfigured to avoid altogether the area the beetles inhabited.

The key, as far as the contractor is concerned, is whether the owner was aware of the problem and whether they disclosed the information ahead of time. Most of these discoveries come as a complete surprise to everyone, and the ramifications are usually borne by the owner.

However, that doesn't mean that the contractor is off the hook. Unexpected delays can throw a real monkey wrench into the project plan even if the builder isn't liable. Any number of problems can arise while waiting for the issue to be resolved. For example:

- ◆ Foundations that were scheduled for fall now must be dug in the middle of winter (think snow).
- ◆ Your low-bid subcontractor who was available to start work this month has been forced to take another job that will have him tied up for a year.
- ◆ Interest rates that were reasonable at the start of the project are now set to rise before project completion.

As I said, it's no laughing matter.

Vegetation Some projects require the contractor to protect and maintain certain natural vegetation that exists on the building site. For example, when grading the site, there may be certain trees that need to be protected and saved, and it is the contractor's job to see to it that they are not harmed throughout the construction process. The builder will place physical barriers such as fences around the trees or other vegetation and flag them with security tape to alert all workers of the challenge. And it is indeed a challenge. Whenever such a request is made, it will invariably slow down production and cause some consternation among the equipment operators, especially if they were unaware of the requirement when they bid on the job.

Wetlands Wetlands protection has become a major environmental concern in our country, and construction (or development) is often in the middle of the controversy. Whenever a contractor prepares to build in an area close to natural wetlands, the contractor must adhere to a number of federally mandated

regulations. I include just a few here (taken from the National Park Service's *Procedural Manual 77-1: Wetland Protection*) to give you an idea of the impact these measures would have on productivity, budget, and schedule:

- ◆ The contractor must install and maintain adequate erosion and siltation controls during construction.
- ◆ Construction activity cannot adversely affect the natural water flow and circulation or negatively impact water-level fluctuations.
- ◆ Water quality must be maintained. The contractor must prevent or control spills of fuels, lubricants, or other contaminants from entering the waterway or wetland.
- ◆ The contractor should avoid the use of heavy equipment in wetland areas. If heavy equipment is used, steps must be taken to minimize any disruption to the soil or vegetation.

None of these actions, other than erosion control, are standard operating procedures in construction.

Historical or cultural artifacts Another unique circumstance that can shut down your job site in a hurry is when you stumble across historical or cultural artifacts while moving dirt or excavating at the site. For example, the discovery of pottery shards or arrowheads may indicate a significant archeological find, and the contractor must stop operations long enough to notify the architect and owner so they can verify the situation.

Another surprise along these lines is the unearthing of bones of any kind on a job site. If this happens, the contractor must stop construction and contact the owner immediately regarding the discovery. Work in the area of the find usually cannot resume until an investigation is done to ascertain the source and significance of the remains. These are clearly not the types of occurrences that you want to happen on your job, but if they do, you must keep things moving as best you can while making every effort to work with the owner and the appropriate authorities until the situation is resolved.

Keep in mind that the typical construction worker is constantly encouraged to complete their work in the shortest time needed, getting

on and off the job site as soon as possible. Anything that slows down this process becomes a frustration to workers, however noble the cause might be. But when workers are performing these extra steps required for environmental protection, it is very important that the superintendent pay close attention as this work is being done. A slipup resulting in damage to a tree root, an endangered species, or a historical artifact could end up costing a whole lot more time and money than the actual measures taken to protect them in the first place.

Cleanup and Trash Removal

With all of the high-risk operations associated with construction, site cleanup and trash removal might not seem like very important issues, but they are. To begin with, a clean site is a safe site. The cleanliness of the building site also reflects on the image of the contractor. Many observers believe that a neat and clean building area is indicative of how the rest of the contractor's business is conducted.

back charges

An amount of money charged against a subcontractor for work that the general contractor performed because the subcontractor failed to do so.

However, it is not an easy job to maintain a clean working environment. One of the greatest challenges to the contractor is in trying to get subcontractors to be responsible for removing their own debris. You would think that this would be a slam dunk, but actually it is a universal frustration among general contractors—so much so that most subcontracts now have a clause in them threatening *back charges* against any subcontractors who fail to clean up after themselves. Even with this threatened penalty, many subcontractors still resist cleaning up their work area, claiming that their bids are already too low to make a decent profit. Having to spend dollars to clean up the job site just adds to the predicament. On the other hand, some are just lazy, plain and simple.

My method for managing cleanup and debris removal was to hire special crews to systematically go through the job site on four-wheelers with small dump trailers at the same time every day and pick up the

trash or cajole subcontractors into picking up their own trash and throwing it into the trailers. I usually hired young people who needed part-time work after school and especially enjoyed driving these vehicles around the site. We even gave them a special nickname—the junkyard dogs! I found that if I could make it easy for the subcontractors to pitch in on the cleanup by bringing the trailer right up to their work area, I had a better chance of getting them to cooperate. Although I had to spend a little more money to make this system work, I found that it was much better than issuing back charges. In my experience, back charges were really only good at causing hard feelings, so unless a subcontractor was blatantly disrespectful regarding my request for cooperation, I didn't apply them. I also never hired that subcontractor again.

Opportunities for Recycling

Construction results in a lot of trash. Every year, thousands of pounds of construction debris must be removed from the construction site. In fact, you might be astounded to learn that approximately 40 percent of all waste in North America comes from the construction and development process, according to the Construction and Demolition Recycling Association (CDRA). (You can learn more about the CDRA by visiting its website at www.cdrecycling.org.)

NOTE

In 2018, Transparency Market Research published an article entitled “Construction Waste Market: Global Industry Analysis, Size, Share, Growth, Trends and Forecast 2017–2025.” In that article it was reported that construction produced 1.3 billion tons of waste and debris worldwide. The same report forecasts that the number is expected to almost double by 2025, to 2.2 billion tons.

Trying to estimate and predict exactly how much waste is going to be generated on any given project has become a futile effort for many contractors. Cleanup and trash-removal operations consistently run over budget and cause great frustration among estimators, construction managers, and superintendents alike.

However, as more and more contractors view this problem as the serious issue that it is, new ways are being found to work with recycling companies to reduce expensive hauling costs and disposal fees. Almost everything that comes out of the construction site is recyclable—concrete, block, drywall, metals, wood, plastics, and cardboard. In 2003, the W.G. Clark Construction Company recycled 75 percent of its job site waste on a Communications Center project located in Renton, Washington. The company ended up saving approximately 20 percent of its estimated cleanup and trash-removal cost by instigating this practice alone. Several other companies have followed suit, and recycling has become a priority on many job sites.

Construction cleanup, debris removal, and trash removal present a very tough management challenge. However, new incentives are being created every day, and new opportunities are emerging for the construction industry to finally conquer this burden.

There's More to It Than Meets the Eye

From a distance, construction just looks like a bunch of workers and materials hustling and bustling about the building site. Having to pay so much attention to noise, dust, mud, spotted frogs, and trash removal was probably not what you had in mind when you first considered construction management as a career. But this is all part of the process, and the construction manager is really charged with creating and maintaining a job site environment in which people can perform their duties at the highest and most efficient level possible. It's not an easy task but definitely a challenging one.

Now that you have a better sense of what the contractor is actually up against while trying to manage the construction operations, let's take a closer look at exactly how they actually accomplish this task. The best place to start is by taking a good look at the one individual primarily responsible for pulling off this whole challenge: the superintendent.

The Superintendent

As you learned in [Chapter 5](#), “Project Stages,” the superintendent represents the company leadership in the field and is responsible for the oversight of all construction operations. More than any other person on the construction management team, this individual is responsible for getting the project built on time and within budget. The person is responsible for organizing the job site and managing the construction on a daily basis.

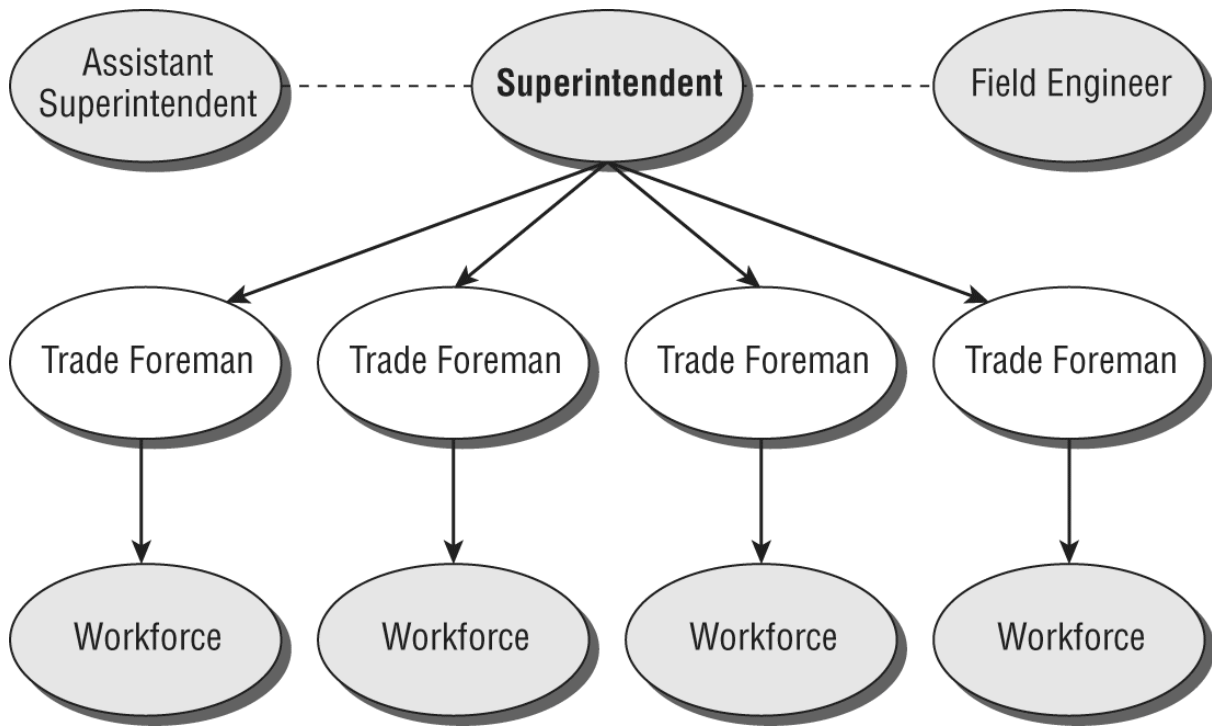
First and foremost, the superintendent must be very knowledgeable about construction. But the superintendent must also be organized and able to lead a diverse workforce. It is the superintendent's job to work with and get things done through other people, primarily subcontractors. At the same time, the superintendent must be able to win their respect and gain their confidence and cooperation.

The superintendent and the project manager continually monitor project progress through a number of field reports and observations. Every day on the job site, the schedule and budget targets are either met or missed. Whenever it appears that the schedule or budget goals are in jeopardy, the two work together to make adjustments to get the project back on track. (I will discuss project controls in [Chapter 12](#), “Monitoring Project Performance.”)

Initially, there are three things that the superintendent must do before the construction work can begin. The superintendent must do the following:

- ◆ Set up the field office
- ◆ Organize the job site
- ◆ Establish the work hours

Once these things are done, the rest of the on-site team joins the superintendent and goes to work managing the construction operations through a number of subcontractor trade foremen. Depending on the project size, the team typically consists of an assistant superintendent and at least one field engineer, as shown here.



Setting Up the Field Office

Think of the field office as the command center of construction operations. From this space, the superintendent directs all of the activities needed to get the project built. The office itself is a temporary facility. In most cases, the field office is a portable trailer on wheels, similar to a mobile home except that the interior is very utilitarian. In other words, do not expect to see a living room and kitchen in the job trailer. However, just because the spaces are utilitarian doesn't mean that they are necessarily small.

Some projects require only a single trailer to accommodate a small on-site project team of three to five individuals. Other projects may be so large that they require on-site office facilities for as many as 30 or 40 people. In these instances, the field office may comprise four to eight double-wide trailers all connected together. These projects may take several years to complete.

Each field office is fully equipped with every kind of office supply and equipment needed to carry on business from the building site. Computers, telephones, fax machines, copiers, plan tables, and plotters are all available to the project team as they go about overseeing the construction and managing the project budget and schedule.

Temporary Utilities

Our temporary command center can't function without proper utilities—water, electricity, heat, air conditioning, and telephone. These utilities are required as soon as the project team arrives on the site and will be needed for the duration of the project. The construction work itself, of course, depends on having these services; all of the various power tools and equipment needed to cut, drill, saw, and weld operate on electricity. A mix-up in the coordination of temporary utilities can actually delay the launch of construction and put a damper on the whole startup operation. For example, having no electricity means bringing in a bunch of portable generators, which are noisy, smelly (gasoline or diesel), and expensive.

Once the site is equipped with the temporary power that it needs to operate tools and equipment, an agreement must be reached between the superintendent and the numerous subcontractors working on the job site. There is a cost associated with these utilities. Even though the contractor may bear the burden of having them brought to the site, the contractor may expect the subcontractors to pay their fair share to use the utilities. On the other hand, sometimes the paperwork associated with tracking the use of the power and water is simply not worth the effort, and it is cheaper for the contractor to just pay for all of the utility bills.

Once construction is well underway, there is the possibility that the construction activities can actually operate using the permanent power sources brought in to serve the new construction. The cost of these utilities may now be billed to the owner instead of the contractor, and the superintendent must make sure that all parties are in agreement regarding these charges.

Portable Facilities

dry shacks

These facilities may be constructed on-site or brought in as modular units equipped with tables and storage lockers. They provide a dry place for workers to eat their lunch and change their clothes. Union agreements often require that the contractor provide a dry shack on-site.

A number of portable facilities support the field office and construction operations. The contractor needs to provide secure tool storage, *dry shacks*, and temporary toilets that are available to all workers on the job site. The placement of each of these facilities is important to the overall efficiency of operations. It is not uncommon for some subcontractors to request that they be allowed to bring their own storage trailers on-site to accommodate their special tools, parts, products, and equipment. These extra facilities must also be taken into consideration when developing the overall site logistics plan. (Site logistics planning is discussed in the next section of this chapter.)

In addition to these primary facilities, the contractor is also responsible for providing the following:

- ◆ Clean drinking water with paper cups
- ◆ Clean washing water and paper towels
- ◆ Trash receptacles and dumpsters

Organizing the Job Site

After setting up the field office, the next challenge faced by the superintendent is organizing the job site for the greatest efficiency and safety. Some construction sites are way out in the middle of nowhere; others may be right in the middle of a major urban area. Either way, the superintendent must have a strategy for directing and organizing all of the materials, manpower, and equipment that will be congregating on the site on a daily basis and moving in and out of the construction area throughout the duration of the project. Every aspect of getting the job done must be considered when trying to prepare the site for construction operations. Decisions about where to place everything

from the portable toilets to the dumpsters can make a big difference in how smoothly the job runs.

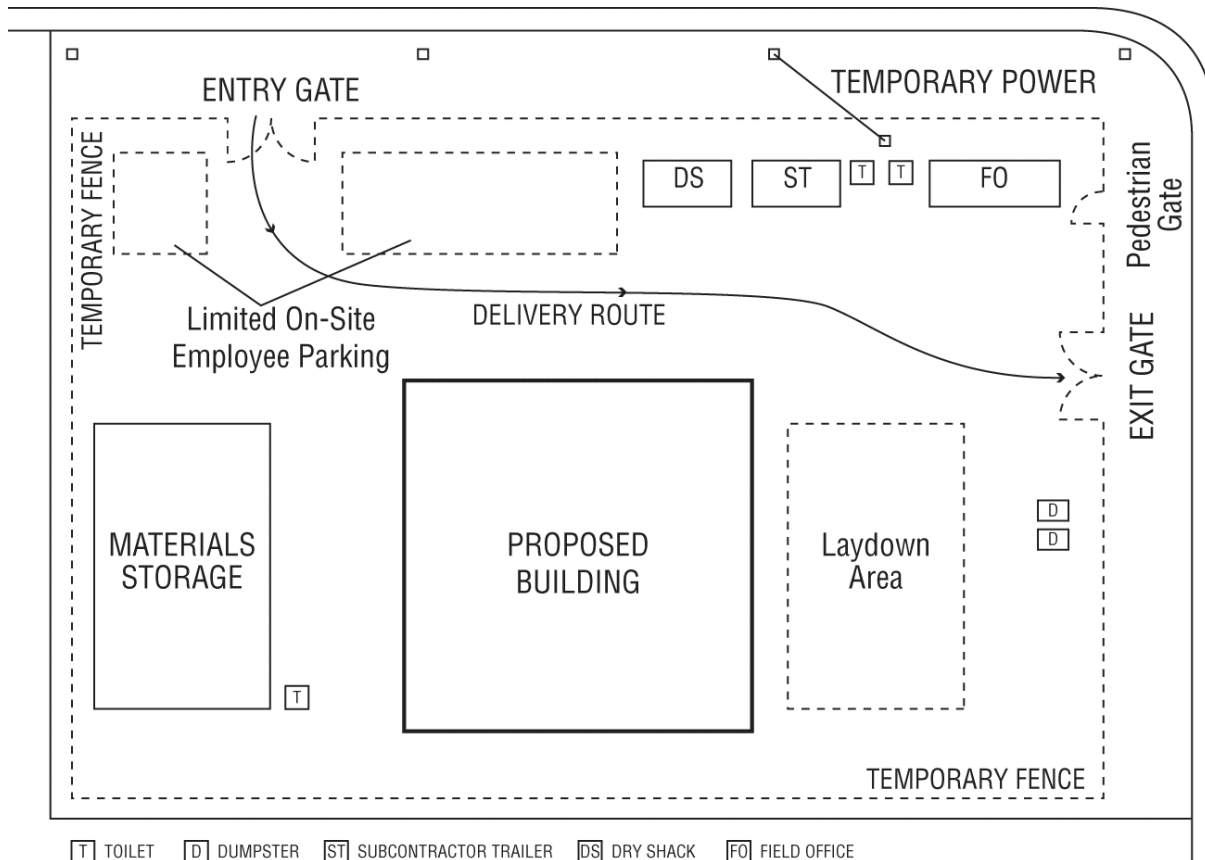
project staging

A layout plan identifying the placement of all temporary facilities needed during the construction stage of the project, such as the office trailer, storage, security fencing, dumpsters, and portable toilets.

Site logistics, also called *project staging*, are crucial to the overall efficiency and coordination of the work. In addition to laying out the most efficient placement of the field office and portable facilities mentioned earlier, the *site logistics plan* should also take into account a number of other factors, such as the following:

- ◆ Material storage and handling
- ◆ Job site security
- ◆ Site access
- ◆ Employee parking
- ◆ Traffic control
- ◆ Pedestrian safety
- ◆ Crane location
- ◆ Miscellaneous facilities

Although it may seem silly to think that the location of the dumpster, the storage trailer, or the tool shed has any bearing whatsoever on project productivity and profitability, studies have shown that job site layout contributes appreciably to the bottom line. The graphic shown here illustrates what a typical site logistics plan might look like.



Let's take a closer look at some of the factors that must be considered when planning job site layout.

Material Storage and Handling

Earlier in the chapter, I discussed the importance of trying to schedule material deliveries as close to the actual date of installation of that material as possible. However, sometimes you need to bring materials on-site before they are ready to be installed. When this happens, you must make sure that they are properly stored and taken care of.

On most large jobs, the superintendent brings in several trailers for use as storage facilities. These trailers can be used to store tools, equipment, materials, or even spare parts for generators, tractors, and power tools. Sometimes subcontractors will bring in their own storage trailer. This is especially true of mechanical and electrical subcontractors. They generally have large pieces of expensive equipment, ductwork, or piping that must be protected from the elements, vandalism, and theft.

laydown area

A designated area on the building site where large orders can be stored and sorted in an organized manner so that the parts can be easily identified for use on the project.

In addition to trailers, it is common for the superintendent to designate a specific area on-site where materials can be stored until they are utilized on the job. This area is often fenced off separately with a locked gate. It's not unusual to assign a field engineer to receive deliveries and manage the inventory coming in and out of this area. In addition to a fenced storage area, the job might require a *laydown area* where very large orders such as structural steel beams, girders, columns, and angles can be sorted for easy identification. Sometimes these two areas are combined into one.

When storing materials, it's important to know that some materials are more susceptible to damage and deterioration than others. For example, certain products can be ruined by mud or snow during extreme weather. Or in hot weather, lumber can dry out and warp. Care must be taken to make sure these materials are properly cared for and always stored on skids or pallets; some should be covered at all times.

NOTE

When it comes to material handling and storage, little things can make a big difference. For example, you should always make sure that delivered materials are unloaded and stacked with the materials to be used first on top of the pile. Otherwise, you will have to spend time moving all of the stuff on top to get to the needed material on the bottom. You never want to handle material more times than necessary. With a little planning, you can minimize the effort.

Job Site Security

Building sites have always appeared as curiosities worthy of a little exploration. Most of us, at least in our youth, have been tempted to hop the fence in the late afternoon to climb the piles of dirt, play around the big tractors, and run in and out of some partially completed structure as if it were a jungle gym placed there just for our pleasure. However, the construction site poses a number of hazards, and it is the obligation of the contractor to secure the premises, protecting the public from the inherent dangers associated with construction operations.

Although public safety is the primary reason for securing the job site, it is also important to protect the installation, materials, tools, and equipment from vandalism and theft. There are several means by which to do this. The most common methods are as follows:

- ◆ Perimeter fencing
- ◆ Guard dogs
- ◆ Private security patrols
- ◆ Electronic alarm systems
- ◆ Night watchmen

These measures enable you to protect the construction project from the people around it, and vice versa. For example, fencing both keeps unauthorized people from entering the work area and protects authorized workers and visitors from hazards that occur within the perimeter of the site. An open excavation, for instance, is clearly hazardous to the safety of workers on the job; it should be fenced off and marked with warning devices such as barricades, security tape, and traffic cones to alert workers to the risks associated with an open pit.

Although some security arrangements may be required by the contract (perimeter fencing, for example), it is really up to the superintendent to decide what measures should be taken to best protect the public and the interests of the contractor and owner.

NOTE

Because most job site thefts occur during times when no workers are on-site, it is best to avoid scheduling material deliveries just prior to weekends or holidays.

Site Access

On some construction sites, access is really not much of a big deal. You might be in a remote area with very little traffic and nothing around you. On other sites, access can become a major issue. This is especially true in highly congested areas. For example, daily traffic may have one entrance, and delivery traffic may need to be routed to another entrance. You also have to think about how much space is available. The turning radius of long delivery trucks, some with booms, becomes a factor, especially on tight sites. You need to have a plan for getting these vehicles close enough to off-load materials. Another consideration is the hours of access, which may be restricted. Of course, this impacts your work hours, all of your deliveries, and your ability to move equipment onto and off the site as needed. All of these details must be considered when developing the site logistics plan.

Employee Parking

Employee parking is another staging plan issue that must be addressed. As with site access, parking on some sites is not much of a problem, especially when there is plenty of room and employee parking can be managed on-site. On smaller sites, parking can be a big problem—and a costly one, too. On some downtown projects, for example, parking must be arranged with a local parking garage, and tools and equipment be moved in and out of the site on golf carts or dollies. In this instance, the superintendent must try to negotiate blocks of parking spaces at reasonable costs or suffer the consequences of their daily workforce depending on random luck to find parking in the area. That's not exactly the best way to create a happy work environment for your troops. However, some contractors meet these challenges in very creative ways. For example, one superintendent I know rented parking spaces from a nearby church that doesn't need the spaces during the

week, and the church benefited by making extra money from the underutilized space.

Traffic Control

Traffic control and pedestrian safety tie right into the site access and parking issues. The traffic associated with the construction process can add a significant burden to heavily traveled streets and highways. The posting of flagmen to direct traffic around the construction site is a common occurrence. This effort adds to the project cost and in heavily congested areas can impact productivity significantly. Because heavy traffic adds a significant risk when it comes to job site safety, this is one aspect of site logistics that cannot be overlooked or neglected.

Pedestrian Safety

Pedestrian traffic must also be taken into consideration when creating the site logistics plan. This is especially true when the building site is located in a downtown metropolitan area. You have all seen covered sidewalks at the edge of busy building sites. These protected walkways are designed and built to protect pedestrians from falling debris as well as from the dust and noise of the construction. Although these temporary structures seem simple in their design, they actually add thousands of dollars to the project budget. However, public safety is not the only use for these wood-framed structures. Some municipalities permit them to be used as public display areas for street art and other community outreach purposes. When this is the case, the contractor can end up saving a little money by not having to paint the structure.

Crane Location and Miscellaneous Facilities

Many construction jobs require the use of a crane on-site to lift and move very heavy objects around the site. These cranes may require a fixed location on-site or be mobile. Where to locate the crane on the building site is a very important decision. Several factors need to be considered. For example, height restrictions, required horizontal reach, and maximum loads influence which type of crane is needed. However, unless the crane is mobile, once it is in place, you are not going to want to move it until you are done with it. It is therefore important to place it correctly the first time. Of course, not all building sites require a crane; some may instead require other types of lifting equipment. If this is the case, it is always a good idea to know exactly what you are going to need

ahead of time so you can properly plan for its use on the job site, even if you don't have to decide on a fixed location.

There are many other miscellaneous facilities, amenities, and equipment needs that should be considered when developing the site logistics plan. A few of these are tool sheds, dumpsters, vending machines, water hydrants, and portable generators.

Establishing Work Hours

Setting work hours is another responsibility associated with construction operations and job site management that the superintendent must attend to. The standard eight-to-four routine is not always the norm in the construction industry. Adjusting work hours to accommodate the task at hand or to accommodate special conditions happens all the time. For example, working in the middle of the night is a common occurrence in highway construction or commercial remodeling that requires working after-hours. Most of us have encountered the late-night road crew constructing a new section of a busy highway.

The superintendent must consider the demands of the project as well as the demands on their workforce in establishing the working hours. There are times when different trades may need to be scheduled to work on different shifts to keep them from getting in each other's way, and then there are other times when all of them must work weekends to get the project back on schedule.

Contractors generally like to start their workday very early, especially during the summer when the temperatures can rise to triple digits in some parts of the country. It is not uncommon for some crews to start the day as early as 5 or 6 a.m. But sometimes the superintendent must adjust hours to better serve the overall project goals. For example, as you learned earlier in the chapter, when noise is an issue, the superintendent may be required to restrict the work hours by starting later in the day to accommodate those neighbors who may still be sleeping at 7 a.m. In these instances, the crews may not be allowed to start work until as late as 8 a.m.

Late starts in construction are not a simple matter. Sometimes they can actually interfere with certain construction operations, and the consequences can be costly. For example, concrete is a fickle material and reacts differently to different temperatures and atmospheric

conditions throughout the day. Under cooler temperature conditions, the later in the day that concrete is placed, the more likely that it will require a longer period of time to set up before it is ready for finishing. And unfortunately, it's not as if the crew can just walk away and do something else while they wait. They must stay with the concrete and continually watch it and test it the whole time it is setting. During certain months of the year, it is not uncommon to find the concrete crews still working under lights at 11 p.m. trying to finish concrete that was poured at 9 a.m. If you have ever been involved in finishing one of these delayed pours, you know how exhausting and frustrating it can be, especially when you know that if you had been able to pour at 5 or 6 a.m., you could have gone home hours ago.

NOTE

Even the workweek may be adjusted to better serve the project and the crews. For example, whenever I had a project that required a one-way travel time of more than one and a half hours, I would schedule the crews to work ten hours per day, but only four days per week. This way the crews could enjoy a three-day weekend every week to make up for the three hours that they had to spend each day traveling to and from the job. It helped tremendously with morale and actually gave the management staff a relatively quiet time every Friday to catch up on paperwork and reports.

Documenting Construction Activity

With all the action happening on the construction site, you would think that paperwork would be the least of your worries. Unfortunately, paperwork is a crucial factor when it comes to job site management—and it is probably the hardest part of the whole job. After all, when you are in the middle of a concrete pour, the last thing you want to do is sit down and record the exact times the trucks arrived and what the temperature was that day. However, this is exactly the type of information that must be tracked and recorded.

It is extremely important that the construction activity be documented throughout the entire duration of the project. There is so much happening and so many conversations going on that unless someone is keeping track of it all, something is bound to be miscommunicated or fall through the cracks.

Obviously, the superintendent must be very knowledgeable when it comes to construction methods and techniques. But the superintendent must also be a stickler for detail when it comes to the paperwork. Good record keeping is a must, and all information should be

- ◆ Accurate
- ◆ Objective
- ◆ Complete
- ◆ Legible
- ◆ Timely
- ◆ Retrievable

Many different mechanisms are used to track and record all of the activities that occur on the job site. In addition to the administrative requirements of construction, much of the information collected and documented throughout the construction process is used to analyze project performance and make management decisions. Let's take a look at some of these mechanisms now.

Project Meetings

Throughout the construction process, a number of meetings take place at the job site. Sometimes these meetings are scheduled at regular intervals, such as weekly, biweekly, or monthly. At other times, they are called as special meetings to address a specific issue or problem.

The purpose of these meetings is to discuss construction progress and provide a forum in which the major project participants (architects, engineers, contractors, subcontractors, and owner representatives) can discuss their concerns. The meetings are usually somewhat formal in nature with a written agenda.

Meeting minutes should always be recorded at these events. It is common practice to bring in a field engineer or administrative assistant to record these minutes. Every discussion and decision made must be documented. These minutes should become part of the formal record pertaining to the project and be distributed to all appropriate parties in a timely fashion. Any discrepancies found in the minutes should be communicated within a limited time frame—10 days, for example—to avoid misunderstandings later. Any corrections or clarifications to the minutes should be duly recorded and distributed.

Although this formality may seem quite tedious to the seasoned superintendent when there are so many other practical things that may need attention, discipline here protects the contractor's interests throughout the construction process and may help to avoid some sticky conflicts down the road.

NOTE

I always made a practice of using new field engineers to record the minutes at progress meetings. This way they were able to hear firsthand the kinds of issues and concerns that owners, architects, engineers, and subcontractors brought to the table on a regular basis. It turned out to be one of the best training venues that I could provide on the job site.

Logs, Diaries, and Daily Field Reports

One of the best ways to keep up with all of the day-to-day activities that go on at the job site is by tracking them in some type of a standard log or by recording them in project diaries.

Logs

Logs are used to track a number of regular activities occurring on the job site. Some of the more common logs are as follows:

- ◆ Phone logs track phone calls, both incoming and outgoing. They usually record the date and time of the call, the participants in the call, and the purpose of the call.
- ◆ Transmittal logs track the dates and addressees of all transmittals as well as the actual information being transmitted, such as shop drawings, product cut sheets, samples, or some other submittal.
- ◆ Delivery logs help keep up with all of the material and equipment deliveries that are made to the site. The log contains the date of the delivery and the material received, and it notes any problems with the order and the actions taken.
- ◆ RFI logs track all requests for information submitted to the project participants and their responses. The date the RFI was sent and the date that the response was received are also noted in the log.

Diaries

Every member of the project team, but especially the superintendent, should be encouraged to keep a project diary. This tracking tool can take the form of a simple spiral notebook or something more elaborate, such as a day planner or electronic organizer. The diary is used to track all of the day's events in a summarized fashion and in the individual's own words. Diaries are used to note daily work activities, conversations, observations, and any other information worth recording. It is important that each member of the team keeps their own diary, because different people will have different interactions and conversations throughout the day. The diaries provide a reliable historic record and can become very important when disagreements or discrepancies arise on the job. Handwritten and electronic diaries are often permissible in courts as evidence of actual events and conversations.

Daily Field Reports

In addition to the informal project diaries, most construction companies require that a more formal record be kept. These field reports are intended to simplify the capture of some fundamental information needed to track job progress and confirm that various project requirements are being met. For example, a notation indicating that an inspector was on-site and approved a footing excavation would verify that required quality checks are being conducted. The reports are usually written on preprinted standard forms that contain consistent information. They are relatively easy to fill out and must be filed with the superintendent's signature and date marking it as an official document. The following are the types of information recorded:

- ◆ The name of the individual making the report
- ◆ The date, project name, and location
- ◆ A brief description of the day's activities
- ◆ The temperature and general weather conditions
- ◆ The contractor's own work forces on the job
- ◆ The subcontractors' personnel on the job site
- ◆ Materials or equipment delivered
- ◆ Equipment used on the job
- ◆ Visitors to the job site
- ◆ Other notable events

Daily reports are often summarized into weekly or monthly reports that are distributed to upper management within the company. These reports make up some of the data used to analyze project performance and make adjustments to the overall project plan.

Labor Records

If the popular adage “Time is money” holds true, then labor represents the greatest risk to the construction schedule and budget—and indeed it does. Keeping accurate labor records is one of the most important functions of construction managers in the field. The data that they collect by way of time cards is extremely valuable to the construction

company. The time cards provide the payroll clerk with all of the information needed to calculate wages and distribute paychecks—which is pretty important, especially if you are one of the workers expecting a check. In addition, time cards provide the fundamental information needed by the construction manager to track and monitor productivity and labor expenditures.

Employee Name	Trade Class	RT/OT	Cost Codes				Rate	Total Hours	Gross Amount
			3.010	3.020	3.120	3.801			
Stevens, Pete	Concrete Finisher	RT			2	6	\$27.00	8	\$216.00
		OT							
Platt, Debbie	Labor	RT	2	2	4		\$18.00	8	\$144.00
		OT							
Doud, A.J.	Carpenter	RT		5	3		\$24.00	8	\$192.00
		OT							
Michaels, Ron	Labor	RT		2	3	3	\$18.00	8	\$144.00
		OT							
Alvarez, Manny	Rodman	RT	4	2	1	1	\$29.00	8	\$232.00
		OT							

On large projects, time cards are usually filled out by supervisory personnel for each trade or labor group working on the job. If it is a small job, the individual workers record their hours on a weekly time card. In either instance, once the cards are completed, they should be reviewed and checked by the superintendent for accuracy before being sent to the payroll clerk.

The information gathered from the time cards is used to create a weekly labor report, typically prepared by the superintendent or assistant superintendent. The report tracks labor hours and dollars spent on various aspects of the work. Labor is categorized and tracked by cost codes, which I will explain in much greater detail in [Chapter 12](#). But for right now, it's sufficient that you understand how the report is used and why it is so important. The purpose of the report is to summarize cumulative labor costs and compare them with budgeted labor costs. This information helps the management team keep the project on target for meeting its cost and schedule goals.

Visual Records

You've heard the expression “A picture is worth a thousand words.” This is certainly the case in construction. There are many reasons for visually recording work progress on the job site. Progress photos help

document construction methods, highlight and capture problem areas, and supplement written reports. For example, some contractors are using videotape and still photos to record the location of wires and pipes in walls in lieu of sketching them on the as-built drawings. This way, everyone has a record of where these items are after the walls are covered with drywall. This can be very helpful, especially if you decide to remodel the space down the road. With digital photography, you can take hundreds of photos on your project site and easily archive them electronically for records and historical reference.

Web Cameras

Webcams record images or live video streams from remote digital cameras and are usually accessible for viewing on a project website. This technology is utilized in a variety of ways but has become quite popular in construction and is now readily available on many job sites. These cameras provide 24-hour access to the building site by any member of the project team who is authorized to access the website. The opportunity now exists to sit in an office hundreds of miles away and attend an on-site meeting where a specific construction problem is being discussed. You can see the work as it is being performed in real time. Although web cams should never be used as an excuse for not visiting the job site in person, they are definitely useful for keeping an eye on things between visits.

NOTE

In addition to providing real-time access to the job site, web cameras have become an amazing tool for teaching construction management in the classroom. Streaming video creates the opportunity to take your students on a virtual field trip.

Correspondence

Every day, numerous communications are generated among the project participants. Emails, letters, and faxes fly back and forth among the architects, engineers, owner reps, building officials, subcontractors, material suppliers, testing organizations, government agencies, and

community groups. All of the correspondence must be filed and recorded throughout the duration of the project. The types of documents that must be saved include the following:

- ◆ Submittals
- ◆ Payment requests
- ◆ Punch lists
- ◆ Change orders
- ◆ *Transmittals*
- ◆ Requests for information
- ◆ Letters
- ◆ Emails
- ◆ Faxes
- ◆ Miscellaneous items

transmittals

A tracking document that serves as a cover notification to any communication, submittal, or shop drawing being transmitted among the project participants.

Today most of these documents are created and stored electronically. It should go without saying that these records should be backed up on a regular basis. Handwritten documents are usually filed in three-ring binders. Although this may seem like a lot of work, it takes only one major claim or lawsuit to justify the effort.

Paperwork and record keeping are not the only non-construction-related activities that the superintendent and on-site construction management team must contend with. They must also handle a number of public relations issues.

Public Relations

Every construction project requires some level of public relations work to be managed by the superintendent. Because the superintendent is the frontline representative for the company, it is important that good relations be established and maintained throughout the duration of the construction. Although most superintendents will probably tell you that they would rather deal strictly with construction issues, they understand that they must sometimes contend with owner relations, employee issues, subcontractor conflicts, company image, and publicity.

Owner Relations

I cannot stress enough how very important it is to maintain positive, cooperative relations with the project owner and their representatives. This requires a high level of communication. Making the extra effort to ensure that the owner is in the loop when it comes to project progress is vital.

Although most formal communications must be routed through the architect, I have found that it is very beneficial for the project manager to pick up the phone and check in with the owner (or the owner's job site representatives) on a weekly basis. The superintendent is really the first line of communication on the job site, but most owners really appreciate the extra consideration. You would be amazed at how often a potentially serious conflict can be defused with just a simple phone call. Whatever action can be taken to catch and discuss problems while they are still small is always in the contractor's best interest.

One of the ways that the construction industry has increased overall owner involvement in the construction process is through a variety of collaborative software programs. These programs establish intranet sites that allow the owner to take part in the numerous discussions between the designers and contractors as they work out the details of the construction. This helps eliminate problems when someone gets left out of the communication loop. Most large contractors now use some type of collaborative software to integrate all of their project management systems. Web cameras are often linked to these intranet sites, which allows the owner and other authorized parties to watch the work as it is being performed.

NOTE

One of the most popular construction management software programs on the market today is Procore. This platform is a cloud-based application that helps construction companies increase their project efficiencies and accountability by streamlining project communications and documentation. ProCore offers applications in project management, quality and safety, construction financials, and field productivity. Users can access and manage their projects and information from any web-connected mobile device, tablet, laptop, or desktop. To learn more about Procore, go to <https://www.procore.com>.

Employee Relations

A number of employee issues must be addressed by the superintendent when managing the construction operations. Some of them warrant strict policies and procedures, such as sexual harassment and drug and alcohol use, while others are dealt with only as issues arise, such as personality conflicts among individual project team members. Let's take a look at some of the more serious problems.

Racial and Sexual Harassment

Harassment is a serious issue and should not be tolerated in any work environment. The company leadership must send a very strong message regarding specific anti-harassment policies. All managers and superintendents should be trained to recognize and stop all forms of racial and sexual harassment and be required to communicate a zero tolerance for harassment philosophy to the workforce on-site. Failure to do so can end up being very costly to the contractor and destroy company morale in a hurry.

Even seemingly harmless actions such as graffiti can no longer be viewed as naive expressions. A company can now be held liable for failing to curb such immature behavior when it contains racial or sexual innuendo. For example, in January 2000, a \$1.3 million settlement was

reached between the U.S. Equal Employment Opportunity Commission (EEOC) and a large construction company based in New Jersey that performs work throughout the United States. The lawsuit arose from complaints received by the EEOC regarding racial and sexual harassment at a specific construction project in Illinois. The harassment included racist and sexist graffiti in portable toilets on the job site.

The attorney prosecuting the case made this statement upon notification of the award: “This case ought to serve as a lesson to the construction industry at large. Racial and sexual harassment, including racial and sexual graffiti, is no more acceptable at construction sites than at other places of business. It's illegal, and construction industry employers who permit it may be looking at costly litigation.” The attorney went on to say, “the case was important because it challenged a persistent problem in the construction industry, harassment in the form of graffiti.”

Obviously, there are more blatant expressions of harassment than graffiti, but this example shows just how serious the issue is. No matter what your views are regarding the credibility or fairness of harassment claims and awards, there is no doubt that the stakes in permitting questionable behavior are getting very high. A workforce left unchecked when it comes to any kind of irresponsible and harassing behavior is a liability.

Drug and Alcohol Policy

Construction is a dangerous business. The use of drugs and alcohol cannot be tolerated on the job site. It is critical that every construction company have a written policy regarding substance abuse. The policy must be posted and clearly visible on the job, and the superintendent must uphold the requirements of the policy to the letter. The superintendent is responsible for making it crystal clear to every subcontractor and every worker on-site exactly what that policy is and what the consequences of violating it are. (This very important issue will be addressed in further detail in [Chapter 13](#).)

Subcontractor Relations

It would probably be a miracle if your construction project completed without experiencing at least one conflict among subcontractors,

between a subcontractor and a vendor, or even among your own management team. But part of the job of a superintendent is to referee conflicts and do whatever can be done to defuse tensions and maintain high morale among all members of the project team. This is not always an easy task, but it is a crucial one. The project's success depends on it.

Most conflicts on the job site arise out of misunderstandings and scheduling snafus, both of which can be avoided. Good communication networks and conscientious planning efforts help prevent most of the serious conflicts that can arise among co-workers. Getting projects built on time and within budget is hard enough when everyone gets along and enjoys what they are doing every day. Trying to accomplish this task when people are fighting and complaining just makes it that much more difficult. The best superintendents possess at least as much leadership ability as they do construction knowledge.

Company Image and Publicity

Although it may not seem as if publicity should be considered part of construction operations or job site management, the truth is that your construction project is one of the biggest advertising tools that you have. The problem with this notion is that the publicity could end up being a good thing or a bad thing. For example, if your project is a high-profile, greatly appreciated facility, viewed as contributing to the overall betterment of the community, that is a good thing. On the other hand, if the project ends up in the middle of some political or social controversy where picketers are standing outside your entrance gate every morning, that can be a bad thing. Either way, the issue must be managed both at the job site level and at the corporate level. The key is not to let the publicity interfere with the actual work of getting the project built in as timely a manner as possible.

To start, it always helps to be perceived as a good neighbor. Keeping the job site clean, limiting the noise, and controlling the dust all adds to your company's image as a responsible contractor. Making the effort to keep nearby residents and businesses informed about your activities—especially those that will cause inconveniences, such as late-night concrete pours or temporary traffic detours—will help maintain harmony and save you a lot of headaches.

There are numerous ways in which to make an impression while constructing your project and doing your job. As stated earlier, nothing speaks louder than the quality of your work and the conduct of your people. However, there are a couple of simple additional things that you may want to consider, covered next.

Signage

Job signage is one of the easiest ways to advertise your company and bring attention to your construction abilities. Most construction contracts require that the contractor fabricate and install a large construction sign at a prominent location on-site that announces the project name, the project architect, engineers, general contractor, major subcontractors, and major financier.

Other types of signage are commonly displayed on construction sites. There are signs painted on company vehicles and company equipment and logos pasted on company hardhats. Many contractors fly large

banners at the top of their high-rise buildings under construction or on top of their cranes high in the air to advertise their company name. I recently visited a rather prominent developer/builder on the East Coast, and I was surprised to witness three superintendents all arguing over which one was going to get to fly the largest of the company banners on the job. Apparently all three projects had high visibility, and each superintendent wanted to make sure that the community was aware of exactly who was responsible for bringing these new facilities to the area.

Dealing with the Media

When you work on high-profile projects, it is not uncommon to encounter the press. Sometimes they may even show up on your job site unannounced. The superintendent must make sure that they are never allowed to wander around the construction site unescorted. First, it is dangerous, and second, you need to be fully aware of what they are photographing with their cameras and who they are talking to.

Some projects actually warrant a full-time public relations person to handle all media requests. However, if you do have the opportunity to be interviewed by the press or for television, make sure that you are equipped with accurate information and the authority to speak. It is always a good idea to discuss publicity issues with the owner up front. You don't want to do anything that might damage your relationship, and it is very easy to slip up and say something you should not have said. The possibility of your words being misconstrued is always a risk.

On the other hand, under the right conditions, free press can end up being a boon for your marketing plan. For example, I had a client back in the early 1990s who was remodeling a unique historic home. The local newspaper decided to do an article on the project (because of its historical significance) and interviewed me at length on the job site. A photo of me inside the house and a lengthy article ended up on the front page of the real estate section in the Sunday edition of the paper. That little interview ended up being worth about \$15,000 of free publicity for me. The phone started ringing off the hook from all over the state. Apparently a lot of people were interested in remodeling their historic homes!

NOTE

It may surprise you to learn that both the National Association of Homebuilders and the Associated General Contractors conduct workshops teaching contractors how to deal with the media and do live interviews. I took the course myself years ago and can tell you that it was very professional and improved my public interviewing skills tremendously. Once again, you can clearly see that there is a lot more to this construction business than bricks, sticks, hammers, and nails!

Applying Technology

The tasks associated with construction operations and site management are quite varied and generally take place in real time at the project site. Even though it has been reported by some that 75 percent of the construction management process takes place in the field during the actual construction phase, technologies to support these activities have been slow to develop. However, we are beginning to see more and more technologies developed for field work.

Often dubbed *construction field mobility software* or simply *construction field software*, these technologies typically use pen-based tablet PCs loaded with digital plans and specs to automate field processes associated with everything from productivity, change orders, and submittal approvals to deliveries, quality checks, and the management of punch lists. Their primary advantage is to communicate field information instantaneously back to the office or directly to subcontractors, vendors, architects, and clients so that decisions can be made and actions taken quickly. You can just imagine how this relieves the superintendent, field engineers, and other on-site personnel from the tedious task of making field observations and then going back to the job site trailer to follow them up with all kinds of reporting forms and paperwork. Instead of lugging paper plans and specs around the job site and recording everything on clipboards to be transferred to field notebooks, writing up RFIs, and documenting punch-list tasks, the field personnel can simply communicate their needs and requests in real time by making their notes in their PC

tablets, which link to other software programs and technologies. This frees them up to focus on more important tasks such as overseeing construction and making timely decisions to keep the project rolling.

These new field-friendly devices are growing in popularity, especially with new superintendents and on-site project managers. As this trend continues, they are likely to become standard equipment on most job sites. ProCore has established itself as a prominent developer of these construction field software programs. As such equipment is increasingly embraced, we will begin to see a whole generation of field mobility devices and software utilized on the construction site.

Terms to Know

back charges	site logistics plan
concrete washout station	straw wattles
dry shacks	transmittals
laydown area	will-call

Review Questions

1. Identify at least three issues that the superintendent must be concerned with when trying to manage construction operations.
2. When scheduling subcontractors for the job, you should try to follow three fundamental rules. What are they?
3. What does it mean to order something on will-call?
4. Identify at least three factors that can negatively impact construction productivity.
5. Identify at least three environmental issues that might interfere with the project schedule and cause unexpected delays on the job.
6. What is a laydown area?
7. What types of information should be shown on a site logistics plan? Name at least four items.
8. Why is it important for the job superintendent and the other members of the on-site team to keep project diaries?
9. Why is it important to accurately report hours and cost codes on time cards?
10. Identify the way in which the construction industry has increased overall owner involvement in the construction process.
11. What does SWPPP stand for and what is its purpose?

Chapter 11

Project Planning and Scheduling

In This Chapter

- ◆ How schedules are used in construction
- ◆ How to plan job activities
- ◆ How to assign activity durations
- ◆ How to determine when the project will be complete
- ◆ How to update the schedule

Trying to take on a construction project without a well-thought-out plan is like trying to drive to an unknown location without a map. Without a plan, there is no way to coordinate your workforce, no way to schedule deliveries, no way to track progress, and no way to make adjustments when you do get off track. As a matter of fact, you won't even know that you are off track unless you have a plan. And given what is at stake if the project should stray off course, it would be ludicrous to think you could manage the construction of a multimillion-dollar facility, or even the construction of someone's home, without a plan. The primary tool associated with project planning is the schedule.

In the introduction to [Chapter 8](#), “Estimating Project Costs,” I said that there are always two questions asked by a client considering an investment in construction: “How much?” and “How long?” You learned in [Chapter 8](#) that estimating addresses the “How much?” question. Scheduling addresses “How long?”

Planning and scheduling concern two interrelated elements of construction management: strategy and time. Every construction project presents a new set of circumstances and conditions. The project team must come together at the start of the job and hammer out the details associated with both of these elements before the first shovel of dirt is turned on the project.

It's All About Time!

We've all heard the expression "Time is money." When it comes to managing a construction project, that statement is especially true.

Let's look at it from the owner's perspective. Manufacturers, industrial facilities, or service facilities do not make their money by constructing buildings. They make their money by making and selling widgets or providing their services. As long as their new facility is under construction, it is a liability. The facility becomes an asset to them only when it is completed and can function as it was intended. So, completing a project on time is a *big* deal. However, completing a project on time does not happen by accident. It takes a great deal of effort and planning. You have already learned in previous chapters that there are many factors that can interfere and delay the work. A good plan and a reliable schedule will help you prepare and avoid some of those factors that can derail your project.

Trying to plan, assign durations, and schedule every little activity associated with building a project that is going to take 1, 2, or even 10 years is an awesome task. But it is exactly what you are challenged to do as a construction manager. You must break the project down into manageable activities linked to increments of time that can be monitored and adjusted as the project schedule moves along.

How long will the project take to complete? Just as with cost estimating, no one really knows until the project is all done. But as a construction professional, your job is to make your best educated guess based on the experience of your project team and using the planning and scheduling tools available. Let's take a look at some of those tools now.

Types of Schedules

Although several different types of schedules are used in the construction industry, the two most common types are *Gantt charts* (also called *bar charts*) and *network diagrams*. Which type a construction manager uses depends on a number of factors, some company-related and some project-related:

Gantt charts

Considered revolutionary when Henry Gantt first published this planning tool around 1910, a Gantt chart is a type of bar chart that illustrates a project schedule. It illustrates the start and finish dates of the various activities of a project.

network diagrams

A common type of construction schedule, also called the critical path method (CPM), which depicts a continuous chain of activities showing both activity durations and the relationship of the activities. There are two types of network diagrams: Arrow Diagram Method (ADM), or activity-on-arrow (AOA), and Precedence Diagram Method (PDM), or activity-on-node (AON). Currently, PDM or AON scheduling techniques are mostly used. PDM as a scheduling technique allows for overlapping of concurrent activities so most scheduling software tools mainly utilize PDM.

- ◆ Size of the company
- ◆ Volume of work
- ◆ Type of construction
- ◆ Project size
- ◆ Project complexity
- ◆ Computer capability

◆ Contract requirements

For some projects, a simple Gantt chart is all that is needed, because the project is straightforward with a limited number of activities and systems. Complex projects require the more sophisticated scheduling techniques made possible by network diagrams. Most contractors employ both types of schedules and apply them to best suit the scheduling needs presented. Most network diagrams can be displayed as a Gantt chart or bar chart.

NOTE

You will encounter a whole menagerie of scheduling techniques and formats in the construction industry. Although practically all large construction companies today use some type of computerized network scheduling program, some smaller operations, especially in the residential market, still depend on hand-drawn Gantt charts or use Excel spreadsheets

Gantt Charts

You are probably pretty familiar with Gantt charts already. The big advantage to Gantt chart schedules is that they are very easy to understand and follow. That's because they can relate activities, and their durations, to calendar days. You can easily see and understand when an activity will begin and when it will end. The biggest disadvantage to Gantt charts is that they do not show the interrelationships among the activities. For example, Gantt charts are not very good at showing the impact that a delay in one activity might have on another activity or on the overall duration of the project. These impacts can be shown only in a network diagram. For complex projects, it is critical to be able to assess these relationships.

Activities	Weeks																							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
Layout																								
Sitework & excavation																								
Foundations																								
Structure																								
Roof																								
Walls																								
Exterior doors & windows																								
Interior partitions																								
Finishes																								
Plumbing																								
HVAC																								
Electrical																								
Closeout																								

NOTE

Gantt charts provide visual clarity. They are very good schedules for presenting the project timeline to the owner, end-user groups, and the public. Such charts are easily understood and do a good job of identifying when things start and when things end, which is what an owner is most interested in. Owners don't particularly care about the relationships between activities—they are primarily concerned with when the job will be done. The ease of reading Gantt charts has led the scheduling software industry to create a bar chart view even when using PDM scheduling.

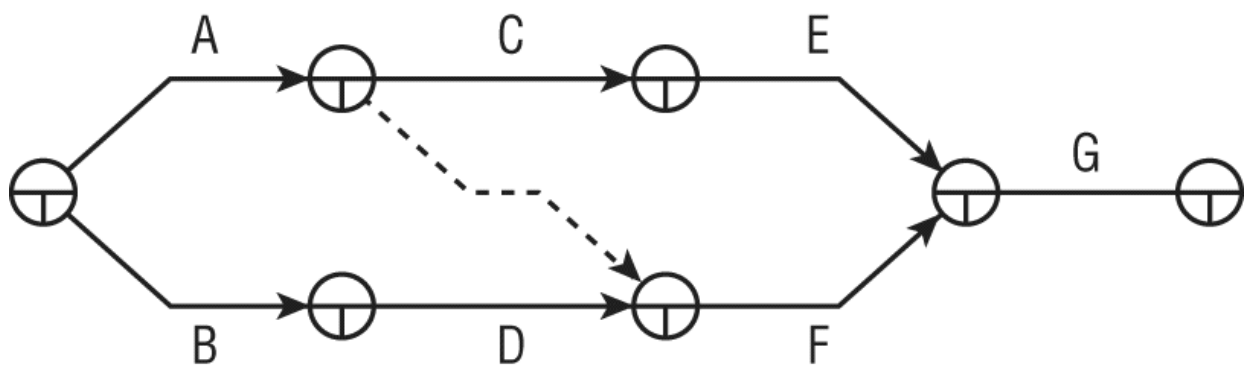
Network Diagrams

Many activities in construction are dependent upon other activities in construction. For example, you can't paint until the drywall is in place, and you can't install drywall until the walls are framed, and you can't frame walls until the floor system is in place, and you can't install the floor system until the foundation is in place. I could continue with this string of activities, but I think you get my point.

Not only are the activities often dependent upon one another, but many activities also overlap or run parallel to one another. For instance, electricians can be pulling wire on the inside of the building at the same time the masons are installing the brick veneer on the outside of the building. Network diagrams give us a structural tool that combines activity relationships and activity durations to best determine the right schedule for the project. Although Gantt charts are very easy to understand, they don't really provide the level of sophistication needed to evaluate and examine the relationships between activities as well as the network diagram.

The network diagram method of scheduling, also referred to as the *critical path method* (CPM), is the most common type of schedule used in the commercial, civil, and industrial construction industry today. (I'll discuss the critical path later in the chapter.) Although there are plenty of projects that can be managed from a Gantt chart schedule, the more complex jobs require the more sophisticated method.

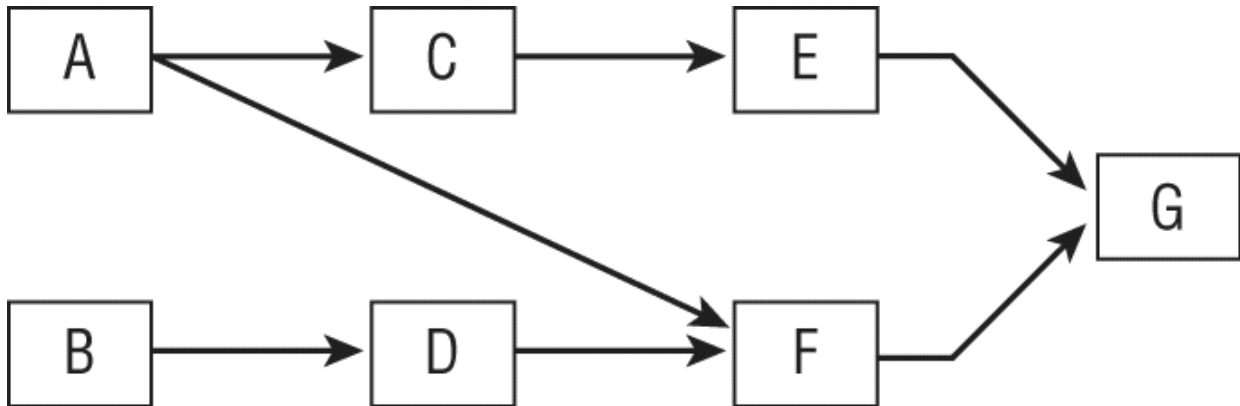
There are two techniques used to develop a network diagram. The first is called the Arrow Diagram Method (ADM). Activities are noted on the arrow, as shown next.



The second technique is called the Precedence Diagram Method (PDM). With the PDM approach activities are indicated on the node, as shown next. The Precedence Diagram Method, is sometimes called *precedence diagramming*, and is the method of choice for most of the industry. Therefore, my focus throughout the chapter will be on precedence diagramming or the PDM approach.

precedence diagramming

A graphic presentation of a schedule depicting project activities on a node with an arrow that depicts the dependencies that exist between the activities.



NOTE

The Arrow Diagram Method (ADM) was once called the activity-on-arrow (AOA) method. The Precedence Diagram Method (PDM) was referred to as the activity-on-node (AON) method. Currently, the PDM or AON scheduling techniques are mostly used. PDM as a scheduling technique allows for overlapping of concurrent activities so most scheduling software tools mainly utilize PDM.

How We Use Schedules

Schedules serve a number of purposes in the construction industry. How the schedule is to be used will determine the complexity and level of detail that it contains. Because it is a communication and management tool, it's important that the information being conveyed is understandable and appropriate for its intended purpose.

Detailed schedules As the name implies, detailed schedules break major work activities down into smaller tasks so the schedule can be analyzed in greater detail. For example, foundations would be broken down into formwork, reinforcing, and cast-in-place concrete. These categories would be broken down even further in the schedule. Detailed schedules are often used at the field office level to discuss the finer points of a work activity. They are often pinned up on the office wall with highlighting and red lines all over them as details of the job are discussed.

Summary schedules Summary schedules group activities under broader headings such as mobilization, site work, foundation, and rough framing. These schedules are most often used for management reports and presentations where it is important to convey the overall plan and status of the work but not necessarily all of the details of that plan. Summary schedules might be developed at the Work Breakdown Structure (WBS) level.

Mini-schedules Basically, a mini-schedule is any portion of a summary or detailed schedule broken down into even finer detail. Sometimes a particular division or area of work requires more scrutiny regarding the various activities needed to accomplish the work—such as the mechanical division, which includes plumbing and heating, ventilation, and air conditioning (HVAC).

short-interval schedules

Also called look-ahead schedules, they are typically prepared by superintendents and focus on relatively short periods of time, such as two to six weeks. These schedules are usually provided to trade contractors and focus on specific areas of work in greater detail than is provided in the overall project schedule.

Short-interval schedules *Short-interval schedules*, also called *look-ahead schedules*, are developed by superintendents and trade foremen to coordinate activities and manage the work flow

over a relatively short period of time, usually two- to six-week intervals. They used to be hand-drawn but with the use of computer software, most look-ahead schedules are completed with either Excel or a filtered view from a scheduling tool, and are distributed to the specific trades involved. Although they originate from the larger detailed schedules intended for management, the look-ahead schedule really acts like an individual work plan for the work crews on site.

Special-purpose schedules Not all schedules used in construction are used to organize and sequence work. Some schedules are used to keep track of activities that support the work, such as delivery schedules, equipment schedules, submittal schedules, and inspection schedules. However, some of these activities should also be integrated into the detailed schedule to make sure that their impact is not overlooked in the overall plan. I'll explain more about the importance of an integrated schedule later in this chapter.

Now that you have an idea about how schedules are used, let's take a look at how to create one.

Building the Schedule

One of the great things about being on the team that develops the project schedule is that you really get to think through the project before it is ever built. Similar to the estimating process, scheduling forces you to consider details and elements of the job long before you ever encounter them on the job site.

You'll get to think about all of the materials, labor, subcontractors, and equipment that it will take to complete the project. You'll also get to consider all the factors that influence the efficient use of those resources. You'll have a chance to ponder and discuss the circumstances that could slow down the process and cause the project to be delayed. You'll have an opportunity to develop the strategy that will carry the project to a successful completion.

It's a lot of work to mentally process all of this information, but this is what it takes to put together a construction schedule. It also takes experience and a good knowledge of the construction process so that you can identify and sequence all of the activities needed to complete the job. In addition, you'll have to perform a few scheduling calculations.

Because most construction projects are scheduled using the Critical Path Method with network diagrams, I am going to focus my discussion on how to build a precedence diagram schedule. There are three fundamental stages to this process:

- ◆ The planning stage
- ◆ The sequencing stage
- ◆ The scheduling stage

I'll walk you through these three stages.

The Planning Stage

Planning is at the heart of creating the schedule. Just as with estimating, you need to start with the drawings and specs. You need to read the plans (floor plans, elevations, details, and sections) in order to understand and identify what activities need to be completed

in order to build the project. An activity is a task, function, or decision that has a time commitment, or duration, associated with it. Activities provide the fundamental building blocks of the schedule.

Although novice builders can usually come up with an activity list, the more experienced you are, the easier it is and the less likely you will overlook any of the steps needed to get from A to Z—or in construction terms, from mobilization to project closeout.

When developing an activity list, it is important to consider the purpose of the schedule and who will use it. The number of activities and the level of detail needed in the schedule will vary from job to job. The more complex the project, the more detailed the activity list will be. The detail level should correlate with the control level desired. The goal is to have enough activities and just the right amount of detail so that you can effectively monitor and manage the work flow (see [Table 11.1](#)).

[Table 11.1](#) Level of Detail

Activity Detail: Adequate	Activity Detail: Too Much
Frame floor system	Frame floor system –Install sill plates. –Install rim joists. –Install floor joists. –Install blocking. –Install subfloor.
Frame wall system	Frame wall system –Install bottom plates. –Install studs. –Install headers. –Install top plates.
Frame roof system	Frame roof system –Install roof trusses. –Install bracing. –Install roof sheathing.

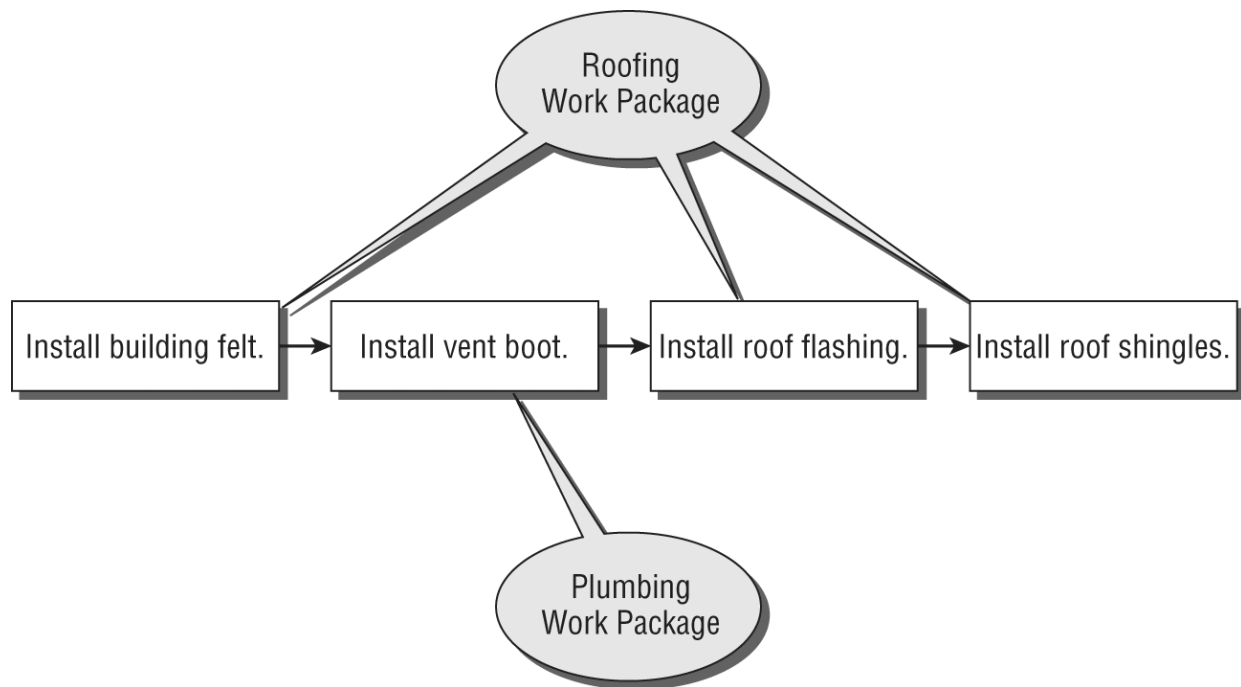
Using the Work Breakdown Structure

What is the best way to make sure you have identified all of the activities needed to manage the project effectively? In [Chapter 8](#), I introduced you to the concept of the work breakdown structure (WBS). If you recall, the purpose of the WBS is to organize and identify the work of the project by breaking each division into separate work packages, assembled around the work activities typically performed by a single trade subcontractor or work group. When estimating, you use the WBS to develop bid packages for pricing purposes. When scheduling, you use the WBS to breakdown the scope of work for the project into smaller manageable chunks of work to help develop your activity list.

For example, when estimating a work package for roofing, you would include three activities:

- ◆ Install building felt.
- ◆ Install roof flashing.
- ◆ Install roof shingles.

Each of these activities would be performed by a roofing subcontractor. However, the construction manager has to be careful not to let any required work activity slip through the cracks. This roofing work package is an excellent example, because there is one more activity that must be performed by the roofer but is typically included in the plumber's work package. That item is the plumbing vent flashing, commonly called a *vent boot*. The vent boot (special flashing configuration) is installed after the building felt but prior to the shingles.



This unique circumstance requires a special schedule consideration because the rest of the plumbing package will most likely not be performed until later in the schedule. So, although the WBS is very helpful when it comes to identifying activities for the schedule, you must be aware that trade contractors (or parts of their packages) may appear more than once in the schedule if they perform more than one activity or if they perform work at different stages of the project. This is why the WBS for a schedule needs to breakdown the work scope, and not who is doing the work.

Interface issues among trades is just one of the factors that can make the activity-listing task kind of tricky. That's why it is so important to engage team members with experience in the scheduling development process whenever possible. The ultimate goal of the construction manager is to make sure that there are no overlaps and no holes in their activity list and overall work plan.

Types of Activities

There are hundreds of steps to getting from mobilization to project closeout, and although all of the steps have a time frame associated with them, they don't all have to do with the actual building of the structure. Some have to do with supporting the building of the structure, such as submitting light fixture orders or securing the

building permit. There are three types of activities that must be planned and included in the schedule: administrative, procurement, and production. Most schedules include all three types of activities.

Administrative activities These activities are mostly associated with contract administration tasks such as permitting, submittals, inspections, and testing. All of these activities can eat up a lot of time and are probably some of the most unpredictable activities on the schedule. Permit processing, for example, is really out of the contractor's hands. Therefore, the contractor has very little control over the activity. Although the contractor knows that the activity must occur and when it must happen, the duration of this activity is often a hopeful guess. It's the same thing with submittals. Sometimes a color or sample submittal is rejected initially by the architect, and the contractor has to resubmit it for approval. So, predicting time on these types of activities can be pretty nerve-racking, especially when the scheduling of the actual construction work depends on accurate time estimates.

Procurement activities These activities are primarily associated with obtaining materials and equipment for the project. They can be some of the most crucial activities in the schedule and, if not properly considered, can cause major delays on the project. For example, steel is often a long lead item (you learned about long lead items in [Chapter 8](#)). If the steel delivery activity is not accurately displayed in the schedule and the ordering of the material comes later in the project than it should have, the project may suffer dire consequences. Once again, that's why it is so very important that several experienced members of the project team be involved in creating the activity list.

Production activities These activities identify tasks that are associated with the physical building of the project, such as pouring concrete foundation, erecting structural steel, or hanging acoustic ceiling. For further clarification, sometimes these activities have to be identified with their location. For example, in a multi-story office building, an activity might read “Hang first-floor acoustic ceiling.”

Some production activities don't actually require any physical effort, but they do take time. For example, concrete requires a certain amount of time to cure. Although there is no physical activity associated with the curing of concrete, the activity needs to be identified in the schedule because there is a time requirement associated with it.



Although a number of these types of activities should be integrated into the detailed schedule, sometimes they are assembled into a special schedule, as indicated earlier in this chapter.

The Sequencing Stage

Once you have identified all the activities that need to be performed on your project, it is time to develop the sequencing of those activities, or *network logic*. In other words, in what order must these activities occur, and which ones can occur simultaneously? This is where we begin to consider and define the relationships among the various activities. As stated earlier, the PDM technique is the most commonly used method in the industry, so this is the technique that I will describe.

network logic

The order in which activities are sequenced in the network diagram relative to their interdependent relationships.

When developing the sequence, there are four types of activity relationships to consider.

- ◆ **Physical relationship**—Work activities that require the predecessor activity to be completed before the successor activity

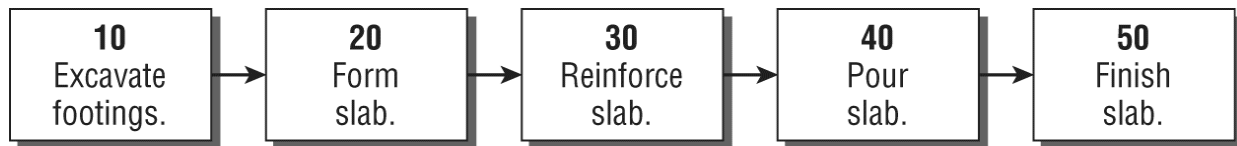
can be completed. Example: Footing excavation must take place before placing the concrete in the footing.

- ◆ Safety relationship—Work activities that would be unsafe or cause a safety hazard if completed at the same time. Example: Performing roofing while another subcontractor is doing work below them like installing siding.
- ◆ Resource relationship—Work activities that need the same resource and both activities cannot be completed by the same resource. Example: Where the subcontractor has only one crew, so they cannot work on multiple levels at the same time. The crew will move from framing one level to framing the next level.
- ◆ Preferential relationship—Work activities where the contractor and subcontractor have a preferred way or sequence of performing their work together. Example: Painting the walls first, then install the flooring, and then install and paint the trim.

Developing the Precedence Diagram

A network diagram is nothing more than a work plan. Although the work plan should flow without interruption, it must be understood that the order in which the work occurs is somewhat flexible. In other words, different contractors will take a different approach to sequencing the work. For example, the coordination of interior trim work with painting can be handled in a couple of different ways. Some contractors will insist on installing all interior trim first, taping it off, and then painting the walls. Others will insist that the walls should be painted first, then the trim should be installed, and then touch-up painting should be done. Both sequences will work. The construction manager, along with the project team, will decide the best path to move the project from start to finish. The great thing about this process is that it gives the project team an opportunity to brainstorm the plan together and organize the job before it goes to the field. The important thing is that once the plan is in place, the team actually uses it!

In the PDM approach, each node identifies an individual activity and is assigned an activity number. This number must be unique and now with BIM, some will build intelligence into the number.



The numbering system is particularly helpful for monitoring purposes and for identifying the activity with the owner, subcontractors, and vendors. Most current scheduling tools will automatically assign a unique identifier but will allow the users to re-number as needed either manually or automatically.

Relationships Among Activities

All network diagrams have a beginning and an end, and they are intended to flow continuously. Except for the first and last activity in the network (normally identified as start and finish milestones), each step has some activities that must come before it and some activities that must come after it. To figure out the network logic, you must ask the following basic questions regarding each individual activity:

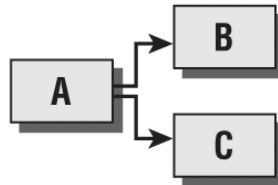
- ◆ Which activities must be completed before this activity can begin?
- ◆ Which activities can be started once this activity is completed?
- ◆ Which activities can be going on at the same time as this activity?

Once you have figured out the sequencing logic, you can start to plot the network. This can be a messy endeavor. It usually takes several tries before the team can get it just the way they want it. Once again, this is where experience really comes in handy. The following diagrams illustrate some of the sequencing patterns that start to emerge once the activities are evaluated.

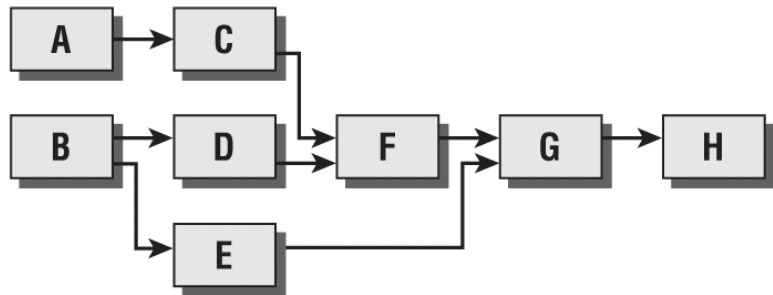
A must occur before B occurs, and C can't happen until B is complete.



A must occur before B and C can occur. B and C can occur simultaneously.



H cannot be done before G, and G is dependent upon the completion of E and F. F can't happen before C and D. D and E are preceded by B. C can't start until A is done.



NOTE

The invention of the Post-it note was a boon for construction scheduling. Post-it notes are often used to work out a network's logic on a wall, large piece of paper, or white board. Each activity is written on a sticky note and then placed in the proper sequence. On a complex project, it can take a lot of shuffling the notes around to get it right!

The Scheduling Stage

Now that all of the activities are identified and all of the sequencing is figured out, it is time to assign durations to each activity. After all, you don't really have a usable schedule until time is factored into the

equation. Although you already considered productivity as a factor of the estimate when you calculated unit costs, scheduling requires a different kind of estimate. Unit costs are applied to quantities of work and deal with “How much?” Schedules deal with “How long?” and reflect the efficiency with which you coordinate and utilize the resources needed to perform the work. You must accurately predict, to the best of your ability, how many days, weeks, months, or years it will take to complete the project. Several tools are available to you for making this prediction. You start by estimating how long it will take to perform each individual activity in the schedule.

Determining Activity Durations

In determining activity durations, the cost estimate is a good place to start because productivity can be determined from quantities already calculated in the estimate, but most construction managers and superintendents will rely on their experience and information obtained from their subcontractors when calculating durations for specific activities. But keep in mind that predicting durations is not an exact science. Even if you have been successful in identifying all of the steps needed to complete the job and have figured out the best way to sequence the activities, you may still miss the mark if you miscalculate the time it takes to complete the individual tasks.

When trying to establish activity durations, the project team must assess all factors that may potentially impact the time needed to complete any one of the activities. As you learned in [Chapter 8](#), weather impacts several activities in construction. For example, it takes a lot longer to finish concrete in the winter than it does in the summer. On the other hand, installing interior trim is virtually unaffected by the weather or the time of year. Here are some basic rules to follow when trying to determine activity durations:

- ◆ Try to evaluate each activity as an independent operation.
- ◆ Consult with experienced tradespeople to get their time estimates regarding specific activities.
- ◆ Initially, assume a standard crew size and makeup for the activity.
- ◆ Adjust production rates to fit the specific job conditions.

- ◆ Use a standard eight-hour day as your unit of measure.

Once you come up with how long you think each activity will take, it is time to start putting all of this information together to create the schedule network and use it to determine the overall project duration. We always determine the duration of the activities in work days not calendar days.

How Long Will This Job Take?

At first glance, it may seem quite easy to come up with the overall project duration by adding up all of the individual activity durations. Ah, but remember: not all activities require that all preceding activities be complete before they can begin. Many activities can be going on simultaneously. As a matter of fact, one of the goals of the construction manager is to maximize the workday output by coming up with ways to have multiple crews working on multiple activities without interfering with one another.

So if we don't just add up the individual durations, how do we figure out how long the project will take to build? This is where the CPM concept comes into play. By using the CPM precedence diagramming method, you are able to determine the following:

- ◆ How long it will take to complete the project—the overall schedule length
- ◆ What activity times must absolutely stay on track in order to meet the planned schedule—critical path
- ◆ What activity times have some leeway and flexibility in them without jeopardizing the schedule

critical path

The longest path through a network diagram schedule and includes those activities that have zero days of float. The critical path determines the overall project duration.

One of the reasons that the PDM works so well in construction is because it allows you to calculate the *critical path*. The critical path is the continuous chain of activities with the longest overall duration—or, more simply, the critical path is the project duration. Any delay in any activity along the critical path results in a delay in the overall project. If you are a construction manager or superintendent trying to meet your schedule targets, then it is pretty important for you to know which activities will impact the outcome most significantly so you can focus your attention there.

Schedule Calculations

Now it's time for the fun part of scheduling. It's time to do some calculations. By knowing each activity's individual duration and by using some standard critical path calculations, you can determine the early start, early finish, late start, and late finish of each activity. Not only that, but you can also determine exactly how much *total float* or slack you have in the noncritical activity times. Here I explain what each of these terms mean:

total float

The amount of leeway available to start or complete an individual schedule activity before it affects the planned project completion.

Early start (ES) This is the earliest possible time that an activity can start according to the relationships associated with the activity.

Early finish (EF) This is the earliest time that an activity can finish given its allocated duration.

Late finish (LF) This is the latest time that an activity can finish without delaying the project's completion as planned.

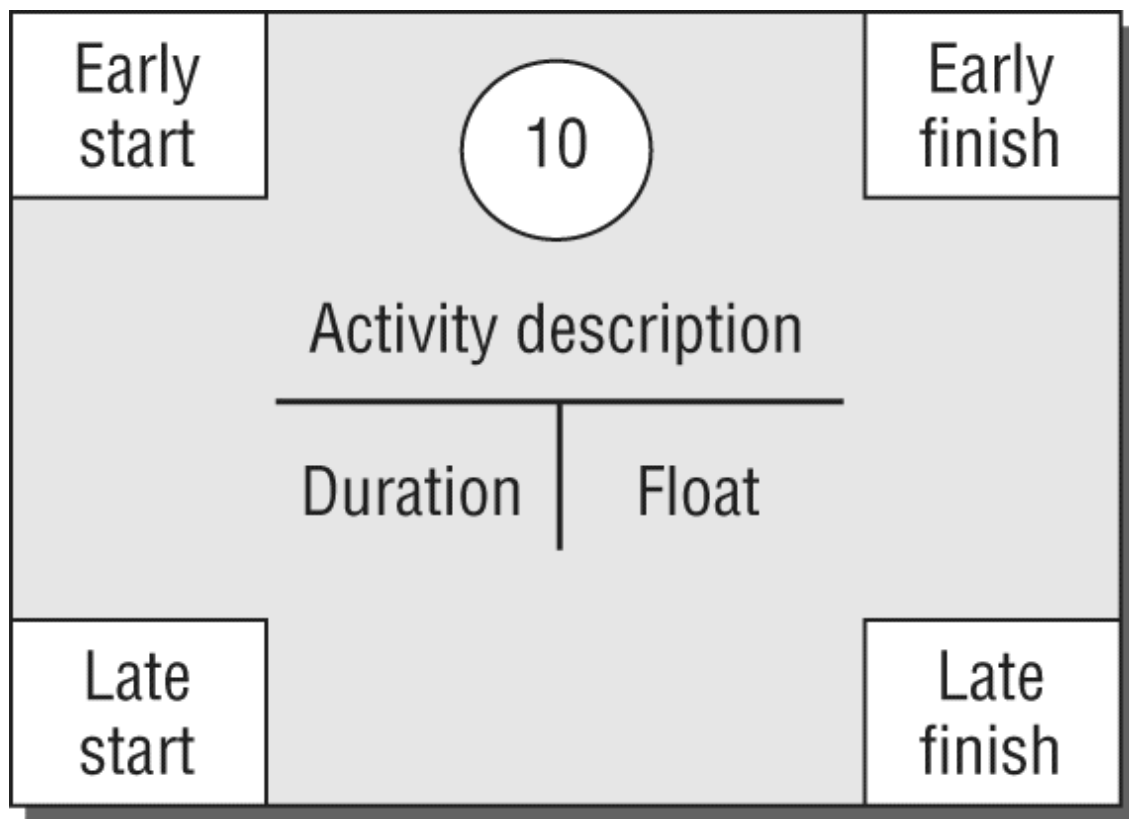
Late start (LS) This is the latest time that an activity can start without delaying the project's completion as planned.

Total float (TF) This is the amount of time an activity can be delayed before it impacts the project's completion as planned.

Total float also allows an activity to exceed its planned duration without becoming critical if its completion remains within its total float allowance.

Free float (FF) This is the amount of time each activity can be delayed before it impacts the successor start date.

Each of these concepts, along with the individual activity durations, is used to complete the schedule calculations. It all starts with the activity node. When you create the network, each node represents an individual activity, and all of the information listed earlier plus duration is labeled on the node, as shown here.



Let's presume that you have listed all the activities to complete a small project. You have come up with the proper sequencing and figured out how long each activity is going to take. [Table 11.2](#) lists all of your project information. (For illustration purposes, I am using letters to designate activities instead of descriptions and numbers.)

Table 11.2 Activity List

Activity	Dependent on Activity	Estimated Duration
A	—	1 day
B	A	3 days
C	A	2 days
D	A	4 days
E	B, C	2 days
F	C	5 days
G	E	3 days
H	E, F	6 days
I	D	3 days
J	G, H, I	3 days

Now you can use the information in the table to create a network diagram and do the critical path calculations. Once the network is drawn, you basically have to perform three computations; a *forward pass*, a *backward pass*, and a float calculation.

forward pass

A scheduling technique used to calculate an activity's early start and early finish. The forward pass must be completed before the project duration can be determined.

backward pass

A scheduling technique used to calculate an activity's late start and late finish.

Forward pass The forward pass determines the early start date, early finish date, and overall project duration.

Backward pass The backward pass determines the late start date and the late finish date.

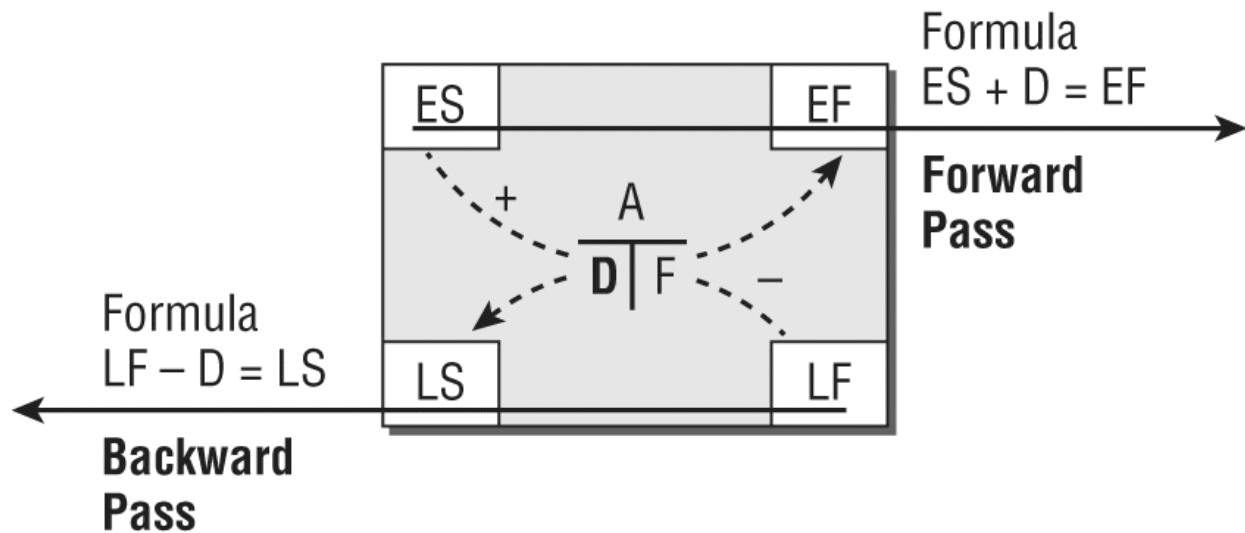
Total float calculations Total float for individual activities can be determined after the backward pass calculations are complete because total float is the difference between the late dates and the early dates.

There are some simple formulas and some basic rules to follow when making these calculations:

Early start + duration – 1 = early finish The forward pass calculations start at the beginning of the diagram at the first node and proceed forward to the end of the network. The first activity always has an early start time of “1,” so the first activity's early finish will always be equal to its duration.

The early finish of the last activity in the network equals the total project duration. Whenever a node has more than one activity preceding it, the highest early finish number must pass forward as the early start number on the node.

Late finish – duration + 1 = late start The backward pass calculations cannot be done until the forward pass is complete and the project duration is known. Backward pass calculations start at the end of the diagram and work backward to the beginning of the network. To start the pass, the late finish for the last activity is the same as the early finish for that activity. Whenever a node has more than one successor activity, the lowest late start number must pass backward as the late finish number on the node.



Float = late finish – early finish or late start – early start
 Float cannot be calculated until you complete the backward pass.
 It makes no difference which formula you use to calculate float.
 The important thing to know is that those activities with no float make up the critical path.

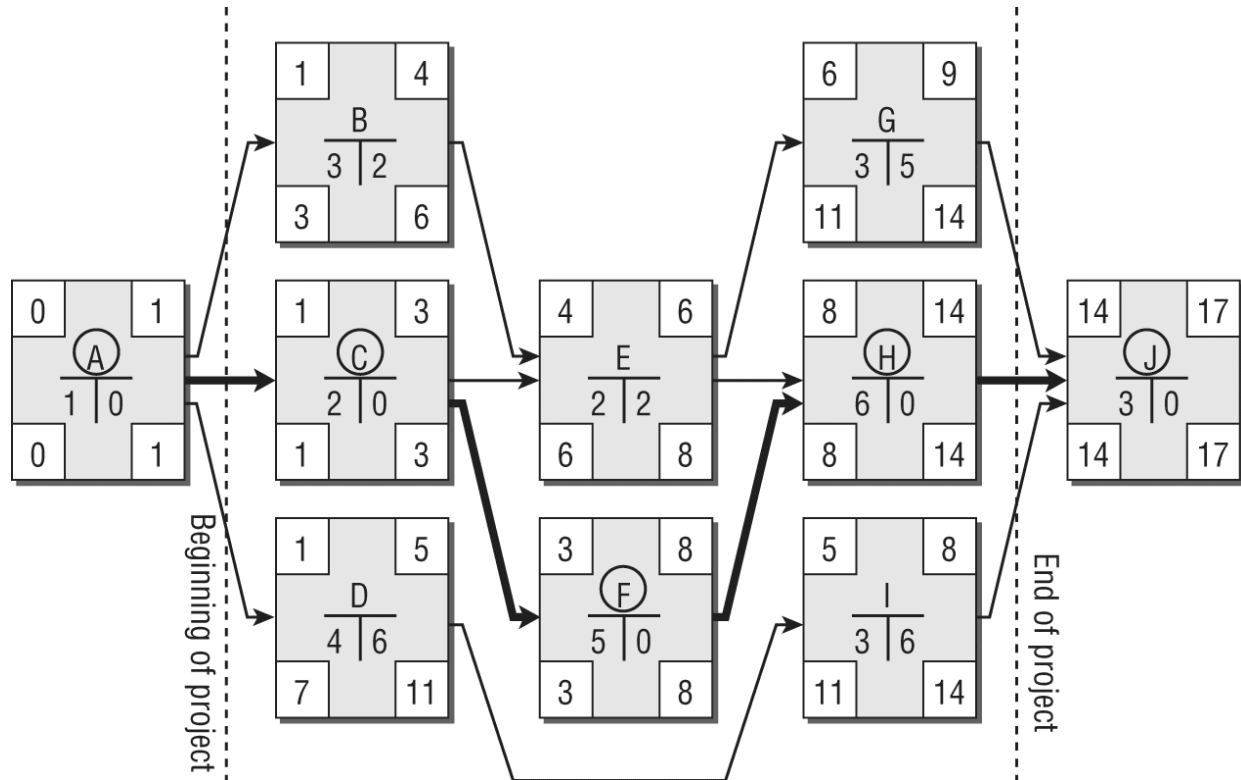
NOTE

In scheduling software, the program tools will calculate dates for each activity start and finish, taking into consideration when there are holidays and nonwork days.

The following network diagram, created from the information in [Table 11.2](#), illustrates a completed forward pass and backward pass, along with float calculations. The critical path is highlighted with a heavy black line, and the activities are circled. The results of these calculations are also shown after the diagram.

Project duration	17 workdays
Activities on the critical path	A, C, F, H, J
Noncritical activities, with float	B, D, E, G, I
–Activity B's total float	2 days
–Activity D's total float	6 days

–Activity E's total float	2 days
–Activity G's total float	5 days
–Activity I's total float	6 days



Keep in mind that each number in the diagram represents a workday, not a calendar day.

NOTE

The critical path can change throughout the duration of a project. Activities that possessed a lot of total float at the beginning of the project can become critical if they are delayed too much and exceed their total float. This is why it is very important to monitor and track all activities in the network, not just the critical ones.

It can take several years to become really proficient at creating network diagrams and CPM schedules. But I'm sure you can see what a powerful tool they can be for managing the construction schedule.

Fortunately, several computer programs are available that can create the networks and do all of the calculations for you, but you still have to come up with the activities, the sequencing, and the durations. These scheduling skills and abilities are fundamental to construction management.

NOTE

Several popular construction scheduling software programs are available. They include Oracle Primavera (P6), Elecosoft Asta Powerproject, and Microsoft Project. Sometimes the contract will actually require the contractor to use a particular software program because it corresponds to the system that the owner already uses internally. When this happens, the contractor is obliged to buy, learn, and use the new software, or propose an alternative and then train the owner.

Once you have created the schedule, it's time to actually put it to work. Next I'll explain how to use it to direct the construction operations and keep the project team updated regarding planned activities and job progress.

Communicating and Updating the Schedule

The schedule is one of the most powerful management tools that you have. It allows you to communicate the overall game plan for accomplishing the project goals to the owner, the subcontractors, the vendors, and your entire project team. But that doesn't mean that you can just sit back and watch the work unfold precisely as you had predicted. No, it's a lot messier than that. Both you and I know that most things in life don't always go the way we had planned. There is a lot of tweaking that takes place on that schedule before you ever get to a finished project.

Lots of things can go astray—deliveries can be delayed, the plumbers or electricians or carpet layers may not show up when they are supposed to, and your crews won't always accomplish what you had hoped they would in a workday. The schedule is not some fixed, rigid document that gets created and doesn't ever change. It is a dynamic tool, and every activity's duration on the schedule is tracked and monitored, with adjustments being made all along the way. Therefore, the schedule must be updated to reflect these adjustments on a regular basis.

These frequent updates must be communicated to the affected parties in the most efficient manner possible. Although you can always find a working version of the schedule pasted somewhere on the office trailer wall (remember the one with all the red lines and highlighting on it), it would be almost impossible to keep up with all of the changes manually. As previously mentioned, most construction companies use computerized scheduling software, and anyone working as part of the on-site construction management team will be familiar with this software. With a few keystrokes, any of the team members, such as a field engineer or assistant superintendent, can input changes and adjust activity starts, activity finishes, and activity durations. Once these modifications are entered, the computer automatically adjusts the overall schedule and re-calculates the critical path if need be. The updated schedule can then be electronically transferred to the senior management back at the main office as well as the subcontractors, vendors, designers, and owners. The updates can occur at time intervals as needed, but in most instances the overall schedule adjustments are posted monthly for the

owner, but weekly updates are needed by the superintendent to manage the near term work activities and discuss work scope with subcontractors and vendors.

Notifying Subcontractors

It is critically important that these changes get communicated in as timely a fashion as possible, especially to subcontractors. When a subcontractor signs on to perform a portion of the work, the subcontractor will create work plans and schedules based on the start date and finish date originally negotiated with the superintendent. Remember that subcontractors are performing work for a number of general contractors on a number of different jobs. They cannot drop everything they were working on just because you modified your schedule. The sooner the project manager or superintendent notifies them, the better. In this case, you don't want to wait until the overall schedule revisions are completed. You want to communicate specific time-line changes to your subcontractors using the more detailed short-interval schedules that I mentioned earlier in this chapter. These more detailed schedules are updated weekly and discussed with the individual subcontractor at an on-site meeting.

One of the common complaints lodged by subcontractors is that superintendents wait until the last minute to spring schedule changes on them. They then must hustle and scurry trying to adjust all of the schedules for their other jobs. They are forced to juggle their crews, causing significant inefficiencies and possibly disrupting the work flow on other projects. Getting such short notice is very frustrating and certainly not appreciated. Superintendents (and their companies) get a reputation for how they handle these schedule adjustments, and the subcontractors' pricing will often reflect their frustration with repeated occurrences of poor planning. Companies that convey schedule changes promptly and do a good job keeping the subcontractor in the communication loop may actually receive lower subcontractor bids than those who have a reputation for last-minute adjustments.

As potent a management tool as the schedule is, a superintendent who fails to make proper use of it will never benefit from its value. Constant monitoring of the actual project performance relative to the

planned performance helps the superintendent keep on top of the schedule changes. Once the actual performance data is entered into the schedule, the updates can be made very quickly and revisions can be communicated to the subcontractors immediately. This allows the subcontractors to likewise adjust their schedules as the project moves along.

Applying Technology

Planning activities, assigning durations, and scheduling every little work item associated with building a project are incredible tasks. It only makes sense that construction scheduling software has been readily used in the construction industry for some time.

Long before these software solutions were available, the construction manager would have to build a paper specimen of the schedule; depending on how in-depth the project was and what type of schedule was needed, the task could take days to develop and use up reams of paper that could circle a room once it was taped together and prepared for display.

Today computer programs have reduced the scheduling task to entering activities and assigning durations and sequencing relationships. With this information, the program will develop the network diagrams and Gantt charts necessary to establish the project plan and track progress. Furthermore, many scheduling programs will also allow the construction manager to handle everything from time sheets to resource management.

Because project scheduling is not limited to construction, a number of programs are available; for example, Microsoft Project can be used for construction but was not specifically developed for it. Some programs are quite simple, and others are very complex; of course, there is a wide range of price points available. And although just about any scheduling program can be used, several have been developed specifically for the construction industry. These are currently the most popular:

- ◆ Primavera P6 by Oracle
- ◆ Asta Powerproject by Elecosoft

Terms to Know

backward pass network diagrams
critical path network logic
total float precedence diagramming
forward pass short-interval schedules
Gantt chart

Review Questions

1. What are the two most common types of schedules used in construction?
2. Name the two techniques used to create a network diagram.
3. Precedence diagramming is another name for which type of network diagram?
4. What is a look-ahead schedule, and how is it used?
5. What are the three stages of network diagram development?
6. Name the three different types of activities that are included in the typical schedule, and give an example of each.
7. What is the critical path, and why is it important from a project management standpoint?
8. What is total float, or slack, in the schedule?
9. What are the three scheduling calculations that you must perform in order to determine the project duration and the critical path?
10. After you complete a forward and backward pass, how do you know which activities are on the critical path?

Chapter 12

Monitoring Project Performance

In This Chapter

- ◆ What factors influence project performance
- ◆ What types of field information must be collected
- ◆ How project costs are tracked and reported
- ◆ How the project schedule is monitored
- ◆ How corrections and modifications are implemented
- ◆ How project performance is documented

Once the construction contract is executed, it is the goal of the construction management team to complete the project for the contracted dollar amount and within the agreed time frame. This goal seems reasonable enough. After all, the superintendent and field crews can be counted on to do their jobs, and we can assume that our estimates and schedules are accurate. All we have to do is get out there and get the job done, hoping that everything turns out all right.

If only it were that simple. Once the construction starts, the “keeping score” element of construction management (referenced way back in [Chapter 2](#), “What Is Construction Management?”) kicks in. Every purchase order, subcontract, material invoice, and employee time card must be monitored, tracked, and recorded to ensure that the project plays out according to plan and has a reasonable chance of meeting the project goals for time, cost, and quality. If any one of these goals appears to be headed in the wrong direction, the project manager and superintendent will work together to determine the best course of action to correct the situation.

In this chapter, you will learn how important it is to monitor and report accurate field information and will see how this information is used to make management decisions that improve the overall chances of bringing the project in on time and within budget.

The Project Control Cycle

Construction is a dynamic process, and no two projects are ever alike. Even if you have years of experience, every job presents a new set of circumstances and challenges no matter how good a job you do preparing during the pre-construction stage. The project manager and superintendent work together to come up with the best plan they can, trying to anticipate every obstruction and difficulty that might impede progress and jeopardize the successful completion of the project, but they still can't foresee every contingency.

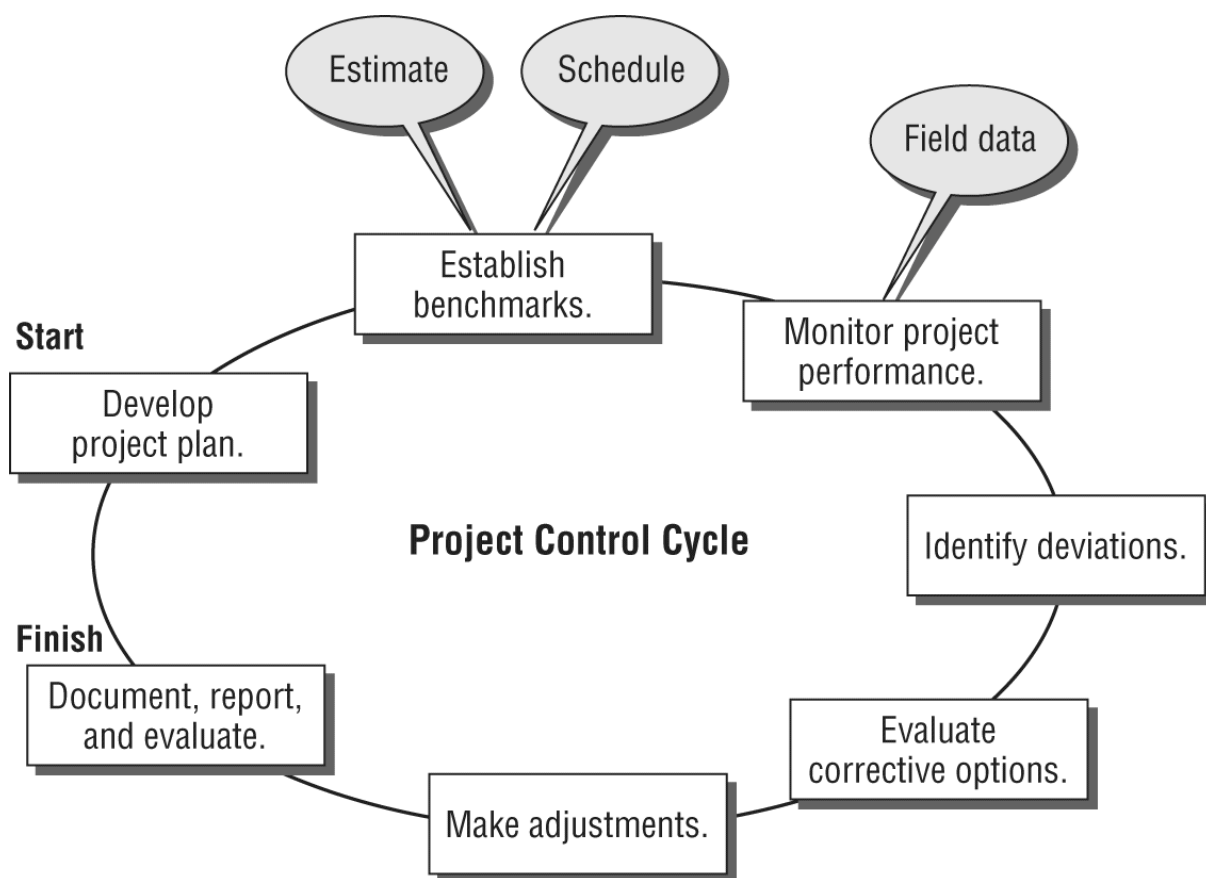
Even with all of this expert planning, the project must be monitored from beginning to end to ensure that all of the targets for time, cost, and quality are met. The whole process must be properly managed through a project control system that utilizes the plans, specs, estimate, and schedule.

All of these documents taken together establish the road map for getting from the start of construction to the final completion of the project. Using this road map, the project manager and superintendent must maneuver all of the resources in the right direction, making adjustments as they go, to keep the project on track and on target. Project control requires continuous monitoring and evaluation of actual performance relative to the estimated performance for all aspects of the job that have an impact on cost, time, and quality.

The project control cycle begins with the project plan and ends with the final project debriefing and evaluation. There are seven fundamental steps to the process:

1. Develop the project plan.
2. Establish the project benchmarks.
3. Monitor the project performance.
4. Identify performance deviations.
5. Evaluate corrective options.
6. Make adjustments as needed.
7. Document, report, and evaluate results.

It is important to track every aspect of project performance all the way back to the planning stage. This is where every project begins, and it is where every project should end—with a complete debriefing and evaluation of what worked and what didn't work. It is also a time to reconcile actual costs and labor productivity information to update existing company records in preparation for the next cycle of project planning and estimating. It is an excellent opportunity to capture lessons learned and to create some best practices for future implementation. Unfortunately, many construction teams fail to complete the last step in the cycle and never properly assess their project's overall performance. Everyone is usually anxious to move on to the next project, and it's very tough to get all of the parties together for even a couple of hours at the end of the job. It takes a great deal of discipline to consistently take advantage of this opportunity and learn from it. In my experience, I have found the project debriefing to be one of the most effective training mechanisms for every member of the team, from the project engineer to the project manager.



The Feedback Loop

At the heart of every project control system are information and a good reporting process. Successful construction management and project control depend on sound information, which comes from actual project performance data. This data originates in the field and is reported on a daily, weekly, and monthly basis. The following are some of the sources of information used to track job performance and feedback into the project control system:

- ◆ Daily field reports
- ◆ Time cards
- ◆ Subcontractor billing statements
- ◆ Delivery tickets
- ◆ Material invoices
- ◆ Equipment time tickets
- ◆ Job logs

I cannot stress enough how important it is to get complete and accurate data from the field. This is a challenge, and I must say that it is often a weak link in the project control cycle. With all of the activity and commotion going on at the job site, it is hard to ask a superintendent to be meticulous about tracking and recording cost data and time card information. They usually have their hands full trying to manage all of the subcontractors, answering questions, scheduling inspections, and getting work ready for the next day. However, this information serves two critical functions:

- ◆ It is used to detect variances between the actual cost, time, and productivity performance and the planned estimate and schedule.
- ◆ It is used to develop the historical estimating databases and productivity factors used on future projects.

If this information is inaccurate or incomplete, it may mitigate the effectiveness of the project control system and feed faulty data into the estimating and scheduling references, tainting those procedures' reliability on future projects.

Factors Impacting Project Performance

Controlling project time and costs requires a heads-up kind of attitude. The ability to anticipate and ward off potential project disruptions is a basic characteristic of the successful construction manager. However, even when the project team applies all of the tools and techniques available to them, most projects will still be derailed somewhere along the way. Practically every job will experience time delays, cost overruns, or quality failures during the course of construction. As hard as we try to make a perfect plan, it is virtually impossible to predict and anticipate every possible occurrence that could cause a hiccup in our scheme. So hiccups are inevitable. Therefore, it is a good idea to know in advance where these glitches might come from.

A number of factors can influence our job performance. Some of them are beyond our control, and some of them are a result of poor management or lack of foresight. I've listed some of these factors here and explain how they can influence project performance.

Weather conditions Weather is probably the most common and most obvious reason for work slowdown resulting in cost overruns. Work proceeds much more slowly under adverse weather conditions, and such conditions can impact the quality of the work as well.

Quality of the workforce As a general contractor who hires subcontractors, you don't really have any control over the subcontractors' workforce. Therefore, you have to trust that your subcontractors will provide experienced workers on your job. This is why, in my opinion, all subcontractors should be prequalified. The risks associated with poor work quality are significant. If there is a problem, the poor quality will result in rework, and rework slows down job progress and can impact safety. The potential losses due to poor quality can put the entire project in a tailspin, and if this occurs, the project manager must take immediate steps to mitigate the situation.

Quality of the supervision Obviously, if you don't have proper supervision on the job, there are going to be problems. Many issues have to be addressed every single day on the job, and everyone looks to the superintendent for direction and clarification regarding those issues. If you have an inexperienced

superintendent who is not up to speed on the project, the type of work, or the systems in place to manage the project, you are going to have a disaster, plain and simple. As I've said before, this is why good superintendents are worth their weight in gold.

Incorrect sequencing of work Unfortunately, there are times when pressure from an owner or from the main office can cause a superintendent to schedule work out of sequence and before it is ready, just to appease some unrealistic demand for action. But no one knows better than the superintendent and the field personnel how the work needs to be scheduled to keep things on track. Sometimes a work activity is initiated just to give the appearance of making progress when in reality these artificial starts just waste time and cause all kinds of havoc on the job. If this occurs too often, the inefficiencies will eventually show up and expose the real story.

Change orders Change orders can be one of the most insidious factors influencing project performance. A little change here or there often seems like no big deal. Many contractors fail to ask for additional time when they process the cost of the change, thinking that they can wiggle the extra work into the existing schedule. Then all of a sudden, these seven or eight little change orders are causing the job to run two weeks behind, and then it is a *big* deal!

Overcrowded job site One of the things that can actually hinder work productivity is having too many people on the job. I have heard more than one subcontractor complain about packing too many workers in tight quarters trying to get a job done. They end up getting in each other's way and tempers can flare. It becomes so counterproductive that it actually slows down the job instead of speeding it up as planned.

Defective materials Discovering that the material or equipment that you were planning to install is defective is a real problem. It is certainly one that can be avoided with proper quality control. But in some cases, this defective material is not discovered until the workers are on the job ready to start the project. By this time, it is way too late. The time has already been wasted, and it will take time to reorder the material and reschedule the crews to install it.

Inadequate tools and equipment Having the right tools and equipment on a construction job may seem like a no-brainer. But

again, when so much of the work of the contract is passed on to subcontractors, you don't always have control over even these simple aspects of the job. I can't tell you how many times I have seen work installed improperly because the craftspeople didn't have the right piece of equipment or right tool that day or how many times I have seen equipment operators go home early simply because they didn't have an extra linchpin or some other minor fitting for their \$250,000 piece of equipment.

NOTE

Whenever I interviewed new subcontractors, I would always try to meet them at their place of business or at a job site where I might get a glimpse of their people working or at least get to see the subcontractor's pickup truck and equipment. It may seem silly, but I always thought that the way subcontractors kept their trucks (neat or messy) was a pretty good indication of how they did their work and took care of their tools and equipment. The subcontractors with the neat, clean trucks were usually the ones who produced the higher-quality work—not always but many times.

Late deliveries Late deliveries are probably one of the most frustrating causes of schedule delays and cost growth in construction. Once again, the contractor has very little influence or control over the manufacturing or fabrication processes involved in the making of many of the products or equipment used on the project. However, the stakes can be very high for the project if items arrive late. That's why on projects with critical lead-time items, it is best to assign someone to do nothing but expedite deliveries and stay on top of the project buyout schedule.

No matter how well you have planned, estimated, and scheduled your job to go a certain direction, these are just a few of the things that can easily impact your project's outcome in a negative way. Some of them seem trivial, yet they are exactly the kinds of things that can get your cost, time, and quality off track in a hurry. As a construction manager, you must be forever vigilant and on the lookout for disruptions and

inefficiencies that will derail your plans. You can never avoid all of the potential problems, but having some idea about how different factors can affect the job will give you a head start when trying to correct course after a problem does hit.



Real World Scenario

Sometimes Nice Guys Really *Do* Finish Last

In an effort to be amiable and cooperative, many contractors bypass the opportunity to add workdays to the schedule when processing a change order, especially if it is something minor. They carefully calculate the cost of the change but often do not fully consider the consequences to the schedule. However, change orders almost *always* cause an interruption in the workflow and impact productivity. Although one or two changes might be absorbed into the schedule, eventually these interruptions will show up as a problem. It is very difficult to backtrack after the extra work is already done and try to convince the architect and owner that you should have asked for additional time. It is in the best interest of the contractor to always make a request for additional time when processing a change order. Even if you aren't granted the extra time, documenting your request will help build your case when the 15th change comes around and you are now looking at a serious schedule issue.

Tracking Quality, Cost, and Time

By now, you are familiar with the three primary elements associated with managing the construction project: quality, cost, and time. These factors must be monitored throughout the duration of the job. Each of these elements has a corresponding tool that we use as a benchmark to track performance, as shown in [Table 12.1](#).

Table 12.1 Management Elements and Tracking Tools

Management Element	Tracking Tool
Quality	Plans and specifications
Cost	Estimate
Time	Schedule

Our goal as construction managers is to manage the project so that the performance of the project meets or exceeds our estimated or anticipated performance for each of these elements. And though we won't know whether we have met all project goals until the job is complete, tracking the deviations between actual and planned performance throughout the project will help identify problem areas so adjustments can be made along the way to correct any significant discrepancies. Let's take a look at how each of these primary elements is tracked and monitored throughout the construction process.

Tracking Quality

The plans and specifications are the primary tools used to monitor project quality. The best way to track quality performance on a project is to prepare and implement a comprehensive quality plan. The project manager and superintendent usually team up to put this plan together and use it to monitor the project from start to finish. Depending on the project size, sometimes a special quality officer or quality engineer is assigned to the job to assist the superintendent in this task.

The fundamental purpose of the plan is to verify that all materials and workmanship comply with the requirements spelled out in the plans and specifications prepared by the designer. A number of administrative and physical checks are used to track quality:

- ◆ Field observations

- ◆ Submittals
- ◆ Shop drawings
- ◆ Mock-ups
- ◆ Inspections
- ◆ Field tests

Because quality and safety contribute so greatly to project success, the control of these two elements is really classified as a separate construction management function. Therefore, [Chapter 13](#), “Managing Quality and Safety,” is dedicated entirely to this topic. In this chapter, I will focus on the other two project controls—time and cost.

Tracking Project Cost

The original estimate used for bidding purposes is converted to a project budget and establishes the benchmark from which project costs are monitored and tracked. During this conversion process, which usually takes place right after the contract award, quoted prices are confirmed with purchase orders and subcontracts. Sometimes there are minor adjustments made in the budget because of price fluctuations between the time when the job was bid and when the work begins, but generally the budget contains the same work packages developed in the estimate.

Each work package identifies the activities needed to complete a division or section of work. You'll remember from [Chapter 8](#), “Estimating Project Costs,” that these work packages and activities are usually identified by a CSI MasterFormat reference number. These reference numbers take on an even more important role when applied to project *cost control*.

Cost Control

Once the budget is confirmed, each activity in the budget is assigned a *cost code*. Cost codes are used to track all items of work contributing to the overall project costs. That includes material, labor, equipment, subcontracts, and overhead. All job information regarding cost is tracked via these cost codes. Every item on a material invoice, every man-hour logged on a time card, and every subcontractor payment are assigned a cost code and recorded. These codes are used to compare

actual job costs with the estimated job costs throughout the construction process.

cost control

A continuous monitoring process used to track the variances between actual performance and planned performance on a project, specifically concerning cost and time.

cost code

A reference number used to track cost and schedule information on materials, labor, subcontracts, equipment, overhead, and fees throughout the project control process.

These cost codes usually start with the CSI reference number associated with the activity, and then for further detail another number is assigned that represents the type of cost. For example:

Activity	Code
Material	1
Self-performed labor	2
Subcontracted labor	3
Equipment	4
Job site overhead	5

So, if I were the job superintendent tracking sprayed insulation cost on a project, I would assign the following cost codes to the invoices that came across my desk:

Item	Cost Code (CSI Number — Type of Cost)
Material invoice	07 21 29-1
Subcontractor bill	07 21 29-2
Equipment rental	07 21 29-3

Larger contractors will also assign a year and job number to the cost code. For example, assuming that the previous project was a large

contractor's fourteenth job of this year, the material invoice might be coded as follows:

Year project started: 2019
Project no.: 14
CSI division: 07 21 29
Type of cost: 1 (material)
Cost code: 2019 14 07 21 29-1

Smaller contractors might simply identify each of the invoices by the client name along with the cost code.

Smith 07 21 29-1

The point is to make the codes as user-friendly as possible while still providing the level of detail needed to properly analyze the project costs. Each invoice amount would be recorded according to the cost code assigned to it by the superintendent. Material costs, labor costs, and equipment costs could be tracked separately, or you could combine them into a single work package total. Either way, you could compare the actual cost to do the building insulation with the budgeted amount and note any discrepancies.

All invoices and subcontractor billings are eventually transferred to the contractor's cost accounting department. The accounting department also tracks the project according to the cost codes and submits reports identifying total material, labor, subcontract, equipment, and overhead costs incurred on the job. The project manager uses these and other reports to monitor the project performance from a big-picture perspective.



Real World Scenario

Spot Check the Cost Coding

It's not uncommon for a vendor to list more than one cost code item on a single invoice. For example, the same invoice could have materials that fall under three different divisions—let's say lumber (Division 6), mortar (Division 4), and rebar (Division 3). When this happens, it is important to make sure that someone is taking the time to separate the material costs according to their respective codes. Unfortunately, people get lax, and they start lumping all of the material under one code. This, of course, taints the accuracy of the information, which results in faulty reporting. As a construction manager, I was always vigilant about doing random checks on job tickets just to make sure everything was being properly coded. It was part of my management systems quality assurance program.

Analyzing the Discrepancies

In many instances, merely knowing the aggregate cost of the item of work is not enough. This is especially true when you discover a significant discrepancy between actual costs and estimated costs. Further analysis is needed to figure out exactly what is causing the discrepancy.

For example, knowing that you have a cost overrun with building insulation might not be very useful if you don't know why. Even if there is nothing that you can do about the overrun, knowing what caused it will help you better plan for the next job. (Remember, actual costs are what establish the estimating database and productivity rates in the first place. Very important information!)

In addition to analyzing the dollar amounts listed on job invoices and billings, it is often necessary to track the quantities purchased. For example, [Table 12.2](#) illustrates a more detailed picture of what is going on regarding building insulation cost. Both the quantities and costs have been tracked and converted to unit costs so that an analysis can be made at a deeper level.

variance

The cost or time difference between the actual project performance and the planned project performance.

You'll notice that the building insulation work package is over budget by \$1,564 (about a 14 percent overrun). With further analysis, you can see that the *variance* is not a result of either an increase in material unit cost, labor unit cost, or equipment unit cost. In fact, you can see that we were able to secure the labor at a better rate than we had estimated. If we hadn't been able to get a better buy on labor, we might be experiencing a much worse situation with a \$2,242 loss. The problem appears to be the quantity of material needed—the overage is a little more than 20 percent. This error in quantity has caused an overrun in material costs and equipment costs.

Table 12.2 Cost Analysis

Division 07 21 00 – Thermal Insulation	Estimated	Actual	Variance
Quantity	18,800 square feet	22,600 square feet	(3,800 square feet)
Material unit cost	\$0.30 per square foot	\$0.30 per square foot	—
Total material	\$5,640	\$6,780	(\$1,140)
Labor unit cost	\$0.19 per square foot	\$0.16 per square foot	\$0.03 per square foot
Total labor	\$3,572	\$3,616	(\$44)
Equipment unit cost	\$0.10 per square foot	\$0.10 per square foot	—
Total equipment	\$1,880	\$2,260	(\$380)
Total	\$11,092	\$12,656	(\$1,564)

If the superintendent had looked only at the invoice amounts and compared those totals with the estimated totals, he might have blamed the problem on bad pricing of material and equipment. However, a more detailed analysis shows that the problem lies with the incorrect

quantity amount. The superintendent can now investigate what is at the root of this error. There are five possible causes:

- ◆ Poor-quantity takeoff (estimating problem)
- ◆ Poor-quality plans (inaccurate dimensions)
- ◆ Excessive waste (poor quality control)
- ◆ Change order (new quantities not yet reflected in the estimate)
- ◆ Error in the invoice

NOTE

Cost overruns resulting from doing extra work requested by the owner are not cost overruns at all. Remember, the extra work is performed as a change order to the contract and increases the contract price (and the schedule). It is best to track change orders as separate work items so they don't distort the costs (and time) associated with the original work.

It is important to understand that in making the comparison between actual and budgeted cost, the expectation is not for each individual component of the job to be within budget. Instead, the challenge is to manage the overall project cost within budget. In reality, it is very *unlikely* that each individual element of the job will come in exactly as estimated. Some work items will be over budget, and some will be under budget. The hope is that in the end, the plusses and minuses will balance themselves out.

[Table 12.2](#) (shown earlier) illustrates the types of variances that can be experienced when tracking job costs. Incorrect quantities may be the culprit causing the overrun (or surplus), as shown in our example. On the other hand, the estimated unit pricing for materials, labor, or equipment may be to blame. Whatever it is, it is the construction manager's job to find out and make a correction or adjustment along the way that will assist in getting the project back on track. The key is to have the information that you need to identify and assess the problem.

NOTE

You can see that there are many different angles from which to view project performance. Understanding how to organize and analyze the information that you have is a critical component of construction management.

Computers have made this job much easier on everyone involved. Once the data is inputted, there are programs that can create just about any kind of report that you want. However, it is still very important to make sure that the information you are inputting is accurate. You know the saying—garbage in, garbage out!

Taking Corrective Action

Most cost overruns are not the result of bad material or subcontractor pricing or even quantity takeoff errors. After all, material prices are often locked in with a purchase order, and vendors will usually honor their price quotes for 30 to 90 days. Likewise, subcontractor pricing is guaranteed through the subcontract. So, material or subcontractor pricing variances are rare and are usually not the cause of budget overruns.

However, when overruns do occur, the superintendent or project manager can do a few things to mitigate the impact on the budget:

Material price escalations For the most part, small price fluctuations are non-events when it comes to cost control. As previously stated, the job of the construction manager is not to micro-manage every single individual activity cost as much as it is to try to control the material costs within the various divisions of work. There will be wins and losses when it comes to individual activity material prices, but in the end, the goal is to meet the budget for the overall project.

However, there are occasions when material prices can drastically change between the time of the bid and the time you order the material for the job. Over the years, there have been periods when lumber, drywall, or some other product has seen extreme price fluctuations over relatively short periods of time. On smaller jobs,

the contractor either absorbs the loss or negotiates with an understanding owner for some amicable compromise or shared exposure regarding the price increase. On larger jobs, these drastic price increases become quite troublesome.

escalation clauses

Usually negotiated into the construction contract when there is suspicion that some pricing component of the estimate is in a high state of flux. The clause allows for some fluctuation in the contract price based upon the current pricing of the suspected component.

For example, in 2004, steel prices more than doubled in the United States. Multimillion-dollar projects had been bid and went under contract before the prices skyrocketed, and many of those projects were negotiating *escalation clauses* into the contract. Steel is a primary building material, in some cases constituting a significant percentage of the project cost. No reasonable owner would try to hold a contractor to the original pricing of steel when the potential loss to the contractor could reach into the millions of dollars. There aren't many contractors who can suffer such catastrophic losses and still stay in business. And it certainly doesn't do the owner any good to let the contractor go and start the process from scratch. In these situations, the best deal is to negotiate a fair and equitable solution.

Subcontract increases Most subcontractors honor their price quotes once the subcontract is signed and the job has started, even if they experience minor price increases on their end of the deal. There is very little risk to the general contractor or to the project budget. The estimated price and the actual price are usually one and the same, unless, of course, there are change orders.

Sometimes a subcontractor reneges on a price before the subcontract is executed. When this happens, the general contractor has three options: contact one of the other original bidders and try to negotiate a price that both parties can live with;

rebid the section of work altogether; or go out and negotiate on the open market, trying to secure the original pricing or better.

The most difficult situation to remedy is when a subcontractor gets into financial trouble and goes out of business before the job is complete. When this happens, it puts the project in a real tailspin, especially if the subcontractor in trouble ends up being one of your primary subcontractors—such as steel or mechanical.

Often the bonding company will step in and provide another specialty contractor to complete the work, but you can imagine what this sort of disruption does to the schedule and therefore the budget. The ramifications can be severe, and there may be no recovery from the damages. During a crisis like this, it is best for the owner, the contractor, and the architect to sit down and come up with a plan to mitigate the potential losses for everyone.

Quantity errors As our previous example suggests, there are times when a simple quantity takeoff error throws a monkey wrench into our budget calculations. When this happens, it is best to find the error as soon as possible, preferably before you have committed to any purchase order or subcontract. If you find the error before committing to any pricing, you still have time to go out and negotiate your very best deal on the affected materials and labor in an effort to mitigate the obvious loss that you will suffer because of the inaccurate takeoff (presuming that the error results in a deficiency). Otherwise, the best that you can do is find other areas of work with opportunities to save budget dollars, offsetting the loss resulting from the quantity error.

Labor Risks

So if material and subcontractor pricing are not at the root of cost overruns, what is? Most budget problems originate from inaccurate labor estimates, particularly self-performed labor. The difficulty really lies with trying to accurately predict the work output of crews—in other words, in trying to guess what a given crew's productivity might be on any given day, under any given circumstances. Obviously this is not an easy prediction to make, but estimators, superintendents, and project managers do it every day, and they sign contracts and plan multimillion-dollar jobs based on their guesses. (Now you understand

why most work in construction is subcontracted to specialty contractors—there's far less risk, at least to the general contractor.)

Productivity is the most unpredictable element of project planning and project control. Productivity has a significant influence on both cost and time. The project estimate and the schedule are based on certain productivity rates. There are so many things that can impact productivity that you are really just playing the odds when you plug a rate into your estimate. However, there are ways to increase those odds, and I will address productivity and its influence on both the budget and the schedule in the next section.

Tracking Project Time

Tracking project time is just as important as tracking project cost. Not only is the contractor obligated to complete the contract for a specified dollar amount, but he is also required to deliver the completed project within a specified time frame. Otherwise, there may be some pretty serious consequences in the form of liquidated damages—or, at the very least, an extended schedule will cause a rise in overhead expenses, increasing the risk of financial loss on the project.

In the previous chapter, “Project Planning and Scheduling,” you learned that overall project duration is calculated by figuring out how much time each individual work activity is going to take and by determining how that work will be sequenced. Once these two pieces of information are established, you can build the schedule. The schedule is the tool used to track progress throughout the construction process.

The schedule identifies the critical activities' start and finish dates, as well as the amount of flexibility that the superintendent has in scheduling activities with float. The critical path is, well, critical when it comes to managing the time to complete the project. If a single critical activity gets off track, the overall job duration will be extended and the planned completion date will shift.

Schedule Control

Schedule control requires a continuous monitoring of the activity durations identified in the schedule. The superintendent's job is to track the progress of each work item, trying to keep the job moving as efficiently as possible and assessing the impact of any delay on the overall schedule.

If an activity does get off track, it is the superintendent's job to figure out what went wrong and then to take steps to get the project back on schedule as planned. There are numerous reasons why an activity may be delayed. It could be because of weather, a shortage of manpower, late deliveries, waiting for information, or countless other reasons. But most schedule glitches have to do with productivity.

NOTE

Schedule control is all about managing the durations associated with the individual work activities. Getting the subcontractors involved and creating specific work package short-interval schedules can really help this process.

Analyzing the Delays

As stated in the previous section, the greatest risk in planning and scheduling the work to be done on a project is in predicting workforce productivity. Productivity has to do with how much work can be produced by a fixed crew size in a certain unit of time. If you remember, back in [Chapter 8](#), you learned that productivity rates are used in the estimate to calculate the unit costs for an activity. You then use that same productivity rate to come up with activity durations in your schedule. For example, if you stick with the building insulation scenario, you can estimate the following:

- ◆ Two carpenters can install 2,500 square feet of wall insulation in an 8-hour day.
- ◆ If there is 22,600 square feet of insulation to install on the job, it will take 9.04 days to complete the job.
- ◆ It would be logical to plug 9 days into our schedule for installation of the wall insulation.

However, what if the crew is unable to install 2,500 square feet of insulation in an 8-hour day? Let's say that, for whatever reason, they are able to install only 1,600 square feet of insulation per day. In this case, the job is going to take 14 days to finish instead of the planned 9

days. This becomes a real problem because a delay in the installation of the wall insulation will delay the installation of the drywall, which will also delay the interior trim work and painting. Obviously, this ripple effect is something that the superintendent needs to avoid if he wants to keep this project on course.

Taking Corrective Action

When one or more activities (especially critical ones) get seriously off track, the superintendent and project manager must decide what steps to take to mitigate the effects of the delayed schedule. They may choose to compress the schedule by accelerating certain activities within it. This process is called *crashing the schedule*, and the superintendent can accomplish the objective by taking one of three actions (or if necessary, a combination of actions):

crashing the schedule

To takes steps that accelerate activities in the schedule, resulting in an earlier completion date.

- ◆ Have the crew work overtime.
- ◆ Increase the size of the crew.
- ◆ Work two crew shifts per day.

Although crashing will accomplish getting the project back on schedule, there is a cost to achieving this goal. Crashing causes the direct costs (materials, labor, and equipment) of the activity to go up. The objective is to figure out the most efficient way to speed up the activity with the least amount of cost impact.

Using the previous example, let's presume that insulation is on the critical path for the project. The bottom line is that you don't have 14 days to install the insulation. The insulation work package must be completed in 9 days as planned or less; otherwise, you jeopardize the project completion date. You must crash the schedule, and insulation is the work item to crash.

Let's consider each of the choices listed earlier.

Scenario #1: Crew Works Overtime

The first option would be to work your original crew overtime to complete the insulation work within the scheduled time frame of 9 days:

- ◆ A production rate of 1,600 square feet per 8-hour day = 200 square feet per crew hour.
- ◆ A total quantity of insulation of 22,600 square feet divided by 200 square feet per hour = 113 crew hours needed to complete work.
- ◆ Must complete work in 9 days or less.
- ◆ 113 crew hours divided by 9 days = 12.5 crew hours per day to complete work in 9 days.
- ◆ 12.5 hours per day = 8 hours at regular pay and 4.5 hours at overtime pay for 9 days.
- ◆ Crew rate is \$50 per hour for regular time.
- ◆ Overtime rate = $1.5 \times \$50 = \$75$ per crew hour.
- ◆ Total overtime = $\$75 \times 4.5 \text{ hours per day} \times 9 \text{ days} = \$3,037.50$.
- ◆ Total cost to crash the schedule using overtime = \$3,037.50.

Things to consider: Can the crew maintain the 1,600 square feet per day production rate for all 12.5 hours per day for all 9 days? Will the crew be too tired to maintain the pace? Should part of the overtime be worked on Saturday? Will quality suffer?

Scenario #2: Size of Crew Increases

The second option considers increasing the crew size to achieve the objective of completing the insulation work in 9 days or less:

- ◆ 1 crew working at a rate of \$50 per hour $\times$ 8 hours (1 day) = \$400.
- ◆ 22,600 square feet divided by the productivity rate of the 1 crew (1,600 square feet per day) = 14 days $\times$ \$400 per day = \$5,600.
- ◆ You do not have 14 days to complete the work. You must complete the work in 9 days or less.
- ◆ Presuming that a second two-person crew can install 1,600 square feet of insulation per day, the total productivity for two crews will

be 3,200 square feet per day.

- ◆ 22,600 square feet divided by 3,200 square feet per day = 7.06 days = 7 days.
- ◆ \$50 per hour $\times$ 8 hours = \$400 per day per crew $\times$ 2 crews = \$800 per day $\times$ 7 days = \$5,600 total.
- ◆ The cost to add the second crew is no more than the cost of letting the original crew work for 14 days. Both options will cost \$5,600.
- ◆ However, working the one crew for 14 days is not an option. The cost to work the original crew for the allotted 9 days would cost 9 days $\times$ \$400 per day = \$3,600.
- ◆ The cost to work the two crews for 7 days less the cost to work the original crew for 9 days = \$5,600 – \$3,600 = \$2,000.
- ◆ Crashing the schedule by increasing the crew size adds \$2,000 more than the activity was planned to cost in the first place but also reduces the overall schedule by two days.

Things to consider: Overcrowding of work area? Consistent quality? Decreasing the overall schedule by two days will decrease the overhead for the project by two days.

Scenario #3: Two Different Crew Shifts per Day

The third option assigns two crews to work different shifts in the same day. Although the second shift would be paid a shift differential wage, it would be less expensive than overtime.

- ◆ The original crew would have to work 14 days to install 22,600 square feet of insulation at a production rate of 1,600 square feet per day.
- ◆ You would need to shave 5 days off this duration to complete the insulation within the 9 days provided in the original schedule.
- ◆ Working the original crew for only 9 days (as planned) and adding a second shift (4 p.m. to midnight) of workers for the first 5 of those 9 days would accomplish the activity within the 9-day schedule, given the production rate of 1,600 square feet per day per crew.

- ◆ Keeping with the 9-day maximum schedule duration for insulation at a production rate of 1,600 square feet per day per crew, a second crew would have to work for 5 days.
- ◆ The first crew would work at $\$50 \text{ per crew hour} \times 8 \text{ hours} = \$400$ per day.
- ◆ The second shift crew would be paid a shift differential wage of $\$60 \text{ per hour} \times 8 \text{ hours} = \$480$ per day.
- ◆ First 5 days when both crews work 8-hour shifts = $[\$400 + \$480] \times 5 \text{ days} = \$4,400$.
- ◆ Only the daytime crew works the next 4 days of the schedule = $4 \times \$400 = \$1,600$.
- ◆ Total cost for both crews = $\$4,400 + \$1,600 = \$6,000$; less the cost of the original crew for 9 days as scheduled ($\$3,600$) = $\$2,400$ to crash the schedule.

Things to consider: Would night shift productivity be equal to daytime shift productivity? What about supervision at night? Must bring in temporary lighting and maybe heating, depending on the time of the year. Does the owner have any objections to working at night?

Three Scenarios Summary

Here is the final tally of the three scenarios:

- ◆ Scenario #1 costs \$3,037.50 and meets original schedule requirements.
- ◆ Scenario #2 costs \$2,000 and reduces original schedule by two days.
- ◆ Scenario #3 costs \$2,400 and meets original schedule requirements.

Of these three scenarios, it appears that the least expensive way to crash the schedule is by doubling the crew size (scenario #2). This effort would bring the activity back on schedule and cost only \$2,000. And because the work could be completed in seven days instead of the required nine days, the overall schedule would be shortened by two days. This would save on overhead expenses. The overhead savings would help offset a little bit of the cost to crash the schedule.

NOTE

Much more analysis takes place when professional construction managers contemplate crashing the schedule. Trying to fully detail that analysis process would go beyond the scope of this book. However, the example provided here demonstrates the principle behind crashing and some of the logic that goes into making the decision.

I hope you can begin to see the interrelationship between time and cost when it comes to project controls. Even though cost and schedule are independent management factors, when it comes to tracking project performance, they are interconnected. Let me give you a brief look at how construction managers consider both of these factors at the same time.

Assessing Overall Project Status

Construction managers often use a technique called *earned value analysis* for determining the overall status of the project relative to both cost and schedule. You can use this technique to measure individual activity performance and total project performance.

earned value analysis

A technique used in construction to determine the estimated value (earned value) of work completed to date on a project and compare that to the actual work completed on the project.

The first step in the process is to determine what percentage of the work you have completed on the project. You can calculate this by measuring the quantity of work installed to date relative to the total quantity of work to install overall. For example, if you have a total of 3,000 square feet of floor tile to install and you have installed only 1,500 square feet so far, you are 50 percent complete with the work.

The next step determines the earned value of the completed tile work. To calculate earned value, you multiply the percentage of work completed times the budgeted dollars (budgeted in the estimate) or work hours (budgeted in our schedule) for that activity. So, let's say the tile is budgeted to cost \$21,000 and requires 261 man-hours to install. The calculation would look like this:

Earned value = % of work complete $\times$ budget for that work.

For cost: Earned value = 50% $\times$ \$21,000 = \$10,500.

For time: Earned value = 50% $\times$ 262 hours = 131 hours.

The work is 50% complete and has earned \$10,500 and 131 hours.

The last step in the process is to determine the actual work hours or dollars spent to date on the project. Let's presume that we have actually worked 17 days (136 hours) and spent \$11,300 so far to complete the tile work. There are two basic calculations that you can now perform to ascertain the cost and schedule variances to date:

Cost variance = Earned value – Actual dollars spent.

Cost variance = \$10,500 – \$11,300 = (– \$800).

Schedule variance = Earned work hours – Actual (budgeted) work hours.

Schedule variance = 131 – 136 = (–5 hours).

In this example, the tile work is clearly over budget and taking more time than was planned. This example represents only one activity, but the same calculations could be done to evaluate overall cumulative project performance by adding up all of the project costs and all of the project man-hours and using the aggregate sums in the calculations. Obviously, if you were 50 percent complete with your project and you discovered that you were lagging in both cost and time, you would not be a happy camper. As a matter of fact, your job would be in pretty serious trouble.

This analysis should be performed at intervals that are appropriate to the job. The more complex the project, the more frequently these evaluations may be performed, but it all depends on the level of management detail desired by the project team.

Documenting Project Performance

The last stage in the project control cycle is the documentation stage. Throughout the entire project control process, information is being gathered and utilized to check status and make adjustments and changes to the project budget and the schedule as needed. Once these changes are made, they are communicated to all of the appropriate parties, and the updated documents continue to be monitored, evaluated, and adjusted again and again until the project is complete.

Upon completion of the project, all of the actions that occurred relative to controlling the overall cost and schedule must be documented so that a historical record of the process can be archived for future reference. These historical records provide valuable information for the estimating and scheduling departments if they take advantage of these resources. However, I have found that this is sometimes an overlooked opportunity for process improvement.

Management Reports

During the construction process, several formal reports are created that document project progress, provide *forecasts* for the completion date and cost, and highlight any other risk factors or target dates that might significantly influence the project outcome. These reports are developed and issued to the project participants on a regular basis throughout the duration of the project. They may be distributed monthly, bimonthly, or quarterly. They are in addition to the numerous working reports used in the field by the superintendent and project manager to monitor the budget and schedule on a day-by-day basis.

forecasts

Periodic predictions stated in reports as to the final cost and schedule outcomes on a project while the work is still ongoing.

It is certainly important that the superintendent and project manager be able to predict when the project will be complete and what the budgetary results will be. But these reports also help inform senior management, owners, and designers of what to expect. These progress reports should address four fundamental project control questions:

- ◆ How is the project doing overall? Is it on target or off target?
- ◆ What sections of work appear to be most vulnerable?
- ◆ Is overall productivity improving or declining?
- ◆ What is the projected completion date and budget outcome?

These reports can be organized in any fashion that serves the project team. For example, some reports may reveal overall variances for a certain group of work packages—let's say site work, concrete, and masonry. Others may be broken down into specific variances for labor, material, subcontracts, equipment, and overhead. And others may simply display overall job performance, forecasting completion costs, and variances per division, similar to the one illustrated here.

Rocky J. Construction

Project: Sedona Municipal Building
Project Manager: J.W. Jones
Superintendent: P.A. Weber

Cost Report

Report Date: June 15, 2019
Data Date: June 15, 2019
Start Date: March 14, 2019
Finish Date: March 30, 2020

WORK DIVISION	BUDGET	COMPLETE	ACTUAL TO DATE	THIS PERIOD	ESTIMATE TO COMPLETE	FORECAST	VARIANCE
Sitework	\$97,900	90%	90,400	0	6,700	97,100	800
Concrete	\$422,000	40%	168,800	50,000	204,300	423,100	(1100)
Masonry	\$123,000	60%	70,200	2,300	48,500	121,000	2000
Steel	\$39,800	30%	11,900	5,000	30,000	46,900	(7,100)
Wood	\$41,300	0%	0	0	40,000	40,000	1,300
Therm/Moist	\$96,000	0%	0	0	92,300	92,300	3,700
Doors/Window	\$79,500	0%	0	0	79,500	79,500	0
Finishes	\$279,000	0%	0	0	277,900	277,900	1,100
Specialties	\$49,500	0%	0	0	51,000	51,000	(1,500)
Equipment	\$4,300	0%	0	0	4,300	4,300	0
Furnishings	\$9,800	0%	0	0	9,500	9,500	300
Special Construction	\$32,400	10%	3,200	5,000	25,000	33,200	(800)
Conveying	\$89,000	30%	28,000	0	58,500	86,500	2,500
Mechanical	\$303,000	20%	61,000	0	240,000	301,000	2,000
Electrical	\$184,500	20%	37,000	8,000	139,500	184,500	0
TOTALS	\$1,851,000	25.42%	470,500	70,300	1,307,000	1,847,800	3,200
Job Overhead	\$125,900	30%	37,800	2,500	85,000	125,300	600
TOTALS THIS REPORT	\$1,976,900	25.71	508,300	72,800	1,392,000	1,973,100	3,800

Surprises are never a good thing in construction. The more informed your team is regarding the status of the project, the more likely that it

can indeed be managed to a successful completion.

Evaluating Project Performance

I started this chapter by expressing how important I think it is to debrief the overall project performance when the job is all done. The purpose of this session is not simply to talk about whether the job made money or was brought in on time. The purpose of this meeting is to share information about what worked and what didn't work all along the way. As I stated earlier, this debriefing can be one of the richest learning environments for everyone on the project team.

The value of the information that can come out of this type of evaluation meeting is tremendous. For example, the selection of a new subcontractor may have turned out to be a huge mistake, and that information needs to be passed on to other superintendents and project managers. Or the team may want to report that this particular owner was one of the best that the company has ever worked for and the business development folks may want to instigate some public relations work with this client for future work. Or members of the project team may just want to share lessons learned about some construction technique or management strategy. Here are a few examples of topics that might get discussed at a project debriefing meeting:

- ◆ Target goals and achievement
- ◆ On-site field team performance
- ◆ Office support
- ◆ Owner issues
- ◆ Designer issues
- ◆ Building inspections
- ◆ Communication issues
- ◆ Quality control issues
- ◆ Subcontractor performance
- ◆ Vendor and supplier performance
- ◆ Unusual circumstances or conditions

The bottom line is that the construction business is getting more and more competitive. It is the smart company that takes advantage of the learning opportunity available to them after each project. Setting aside a half day to debrief a project is a small investment to make for gaining construction management expertise, savvy, and know-how. Not only that, but it really contributes to a company's overall commitment to developing a quality management attitude up and down the ranks of the enterprise. You will learn a lot more about quality in the next chapter.

Applying Technology

I've already covered estimating and scheduling software applications in previous chapters. In many cases, these programs have features that allow the user to track actual performance against planned performance, which is what you need in order to evaluate and forecast progress and make adjustments as necessary to keep a project on track.

Many of the construction management software programs available today are integrating the estimating, accounting, and contract administration functions into a single program to make certain that project information such as cost overruns, percent complete, units in place, and numerous other project control types of data are immediately available for analysis. Because of technology, a construction manager can easily access the reports needed to check project status at a given time.

Terms to Know

cost code	escalation clauses
cost control	forecast
crashing the schedule	variance
earned value analysis	

Review Questions

1. What are the seven fundamental steps included in the project control cycle?
2. What are the two essentials of an effective project control system?
3. Name three sources where you might gather field information needed to develop your project controls.
4. It is important to receive accurate and complete information from the construction job site. Name two specific construction management functions where this information is used.
5. What is a cost code, and how is it used in project controls?
6. Name at least three factors that can impact project performance.
7. What is an escalation clause, and how is it used in the construction contract?
8. What is the riskiest element of project planning and project control?
9. What does it mean to crash the schedule?
10. Regarding project controls, what does it mean to forecast in construction management?

Chapter 13

Managing Quality and Safety

In This Chapter

- ◆ Elements of a quality management plan
- ◆ How to define construction quality
- ◆ The difference between quality control and quality assurance
- ◆ Elements of a safety management plan
- ◆ About the economics associated with quality and safety

Quality is the third leg of the three-legged stool mentioned way back in [Chapter 2](#), “What Is Construction Management?” You will recall that the three-legged stool represents the three primary elements of construction management: cost, time, and quality. You may also recall that safety makes up the foundation of that stool and that without safety, the effectiveness of our management efforts is really in question.

Quality not only impacts aesthetics, appearance, and durability—it also impacts performance. And poor performance can lead to failures in everything from an improperly installed section of roof flashing resulting in a leak to the deflection of a structural steel beam resulting in a roof collapse. There is no question that failures due to poor quality cost dollars and time, but in some instances, poor quality can even cost lives or serious injury.

The characteristics of a good quality management plan and a good safety management plan are quite similar. Although each is defined by distinct concepts and specific mechanisms of control, which I will explain, it makes sense to administer quality and safety plans as one integrated management function. In this chapter, I present both of these very important components of construction management.

Attitude Is Everything

Good contractors stake their reputations on quality and safety. You can write all of the policies, procedures, and rules that you want, but the truth is, if the leadership of the company has not established a foundational attitude of superior workmanship and an immovable stance on safety, it will all be for naught. When it comes to quality and safety, attitude is everything. And this attitude must emanate from the highest levels of leadership and management down to every single worker and subcontractor in the field. Successful construction managers are well aware of what they must do to achieve quality results and maintain high safety performance. They must do the following:

- ◆ Insist on good quality plans and specifications whenever possible.
- ◆ Provide experienced and adequate supervision on all jobs.
- ◆ Provide thorough and adequate inspections.
- ◆ Make sure that all workers are qualified to do the job they are hired to do.
- ◆ Never accept inferior work.
- ◆ Above all else, instill an attitude toward high quality and safety throughout the company.

However, sometimes even these are not enough. Although the project manager and superintendent are accountable for developing and implementing the quality and safety plans on the job, they must have support and participation from the field: quality and safety are ultimately achieved at the labor force level. Employees and subcontractors alike must embrace the plans and be encouraged in and recognized for their efforts to produce high-quality work and a safe work environment. And when they are, it sends a loud message, not only to other workers on the job but also to the project owner and the public at large. This is the goal of the construction manager.

Developing the Quality Management Plan

High quality on the job site, or anyplace else, does not just happen automatically. There must be an intention about it. In other words, quality happens on purpose.

The construction manager must have a quality management plan in place long before the first shovel of dirt is turned on the job. Achieving high quality in construction requires a comprehensive, systematic approach that looks at every detail involved with moving the project from an idea on paper to the final product—a building, a bridge, or a highway.

If you think back to [Chapter 2](#), you'll remember a number of characteristics that make construction unique. It is exactly these characteristics that make quality management such a great challenge. Take a quick look at a few of those characteristics once again just to refresh your memory and put this quality challenge in perspective:

- ◆ Unlike products produced in a factory, the construction project is built on-site, under uncontrolled climate conditions.
- ◆ Every project is built as a prototype.
- ◆ Every building site presents a unique set of conditions relative to topography, accessibility, and security.
- ◆ Many materials must be fabricated from scratch, so you can't depend on the consistency that comes from mass production.
- ◆ The workforce is primarily transient, with various specialty trades moving onto and off of the site as needed.

Let's face it, even under the most stable of conditions, achieving consistent quality results is no easy task. In construction, quality becomes a huge undertaking and constitutes a large part of the construction management goal. To achieve success, you must consider the challenge from both a project perspective and a process perspective. But before you can do that, you must start with a clear understanding of the expectations for quality.

Defining Quality

In construction, quality is defined as meeting or exceeding the requirements established in the design documents. Fundamentally, the quality of the construction project is set through the plans and specifications provided by the architects and engineers. There are various

levels of quality that can be specified for any given project. The design team works with the owner to determine exactly what their expectations for quality are. Budget is usually a factor that must be considered when setting the quality standard. Obviously there is a range of products and materials that can be selected for utilization in a new facility. Not every automobile is a Cadillac; some must be manufactured as Fords or Chevrolets to meet a particular market and budget need. The same is true in construction. Not all facilities will be constructed using Cadillac materials and standards. But that determination is made by the owner, not the contractor.

Back in [Chapter 8](#) (“Estimating Project Costs”), you learned that there were several factors that would impact project cost. Quality was one of those factors. Just to give you an idea of how significantly quality can impact price, let's consider several different project types specified at various quality levels. [Table 13.1](#) illustrates the range between three quality levels—low, medium, and high. You can see that even with parking garage construction, the price range relative to quality can be considerable.

[Table 13.1](#) Price Differences Based on Quality

Project Type	Square Footage	Low Quality	Medium Quality	High Quality	Difference High/Low
Apartment	70,000	\$4,732,000	\$5,605,000	\$6,806,000	30%
High School	120,000	\$6,999,000	\$8,966,000	\$11,345,000	38%
Warehouse	50,000	\$1,520,000	\$2,218,000	\$3,091,000	51%
Parking Garage	90,000	\$2,543,000	\$3,737,000	\$6,436,000	60%

In construction, the job of the project team is to deliver whatever quality standard has been set for the facility by the design team.

Primary Objectives of the Plan

Construction is not a perfect science, and it would be impossible to produce a project without some defects, failures, or complaints. After all, you are working with imperfect materials and imperfect people. How could you expect otherwise? However, the goal of the construction manager is to produce a project with as few defects, failures, and

complaints as possible. So, how do you do that? Fundamentally, your plan must focus on three primary objectives:

- ◆ Doing things right the first time
- ◆ Preventing things from going wrong
- ◆ Continually improving the process

rework

A term used to describe defective construction work that must be redone or corrected.

callback

A request from an owner that a contractor return to the job site to correct or redo some item of work.

If your plan addresses these three objectives, then *rework*, *callbacks*, and corrective actions will be kept to a minimum, and your job will have a much higher chance of success. Let's consider these objectives one at a time.

Doing Things Right the First Time

The first goal of the quality management plan is to get things done right the first time. Getting it right in construction doesn't always mean getting it perfect. For example, it is rare to find a concrete floor slab that is perfectly level. But it is commonly expected that a floor slab be level or flat within certain tolerances. For example, residential concrete slabs on grade are expected to be troweled smooth and flat to a tolerance of 1/4" in a 6' radius. This is not perfect, but it is a common standard of quality expected in the industry.

However, before you can focus on doing things right, the project team must first know what the quality standards are and the best way to achieve them. Workers can't do the job right the first time if they don't have the proper skills, the necessary level of experience, adequate supervision, and the tools and equipment needed to perform the task. In most cases, the superintendent is responsible for seeing to it that the workforce is

prepared and motivated to complete the task at hand. This is just one more reason why superintendents are such a valuable asset to the company.

Preventing Things from Going Wrong

We all know that hindsight is 20/20, but that won't cut it if your objective is to prevent things from going wrong in the first place. Meeting this objective requires a high sense of awareness, adequate preparations, and clear communications. To prevent things from going wrong, the team must stay one step ahead of the work in terms of oversight and supervision. A *preparatory inspection* is one of the best ways to avoid miscues and rework that can disrupt the schedule and negatively impact the budget. (Preparatory inspections will be discussed in detail later in this chapter.) Unfortunately, there are many projects whose pace is so fast and furious that the project team has all it can do to perform the required inspections, let alone these preparatory ones. So, things do go wrong and they must be corrected, but the goal is to catch everything you can before it becomes an issue. And this job must be the responsibility of the entire project team, not just the superintendent, if you want to have any chance at all of achieving the objective.

preparatory inspection

Inspections, sometimes called *pre-inspections* are designed to check progress and make sure everything is ready for the next stage of construction.



Real World Scenario

What Is Right?

Usually the plans and specs dictate the expectations for quality and “what is right.” However, I have found that many owners do not understand what the specifications actually say, even though they paid an architect to prepare the documents for them. On more than one occasion, I have had an owner come on to the job expressing concern for quality, only to find that we have indeed met the expectations spelled out in the plans and specs. Unfortunately, the expectations of the owner are not always reflected in the plans and specs, and the end result is not what they had in mind. However, in my opinion, this is a communication and education problem between the architect and the owner more than it is a quality issue. Even so, it is the contractor who is usually left to deal with the owner's disappointment and frustration.

In my experience, I have found that an owner's expectations for quality are sometimes unrealistic and impractical. For example, anyone expecting perfectly matched wood grains on a set of oak cabinet doors has an unrealistic expectation that can never be met. Wood grains are random, and that's just the way it is. And yet I have had clients ask for doors to be replaced (several times) for this very reason.

So, the lesson here is to always make sure that everyone involved in the project—the owner, the architect, the contractor, and the craftspeople—all know what the quality expectation is so they can get it right the first time.

Continually Improving the Process

The third goal of the quality management plan is to continually improve the work processes and systems that support the work. The concept of continuous improvement is grounded in the work of Edward Deming and is commonly known as *Total Quality Management (TQM)*. His theories suggest that no matter how good your product, process, or performance is, it can always and forever be enhanced. The key is to approach quality as a never-ending, incremental, continuous improvement process.

Total Quality Management (TQM)

A recognized quality control and quality assurance program based on continuous quality improvement practices.

NOTE

Deming was a statistician by trade, and he defined high quality as meaning low variability. In other words, we have a quality expectation (or standard) and we have our performance relative to that expectation. The gap between the two variables equals our opportunity for improvement.

Tom Peters, the author of *In Search of Excellence*, once said that it was much easier to improve 100 things by 1 percent than it was to change one thing by 100 percent. When I was in business, I always tried to remember this concept and found that continuous improvement works best in baby steps versus giant leaps. Here are the steps that I used when implementing TQM in my firm and on the job:

1. Identify the problem.
2. Break the work down into its smallest pieces or steps.
3. Identify the weak link.
4. Determine the remedy.
5. Apply the remedy.
6. Measure the results.

The last step, measuring the results, is a critical one when it comes to TQM. It is important that you are able to document the improvements that you are making. From a management standpoint, “feeling” like you are making progress is not good enough. The only way that you can be sure that your remedies or corrections are working is to measure the results. The following is a simple technique for tracking improvement efforts:

Problem

Hairline cracks in drywall where wall and ceiling meet

Problem	Hairline cracks in drywall where wall and ceiling meet
Goal	Reduce number of customer callbacks to make drywall repairs
Remedy	Replace paper drywall tape with fiberglass flex tape
# of callbacks before remedy (Jan. to June)	47
# of callbacks after remedy (July to Dec.)	9

NOTE

The Construction Industry Institute (CII) published *Guidelines for Implementing Total Quality Management in the Engineering and Construction Industry*. The manual is based on the results of a research study conducted earlier that showed that the implementation of TQM practices resulted in improved customer satisfaction, reduced cycle times, documented cost savings, and a more satisfied and productive workforce. This document is available on the CII website at

<https://www.construction-institute.org/resources/knowledgebase/best-practices/quality-management/topics/rt-031#>.

The QA/QC Functions

The construction process can be complex and often chaotic. Given the number of products, players, and unique characteristics associated with construction, you can certainly understand how it might be very difficult to put together a comprehensive quality management plan. The task really requires a twofold approach.

quality control

A quality management approach that addresses quality at the project level and deals with conformance to the plans and specs through submittals, mock-ups, shop drawings, inspections, and testing.

You must consider quality first from a “project” perspective and then from a “process” perspective. The two approaches may be categorized as *quality control* at the project level and *quality assurance* at the process level. The industry often lumps the two concepts together, referring to the quality control function as the QA/QC function. However, each of the two concepts has a unique focus

quality assurance

A quality management approach that addresses quality at the process level and deals with policies and procedures associated with hiring, training, safety, subcontracting, and procurement.

with distinct mechanisms and techniques for its management. Let's consider the differences.

Quality Assurance

Quality assurance (QA) takes a long-range view toward developing systems that produce high-quality work consistently over time. To be effective, a good quality assurance plan must influence every aspect of the company, from the management to the field. The concept implies that if the proper procedures, policies, and systems are institutionalized throughout the organization up front, the outcome at the project level will be much more reliable. Let's look at the ways some construction company practices can affect quality for better or worse:

Hiring practices The quality of the hire will obviously affect the quality output on the job site. Finding people who have been trained properly in their respective trades is at the core of any quality assurance program. When I was a construction employer, I discovered that individuals could learn the wrong way of doing things as easily as they could learn the right way. I was constantly on the lookout for people who were trained to do things the right way and had a good attitude to go along with it. Unfortunately, when workloads become very heavy, there is a tendency to hire just about anybody who knows anything about construction just to place bodies on the job. This is always a mistake and a sure bet that quality will suffer.

The construction industry is known for its high employee turnover, especially on the craft worker side. However, I found that setting high quality standards helped the company retain a high percentage of employees for longer periods of time. Most construction workers take great pride in their work and seek out job environments that promote high quality and safe practices.

Training programs A commitment to quality requires a commitment to training. Quality assurance equates to a quality training program. Employees must be trained consistently in the technical skills and techniques needed to perform the work as well as in the policies, procedures, and methods of quality control to be implemented on the job site. Shortchanging the training component of your quality assurance program will result in inconsistent performance that will hurt the project in the long run. And once again, when the workload gets very busy, this commitment can sometimes lapse to the detriment of the whole company.

Safety Safety must always be part of the quality assurance plan. Establishing strict rules and regulations regarding safety procedures and practices is a must. These rules and regulations must apply to all aspects of the construction work: equipment use, material handling and storage, hazardous materials communications, substance abuse policies, accident prevention, and personal protective equipment requirements. This is one part of the overall quality assurance program that cannot be compromised no matter what the condition of the market or the pace of the project.

Subcontracting practices You are well aware that the majority of the construction work on a project is performed by subcontractors. And subcontractors are often selected the same way that general

contractors are selected—by low bid. Unfortunately, this methodology does not always result in the best quality. As a matter of fact, the old adage “You get what you pay for” often comes true when we award the contract to the subcontractor with the lowest price. However, if we are truly committed to high quality, it is crucial that we develop a subcontracting policy that will garner bids from the best craftspeople in the market. One way to do this is to prequalify subcontractors in advance of bidding. Prequalification can be accomplished by sending out questionnaires requesting information regarding past performance and client references. In my own practice, I would also interview subcontractors one on one before soliciting bids from them. This helped me get a sense of their attitudes toward quality and safety as well as their actual skills and performance level. When bidding jobs, we always tried to work with subcontractors that were on our prequalified list. This practice would help ensure a quality workforce on the job.

Procurement methods I found very early on when running my company that one of the best things I could do to maintain high quality and high productivity on the job was to work with high-quality vendors. The practice of prequalification can also be applied to your procurement practices. There are hundreds—thousands—of materials and equipment that must be delivered to every project. You cannot afford to deal with companies that aren't able to meet your demands for quality and on-time delivery. Poor performance by your vendors can really sabotage your job and your commitment to quality. Implementing a vendor prequalification system as part of your quality assurance program is one way to increase the odds of receiving top-quality service when it comes to material and equipment procurement.

Employee incentives It is important for management to send clear messages about its commitment to quality. One of the best ways to do that is to create incentives and recognition awards as part of the quality assurance program. Recognizing and rewarding exceptional performance relative to quality (and safety) by individual employees, project teams, subcontractors, and vendors is one way to do just that. Rewards may or may not be monetary. Many contractors have found that public recognition with an award plaque, weekend getaways, fishing trips, and fancy dinners with spouses all work pretty well as incentives for high-quality performance. The point is that management must put its money where its mouth is and reward the good work and high quality that it demands.

Quality Control

Quality control (QC) addresses quality at the project level and is implemented on the job site. Quality control primarily deals with issues relating to conformance to the plans and specs. All of the materials, systems, and workmanship applied to the project must conform to the requirements set forth in the contract documents. Quality control is accomplished using a number of different mechanisms: submittals, mock-ups, shop drawings, inspections, and testing, which are all called for in the project manual.

Mandated Controls

The typical construction contract establishes a number of controls and procedures designed to ensure that the quality of the materials, equipment, and workmanship used on the job are as specified by the designer. Several of these requirements were introduced in [Chapter 9](#) (“Contract Administration”) and [Chapter 10](#) (“Construction Operations and Job Site Management”), but I’ll go into a little more detail regarding exactly how you use them to control the quality of the project.

Submittals In [Chapter 9](#), you learned about submittals. The contractor is responsible for providing some form of documentation or sample to the architect to verify that all materials and equipment comply with the requirements set forth in the contract documents. This is the first step in the quality control process. The documentation usually consists of catalog specification sheets (often called cut sheets) or brochures that relay information regarding model number, size, configuration, color or finish, weight, and other specific data about the product. The architect is charged with approving or rejecting each submittal. Once the product is approved, the construction manager orders the material.

However, the quality control process does not end with the submittal approval. After the materials and equipment are ordered, each delivery arriving on the job site must be checked to ensure that it is correct and in accordance with the purchase order and the submittal. If the materials are not as specified and approved, they should not even be unloaded from the delivery truck. They should be rejected immediately and sent back to the supplier. The challenge is to make sure that every delivery gets inspected and checked as it arrives, not days later or, worse yet, hours before you are ready to install the product. Finding out that a product is not as ordered this late in the

game can really put a monkey wrench in the works, but considering how busy a job site can become, unfortunately sometimes it does happen.

Mock-ups Mock-ups (also referenced in [Chapter 9](#)) take the submittal concept one step further. Mock-ups require the contractor to build small models utilizing the specified materials. In a mock-up, specific nuances such as colors, shades, tones, patterns, and textures of an installation can be better observed and inspected. Although mock-ups are not practical for every installation, they are particularly useful when the expectation for quality cannot be easily conveyed in writing. For example, a catalog cut sheet can easily convey the color, style, and installation of a towel bar, or even the standard 4-inch ceramic tile installed on the wall behind the towel bar. However, when it comes to a stained concrete patio, the actual look of a “sand drift” or “tawny brown” color cannot be easily conveyed in a brochure. The only way to confirm the quality expectation when it comes to the color and texture of the concrete would be to construct a small sample. The contract documents will specify when and where mock-ups are required; however, there are instances where it is definitely in the contractor's best interest to construct mock-ups for owner or architect approval even if the contract documents do not require them.

Shop drawings You also learned in [Chapter 9](#) that anything that has to be fabricated specifically for the project (roof trusses, steel girders, and so on) must first be approved via a shop drawing. These drawings indicate dimensions, materials, finishes, and details associated with their installation. They usually originate with the material supplier or the subcontractor and eventually end up on the architect's desk for final approval. Once the drawing is approved, fabrication begins, and the product is eventually shipped to the job. The superintendent assigns a field engineer or a quality control person to verify that the product that arrives on the job site has been built in accordance with the shop drawing. If it has not, then it must be rejected and reordered. You are probably beginning to see how important it is to prequalify subcontractors and suppliers as part of your overall quality assurance plan. An error in the fabrication of a long lead (time) item can put the whole construction schedule in jeopardy.

Testing standards There are a number of quality standards associated with the testing and manufacture of various products. The specifications spell out which testing standards must be met by the

materials and equipment used on the project. The primary testing agency for construction in the United States is the American Society for Testing and Materials (ASTM). ASTM is one of the largest voluntary standards development organizations in the world for materials, products, systems, and services. Almost every division of the specifications makes some reference to an ASTM standard. Every product or procedure designated by an ASTM test number in the specifications must meet the standards set out by the agency. An example of a common ASTM standard as it appears in a set of specifications is shown here.

2.06 Concrete Mix

A. Mix Design: Select proportions for normal weight concrete in accordance with ACI 211.1. The laboratory used to prepare the mix design shall meet the requirements of ASTM 1077.

B. Ready Mix Concrete: Mix and deliver ready mix concrete, in accordance with ASTM C94.

C. Requirements: Provide concrete to comply with the following criteria:

1. Flexural strength (ASTM C78)
 - a. Modulus of rupture at 28 days to be 650 psi minimum
 - b. Modulus of rupture at 90 days to be 90 psi minimum
2. Compressive strength (ASTM C39): As determined by mix design for 7 and 28 days
3. Water/cement ratio: 0.45 maximum by weight
4. Cement content: 520 lbs./cubic yard minimum
5. Air entrainment (ASTM C231): 3–4%
6. Slump (ASTM C143): 3 inches maximum without plasticizer and 4 inches maximum with plasticizer

Another common testing agency often referenced in the specifications is Underwriters Laboratories Inc. (UL), an independent product-safety testing and certification organization. In 2016, 22 billion products had the UL label attached to them worldwide. In most instances, the contractor doesn't really need to worry about whether a product is UL listed or not because almost all products manufactured in the United States carry the UL label. However, there is always a slight chance that a product could slip through the submittal process and not be checked. I learned my lesson years ago.



Real World Scenario

Always Check the Label

Several years ago when I was building a home for a client in Virginia, I left the selection of the zero-clearance fireplace up to the owner. (A zero-clearance fireplace consists of a metal firebox with a triple-walled stainless steel chimney instead of a masonry firebox and chimney and can be installed in close proximity to the wood framing.) The owner went down to the nearest fireplace store and picked out a popular brand of fireplace, and we proceeded to install it in the house. We framed it in, installed the chimney, faced the firebox with a beautiful marble tile surround, and wired the automatic circulating blower fan attached to the firebox.

At the final inspection for owner occupancy, the building inspector informed me that the fireplace had to be removed because it did not meet code—the blower fan did not have a UL label on it. Instead, it had a Canadian testing agency label on it. Well, there was no way that the owner, or I, wanted to tear out the fireplace. We proceeded to research the Canadian testing agency and found that their standard met or exceeded the requirements of the UL label. However, the building inspector wouldn't budge and wouldn't allow the owner to move in. Finally, the city manager got involved and allowed the owner, who really wanted that particular fireplace and was perfectly satisfied with the quality, to write a letter holding the building department and me, the contractor, harmless for any damage or injury occurring as a result of using the fireplace. All of this effort took about four weeks to resolve, and the owner was not allowed to move into his new home for that period of time. You can bet that from that point forward, I made sure we always checked the labeling of every device we installed.

Independent testing and inspections There is another set of testing and inspection procedures often required by the contract that must be conducted in the field while the work is in progress. These inspections and tests are usually performed by an independent testing agency or engineering services firm. Here are some examples of common field tests:

- ◆ Soil testing for compaction
- ◆ Concrete testing for slump and strength

- ◆ Structural steel testing of welds and bolt torque
- ◆ Asphalt testing for mix design and strength
- ◆ Aggregate testing for material composition

The test agencies will send specially trained personnel to the job site to perform the inspections or tests. Sometimes the test must be conducted in special laboratories off-site, and samples are collected on-site to take back to the lab. After the results are obtained, test reports are submitted to the contractor and filed with the architect or owner. The products and installations that do not meet the test standards specified must be removed and redone. You can imagine how costly this can be if the deficiency shows up in something like a large concrete pour. Close coordination between construction operations and required testing is a must, and it is the superintendent's job to make sure that these tests happen in a timely fashion.

Building code inspections Most people are familiar with the type of inspections related to the local building code authority. When you obtain a building permit, which is required for most construction projects, there is a schedule of inspections that must occur as the work progresses. The main purpose of these inspections is to make sure that the work conforms to the local building code. Originally, there were three primary building codes, adopted by different areas of the United States, that set minimum quality standards for the various sections of work associated with construction.

- ◆ The Uniform Building Code was adopted by most of the West.
- ◆ The National Building Code was used chiefly in the Northeast and Midwest.
- ◆ The Standard Building Code was used mainly in the South.

In 2000, the governing bodies of each of these different building codes developed a single comprehensive code called the International Building Code (IBC). Every state in the US has adopted the I-Code, as it is sometimes called, and issue their building permits under the jurisdiction of this code.

When a code violation is found, the building official issues either a correction notice or, in more serious instances, a stop work notice to the contractor. Under the correction notice, the contractor may continue working but is ordered to make the correction within a reasonable time frame and call for a reinspection. However, when

the deficiency is potentially life-threatening or requires immediate action, all work on the job must stop until the correction is made. The cost to shut down a project and restart operations is significant and must be absorbed by the contractor. Stop work notices are serious business and should always be avoided whenever possible.

Supervisory inspections The contract specifically spells out the responsibility of the contractor to provide proper supervision of the work throughout the construction process. The superintendent is ultimately responsible for assuring the quality (and safety) of all self-performed work and subcontracted work. The superintendent is the one who sets the standards of performance on the job. Large projects may call for full-time quality-control inspectors or quality engineers. But on small- to medium-sized jobs, the quality control tasks are often handled by an assistant superintendent or job foreman as directed by the superintendent. They often make use of quality inspection checklists similar to the one shown here.

Although it is relatively easy to determine whether a model number, color, or size conforms to the requirements of the contract, it is a little tougher to know what represents high quality when it comes to workmanship. Therefore, it is important that the quality control personnel be pretty familiar with standards associated with a number of trades. For example, the person must be able to discern high-quality work from inferior work in plumbing as well as rough carpentry, in concrete as well as electrical, and in roofing as well as drywall. Obviously, there are some inspection tasks that must be handled by the more experienced members of the project team.

ABC Construction

Peppermill, AZ

Job Name: Jefferson Natl. Bank

Location: 561 Piedmont Street
Jefferson, AZ 90777

Contractor: Smith Excavating Service

Contact: Bob Smith

Phone: 555-714-3122

Quality Checklist – Backfill

- ☒ Work complies with local, state, and national codes.
- ☒ Foundation voids, cracks, or honeycombs patched and sealed watertight.
- ☒ Wall ties in poured concrete foundation broken off and all tie holes filled with black plastic cement.
- ☒ Seam between foundation and footing sealed watertight.
- ☒ Basement foundation dampproofing completed according to quality standards.
- ☒ Footing drains installed properly according to plans.
- ☒ Debris and trash removed from trenches around foundation.
- ☒ Utilities and plumbing connections approved and inspected, as required.
- ☐ CR Foundation properly braced.
- ☐ HOLD Backfill done in 8" lifts and compacted as required.
- ☐ HOLD Fill dirt clean and free of rocks and debris.
- ☐ HOLD Backfill surface is at least 8" down from the top of the foundation.

Superintendent's Signature: J.W. Jackson

Date: June 8, 2019

Correction Required (CR):

South elevation requires additional bracing. Do not backfill until all bracing is properly installed. Contacted Bob Smith on Tuesday, 6/8/19 at 3:30 p.m.

ABC Construction

Peppermill, AZ

Job Name: Kramer Medical Lab

Job Number: 22-04

Superintendent: JWJ

Quality Engineer: CWP

Quality Deficiency Log

No.	Initial Inspection	Description	Location	Responsible Party	Contact	Date Corrected	Re-inspected	By
1	6/08/19	Stair riser height is not per plans and spec.	West entrance	Baylor Bros. Concrete	Bob Smith	6/23/19	6/24/19 OK	CWP
2	6/08/19	Exterior light fixture has cracked globe.	West entrance	Carvel Lighting	Karen Jones	7/01/19	7/02/19 OK	CWP
3	6/17/19	Dent in metal toilet partition door—stall 3.	Men's room	Westside Specialties	Mike Davis	6/29/19	7/02/19 OK	CWP

When work or materials are found to be inferior, they must be rejected outright. Each occurrence should be noted in an inspection report, and all deficiencies should be tracked via a deficiency log. It is the quality control engineer's job to follow up on each deficiency until the item has been corrected to the satisfaction of the superintendent.

Going the Extra Mile

Construction companies that enjoy good reputations for high quality usually go way beyond the mandated methods spelled out in the contract documents. Their quality assurance philosophy requires that they go the extra mile. They implement processes that help them achieve a level of quality beyond the minimum, resulting in less rework, fewer callbacks, and ultimately more repeat business. Let's take a look at a few of these extra efforts:

Preparatory inspections Preparatory inspections are usually conducted by personnel employed by the general contractor. These inspections are designed to check progress and make sure that

everything is ready for the next stage of construction. A good example of a preparatory inspection is a pre-roofing inspection. There are a number of layers of materials that make up the typical roofing system. For a built-up roof, there is metal or wood decking, insulation, an underlayment of some kind, perimeter flashing, several layers of building felt, and gravel ballast. The superintendent may request a preparatory inspection at each step of the installation. For example, the superintendent may want to inspect the roof deck first, then the insulation, then the underlayment, and all the way down the line. This inspection process is very different from inspecting the installation only after the roof is 100 percent complete, and the chances of achieving superior results are much higher.

Not all contractors conduct preparatory inspections, but in my opinion, they should. If you remember the cost/influence curve from [Chapter 2](#) (“What Is Construction Management?”), you know that it costs a lot less to correct an error or defect early in the work sequence than it does after the system is completed. This is the concept behind the preparatory inspection.

Zero-punch list You learned about punch lists back in [Chapter 5](#), “Project Stages.” The concept behind a zero-punch list is to complete the final walk-through inspection with few or no punch items noted on the list. The methodology used for achieving a zero-punch list (or near-zero-punch list) is similar to the process used to conduct preparatory inspections. The idea is to inspect the work as it progresses, instead of waiting until it is completed, only to find that the quality is unacceptable. For example, let's assume that we have a 600-square-foot area that is going to receive 6" × 6" ceramic tile. The contractor would first pre-inspect the area (preparatory inspection) to make sure that the subsurface is clean and free from defects. Then the contractor would request that the tile setter install only a small amount of work, say 100 square feet, and then call the superintendent for a pre-inspection. The superintendent would pre-inspect the small area of tile, noting any deficiencies or variations from the specified quality indicated in the specifications, such as the grout joint width. If there are any, the subcontractor would have to make the adjustments and corrections before proceeding with the work. This pre-inspection accomplishes two goals: first, the subcontractor is now well aware of the quality standard expected by the superintendent, and therefore the end result should meet the expected quality; second, the cost to correct the deficiencies has been kept to a minimum.

field observation report (FOR)

A report used to track questionable quality and safety performance on the job site.

Field observation reports Even though there are a number of procedures set forth in the contract documents to ensure quality on the job, one of the most effective methods for managing quality, especially workmanship quality, is the *field observation report (FOR)*. Many construction companies initiate a process by which every employee, subcontractor, and visiting vendor is encouraged to report any work item suspected of being installed incorrectly or failing to meet a quality or safety standard. Each of these observations is recorded on an FOR form and given to the quality engineer or person in charge of the task. The quality engineer notes each of these observations in an FOR log and follows through until the item in question is verified or corrected as needed. This is a little different from the standard deficiency report previously mentioned. The deficiency reports are a result of the formal supervisory inspection process; field observation reports are initiated by anyone at any level of the organization. In other words, a laborer who is cleaning up the job site might question the spacing on the anchor bolt layout on a concrete slab because something looks out of the ordinary. The laborer would report that question to the quality engineer, who would be obligated to verify that the spacing is correct. And if the spacing was not correct, the quality engineer would be responsible for notifying the appropriate parties to get the problem fixed.

Safety as a Component of Quality

Much of the quality management plan focuses on compliance with the requirements of the plans and specs relative to materials and workmanship. Compliance with the quality requirements often equates to compliance with the safety requirements—at least up to a point. For example, construction specifications dictate quality, and most specifications call for electrical devices on the job to be UL certified. A UL label on a product certifies that the product is deemed to be safe. If the product meets the quality requirement in this case, it also meets the safety requirement. There are a number of instances where quality management and safety management overlap. However, there are some safety management issues that must be considered separately. Let's take a look at some of these issues and discuss the individual elements of a good safety management plan.

The Safety Manager Role

Project managers and superintendents are responsible for the overall safety of their workers on the job site and all of the equipment and materials that they must handle. They must set the standards for safety right up front and be forever diligent regarding adherence to the safety plan.

However, the day-to-day management of the safety plan is usually assigned to an individual project team member. Because there is such a close relationship between quality and safety, it is not uncommon for the project manager to assign one person to hold the position of both the quality engineer and the safety officer. It depends on the size of the job. Larger jobs may require an independent quality engineer and safety officer. On smaller jobs, the assistant superintendent often covers the responsibilities. But whether the functions are handled by one person, two persons, or someone in a dual role such as an assistant superintendent, it is very important that the individual(s) responsible for safety management take their job seriously.

After all, the company's reputation and every worker's safety depend on their efforts.

NOTE

The field observation report can also be used to monitor and report any unsafe job conditions or work practices. Many quality control mechanisms double as safety control mechanisms.

A Dangerous Business

Construction is dangerous work and accounts for about 21 percent of all occupational fatalities. Historically, the construction industry, above all others, has held the top spot for injuries and illnesses in the United States. (Recently, manufacturing has taken over this dubious distinction.) In 1970, the federal government established an agency specifically charged with developing safety standards for construction and all other industries in the United States. That agency is the *Occupational Safety and Health Administration (OSHA)*.

Occupational Safety and Health Administration (OSHA)

The federal agency responsible for establishing safety standards for construction and all other industries in the United States. The agency also has the authority to enforce those standards through rigorous inspections at the job site and to issue citations to and assess fines against any contractor or subcontractor for violating these standards.

OSHA plays a big role in construction safety. It not only establishes the safety standards for the construction industry but also has the authority to enforce those standards through rigorous inspections at the job site. OSHA has the authority to issue citations to and assess fines against any contractor or subcontractor for violating these standards. A serious violation of an OSHA regulation can result in a fine of up to \$13,260 per violation. A repeat violation can result in a fine as high as \$132,598. These are serious penalties, the kind that can put a small builder or subcontractor out of business. And if the fines themselves don't put them out of business, the increased workers' compensation premiums will.

Repeat offenders aren't always easy to spot. Although owners often screen their general contractors' safety records through prequalification statements prior to bid, contractors generally do not have time to screen their subcontractors during the bidding process. (Remember the chaos on bid day mentioned in [Chapter 3](#), "How We Get the Work"?) However, if a subcontractor has a history of multiple OSHA violations, word will get around, and eventually the violator will more than likely be forced to close shop.

The consequences associated with unsafe practices and reckless behavior in construction are significant. It is important that superintendents and construction managers at all levels be rigorous and unrelenting when it comes to enforcing the safety policies of the company. However, the responsibility still boils down to the actions of the individual men and women on the job site. Every employee must be made aware of the safety policies and the consequences for failing to adhere to them. It takes only one employee to fail to tie off on a rebar cage or to leave their hard hat in their pickup truck for just a minute to risk the viability of a whole company and the livelihood of all of its employees or, even worse, someone's life.

NOTE

It is the superintendent's responsibility to see to it that every worker on the job site receives safety orientation and training on applicable OSHA standards and company safety requirements and that the worker has enough experience to do the job safely.

Developing the Safety Management Plan

Obviously, it is in contractors' best interest to do whatever they can to keep the workers and materials safe and the equipment in good working order. No construction project should start until a well-thought-out, written safety plan (often called a safety manual) is in place. The number-one goal of the safety plan is to mitigate hazards and prevent accidents. Every worker on the job site should be encouraged to embrace a no-nonsense attitude toward safety and be trained rigorously in safe work habits and hazard awareness. According to the NAHB-OSHA Jobsite Safety Handbook, an effective safety management plan includes four primary components:

Management commitment The job superintendent is responsible for setting the overall tone when it comes to safety on the job site. However, safety must be the number-one priority for every level of management up and down the ladder. The most successful safety management plans include a clear statement of support and commitment by the company owner and include employee involvement in the structure and operation of the plan.

Job site analysis Hazard awareness prevents accidents. An effective safety management plan includes procedures to analyze the job site and identify existing safety hazards and conditions that might become safety hazards. Every person who works on the job should be trained in hazard awareness and be given authority to report any item that may be of concern.

Hazard prevention and control Obviously, if part of your plan is to discover hazards, another part of your plan must be to eliminate or mitigate those hazards. The safety management plan must establish procedures to correct or control present or potential hazards on the job site. This section of the plan focuses on specific safety issues. These are four of the more common issues typically addressed in every safety management plan:

- ◆ Personal protection
- ◆ Accident prevention
- ◆ Substance abuse
- ◆ Hazardous material communications

Each of these issues is discussed in greater detail in the next section of the chapter.

Safety and health training The construction manager must be very persistent in seeing to it that every worker on the site has access to appropriate safety training. This is true for either self-performed work or subcontracted work. Training is an essential component of an effective safety management plan. The scope of the training depends on the size and complexity of the job as well as the characteristics of the potential hazards.

Personal Protection

Personal safety for the individual worker is a fundamental objective for any safety management plan. The superintendent must set strict rules regarding the requirements for personal protection equipment and furnish every worker with the equipment that is needed. If the work is being subcontracted, then the superintendent has to make sure that the subcontractor is providing this equipment for their own workers. Every person who comes on the job site must be made aware of the rules and be expected to follow them—even visitors. I visit a lot of job sites as a professor of construction management, and I often take students with me. Every student is expected to show up on the site with hard shoes (no tennis shoes or sandals), a hard hat, long pants, and safety glasses, at a minimum. If anyone shows up without them, that person is not allowed on-site, period. There are nine types of personal protection equipment:

Protection Equipment Example	
Body protection	Special suits or coveralls
Head protection	Hard hats
Respiratory protection	Respirators
Face protection	Face shields, masks
Eye protection	Safety glasses or goggles
Hearing protection	Ear plugs, ear protectors
Hand protection	Gloves
Foot protection	Steel-toed shoes or boots
Fall protection	Safety harnesses

Body protection	Special suits or coveralls
Head protection	Hard hats
Respiratory protection	Respirators
Face protection	Face shields, masks
Eye protection	Safety glasses or goggles
Hearing protection	Ear plugs, ear protectors
Hand protection	Gloves
Foot protection	Steel-toed shoes or boots
Fall protection	Safety harnesses

Each type is designed to protect the individual against specific kinds of hazards. You don't have to wear all pieces of equipment for every job. Steel-toed shoes, hard hats, and safety glasses are pretty basic and are generally required to be worn at all times while on-site. But face protection, for example, is worn only for activities such as welding. This

equipment is meant to protect individuals from accidents and injuries and, in some cases, even death. Once the contractor makes the personal protection equipment available, it is the individual worker's obligation to follow all rules and regulations pertaining to its use.

Accident Prevention

Accident prevention is the name of the game. This is what all of the safety equipment and tailgate training and awareness is about—and for good reason. In the United States, 90 percent of all work-site fatalities are caused by accidents. The following types of incidents were the primary causes of job site accidents in 2018. It is believed that by eliminating these “Fatal Four” types of accidents, it would save approximately 602 workers' lives each year.

Job Site Accident	Percentage of All Work-site Fatalities
Falls	39 percent
Being struck by materials, equipment, or other objects	10 percent
Being crushed or trapped	7 percent
Electrical shocks	9 percent

The project manager and superintendent (and the whole project team, for that matter) must do everything they can to mitigate hazards that may cause accidents or injuries to the workers and the general public alike. They must look at each item of work in advance and try to anticipate any hazards that might arise and take steps to eliminate that potential. One of the tools that can be used to formalize this process is called a hazard mitigation plan. An example is shown here.

ABC Construction Peppermill, AZ Job Name: Kramer Medical Lab Job Number: 22-04 Superintendent: JWJ Quality Officer: TRD Hazard Mitigation Plan DIVISION OF WORK MASONRY		
Work Item	Potential Hazard	Mitigation Measures
Material delivery (mortar, sand, block)	Heavy traffic Heavy lifting injuries	(1) Traffic control officer to direct trucks – wear orange vest. (2) Wear back brace, steel-toed shoes, and gloves to unload materials.
Mixing mortar	Mortar mixing – turning drum Eye irritation from portland cement Skin irritation from portland cement Electrical shock	(1) No loose jewelry, chains, watches, or clothes. (2) No long hair. (3) Wear safety glasses. (4) Wear gloves. (5) Check electrical cord condition. (6) Check outlet for grounding.
Laying block	Eye and skin irritation from mortar Heavy lifting injuries Falls from scaffolding	(1) Wear safety glasses and gloves. (2) Wear back brace, steel-toed shoes, and gloves. (3) Inspect scaffolding and handrails.

Accidents are called accidents because no one saw the event coming. However, the truth is that most accidents can be anticipated and prevented. A good safety management plan is proactive—anticipating hazards, eliminating them, and preventing potential accidents before they occur.

Tailgate Safety Meetings

One of the ways that the superintendent or safety officer reinforces safety as a high priority on the job site is by conducting weekly safety meetings with workers. Sometimes these meetings are referred to as *tailgate safety meetings* (or toolbox safety meetings), and they tend to be short and focused. The purpose of the meetings is to emphasize safe work habits, to remind everyone to keep a sharp eye out for any conditions that may pose a hazard, and to take any necessary corrective action immediately. There is a long list of tailgate safety topics available. Here are just a few:

tailgate safety meetings

Weekly safety meetings held at the job site and usually conducted by the superintendent. They're also called *toolbox safety meetings*.

- ◆ Keeping the job site clean
- ◆ Keeping stairways and ladders safe
- ◆ Making scaffolds and work platforms safe
- ◆ Working safely on roofs
- ◆ Ensuring excavation and trench safety
- ◆ Keeping tools safe
- ◆ Keeping vehicles safe
- ◆ Ensuring electrical safety

Keeping the job safe is the obligation of everyone on the work site. That's why it is so important to constantly engage the workforce in safety training and the implementation of the safety plan on a regular basis. The tailgate safety meetings are usually conducted by the superintendent, assistant superintendent, or job foreman on a weekly basis and usually only take a few minutes (10 to 20 minutes) to complete. The topics should relate to the type of work being performed at the time of the meeting. It is important that a record of each meeting be kept, noting the date and time, the attendees, and the topic discussed. Such a record is evidence that legitimate efforts have been made to communicate and encourage safe practices on a regular basis.

Substance Abuse

Construction is a dangerous enough business when people are on their toes and alert. However, any workers who might be under the influence of alcohol, illegal drugs, or even legal drugs pose an additional danger to themselves and others who might be working with or near them. Drug and alcohol abuse cannot be tolerated at any level in this industry. Reflexes and judgments must be quick and sharp in construction. People are using power tools and operating equipment on a daily basis, and these tools and equipment can do bodily harm in an instant.

Most construction companies have instituted a requirement for drug testing upon hiring. Some have also instituted random drug testing as an extra precaution. Of course, there is great debate in our society as to whether random testing should be allowed. Many argue that random drug testing is an invasion of privacy. However, in construction, the risks associated with personal safety and public safety are enormous, and effective measures must be taken to ensure that every person working on the site is drug and alcohol free.

NOTE

When drug testing is employed in construction, whether as a condition of hire or as a preventive measure through random testing, the applicable labor unions must be made aware of the policy.

Hazardous Materials Communication

There are numerous construction products that are constituted as compounds, solvents, adhesives, and liquids, and each of these is made up of various chemicals. By law, every worker on the job site has the right to information pertaining to each of the products that they may come into contact with while they do their jobs and any harmful effects that the products may cause. The contractor is obligated to communicate this information and make it readily available for viewing. Therefore, every safety management plan must include a system for compiling and documenting pertinent chemical information on the various products used on the project. The official document used for this purpose is called a *material safety data sheet (MSDS)*.

material safety data sheet (MSDS)

An information sheet documenting pertinent chemical information on various products used in construction.

An MSDS for most chemical products may be obtained from the manufacturer of the product. For example, Sherwin-Williams will provide an MSDS on any of its paint products upon request. It is the contractor's job to obtain all of these sheets and file them at the job site. This task is

often given to a project engineer or the safety officer on the project. These are some of the common products used in construction that require MSDS data:

- ◆ Gasoline and fuel oil
- ◆ Paints, shellacs, varnishes, turpentine, and mineral spirits
- ◆ Detergents, cleaning agents, degreasing agents, and janitorial supplies
- ◆ Wood preservatives
- ◆ Adhesives
- ◆ Acids

Each sheet contains information regarding chemical data and composition, fire and explosive hazard data, physical data such as appearance, odor, or evaporation rate, and handling and storage information. Although the compilation of this file may seem like a tedious job, it is one that cannot be overlooked by the construction manager. Failure to produce a complete MSDS file upon request by an OSHA inspector can result in a significant fine.

The Economics of Quality and Safety

Poor quality and accidents cost the construction industry a lot of money. Rework, callbacks, inefficiencies, waste, and poor workmanship reportedly represent anywhere between 5 and 20 percent of the construction cost for any given project. These costs cut into profits and affect a contractor's ability to compete. Once a contractor gets a reputation for poor quality, it is very difficult to turn that perception around. Likewise, a reputation for high quality will bring work to the contractor without their even soliciting it.

Poor safety performance in construction is very costly as well. Accidents or serious safety violations result in delayed schedules or even job shutdowns. A delayed schedule means lost time, and lost time means increased overhead and lost profits. Labor costs are directly impacted by a construction firm's safety record. For example, when safety performance goes down, workers' compensation premiums go up. This factor alone can cause a project to go from being in the black (making a profit) to being in the red (losing money).

Poor quality and poor safety performance are serious issues that no construction firm can survive—at least not for very long. Is it any wonder that quality control, quality assurance, and job site safety are major components of the construction management function?

The Bottom Line

Time and cost control are a constant pressure in construction, and the need for productivity cannot be denied. Still, we must always balance this pressure with good quality and safety management systems. High quality and safety standards are at the heart of successful construction management. Quality and safety impact everything else we are trying to do in construction management. Our estimates will end up being meaningless if our quality is poor and it results in excessive rework and correction. Our budgets will go bust and our time lines will be erroneous if we are unable to manage our quality and safety. Cost overruns and work delays will run rampant on a job where quality and safety are a low priority.

Fortunately, rework, accidents, and injury are all things that can be prevented. Given the complexity and unpredictability of the construction job site, it takes a tenacious effort. However, construction has seen marked improvements on both fronts over the years, and as owners continue to make bold demands for higher quality, faster schedules, lower

costs, and safe work environments, construction managers will continue to deliver the goods. The construction industry holds tremendous promise for improvement, growth, opportunity, and excellence, and I am certainly proud to be part of it.

Terms to Know

callbacks

field observation report

material safety data sheet (MSDS)

Occupational Safety and Health
Administration (OSHA)

preparatory inspection

quality assurance

quality control

rework

tailgate safety meetings

Total Quality Management
(TQM)

Review Questions

1. What are the three fundamental objectives of a quality management plan?
2. What is the difference between quality control and quality assurance?
3. Name three quality control mechanisms typically mandated by the construction contract that are used to check for conformance to the plans and specifications.
4. Explain the concept behind a zero-punch list.
5. What is an FOR?
6. What is the name of the agency responsible for establishing safety standards and enforcing them through inspections conducted at construction job sites?
7. Identify the four primary components of an effective safety management plan.
8. What are the four primary causes of injuries in the construction industry?
9. Identify at least five items of personal protection equipment that might be utilized by workers on the job site.
10. What is an MSDS?

Chapter 14

Managing Project Risks

In This Chapter

- ◆ The types of risks associated with a construction project
- ◆ The consequences associated with project risks
- ◆ How risks are evaluated and analyzed
- ◆ How risks are mitigated and controlled
- ◆ How a risk mitigation plan is developed

Being a construction manager is something like being a scout sent out in front of the team to head off danger and forge a safe path to the intended destination. It is about anticipating all kinds of risks and responding in a proactive fashion to mitigate and control as many negative factors as possible in order to increase the odds of a successful outcome. The construction manager's job is to bring the project in safely, on time, within budget, and in accordance with the owner's expectations for quality, regardless of how many surprises show up.

In addition to the risks associated with time, cost, quality, and safety—there are others that are far more unpredictable and, therefore, may be overlooked when planning the project. For example, building a new prison close to a residential neighborhood can put a builder in the middle of an ongoing controversy, and the constructor who takes on that project must be prepared to manage the public relations, media attention, and community resistance that may come along with it. All of these things take time to deal with, potentially causing significant delays and bad press that the contractor didn't anticipate when accepting the job. This is all part of the construction manager's job, and in many instances the risks have nothing to do with concrete or steel or manpower or machinery. The construction manager must know how to plan for and deal with risks of every kind, not just those associated with construction. Let's take a look at exactly how they do that.

A Systematic Process

Although the goal is to find, flush out, and eliminate every possible snag and snafu in the way of a successful project, the reality is that bombshells can be dropped on any day of any project. Your job as a construction manager is to continually evaluate the situation, assess the risks, make decisions, and accept the responsibility for the results, good or bad. As likely as it is that you will encounter some surprises along the way on your path from start to finish when constructing a project, there is a way to anticipate and predict risks and their impact before the project even starts. This key step in the construction management process should never be overlooked, and it is important to make sure that you have a reliable, consistent strategy for minimizing project risks—especially when tens of thousands and often millions of dollars are at stake, not to mention your reputation as a construction manager.

Although different construction firms may have their own unique version, the methodology presented in this chapter will illustrate the three foundational steps common to all risk management approaches:

- ◆ Risk identification
- ◆ Risk quantification
- ◆ Risk mitigation

Identifying Risks

The purpose of this first step in the risk management process is to identify the risks that could produce either an increase in cost to the project, a delay in schedule, or a loss of profit. The job of the construction manager is to anticipate and unveil any potential risks that may derail their project or cause harm to any one of the project participants before the project starts. Although every project will have its own unique variety of risks, all will generally fall under one of the following six categories:

- ◆ Prebid risks
- ◆ Design risks
- ◆ Construction risks
- ◆ Political/legal/regulatory risks
- ◆ Financing risks
- ◆ Environmental risks

Let's review each category to gain a better understanding of some the types of risks and challenges that may be encountered on the typical construction project.

Prebid Risks

The risk identification and assessment process actually begins before the contractor even wins the job. It is in the prebid stage that the contractor first considers whether the overall risks associated with the project are acceptable. By reviewing the basic parameters of the project (contract requirements, size, location, budget, and so on), the contractor will assess the various risks and make one of three decisions:

contingencies

An amount of money added to an estimate to cover unknown conditions or risk factors.

- ◆ Bid the project but increase the profit margin or add *contingencies* to account for the added risk.
- ◆ Bid the project but *joint venture* with another contractor partner to share the risks.
- ◆ Reject the project and not submit a bid because the risks are unacceptable.

Most contractors will formalize this prebid risk assessment by looking at each risk factor and determining whether it is an acceptable risk or an unacceptable risk—and to what degree. For example, by using a scale whereby 0 equals a low risk (acceptable) and 3 equals a high risk (unacceptable), the contractor can systematically determine whether to bid the project. The illustration shown here outlines the acceptable risk limitations in making the bid/no-bid decision when first reviewing the plans and specs for a potential project.

Risk Assessment

(0 = low risk, 3 = high risk)	Factor Scores	Total Score	Bid/No Bid Assessment
Contract Risks	0-3	2/15	Risk Limitations
Changes in work	0		4 or more total points: increase profit margin, 6 or more total points: consider not bidding, 9 or more total points: do not bid
Force majeure	0		
Payment process	0		
Retainage requirements	1		
Warranty requirements	1		
Owner Risks	0-3	2/12	Risk Limitations
Reputation	1		4 or more total points: increase profit margin, 6 or more total points: consider not bidding, 9 or more total points: do not bid
Ability to fund project	0		
Payment history	0		
Company culture	1		
Price Risks	0-3	4/21	Risk Limitations
Cost of self-performed work	0		6 or more total points: consider joint venture partner, 9 or more total points: consider not bidding, 15 or more total points: do not bid
Cost of subcontract labor	0		
Cost of overhead	0		
Cost of equipment	0		
Cost of materials	0		
High price materials/equipment	2		
Total project cost	2		
Time Risks	0-3	2/12	Risk Limitations
Overall contract time	1		4 or more total points: consider joint venture partner, 6 or more total points: consider not bidding, 9 or more total points: do not bid
Subcontractor reliability	0		
Time of year	0		
Regulatory bureaucracy	1		
Work/Labor Risks	0-3	2/21	Risk Limitations
Familiar work processes	0		6 or more total points: increase profit margin, 9 or more total points: consider not bidding, 12 or more total points: do not bid
State-of-the-art components	2		
Major demolition or site work	0		
Insufficient ground investigation	0		
Self-performed/sub work ratio	0		
Aggressive unions	0		
Adequate labor pool	0		

(0 = low risk, 3 = high risk)	Factor Scores	Total Score	Bid/No Bid Assessment
Location Risks	0–3	1/12	Risk Limitations
Proximity to office	0		6 or more total points: consider not bidding, 9 or more points: do not bid
Familiar with area	0		
Difficult/remote access	0		
Site congestion	1		
Estimate Prep Risks	0–3	0/18	Risk Limitations
Adequacy of pricing data	0		6 or more total points: consider not bidding, 9 or more points: do not bid
Familiarity of subcontractors	0		
Unable to visit the site	0		
Confusing/contradictory docs	0		
Excessive prep cost	0		
Insufficient time, personnel	0		

If the constructor decides not to pursue the contract, then all the additional risks associated with the project are a moot point. However, if after proper analysis and assessment the decision is to go forward with the bid, then there are several other types of risks to consider.

NOTE

It is quite common to see two construction companies create a *joint venture* on large projects, particularly if the project is complicated or high risk (large hospitals, large bridges, high-tech facilities, and so on). A joint venture is a legal partnership in which each company contributes resources, expertise, manpower, and management expertise. Usually the majority partner (the one with the largest investment) in the joint venture will be assigned as the managing partner. However, both parties are usually involved in the decision-making process throughout the project. For example, during the estimating phase of the project, both companies will prepare their own independent estimates. Then the two companies will come together to reconcile their numbers and agree to a single estimated cost for the project.

joint venture

When two or more construction companies enter into an agreement for a one-time, single-project commitment and share resources and risks to manage and build the project.

Design Risks

It may seem silly to discuss design risks when talking about construction management, but as you learned in [Chapter 2](#) (“What Is Construction Management?”), the trend today toward alternative project delivery methods such as at-risk CM and design-build have the contractor being involved in the design process before construction begins. In some instances, the builder

is contractually responsible for the design, and in those cases it is critically important that design risks are given serious review and consideration in the overall risk mitigation plan. But even when this is not the case, there are many types of design risks that will impact the contractor's ability to deliver the project on time, within budget, and within the quality specifications expected by the owner. [Table 14.1](#) shows some of these design risks along with examples of how they may impact the construction process and end product.

Table 14.1 Design Risks

Design Risks	Description
Poor-quality or inadequate design, drawings, or specs	The information and detail needed to construct an element of work is missing, incomplete, or inaccurate.
Noncompliance with design standards	The design doesn't meet the building code or other regulations.
Owner-directed changes	The owner changes their mind about the design after construction begins.
Excessive design review by owner, architect, or agency	Reviews and the approval process associated with design submittals take longer than typically allowed.
Changes in design standards or regulatory requirements	Regulatory requirements in place at the beginning of the project may change during construction.
Inaccuracies associated with supplemental design information such as soil reports, environmental reports, and so on	The information needed by the contractor and provided by the architect or owner is inaccurate.
<i>Latent design defects</i> affecting contractor's warranty	Defective design details that result in flawed construction after occupancy of the facility (such as a roof flashing leaks because of poor design).

latent design defect

Defects or flaws in design details that are not known until after the construction is complete and time has passed, allowing for the flaw or defect to show itself.

Although some of the design risks noted in the table are really out of the control of the architect, most are directly related to the quality of work the architect or engineer produces. If the contractor is not familiar with the architect or engineer who designed the project, it doesn't hurt to do a little background investigation to get a better sense of their work up front before you bid the job. It is always good to ask other contractors who have worked with the project's architect in the past. They can usually fill you in on how much effort was spent dealing with design flaws and how they were handled during construction. This one conversation can save contractors many headaches down the road.

Construction Risks

Construction risks are a bit easier for contractors to identify, but they should all still be laid out in a checklist to make sure that a discussion takes place to address them. Construction risks run the gamut from factors where the contractor has absolutely no control, such as the weather, to factors where they have significant control, such as safety.

If you refer to [Chapter 10](#), “Construction Operations and Job Site Management,” it becomes pretty obvious where most construction risks originate—in the day-to-day operations on the construction site. They are generally associated with the management of materials, manpower, and equipment. Each construction project is different, and the construction manager should focus on those construction risks that will have the greatest impact on project cost, schedule, quality, and safety. I have shown several construction risks in [Table 14.2](#), but keep in mind there may be a lot more on your project.

Table 14.2 Construction Risks

Construction Risks	Description
Labor availability and quality of labor pool	If the contractor can't access the proper labor needed to complete a project, significant delays may be experienced. Quality issues resulting from an inexperienced workforce can also result in rework and cost overruns.
Differing site conditions	Sometimes the conditions on the building site are not communicated in the plans and specs. This discovery can lead to significant cost increases and delays.
Site access, traffic, parking issues	Projects located in highly congested areas can cause significant delays and storage issues for the contractor when trying to coordinate work.
Property damage or theft issues	The project site might be located in an area where security is an issue. The contractor has to protect the project, materials, and equipment against vandalism and theft.
Coordination with utilities, adjoining neighbors, and so on	Significant coordination efforts must be made when tying in electrical, plumbing, water, and gas lines to main supply lines. This often requires working with a local utility office, and their schedule and the contractor's schedule do not always coincide. Utility coordination can cause big delays.
Adverse weather	Weather is one of the most unpredictable construction risks. Contractors try to plan activities to avoid adverse weather conditions, but it isn't always possible. Having to place concrete in February in Minnesota can be a challenge and add cost to the job.
Labor disputes, strikes	The use of union labor on public projects is often a requirement in some jurisdictions. When this is the case, delayed labor negotiations, disputes, and even strikes are always a possibility.
Availability of materials	The architect may specify materials that are difficult to get or have significant lead times.
Safety	Safety should be paramount on any project. Injuries always impact construction operations at some level and should be avoided at all cost. OSHA inspections will also have an impact on the project workflow and schedule.

Political/Legal/Regulatory Risks

Political, legal, and regulatory risks are often classified as third-party risks and are usually the ones that the contractor has the least amount of control over. And although the builder may be fully aware that the risks exist, there is no way to accurately predict how various jurisdictions and agencies will act. Changes in legislation, regulations, building codes, and permitting procedures can happen at any time. For example, in the late 1980s, the State of California had established a Disabled Veteran Business Enterprise (DVBE) participation program whereby contractors were required to make a good faith effort (GFE) to award 3 percent of all state

contracts to certified disabled veterans. Contractors in the state were well aware of this initiative but understood that it was only a recommendation. However, in July 28, 2009, that initiative changed from a GFE to a legal requirement as part of another unrelated bill passing through the California legislation. This change was not highly publicized, and it caught several contractors and public owners off guard. In many instances, contracts had already been bid and awarded shortly after the July 28, 2009, implementation date, when contractors were unaware of the legislative change. In some instances, the projects had to be rebid in order to meet the new requirement for 3 percent DVBE participation or risk losing state funding. This “surprise” obviously caused significant delays for several project startups, which impacted the overall job schedules.

This is exactly why it is so important to try to anticipate the political, legal, and regulatory risks that may affect your ability to fulfill the expected contract requirements before you submit a bid. This is particularly true if you are a contractor moving from the private sector market to the public sector market. In short, any public project will have far more agency involvement and bureaucratic oversight than a private job. [Table 14.3](#) describes several examples of political/legal/regulatory risks.

Table 14.3 Political/Legal/Regulatory Risks

Political/Legal/Regulatory Risks	Description
Changes in the law	Changes in local, state, and federal laws can affect construction (such as minimum wage law or documentation of employees).
Changes in sales tax or other tax structures	Unanticipated increases in sales or use taxes will impact material costs.
Protester actions, disputes	Any project that might be related to a public concern can get tangled up in a political web. Projects such as prisons, sewage plants, industrial facilities, and even schools can be targets for protest.
Community or adjoining business impacts	Dust, noise, mud, visibility, lights, working hours, and access issues can impact neighbors, the community, or adjoining businesses. For example, if the rerouting of traffic for your project impedes easy access to the parking lot of an adjacent business, you may be opening yourself up for a lawsuit.
Harassment issues	Breaches by employees or subcontractors can affect company harassment or professional conduct policies.

Financing Risks

Financing risks must be considered from several perspectives. First, there are the risks associated with the contractor's own financial position. For example, cash flow is at the heart of any successful business, and many contractors depend on a line of credit in order to maintain sufficient working capital during project execution. If the contractor's credit limit is maxed out just when some big invoices come in from major subcontractors or suppliers, it could mean delayed payments to these important project participants. When payments to subs aren't forthcoming, it may cause them to focus their efforts elsewhere while they wait to receive their payments for work already completed. In other words, they may put the brakes on and not be as readily available to meet your schedule again until after they receive the money that is owed to them—after all, they are just as dependent on cash flow as the general contractor is.

Second, you have to be aware of the financial strength of all of your subcontractors and suppliers, especially the ones with the highest value or most critical work items (mechanical,

electrical, structural steel, and so on). If they get into financial trouble, your project is in financial trouble as well. Only pick those project partners who you know have the financial capacity to complete the work. Also make sure they are bondable and have the insurance coverage needed to mitigate significant financial risk.

Third, you have to look at the project owner's financial picture. You always want to make sure the funding for any project you take on is secured. Believe it or not, there has been more than one contractor who was surprised to learn that their client had run out of money before the project was complete.

And last, the construction manager must be acutely aware of the economic environment at any given time. A contractor's financial status can turn on a dime if economic conditions take a nose-dive. It is no surprise that financial risks are one of the most important indirect factors affecting the health of the construction market. As you learned in [Chapter 1](#), “The Construction Industry,” construction is one of the major indicators regarding the economic health of the United States. And even though none of these risks is directly related to what happens on the job site day in and day out, they will have an effect on everything associated with it. You can find a sampling of financial risks in [Table 14.4](#).

Table 14.4 Financing Risks

Financing Risks	Description
Economic climate	Economic downturns add the risk of bankruptcy, bid shopping by clients, and other negative impacts to a project. On the other hand, economic booms cause price escalation.
Contractor cash flow	Limited lines of credit or the unavailability of credit can cause delays in material buyouts, subcontractor payments, and workflow.
Interest rate increases	If lines of credit are utilized by the contractor or the client to fund projects, then any increase in interest rates would have an adverse effect on the project.
Insufficient client funds	If a client is unable to make timely payments to the contractor, it will shut down the job.
Subcontractor/supplier bankruptcy	Both large and small subcontractors can get into financial trouble. When this happens, every project the sub has a contract on will also be impacted. If bankruptcy should occur, the general contractor will have to hire another subcontractor to take over the job, causing major delays, cost overruns, and headaches for the project.

Environmental Risks

Although some projects are more susceptible to environmental impacts than others (water systems, sewage plants, industrial facilities), the truth is every project is at risk to encounter environmental issues that can throw your budget and your schedule way off track. Even housing developments have to deal with SWPPP regulations (refer to [Chapter 10](#)) and the threat of heavy fines if they do not comply with strict environmental regulations.

Environmental risks are similar to political, legal, and regulatory risks in that the contractor generally has very little control over how any given agency or environmental authority might act as they review regulatory compliance requirements. The fact is any one of the risks shown in [Table 14.5](#) could shut down your project in an instant—regardless of the financial ramifications associated with such a shutdown. More than one contractor can share a horror story about how an endangered species caused them to go bankrupt and lose their business. That's all the more reason to take these environmental risk impacts seriously and do everything you can to anticipate them and develop a plan to mitigate your exposure before the start of construction.

Table 14.5 Environmental Risks

Environmental Risks	Description
Environmental permits and approvals	Environmental permit approvals are delayed or require more time to negotiate than expected.
Hazardous materials or site contamination	Unknown site contaminates or hazardous materials are discovered after the work has commenced.
Archeological findings/unknown burial sites	Unknown artifacts are discovered or an unknown burial site or cemetery is unearthed, requiring the work to stop.
Endangered species	The project has known or unknown endangered species sightings that will require protection and special care during construction.
Wetlands, coastal protection, or flood plain issues	Wetlands, coastlines, and flood plains all require special protection and can impact overall construction approach.

Because the environment is an important issue to most people today, it is important for contractors to be particularly sensitive to a community's interests and concerns in this area. On several occasions when I was in business, I made a point to hold town hall–type meetings to inform citizens of the measures we were taking to protect both wildlife and vegetation during construction, even when it wasn't mandated by some environmental authority to do so. It just makes sense to be aware of the community that you are working in and do everything you can to head off unwanted problems in advance.

Quantifying Risks

Once the potential risks have been identified, the next step is to analyze each one and determine what the likelihood or probability is that it will occur. Once the likelihood of occurrence is established, the next step is to predict what impact that occurrence will have on the construction cost, schedule, quality, safety, client relationship, or contractor's ability to fulfill the obligations of the contract. When any of these risks occurs, the consequences will usually involve the following: the need to perform additional work, the need to redo work that has already been done, delays to the schedule, quality defects, cost overruns, and potential litigation.

To focus attention on the risks that potentially could have the greatest negative influence on a project, the construction manager must be able to quantify and rank each risk. A common method for doing this is to assign numerical values to each factor relative to probability and impact. Once these numbers are assigned, the CM can then calculate an overall risk rating for each factor.

Determining the probability index The probability index represents the likelihood that the risk will occur based on the evaluator's expertise, experience, and judgment. A numerical score from 1 to 3 is assigned to each risk factor as follows:

- ◆ High risk (3) when its probability of occurrence ranges from 75 percent to 100 percent
- ◆ Medium risk (2) when its probability of occurrence ranges from 50 percent to 75 percent
- ◆ Low (1) when its probability of occurrence is less than 50 percent

Determining impact potential The impact potential of each risk factor is based on the evaluator's expertise, experience, and judgment. A numerical score from 1 to 3 is assigned to each risk factor as follows:

- ◆ High impact (3)
- ◆ Medium impact (2)
- ◆ Low impact (1)

It should be noted that risks associated with third parties have a higher uncertainty and thus are often given high-impact scores. Once probability and impact scores are assessed, a risk rating can be determined by multiplying the probability score by the impact score:

$$\text{Probability} \times \text{Impact} = \text{Risk rating}$$

Quantifying Risks

<u>Identified Risk</u>	<u>Probability</u>	<u>Impact</u>	<u>Rating</u>
Confusing, contradictory, or incomplete plans and specs	2	1	2
Differing subsurface conditions	2	2	4
Adverse weather	1	1	1
Community protests	2	3	6
Once risks are rated, it can be determined which ones to focus on and how best to mitigate them.			

The evaluator's analysis is subjective and is usually done by experienced management personnel who have worked on many projects and been exposed to the pitfalls that can occur. In most cases, an evaluation team is formed comprised of senior estimators and project managers. In other words, this important job is not left up to a single individual. Discussions and debates will usually ensue before scores are assigned to each and every risk. Depending on the size of the job, sometimes a project executive is brought into the deliberations as well. If the project is technically complex or involves some type of unique construction approach, it is not unusual to consult with superintendents and appropriate specialty contractors as well.

NOTE

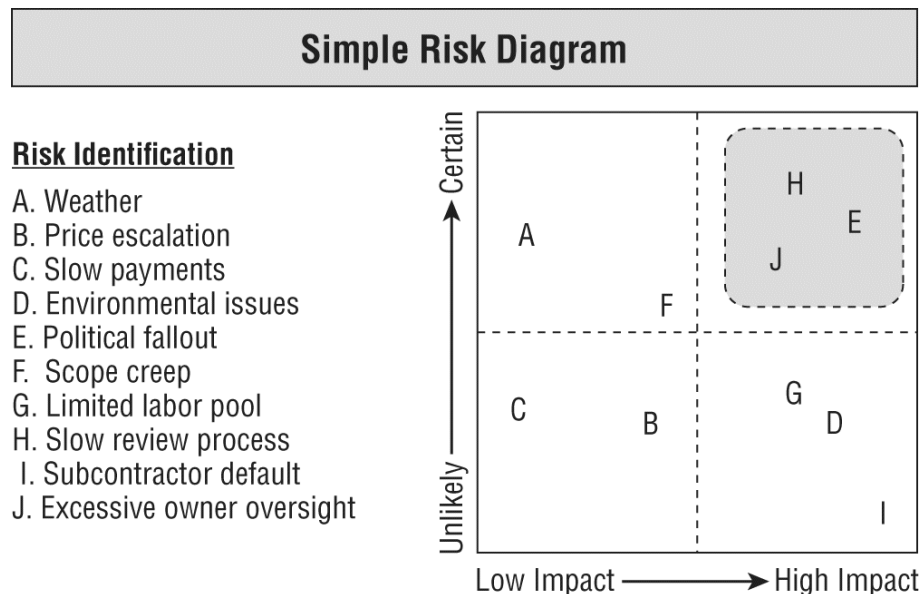
It is important to involve subcontractors and major suppliers in the risk evaluation process whenever you can. They will have insights and experiences that you do not and will be able to share their concerns regarding their areas of work. For example, an electrician may be aware of some material delivery issues that could negatively impact the schedule. If you are unaware, you will not be able to have a strategy in place for mitigating this risk.

Mitigating Risks

Once you have gone through the process of identifying project risks and quantifying them by assigning a risk rating to each factor, you can then determine which risks pose the greatest threat to your project's success. The concept behind risk mitigation is to anticipate as many negative influences on your project plan as you can so you can initiate actions and implement strategies to head them off. This isn't rocket science I'm talking about—it is simply good planning and common sense. A number of strategies can be implemented, and it is likely that a combination of all of them will be put to use on any given project.

Risk Mitigation Strategies

The risks that pose the greatest threat are the ones that you want to focus your risk mitigation strategy on. It is often helpful to chart risk ratings to establish a visual display of where the greatest danger is as you plan your project and strategize to mitigate negative influences.



At this point you have a choice. You can fully accept the risk, you can try to avoid the risk altogether, you can attempt to diminish the impact of the risk if it should occur, you can transfer the risk to others, or you can share the risk with another party to minimize your exposure. All of these approaches are an option, and most will come into play as you plan your strategy. They are described in further detail as follows:

Risk retention Many contractors believe that risk retention is a good strategy only when it is impossible to pass on the risk to others. Or, on the other hand, when the contractor is in the best position to control the situation, they can then afford to absorb the potential economic loss exposure. This is why you see some contractors investing in and buying into concrete plants and structural fabrication facilities. This gives them the control they need to supply their own projects to meet critical schedule deadlines.

Risk avoidance Risk avoidance is just that—don't take the project on to begin with! Or in some cases, there may be parts of a project that you decide are too risky. For example, if there is a great amount of demolition of existing facilities on a project, it might be best to ask the owner to remove that portion of the work from your contract and issue it under a separate contract to a demolition specialist. This is why analyzing that initial risk category (prebid risks) is so important. Risk avoidance is usually a business decision, and many different factors can lead a contractor in this direction at any given time. It can be as simple as a company already having too much work and their inability to take on any more,

or it can be a fear that the funding for the project is going to dry up before the work is completed.

Risk abatement This risk management strategy focuses on reducing the loss potential of any given risk factor in terms of frequency or severity. Risk abatement is often used in conjunction with other risk management strategies, since using this risk management method alone will not eliminate risk altogether. To give you an example of how this strategy is implemented, consider the contractor who negotiates with an owner to avoid extensive excavation in a known “rocky” area by offering an alternative to a subgrade parking structure that may cause radon gas issues for the owner.

contract indemnification

Provisions in a contract that provide protection against possible financial loss, damage, or liability.

Risk transfer Risk transfer is the shifting of risks from one party to another. This can be done in several ways. One of the most common ways, of course, is by subcontracting work to specialty contractors who have expertise in an area (for example, plumbing, electrical, curtain walls, and so on). Another common way in which project risks are transferred is done through conventional insurance. For example, one of the ways to mitigate risks associated with theft of materials or damage to property is to purchase builder's risk insurance. General liability insurance and material and performance bonds are other ways that contractors typically transfer risks to other parties, along with *contract indemnification* provisions.

Risk allocation Risk allocation is the sharing of the risk exposure with other parties. This is usually a business decision made at the onset of the risk analysis at the prebid stage. An example is when one contractor partners with another contractor in a joint venture. This approach is being applied more and more, especially on large, complex projects.

Every construction company will have a different culture when it comes to their relationship and comfort with risk. Some companies are more risk-oriented, while others are very risk-adverse. But regardless of their level of risk acceptance, each company will have to come to terms with their own risk appetites when reviewing projects and determining which risk mitigation strategies are best for them.

After the prebid risk assessment, you may decide that your workload is too great and choose to forgo bidding the project in the first place (risk avoidance). Conversely, you may choose to pursue the project but subcontract a high percentage of the work to subcontractors, thereby shifting the risks to others (risk transfer). On the other hand, some companies like the idea of self-performing sections of work that are most at risk for schedule delays, such as steel fabrication and erection, so they can better control timing for these early release items (risk retention). Under other circumstances, it may be best to simply try to diminish risk exposure by convincing an owner to go in a different direction and not use steel for the structure in the first place (risk abatement). And finally, it may be determined that the risk is so great that it would be better to allocate a portion of it to a reliable, trusted partner and share in the exposure as well as the profits (risk allocation). Each of these strategies may be employed on any given project. The point is, every risk factor should be considered before finalizing the overall construction management plan. Risk mitigation and management are critical parts of the construction management challenge, and learning how to do this well will make you a very valuable employee.

The Risk Mitigation Plan

Once you have made the effort to thoroughly analyze all of the risks that may impact your project, it is time to put together a full-blown risk-mitigation plan that addresses every aspect of risk evaluation, as shown here. In addition to probability, impact, and risk rating analysis, the risk mitigation plan will also show potential consequences and mitigation strategies.

Risk Analysis Probability × Impact = Risk Rating

	Type of Risks	Probability	Impact	Risk Rating	Potential Consequences	Mitigation Strategy
Design Risks						
1	Incomplete drawings and specifications	2	2	4	Delays, rework, increased costs	Thoroughly check drawings for errors or omissions.
2	Owner-directed changes	3	2	6	Delays, rework, increased costs	Develop a clear understanding of owner's objectives.
3	Incomplete or incorrect soil/geotechnical data	1	1	1	Delays, rework, increased costs	Hire a pre-qualified expert consultant.
4	Non-compliance to standards and codes	1	2	2	Delays, redesign, increased costs, re-work	Integrate code reviews into the design process.
5	Design defects affecting constructability	1	1	1	Delays, rework, increased costs	Integrate construction knowledge into the design process.
Construction Risks						
6	Availability of materials	3	2	6	Delays, increased costs, material changes	Proper material management with emphasis on long lead items.
7	Safety	2	2	4	Worker injury, litigation, project delay	Injury Illness Prevention Plan (IIPP), consult OSHA.
8	Weather	3	2	6	Delays, material damage, increased costs	Follow accurate weather reports, include weather days in schedule.
9	Earthwork issues	2	2	4	Need for special equipment, delays, increased costs	Proper site research, add contingency (%).
10	Re-work, defective work	2	1	2	Delays, re-work, increased costs	Hire qualified subcontractors, maintain documentation.

[illegible]

	Type of Risks	Probability	Impact	Risk Rating	Potential Consequences	Mitigation Strategy
21	Unforeseen site/facility contamination	1	2	2	Delays, fines, increased costs	Remain familiar with local environmental abatement contractors.
22	Wetlands	3	3	9	Delays, fines, increased costs	Investigate site conditions before work begins, consider wetlands banking option.
23	Endangered species	2	2	4	Delays, increased costs, project stop order	Check on seasonal sightings and investigate regulation requirements before work begins.

Keep in mind that the risk mitigation plan is a dynamic tool that may need adjusting as the project moves forward. Things change on a daily basis in construction, and the construction management team should never think that they have anticipated every surprise that may arise on a job—that would be naive. As stated in the introduction to this chapter, the construction management professional must be forever diligent, scouting the horizon for anything that might derail the project. The development of a risk mitigation plan early in the construction process is just a practical methodology for anticipating the perils and pitfalls that may occur on a typical construction project on any given day.

The Risk Management Team

Many of the items discussed in this chapter go beyond the tasks that you will be facing when you first start your career in construction management. But as you move from the entry-level positions of field engineer to assistant superintendent to project management and eventually to project executive, you will be involved more and more in decisions associated with evaluating risks—not only from a project perspective but also from a business standpoint. The risks associated with every project will have a direct impact on the success (or failure) of the construction company. For this reason, it is not unusual for the construction manager to consult with senior management and the company's legal team before pursuing large or unusual projects. Many construction firms have strict rules about when senior management and legal need to be brought in to help evaluate the risk proposition for a project. The trigger point is usually linked to the dollar value of the project—as the dollar value increases, so does the need for senior/legal advisement.

You Get What You Plan For

In [Chapter 10](#) you got a pretty good look at the types of issues that a superintendent has to manage on the job site, and in [Chapter 12](#), “Monitoring Project Performance,” you learned about the various tools that are used to monitor project performance. In this chapter, you learned that risk management begins before the project ever starts. The fact is, all of the construction management functions taken together are part of the risk mitigation plan.

Every time actual job costs are compared to estimated costs, that's risk management. When a superintendent holds a tail-gate meeting on the job site to review safety procedures, that's risk management. When the CM reviews a schedule and decides to add another crew to the job in order to pick up the pace, that's risk management. The point is that everything you do in construction management is an effort to identify risks and mitigate them. So, even if you aren't involved in the high-level discussions at the beginning of the job when the formal risk mitigation strategies are being developed, remember that the risk management team that decided to take on the project in the first place is depending on you to carry out your part every day to deliver a quality project, on time, within budget, and without any accidents.

Every project, every site, and every owner is different. Therefore, a thorough assessment of the challenges and risks associated with each new project must be done regardless of how many times you have built the project type. For example, just because you've built several schools doesn't mean that the next one you build won't have some new wrinkle associated with it. You can bet that it will! That's why it is important to develop a standardized risk assessment approach that can be applied to each new project. And if you develop the discipline to use it every time, you will always have a plan in place to effectively identify, quantify, and control most construction risks.

Terms to Know

contingencies contract indemnification
joint venture latent design defect

Review Questions

1. Name the six different categories that most risk factors generally fall under.
2. What is a contingency?
3. What is a joint venture?
4. Name at least three types of construction risks.
5. What is a latent design defect?
6. Name at least three prebid risk factors.
7. Name one estimate preparation risk factor.
8. What two factors must be considered when trying to determine the risk rating for any given risk?
9. Name the five most common risk mitigation strategies.
10. Give one example of a risk allocation technique that contractors might use on a large, complex project when they think they have exceeded their risk tolerance.

Chapter 15

BIM and Beyond

In This Chapter

- ◆ What building information modeling is
- ◆ How BIM is impacting the construction industry
- ◆ What the difference is between CAD, BIM, and VDC
- ◆ How contractors are using BIM
- ◆ How BIM is being implemented
- ◆ How augmented, virtual, and mixed reality will impact construction
- ◆ How BIM and other technologies are aiding collaboration and communication of the project team

Everything we do in construction management is tied to the plans and specs. They provide the benchmark by which a contractor's performance is measured. As you learned in [Chapter 4](#), “The Construction Contract,” the plans and specifications make up two of the three key components of the construction contract. However, one of the most exciting advances in construction over the past few decades is the ever-increasing use of *Building Information Modeling* or *BIM*.

Fundamentally, BIM adds a three-dimensional “modeling” component to traditional two-dimensional plans and specifications, with an added bonus. Every element of the design displayed in the building information model also carries with it data to support a whole array of construction management tasks and activities.

It is not the intention of this chapter to explain the technical aspects of how BIM works from a model building perspective. Instead, you will learn a few ways in which BIM is utilized to support the various

construction management functions. There are many other books and resources that are dedicated to BIM alone and go into great detail and depth about what it is, how it works, and how it is being implemented in the design and construction process. I recommend the book *BIM and Construction Management: Proven Tools, Methods, and Workflows* by Brad Hardin and Dave McCool (Wiley, 2015). My goal is to share how contractors are using this exciting technology and the difference it is making on a daily basis, especially when one of the collaborative project delivery models such as design-build or at-risk CM is being used.

What Is a Building Information Model?

A *BIM model* is a 3D digital representation of the physical and functional characteristics of a building. In a nutshell, the difference between a typical CAD-generated 3D model and a building information model is that the BIM can capture vital information about the entire building process and all of its components. In other words, the power of this technology is that the virtual model is also a vessel in which to load every bit of electronic data that can be collected. That means specification data about materials (weight, size, color, fire rating, maintenance data, and so on), installation instructions for assembly, product warranties, maintenance requirements, and on and on, including productivity and price information. In essence, BIM is a CAD model linked to a database in which you can enter just about any information you want. As such, a BIM model serves as a shared knowledge resource for the entire design and build team. BIM focuses on the integration of information that inevitably adds efficiency to the design and construction process, reduces waste and error, and improves quality. To better appreciate the significance that the merger of 3D representation and data has made on the design and construction industry, let's take a look at how modeling technology has evolved and where it is today.

BIM model

A digital representation of the physical and functional characteristics of a building displayed as a 3D model, with the added capability to integrate a whole array of design and construction data related to cost, schedule, materials, assembly, maintenance, energy use, and more.

Evolution of Modeling

Many decades ago, architectural plans and specs were created the “old-fashioned” way—with pen, pencil, and paper. If you needed to make a change to some part of a document, it meant getting out the electric erasers and redrawing the plan, section, or detail that needed changing. And if that change impacted other elements of the design,

then you'd have to manually go in and modify the other drawings as well, thus more erasing and redrawing. It was very tedious to say the least—so much so that if the changes were major, it was actually easier to start the whole drawing process over again from scratch. However, we have come a long way since the days of hand-drawing our plans. Technology has changed how we plan, how we design, and how we build. Everything is now produced electronically on a computer. It's very likely that your old set of rolled up paper drawings have been replaced by a computer tablet that displays your digital plans on a screen. We still depend on the plans and specifications to guide us through the building process, but how those plans are produced has changed, and continues to evolve.

Computer Aided Drafting (CAD) In the early 1970s, computer-aided drafting (CAD) started making its way into the marketplace. As exciting as this technology was, at first it was able to run only on graphic terminals connected to mainframe computers. But in the early 1980s, CAD programs that were able to run on personal computers began to emerge, and it started to show up in the offices of some architects around the country—and, oh, what an improvement! To put it lightly, CAD turned the architecture community upside down. Designers were able to draw (and erase) lines by electronic means and insert text to create 2D plans and specs—and if they needed to make a change, they could easily do so. CAD allowed architects to produce better designs much faster. Complex shapes that once took hours to create could be drawn in minutes. Wall lines would automatically “snap” into place. Typical items and details could be drawn once and then stored for future insertion into other drawings. Once retrieved, they could be copied, rotated, and oriented into position in seconds. Eventually the technology advanced to include basic 3D modeling capabilities, and all of the 2D line drawings were now able to be represented as 3D objects. Once animation was added, one could “walk through” the front door of a new building and make their way down the hallways, into rooms, and up the stairs with just the touch of a mouse. And if you wanted to get a bird's-eye view, you could experience a “flyover” as well, taking in a rooftop view as well as views from all exterior angles. CAD was a major breakthrough for the

architectural community, and contractors benefited from the breakthrough as well. All of those big rolls of paper plans and specs were now able to be transmitted to them electronically, and with 3D modeling they could get a glimpse of what the project was supposed to look like when it was finished.

But as wonderful as CAD is, even with 3D modeling capabilities, it isn't BIM. In other words, the model that is produced via CAD isn't intelligent. It is simply a 3D representation of a 2D design. For example, the 3D model is not able to detect errors on its own and correct information from one part of the model to another part of the model automatically. The CAD lines simply configure to create 3D objects.

Building Information Model (BIM) While CAD is a technological modeling tool that can accurately depict a facility in 3D perspective, the concept of BIM goes way beyond the 3D capability. BIM is a database-driven modeling system that is designed for collaboration. The model is dynamic and can integrate the design, building, and documentation process across a project's lifespan. The key difference between a three-dimensional CAD model and a BIM file is that each element within the BIM file comes with information attached. That information can include construction details, performance characteristics, and product specifications. The architects, engineers, contractors, subcontractors, clients, facility personnel, and other parties associated with the project can engage with the model in a dynamic fashion and assess coordination schemes and perform clash detection before the project ever goes to the field. A BIM includes all functional systems, including structural beams and columns, electrical wiring, HVAC duct work, piping, ceiling systems, doors, windows, etc., as well as aesthetic features. It is a shared multidisciplinary resource allowing all those working on the project to share information and working processes in order to achieve optimal fit, efficiency and workflow. This allows the team to see mistakes before they reach the field—saving time and money and many headaches along the way. It also allows the team to fix any problems before they finalize the building model for construction. In addition, with cost and time features added to the BIM database, budget and schedule

impacts can also be determined in real time—as design features within the model are adjusted, so will the estimates and the schedule. BIM has been a breakthrough technology for the construction industry, but there's even more great improvements and innovations to come.

virtual design and construction

The act of visually assessing, analyzing, and managing all work on a construction project in a 3D virtual environment before building the project and performing any work on-site, in the real world. The design and construction team can work together collaboratively to plan, design, coordinate, and construct a project before they begin building anything in the field.

Virtual Design and Construction (VDC) Although VDC is sometimes used synonymous with BIM, they aren't really the same thing. The easiest way to describe VDC is to reference how construction companies are using it currently. For example, Mortenson Construction, a large national commercial firm known for its aptitude in technology use, describes BIM and VDC as follows:

- ◆ BIM is a “noun.” BIM has two attributes. The first is the geometry or 3D object. Second is the associated data of the object, like the manufacturer specifications, size, and location. Together, they form smart objects that are “parametric” in nature. So, if the data changes, the geometry changes with it, and vice versa.
- ◆ VDC is a “verb” used to represent acting on the BIM. VDC is simply a visual management methodology using BIM as part of the construction analysis work, such as performing a lighting or engineering analysis.

Virtual design and construction don't have to involve building information modeling, and building information modeling can be done without it being a part of virtual design and

construction. But both are essentially methods for planning and managing projects in a collaborative fashion.

NOTE

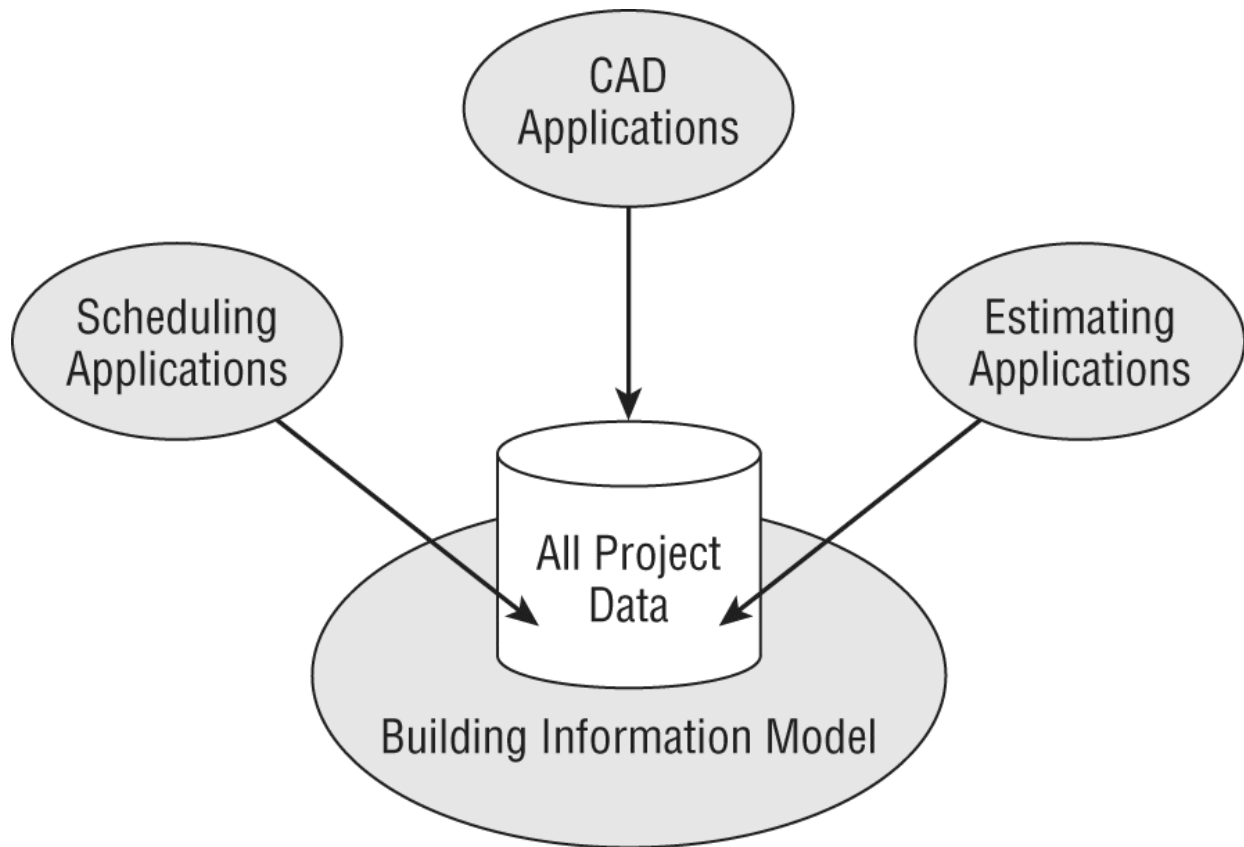
Virtual design and construction should not be confused with virtual reality. VR and VDC are not the same thing. The use of the word “virtual” in VDC is misleading in that it implies that VDC is a digital software and it is not. Virtual reality is an artificial environment which is created by software and experienced through sight and sound provided by special equipment.

Implementing BIM

There are two basic approaches to implementing BIM. One approach assumes that all project information can be loaded into one database to create a single-package BIM. For example, all estimating data and scheduling data would be merged with or added to data comprising the 3D model. This approach, referred to as the *central repository approach*, is considered impractical by many in the construction industry, at least at this stage of the BIM evolutionary process. One common reason for this is that the architects and contractors need different types of information to do their work. Whereas architects may need energy use and building code data to design spaces and calculate heating and cooling requirements, contractors need cost data and activity durations to do their estimates and schedules. Because cost data is connected to the design elements, the architect would have to design every detail in order to have a complete database for estimating purposes, and this is unlikely at the preliminary stage.

central repository approach

The concept that all project information can be loaded into one database to create a single building information model.



Central Repository Approach

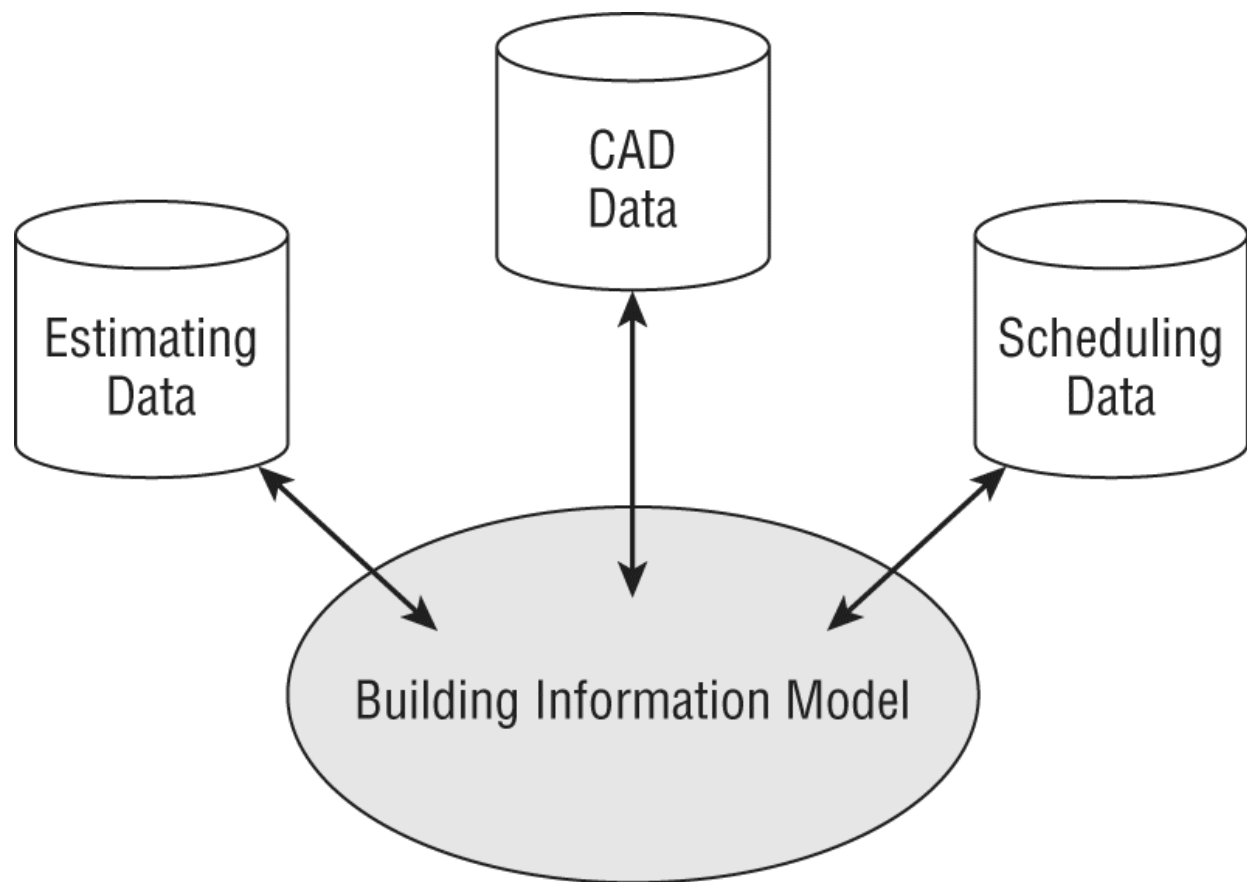
distributed repository approach

The concept that the BIM model consists of a collection of separate databases maintained within distinct programs that can communicate in a way that allows them to exchange at least some of their data.

interoperability

The capability of a system or program to interact with other systems or programs without access or implementation limitations or restrictions.

The second approach, known as the *distributed repository approach*, is the path that most contractors, subcontractors, and subconsultants have taken to implement their BIM activities. With this approach, the BIM model has access to a collection of separate databases maintained within their independent programs. For example, all of the estimating data needed to perform cost computations and the like are maintained in the estimating program. The estimating program is then able to exchange some of its data with the 3D BIM model via a bi-directional link (back-and-forth exchange) to create an estimate for the project. And this can all happen at the preliminary design model stage. What makes this exchange possible is a property known as *interoperability*, and it is really the key to integrating all of the independent-discipline databases to produce the various BIM deliverables.



Distributed Repository Approach

The fact is, at this point in time, no one BIM tool can do everything. It is not at all unusual for the various disciplines (architectural, structural, mechanical, electrical, plumbing, and others) to create their own models, in a distributed fashion, and then use other software applications (such as Navisworks) to create a composite model that allows for clash detection and other types of construction coordination exercises and constructability reviews.

And the good news is that all of this can happen digitally, without having to re-enter information from different sources into the various tools. So, even though we haven't quite achieved the ultimate master model approach to BIM, we have made progress and are benefiting greatly from the efficiencies and cost savings associated with the use of BIM.

NOTE

Building information modeling is being taught as part of the standard construction management education program at many universities across the United States. What is especially encouraging is that this technology, designed to integrate information, is bringing about more collaboration among students from the different design-build disciplines of construction, planning, architecture, engineering, and even facilities management and landscape architecture. Students learning this technology have an advantage when applying for jobs as more companies are seeking employees with this added capability.

Designing with BIM

With BIM, the design process begins by building a model made up of intelligent objects that represent all the elements of the project—walls, roof, windows, beams, stairs, air conditioning units, and so on—that know what they are and what relationship they have with the other objects in the model. So, instead of having to look in different places (plans, sections, elevations, and schedules) for information regarding a particular item, such as a window, all the pertinent information is built into the window in the BIM. The object knows everything about itself—its size, frame material, type of glass, R-value, and so on. And if you change the design, each object will adjust itself to fit the new scheme.

In addition to communicating design intent, BIM allows the designers to run a variety of studies, simulations, and “what if” scenarios in a virtual environment, keeping track of the different databases that comprise the project, thereby tracking the various impacts those scenarios have on everything from energy efficiency, to ADA compliance, to spatial relationships, and every other architectural consideration. Furthermore, as other design professionals get involved with the model, such as structural engineers, mechanical engineers, and electrical engineers, they too can add their project elements and run design scenarios to see how they interface with the architectural components of the model. With BIM, the opportunity to integrate every aspect of the design is a real possibility because all of the physical and functional characteristics of every element of the project are captured in a database format. This makes it easy to share project information with other members of the team. What's more, contractor issues such as constructability, productivity, fabrication, and installation can also be considered while the design is being developed. Let's take a look at just how construction managers can take advantage of it.

Level of Development (LOD)

Just as traditional plans and specs are prepared to various levels of detail at different stages of the process, to convey the overall design intent and information about construction, so too will a BIM be developed to various stages of specificity. As you learned back in

[Chapter 5](#), there are basically four steps to the traditional design process after the programming stage—schematic (or conceptual) design, design development, construction documents, and as-builts. With BIM, the various stages of design are classified as *level of development* or LOD stages. In addition to displaying the geometric information and features of the design, the LOD also defines the data and information associated with the model elements, as well as the reliability of them, at the different stages of the process. Each LOD is identified by a number. The standard LOD “classes” are:

◆ LOD 100—Concept Design

At this stage the model is developed to a very basic level with little to no geometric information provided (e.g. dimensions). However, elements such as overall area, height, volume, location, and orientation are defined.

◆ LOD 200—Schematic Design

At this stage, a general model is created, with a little more information added. Geometric information is provided such as configuration, size, and shape, as well as related informational elements such as approximate quantities. In addition, non-geometric information such as location and orientation may be included.

◆ LOD 300—Detailed Design

This stage represents an accurate model with shop drawing level elements with specific assembly detailing, precise quantities, configurations, sizes, shapes, location, and orientation. Additional non-geometric information can also be attached to the elements at this stage such as cost data for pricing. The accuracy of the measurements, locations, quantities, and other pertinent data is reliable and can now support various construction management processes such the estimating, budgeting, and job cost accounting.

◆ LOD 350—Construction Documentation

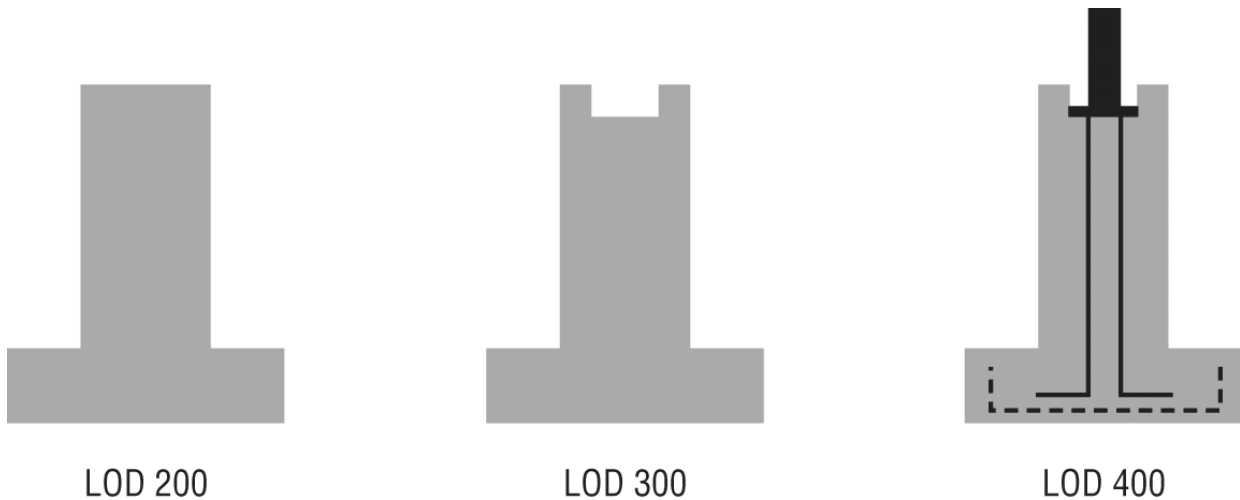
This level adds a little more detail to the model, which allows for cross-trade coordination to aid with the interfaces between the various building elements and disciplines.

◆ LOD 400—Fabrication and Assembly

This level provides detailing for fabrication and assembly purposes at the trades level. For example, this stage is when a contractor can begin to split up components of the detailed model to assign to different subcontractors to perform their work.

◆ LOD 500 – As-Built

This stage of the model provides reliable building geometry, data, and information to support the facilities, operations, and maintenance functions.



General depiction of various LOD stages

Replacing traditional 2D plans and specifications with an information and data rich BIM means it can be used for many different purposes, by many different parties associated with the full life-cycle of a project. Each user group will need a varying level of detail to have the model be useful, but the LOD framework creates a standard that can be applied to suit the needs of the different users.

NOTE

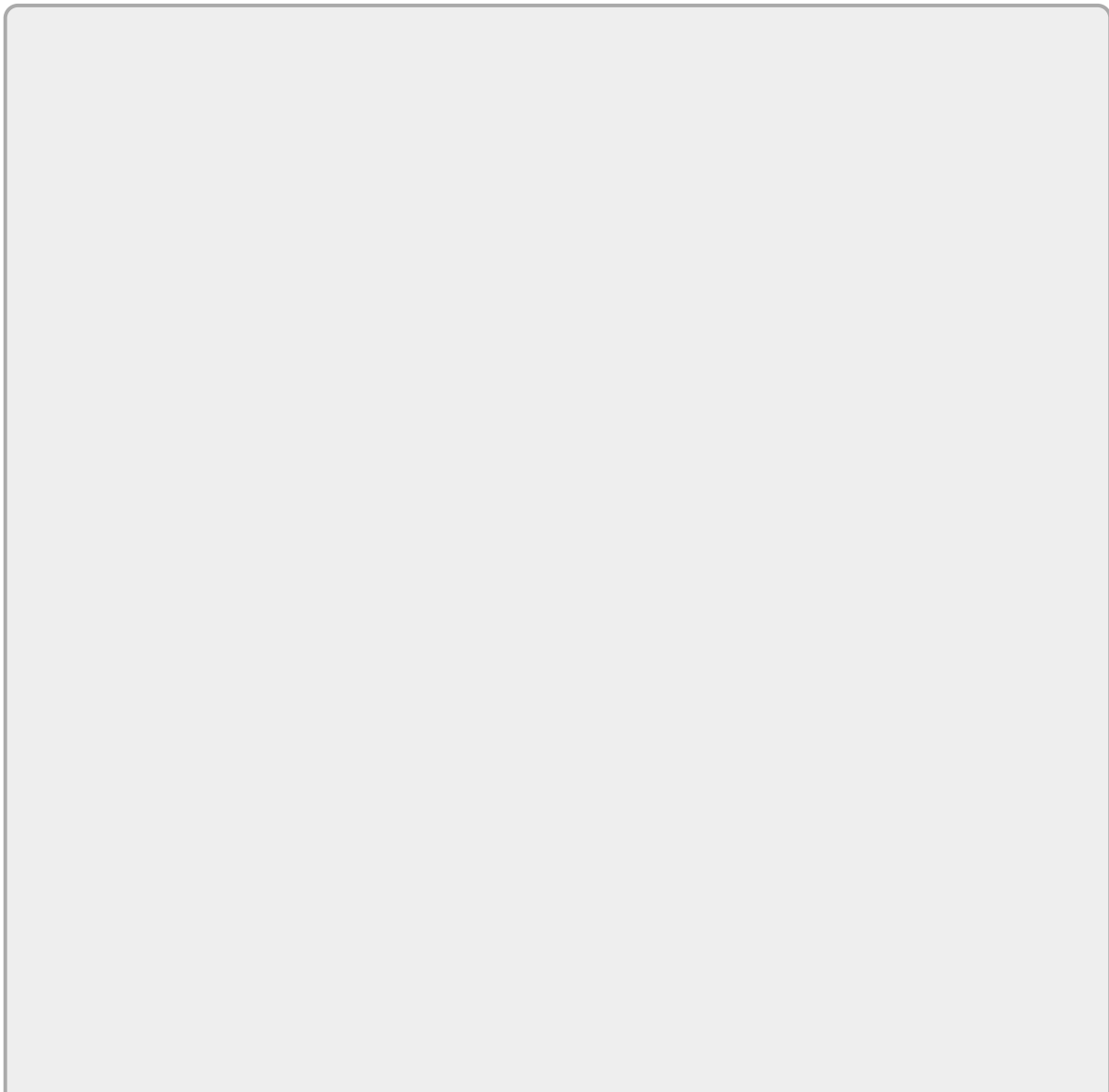
Establishing design intent and automating the development of the design documents is currently the most common use of BIM. As an industry, we have barely scratched the surface regarding the BIM's capabilities and usefulness. For example, even though we could be loading the model with actual manufacturers' objects linked to full product data, we still mostly use generic objects without any data attached at all.

BIM Execution Planning

Because there are many team members, from both design and construction, and maybe even operations and facilities personnel, who will be relying on the BIM to plan, coordinate and execute their work, it only makes sense that a great deal of upfront planning has to go into building the model itself. It will be the responsibility of the VDC team, and the project owner, to determine to what extent the model should be developed to best serve the various parties' expectations. To start, it's key that all parties understand the difference between a design intent model, a construction model, and a facilities management model. Knowing how the model will be used is pretty fundamental to the BIM Execution Planning process.

It is also very important that everyone creating, inputting information, and using the BIM be on the same page when it comes to the rules and standards regarding what the model will look like and how it will be built. Establishing these rules and standards is the primary reason for having a BIM Execution Plan in the first place. The plan allows all of the parties contributing to the model to collaborate, and communicate more effectively. Even if you have nothing to do with the building of the BIM, and are only a user, you still need to understand how it was built and to what levels of development various aspects of the model were created. This understanding is key to the usefulness and reliability of the BIM and the overall success of the project.

Although some contractors, especially the smaller firms, often rely on third-party consultants to develop their BIMs, we are seeing more and more companies train their own modelers, and create new positions associated with the BIM planning task. BIM Management has emerged as one of the newest construction management career paths. In response to the need for BIM managers, the Associated General Contractors (AGC) has created an educational offering for those who want to earn a Certificate of Management in Building Information Modeling (CM-BIM). According to the AGC website, the CM-BIM is an assessment-based credential that denotes knowledge and understanding of concepts related to BIM adoption, practice and process transformation outlined in the AGC BIM Education Program.



BIMstorm

In 2008 an architect in southern California by the name of Kimon Onuma developed a grassroots online exercise known as BIMstorm LAX. Onuma invited 133 design professionals from 11 different countries to participate over a 24-hour period. He also invited 700 additional people to participate as observers, including many contractors and students. The entire group, organized into teams, went to work developing schematic plans for large sections of the city of Los Angeles. With links to GIS applications and Google Earth, they ended up creating conceptual designs for 420 buildings totaling more than 55 million square feet. Buildings ranged in size from a small 600-square-foot house to a proposed 2-million-square-foot bank tower.

What allowed for all of these people, most of whom had no idea what BIM was, to participate in the exercise was a model server developed by Onuma's firm called the Onuma Planning System (OPS). This link allowed people with very little technology acumen and no BIM training at all to access the model and input data through such common software applications as Microsoft Word or Excel. Onuma believes that engaging a BIM should be no more difficult than booking a flight on a travel website like Expedia or Travelocity. In other words, technology should not limit the flow of information in design and construction, but rather, it should enhance it. Onuma created a system that requires no software installation and runs on standard Internet browsers on either PCs or Macs.

Since that first BIMstorm exercise in 2008, more than 15 others have been launched around the world in cities including Boston, San Francisco, Washington D.C., Tokyo, Rotterdam, London, and Vancouver. The BIMstorm experience is an ongoing opportunity for anyone interested in building design and construction. To learn more about BIMstorm and how you might participate in a BIMstorm experience, go to www.bimstorm.com.

Using BIM to Manage Construction

Although architects and engineers are often identified as the primary beneficiaries of BIM, the truth is the construction industry has a great deal to gain from employing BIM technology as well. With BIM you get a chance to build the project in a virtual environment before you build it for real. BIM provides an extraordinary opportunity for contractors to plan their construction approach, methods, and means long before they ever break ground. By running different simulations and analyzing the impacts of each, the contractor can work out in advance many of the glitches and problems that would be encountered in the field. The entire build team (contractor, subcontractors, fabricators, and so on) can work together collaboratively in a *virtual construction* environment to consider numerous scenarios relative to work sequencing, staging layouts, hoisting options, and many other important construction and job site management issues.

virtual construction

A computerized environment where the contractor and their team can simulate, analyze, and plan the construction of a building project before the actual construction process begins in order to head off problems in the field before they occur.

Furthermore, because of the “I” in BIM, the model can expand beyond the 3D features that allow the architect to communicate the design intent and lets us see the project. The “I” permits us to add multiple dimensions to the BIM. Unquestionably, builders can realize many benefits by incorporating BIM into their construction management process. By using BIM, a contractor can better coordinate all of the various trade activities involved in getting a project built and thereby save time, create a safer work environment, eliminate waste, reduce rework, have fewer errors and corrections in the field, produce a higher-quality product at a lower cost, and increase profits.

The construction benefits are so great that most contractors are opting to use BIM even if the owners aren't requiring it for

construction. A number of construction firms have made the investment in the technology and hired (or trained) personnel able to create BIMs so they can convert any two-dimensional CAD drawings into information-rich models to increase their own efficiencies. And, by adding dimensions to the BIM, the model can serve the full life cycle of the project, way beyond the completion of construction.

Most commercial construction companies have made the investment in the necessary technology and training and have incorporated at least some elements of BIM into their businesses. This is good news for members of the younger, tech-savvy generation who plan to enter the construction industry. All construction management activities can be enhanced and optimized through the use of BIM, and it can be applied to any type of construction project—big or small. It will help the entire design and construction team better understand what the project intent is and how best to achieve the project's goals and objectives.

NOTE

It has been reported by the Associated General Contractors that the 2D conversion to BIM for a typical project should take between one to two weeks and should cost between 0.1 percent and 0.5 percent of the total construction costs. This assumes that the contractor has already made the initial investment in software and training and is past the initial learning curve. Some contractors are outsourcing the task to a growing number of third-party service providers.

design-intent model

A building information model prepared by an architect, primarily intended to communicate design information.

construction model

A building information model, typically prepared by a contractor, that links construction-specific information such as work breakdown structures and cost data to project elements in the 3D model.

And even if the architect has supplied a 3D building information model to the contractor at the start of a project, its primary purpose is usually to convey design information, not necessarily data that can support many of the construction management tasks. In other words, it is a *design-intent model* and not a *construction model*. Therefore, it is not uncommon for contractors to create their own construction models in addition to using the architecture model.

Design Visualization

One of the most obvious uses of BIM for both contractors and architects is to communicate the design intentions to all members of the team, including the owner. The old expression “A picture is worth a thousand words” couldn't be truer. It is difficult for many people to visualize what a project is going to look like, and feel like, from 2D drawings and specifications. Not only does the 3D model present the project as it will be built, but it can also communicate an array of information about all of the systems, products, and materials used to build it.

stereoscopic projection

A 3D video display or view of a computer-generated building information model. Stereoscopic 3D is not the same thing as augmented, virtual, or mixed reality.

The BIM also allows the team to run simulations and conduct analyses regarding alternative approaches to both design and construction. By linking *stereoscopic projection* capabilities with the BIM, the benefits of design visualization are really enhanced. An

individual can have the experience of walking around the 3D model—helping the team make faster decisions with confidence.

Design Assistance and Constructability Review

One of the great benefits of BIM is it allows the contractor, along with their trade and supplier partners, to analyze and test a number of construction “means and methods” approaches before ever going to the job site. This gives the contractor the opportunity to discover flaws and issues in the design that cause significant constructability challenges—not to mention flat-out errors or omissions. When these issues are discovered, the contractor can recommend alternative solutions to the architect while preserving the overall design intent. These reviews can also be used to confirm quality standards and assess safety conditions.

Site Planning and Site Utilization

Proper site planning and utilization is a critical job site management task that has significant impact on the project's overall success. With BIM, the superintendent and project manager can sit down and study the existing and proposed utilities, site access options, safety and evacuation concerns, excavation plans and shoring requirements, dewatering issues, crane placement and hoisting schemes, and choices for temporary lay-down storage areas. A number of scenarios can be tested and confirmed, and once decisions have been made as to how to proceed, the contractor can communicate the plan to subcontractors, the owner, and even neighbors if needed.

Integration of Subcontractor and Supplier Data

It is quite common for some subcontractors and suppliers to create their own BIM models. For example, mechanical contractors and steel fabricators often create their own models and end up sharing them with the contractor. These specialty models contain product data, fabrication details, and installation methods that the contractor's model will not have. This allows these subcontractors to integrate their databases with those of the contractors to perform intensive coordination reviews and highly detailed systems analysis. The time and cost savings that this early integration effort brings is huge.

Systems Coordination

One of the most prevalent uses of BIM by contractors today is to perform *clash detection*. Clash detection is kind of like a spatial “spell check” for building components. Clash detection allows for the effective identification, inspection, and reporting of unintended material or system interferences in a 3D project model. For example, the model might reveal some ductwork running into a structural beam. This is obviously a problem that would best be addressed *before* the incident was discovered in the field. The clash detection exercise enabled by BIM can check the interfaces between equipment, fixtures, pipes, ducts, conduits, structural members, and architectural features. Contractors report that they have discovered and resolved thousands of conflicts by using BIM, saving significant dollars and calendar days in rework. These same contractors report a reduction in field-related questions and requests for information (RFIs) by as much as 80 percent on projects utilizing BIM. Now that's a *big* deal!

clash detection

A process for effectively identifying unintended material or system interferences in a 3D project model.

Layout and Fieldwork

Once the design is fully coordinated, data from the BIM model can be used to assist with the *layout* of materials and systems in the field. As a matter of fact, relevant information from the model can be loaded directly into the surveyor's equipment.

Prefabrication

One of the benefits of BIM that may present the greatest opportunity to improve construction operations lies with the potential for prefabrication. With a fully coordinated BIM model, the opportunity to isolate, analyze, and optimize any area of the project is possible. That means that the contractor can consider prefabrication techniques to deliver components of the project, especially those that

are repetitive. Prefabrication usually results in higher quality and lower costs.

Scheduling and Sequencing (4D BIM)

The planning and scheduling functions represent one of the most important aspects of the construction management process. These efforts continue throughout the building process and are constantly being monitored to keep the project on track. By adding schedule data to a 3D building information model, you can create a 4D information model, where time is the fourth dimension.

Adding the fourth dimension to the building information model helps everyone involved in the project visualize the schedule and understand how important proper sequencing of activities is to the overall success of the project. 4D schedules are a powerful tool for phasing, coordinating, and communicating planned work to subcontractors, designers, owners, and other project stakeholders. Scheduling with BIM helps optimize the sequence of construction and manage project logistics.

Cost Estimating (5D BIM)

One of the major benefits of BIM is that each object within the model includes information about its length, width, and height—all of which is needed by the estimator in order to develop quantities for the project. BIM enables accurate quantity takeoffs of materials and building components that can be linked directly to cost databases to create an accurate estimate for the project. Furthermore, the design and the estimate are connected in such a way that any cost impacts associated with changes in the design can be seen immediately by all parties associated with the project. With BIM, the chances of the design getting ahead of the estimate and busting the project budget are less likely.

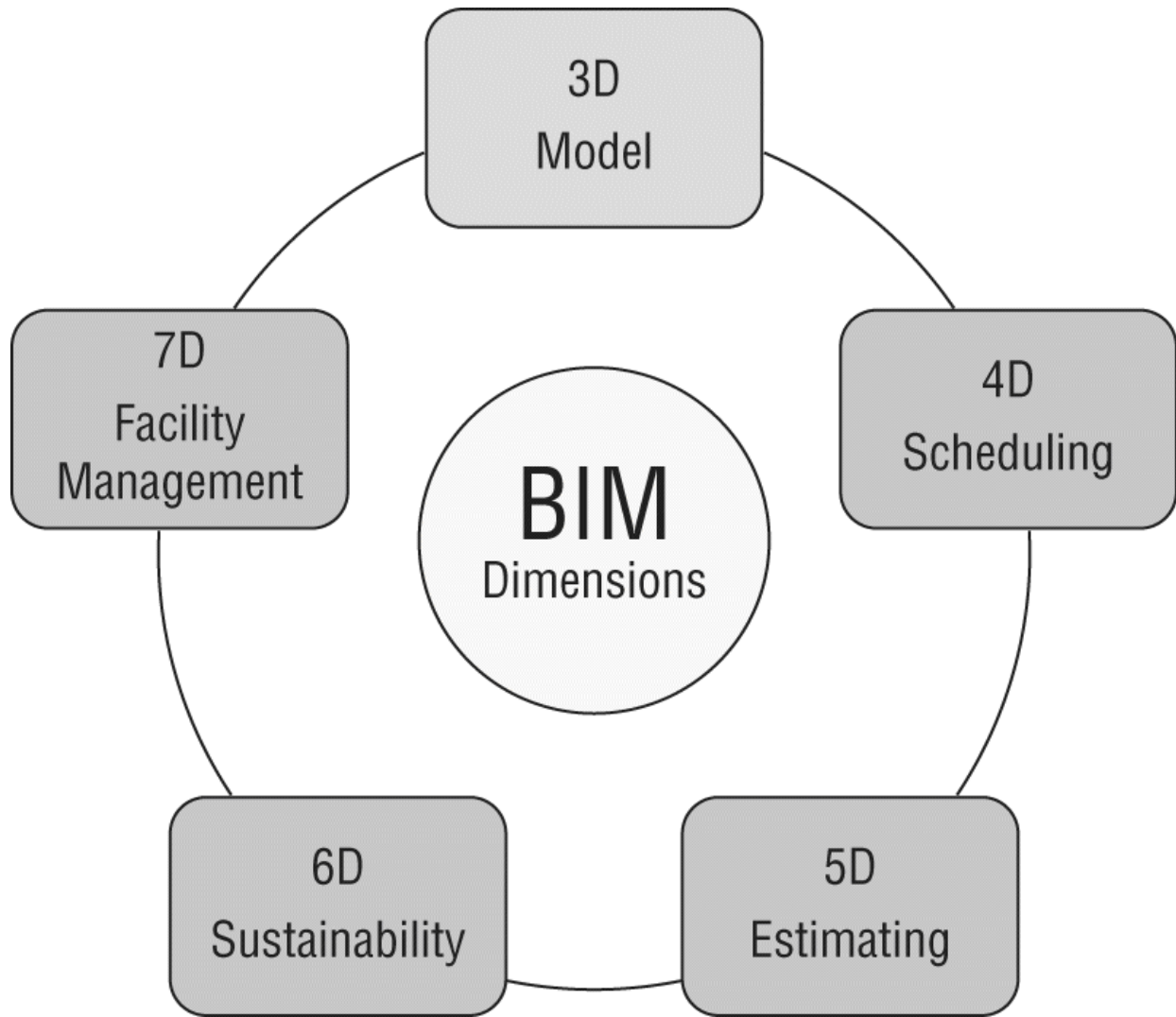
Sustainability (6D BIM)

BIM allows for project teams to do energy modeling on projects before they are ever constructed. The ability to perform complete and accurate energy consumption estimates earlier in the design process

helps project teams meet sustainability expectations set forth by the client. As you'll learn in [Chapter 16](#), reducing energy use, is a primary objective of most sustainability plans.

Facility Management (7D BIM)

One of the primary drivers for the use of BIM is associated with the concept of “cradle to grave” accountability for a project, which includes the maintenance and operations activities after the project is complete. Because the BIM model is updated continuously during construction, the “as-built” record of the constructed project is current and accurate at the time it is turned over to the building engineer responsible for the operation and maintenance of the facility. Not only that, but the information and specifications regarding all of the products, materials, and systems installed in the project can now be directly linked with the equipment and maintenance manuals utilized by the facility's personnel. The ability to manage the operations and maintenance of a building through its life-cycle allows the owner to optimize the asset from design to demolition. The seventh dimension of BIM allows participants to collect and track relevant data associated with every aspect of a facility's function. Loaded with this data, the BIM can facilitate such things as the management of service contracts, repairs, and parts replacements.



Advances on the Horizon

We have certainly come a long way since the earliest days of CAD, but there's still more to come. Already on the horizon are new groundbreaking technologies, apps, and software that will add even greater capabilities to our project teams and their work. Although most applications are still in the early development and adoption stages, they are gaining ground quickly. Here's just a few that are making waves:

- ◆ **Augmented reality** or AR is currently being used across the industry to help customers, architects, designers, and construction personnel visualize new design features applied to existing environments. AR overlays virtual elements on the real world. Just think how helpful this technology can be in helping communicate to tradespeople what the design intent is for a particular application of an architectural detail on an existing facade. Or how about trying to communicate to a client who has a hard time imagining what a new room addition will look like on the elevation of their home. There are currently dozens of AR apps for use on our iPhones.

Augmented Reality

A technology that superimposes or overlays a computer-generated image on a user's view of the real world, thus providing a composite view.

- ◆ **Virtual reality** or VR is a computer-generated simulation of an artificial 3-dimensional environment. A person can interact within the created environment using special electronic devices such as goggles with a screen or gloves fitted with sensors. The user is able to explore and interact with the various elements of the artificial environment as if they were real. Although this is still not commonplace in construction, there are many large companies piloting its use and experimenting with ways to incorporate it into their design and work processes.

Virtual Reality

A computer-generated simulation of an artificial three-dimensional environment. Requires the use of special equipment to interact with the created environment such as goggles or gloves.

- ◆ **Mixed reality** or MR is holographic representations that combine the best aspects of both AR and VR. Mixed reality lets the user see the real world like AR, while also seeing real-looking virtual objects, or holograms, like VR. For me, this is one of the more fascinating applications of new technology. A *hologram* appears as an object just like any other object in the real world, but there's one big difference. A real object is made of physical matter and a hologram is made entirely of light. Holograms can appear completely life-like. They can move, be shaped, and change according to how users interact with them. Unlike VR, where the user is immersed in an artificial environment, holograms are anchored to the real physical space you are engaging.

NOTE

As of April 2019, Microsoft's HoloLens is the first and only fully self-contained holographic computer running on Windows 10. Still in the development stages, it is completely untethered. There are no wires, phones, or connection to a PC needed. Microsoft's HoloLens allows you to place holograms in your physical environment and interact with them. For more information go to <https://www.microsoft.com/en-us/hololens>.

It will be very exciting to watch how these technologies impact our industry and to see who the early adopters will be. Even if these new technological applications have not yet been perfected for everyday use in the construction industry, you can bet that they soon will be.

Other Collaborative Tools

Although BIM is often identified as the most significant technological advancement in the design and construction industry in recent years, there are a number of other software and technological applications that are helping transform the construction process. These technologies have improved collaboration immensely and resulted in better communication, more data integration, less confusion, fewer errors, and far less paper to keep track of. For example, job site tablets have made it a lot easier for field personnel to manage every aspect of project coordination on the fly, in real time. Instead of running back and forth from the field to the job trailer, or from the job trailer to the main office, you now have access to every drawing, field report, RFI, team communication, punch list item, change order, safety checklist, contract document, and more, right at your fingertips via a lightweight mobile tablet. Many of these tablets are offered with rugged cases designed for tough conditions like harsh temperatures, dust, dirt, spraying water, vibrations, and drops. This is an amazing improvement in the management of everyday challenges and issues that need to be addressed on the construction job. The days of hauling around massive rolls of drawings, or shuffling through drawers full of paper records, RFIs, change orders, bids, contracts, specifications, and files is over. Here are two of the most popular software and cloud-based applications in use today:

Mixed Reality

Is the merging of the real world with virtual objects to produce new environments and visualizations where physical and digital objects co-exist and interact in real time. The object is anchored in the existing real environment.

Hologram

A projected object that appears as something real, but instead of being made of physical matter, a hologram is made entirely of light.

- ◆ Bluebeam Revu® has become an industry standard for document coordination and management. Bluebeam is used to convert Microsoft documents and CAD drawings into PDFs. Once the drawings are converted, multiple team members can mark up, edit, redline, annotate, and coordinate every sketch, plan, detail, elevation, and section of the drawings from any device. Team discussions can be communicated and documented in real time, coordinating every detail of the plans and design no matter where the team members are located. Every note, sketch, redline, and edit is available to all members of the team, making decision making and communication far more productive and reliable.
- ◆ ProCore® is a cloud-based comprehensive project management platform that enables the entire project team to access and participate in every type of construction application from a centralized hub. The platform helps manage daily logs, drawings, emails, meetings, job site photos, punch lists, RFIs, schedule, specifications, submittals, timecards, transmittals, bidding, and every type of coordination and management issue. In addition, ProCore has applications for quality and safety management, and project financials as well. <https://www.procore.com/>.

There are many other software or cloud-based applications to assist with every construction management function. It's clear that the industry is making good use of technology across several aspects of the business, such as estimating, quantity take-off, cost control, bidding, document control, and many others. Some companies are further along than others when it comes to adoption of the various tools available to us, but there's no doubt that technology has improved our ability to collaborate resulting in improved communications, fewer errors, increased productivity, and greater efficiencies.

Terms to Know

BIM model

central repository approach

clash detection

construction model

virtual design and construction

virtual reality

design-intent model

distributed repository approach

interoperability

virtual construction

augmented reality

mixed reality

Review Questions

1. What is a BIM model?
2. What is the difference between 3D CAD modeling and BIM?
3. How is *virtual reality* different from *augmented reality*?
4. What is the difference between a design-intent model and a construction model?
5. What is the difference between the central repository approach and the distributed repository approach to implementing BIM?
6. What is clash detection?
7. What are the fourth and fifth dimensions of BIM?
8. What are the sixth and seventh dimensions of BIM?
9. What does the term *interoperability* mean?
10. Name at least three common ways that contractors use BIM.

Chapter 16

Sustainability and the Built Environment

In This Chapter

- ◆ Why sustainability is important
- ◆ Use of life-cycle cost analysis
- ◆ Principles of sustainable building design
- ◆ Types of construction waste
- ◆ Understanding the triple bottom line
- ◆ USGBC and LEED standards

In 1987, the World Commission on Environment and Development put together a report called the *Brundtland Report*. The Commission's goal was to find ways in which construction and development could be put on a sustainable path. The Commission defined "sustainable" to mean:

"Meeting the needs of the present without compromising the ability of future generations to meet their own needs."

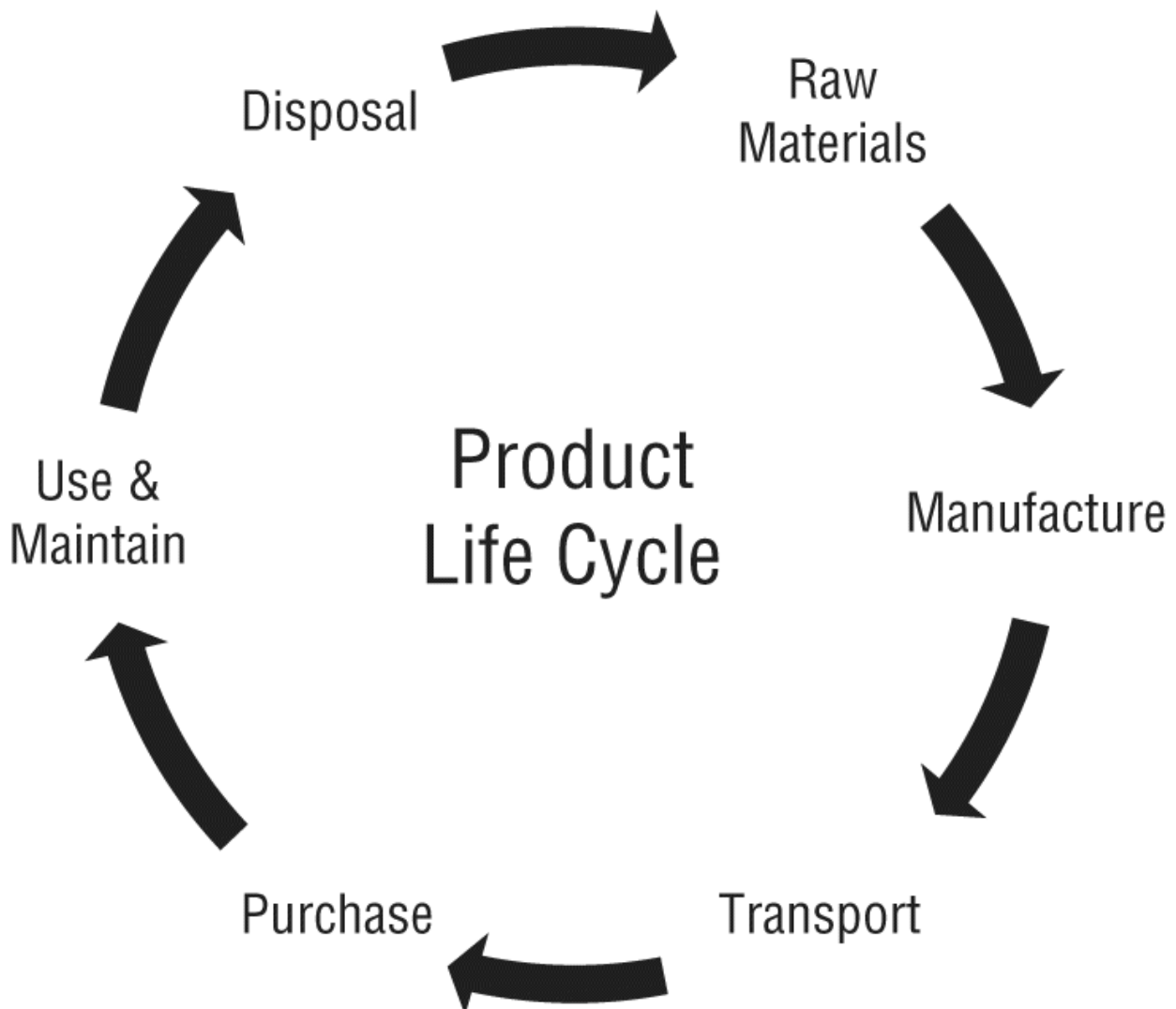
Since the time of that report, we have seen sustainability and green building shift from being merely a popular trend, to an expected mainstream design and construction deliverable. This shift in environmental awareness is a prominent part of the construction business today, and for good reason. According to the EPA, buildings in the United States account for 39 percent of the total energy use, 68 percent of the total electricity use, 12 percent of the total water use, 38 percent of all CO₂ emissions, and 60 percent of the total non-

industrial waste generated (from construction and demolition). All of the people associated with the industry need to be knowledgeable in sustainable practices, techniques, products, and standards.

The overall goal of learning how to build sustainability is to reduce the impacts that our construction methods, and materials, as well as our buildings themselves, have on the environment, our quality of life, and human health. There are many aspects associated with green building and sustainability. Some are just common sense—such as making use of the sunshine through passive solar applications, and using plants and trees for shade and windbreaks to reduce energy consumption to either heat or to cool our buildings. Other aspects may be more progressive, such as photovoltaics and green roofs. However, my primary objective in including this chapter in the book is to introduce you to some fundamental principles of sustainability and to make it clear that building green is an expectation that every construction professional must be ready to deliver on.

Building Process Life Cycle

Before we can begin to think consciously about sustainability, we need to first understand that there is a life cycle to our building process and it doesn't start with breaking ground and installing a foundation, and end with a certificate of occupancy. Before we do any work on the construction site, and after we turn over the keys to the new tenant, there are several steps to the overall building process that need to be considered when thinking comprehensively about sustainability.



Every product we use in the building process starts as a raw material in one form or another. For example, lumber starts as a growing tree, steel starts as iron ore, coal, and limestone, and glass begins as sand.

When we think about sustainability, we have to consider the entire life cycle of every product that goes into our building. We need to have an appreciation for how the raw materials are extracted from the earth and processed, how the product is manufactured and shipped, how it is purchased and used, how it is repaired and maintained, and finally, how it is disposed of. Every step of the process requires resources that are in limited supply—like energy and water. The fundamental objectives of sustainability are to reduce consumption of nonrenewable resources, to minimize waste, and to create healthy, productive environments in which people can live, work, and play.

Life-Cycle Cost Analysis

When trying to assess the economic benefits of sustainability, we must consider and compare the total cost of facility ownership, and not just the initial building costs. The method for doing this is called life-cycle cost analysis (LCCA), and it is very important to understand this analysis process when you are trying to contemplate alternative approaches and make smart choices. LCCA considers all costs of acquiring, owning, operating, maintaining, and disposing of a building and the various building systems within the building. Some products or systems might be less expensive up front, and even though the system may meet the performance expectations required, it may be more expensive to operate in the long run. When considering the full life cycle of a building, initial costs and operating costs must be compared in order to select the one that maximizes net savings overall. For example, performing a life-cycle cost analysis will help determine whether installing an energy-saving water heater, or low-flow faucets and shower heads, which may be more expensive initially, but result in reduced operating and maintenance costs, is cost-effective or not.

life-cycle cost analysis

A tool used to determine the most cost-effective option among different competing alternatives. Consideration is given to costs associated with the full life cycle of a building or system, from initial purchase to final disposal.

Fundamental Principles

There are several ways that we can improve building performance by employing sustainability features and elements throughout the entire planning, design, construction, and commissioning process. It would take an entire book (and there are many written), to discuss all of them in detail. We are going to focus on six fundamental principles of sustainable building design identified by the National Institute of Building Sciences. They are:

- ◆ Optimize site potential.
- ◆ Optimize energy use.
- ◆ Protect and conserve water.
- ◆ Optimize building space and material use.
- ◆ Enhance indoor environmental quality.
- ◆ Optimize operational and maintenance practices.

It's important to understand that the whole project team—architects, contractors, engineers, and subcontractors—need to embrace the fundamental principles of sustainable building and design, and collaborate from the earliest stages of the process, in order to maximize the many benefits associated with sustainability. Let's take a closer look at each one of these principles.

Optimize Site Potential

Design is where we can have the greatest impact on directing our facilities and buildings toward a sustainable life span. Sustainable design principles can be intentionally applied during the design phase of the construction process to reduce negative impacts on the environment. Through design and thoughtful placement, we can create buildings that are in harmony with the natural resources and features neighboring the site, as well as create healthy living and working conditions for the people who inhabit the designs.

Site selection and building layout is the very first opportunity to apply sustainable principles. For example, in order to cause the least disruption to the site, place the building in such a way that the natural

grades and topography compliment the design, minimizing the amount of excavation and earth moving necessary. Smart placement within the existing, natural terrain, might also prevent drainage and erosion problems. Siting the facility to take advantage of the sun for passive solar heating, and prevailing winds for natural ventilation and cooling, are also easy ways to jump start your sustainable design intentions. Depending on what region of the country you are building in, weather always comes into play when designing a facility as well. The sun, wind, rainfall, temperatures, elevation, and humidity all impact design details and product selections. Choosing energy-efficient, water-saving, and eco-friendly products to address these climate and orientation challenges will minimize any negative effects on the environment.

Optimize Energy Use

Because buildings account for 68 percent of total electricity usage in the United States, it's an obvious target for improving energy performance—both in new and existing facilities. Working to attain a *net-zero building* rating is one way to significantly reduce our dependence on fossil fuel-derived energy—one of the hallmarks of the sustainability movement.

net-zero building

An energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.

Fossil fuels—primarily oil, coal, and natural gas—currently comprise the bulk of our energy resources in the United States and around the world. The United States gets 81 percent of its total energy from fossil fuels, according to some sources. We depend on those fuels to heat our homes, run our vehicles, power industry and manufacturing, and provide us with electricity. This is how we generate electricity. Fossil fuel power plants generate steam that drives large turbines that produce electricity. However, these sources of energy are considered nonrenewable, and therefore, are in jeopardy of running out. There

are also concerns about various negative effects produced by burning these fuels and the damage that it may be causing to the environment. Therefore, by reducing our need for electricity derived from nonrenewable resources, we can better protect the environment and reach some of our sustainability goals. By utilizing more *renewable energy* sources such as solar power, wind power, hydroelectric power, and geothermal energy, we are putting some of the fundamental principles of sustainability to use. There are many ways that we can reduce and optimize energy use. Several are initiated through the design process, and others may be applied as retrofit solutions. Here are some identified by the National Institute of Building Sciences:

renewable energy

Energy from sources that are naturally replenishing such as solar, wind, and geothermal power.

- ◆ Reduce heating, cooling, and lighting demand through passive strategies such as *daylighting* and conservation practices.
- ◆ Specify energy-efficient HVAC and lighting systems.
- ◆ Utilize and install energy-efficient appliances and products displaying the Energy Star[®] designation.
- ◆ Employ renewable energy sources such as solar heating for hot water, *photovoltaics*, and *geothermal heating* systems. There are several other options as well.
- ◆ Optimize building performance by employing *energy modeling* programs during design and after occupancy and operations.
- ◆ Optimize system control strategies by using programmable thermostats and other occupancy sensors, such as devices that turn lights on automatically when you enter a room, and turn them off when you leave, as well as CO₂ sensors, and other air-quality alarms.

daylighting

Rather than relying solely on electric lighting during the day, daylighting brings indirect natural light into the building by placing windows, skylights, light shelves, or other openings and reflective surfaces so that during the day natural light provides effective internal lighting.

photovoltaics

Devices that generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material called semiconductors.

geothermal heating

Heat extracted from the earth that exceeds the heat on the surface of the earth.

energy modeling

A computer simulation of a building used to determine or estimate its energy usage.

I have barely scratched the surface in terms of the possibilities for attaining sustainability through energy savings and optimization. Today, building-in energy conservation tactics during the construction phase is almost expected. Frankly, there's no reason not to. There are so many energy-efficient and energy-saving products and appliances, as well as passive techniques, and all types of mechanical applications, that it is probably one of the easiest ways to apply "green" initiatives to your project. The key is to employ several tactics to develop an integrated approach to sustainable energy use and optimization.

NOTE

My favorite resource for anything to do with sustainability is the Whole Building Design Guide (WBDG) put out by the National Institute of Building Sciences. Much of what I have shared pertaining to the six principles comes from the WBDG. It is the most practical and comprehensive source that I have come across. It provides a wide range of building- and design-related guidance from a “whole building” perspective. To learn more about what this valuable resource has to say about sustainability, go to:

<https://www.wbdg.org/design-objectives/sustainable>.

Protect and Conserve Water

In some parts of the United States, and across the globe, water is like gold—it is a very precious commodity. Our water resources are becoming scarcer, even in areas that seemed to have plentiful aquifers in the past. These same aquifers aren’t able to replenish fast enough, primarily due to our consumption per capita increasing on an annual basis. Therefore, attempts to protect water resources, reduce water consumption, and protect water quality should be a part of any sustainability plan. There are many ways that we can be a good steward of this precious resource. Here are some examples:

- ◆ Utilization of water-conserving plumbing fixtures such as low-flush toilets, dual flush toilets, low-flow shower heads, and low-flow faucets.
- ◆ Use of water saving appliances such as high-efficiency washing machines and tankless water heaters.
- ◆ The use of *gray water* for toilet flushing or landscape irrigation and other on-site water needs such as car washing.
- ◆ Development and installation of a water collection system, taking advantage of rain or snow precipitation that can be used for

many water-use functions such as lawn irrigation, toilet flushing, laundry, or landscape features such as fountains.

gray water

Gently used water from sinks, showers, tubs, and washing machines. It is not water that has come into contact with feces, either from the toilet or from washing diapers. Sewage water is referred to as black water and cannot be recycled or reused.

Average Household Water Use	Percentage
Landscaping	50%
Toilet	14%
Laundry	12%
Showers	9%
Faucets	8%
Leaks	5%
Baths	1%
Dishwasher	1%

Any of these features may be designed into new construction or installed during retrofits to existing facilities. Not only will they save on water usage, but they also save money in the long run.

NOTE

The Environmental Protection Agency (EPA) created a voluntary partnership program with manufacturers, retailers, and distributors, homebuilders, irrigation specialists, and utility companies to identify products and services that save water. These products and services carry a special WaterSense label and are certified by the EPA to use at least 20 percent less water, save energy, and perform as well as or better than regular models.

Optimize Building Space and Material Use

Flexibility and use of the facility spaces themselves is an interesting component of this sustainability principle. This is where we might really get creative and begin to think of our building projects as big Lego® sets that could be disassembled and reconfigured for a different use. Or plug and play module systems that would allow for expansion or contraction of spaces. Think of it as reusing or recycling a whole building—and planning that into the design right from the start.

But the major influence of this principle deals with material use. Materials and material selection are a critical component of the building process. This sustainability principle primarily deals with what materials we put into our building projects, and how they are sourced. Our choices will have a substantial impact on the environment and the health and well-being of the people who occupy the facilities we construct.

A sustainable building is constructed using products that are often identified as *green building* materials. What makes a material green is consideration for how it was made, and where it came from. Every building material we use has to be manufactured, processed, installed, shipped, and eventually disposed of. The intention with green building materials is to minimize any negative impacts on the environment and on the health and welfare of people through their

entire life cycle. Their *eco-friendly* nature, aesthetics, durability, performance, and energy efficiency make them ideal choices for any type of building project.

green building

The practice of designing, constructing, and operating buildings to maximize occupant health and productivity, use fewer resources, reduce waste and negative environmental impacts, and decrease life-cycle costs. Green building is at the heart of sustainability.

Green building materials may be developed as new products made from recycled content, or reclaimed items salvaged from another application. Some may be identified as green because of the way they are fabricated, such as low-emitting materials or certified wood. Others will be classified as eco-friendly because they are rapidly renewable materials or sourced locally or regionally. Here are examples of each of these types of green materials:

eco-friendly

Earth-friendly, or not harmful to the environment. This term most commonly refers to products that contribute to green living that help conserve resources like water and energy.

- ◆ Materials made from recycled content—there are many products today that are made from recycled content. Examples include roofing tiles, carpet, composite laminated lumber.
- ◆ Reclaimed materials—these materials are usually salvaged from a previous use. Lumber, floor boards, brick, and doors are some common examples. Once the material is cleaned, and in some cases, repaired, it is ready to be reused in its original application, or repurposed for a new application. For example, old wood doors make beautiful *wainscoting* and wall paneling.

wainscoting

The lower part of the walls of a room, when finished in a material different from the upper part such as wood paneling.

- ◆ Low emitting materials—We have known for some time about the harmful effects of volatile organic compounds or VOCs found in many building materials manufactured using adhesives, resins, and sealants. Fortunately, today you can find all of these materials with much lower, or no VOCs at all. A good example is paint. You can now find a variety of paints that have no VOCs at all.
- ◆ Certified wood materials—Floors, cabinets, decks, and doors are common products made using *certified wood* if you know what to look for. Wood identified as certified meets a standard established by third party, independent evaluators who certify that the wood was harvested from responsibly managed forests. Here in the United States, the standards developed by the Forest Stewardship Council (FSC) is the most reliable certification.

certified wood

wood harvested from responsibly managed forests and certified as such by a third-party evaluator.

- ◆ Rapidly renewable materials—According to the USGBC, a *rapidly renewable material* is any building material made from agricultural products that are typically harvested within a 10-year or shorter cycle. Think straw, cotton, wheat, cork, bamboo, and natural rubber for example. Bamboo and cork flooring products are very popular building products today.

rapidly renewable materials

Natural, non-petroleum-based building materials made from agricultural products that are typically harvested within a 10-year or shorter cycle.

- ◆ Locally/regionally sourced materials—According to the USGBC, a locally or regionally sourced material must be extracted, manufactured, and purchased within a 100-mile radius of where it is to be used. One of my favorite examples of such a product is a black slate roofing shingle that I used all the time when I was in business in Virginia. My design-build firm was located in Buckingham County, and the black slate was extracted from a quarry about 5 miles from my office, and the beautiful, natural shingles were manufactured and sold from the same location. And they come with a lifetime warranty!

NOTE

Buckingham County slate is considered by many to be the finest slate in North America and perhaps in the world. Roofs shingled with Buckingham slate have proven to last well past 100+ years. The original quarry and the Buckingham Slate Company® is still going strong after 150 years in business.

Each of these examples, can be identified as *environmentally preferred products* because they have “a lesser or reduced effect on human health and the environment when compared to competing products that serve the same purpose” as defined by the Environmental Protection Agency. What is most exciting is that we can find ways to improve the “green” quotient for every component of our building envelop and interior—the foundation system, the floor system, the wall system, the cladding system, the roof system, the mechanical, electrical, and plumbing system, and on and on.

environmentally preferred products

Products that have a lesser or reduced effect on human health and the environment when compared to competing products that serve the same purpose as defined by the EPA's Greening of the Government Executive Order 13101.

NOTE

Green products are in great demand, and that demand is growing. It has been reported that worldwide, the green product market is expected to reach \$377,029 million by 2022. Green building materials are used in every sector of the construction industry to address various environmental challenges including the depletion of our natural resources, contamination of our fresh water resources, and air pollution, to name a few.

Enhance Indoor Environmental Quality

I've already discussed several aspects of this particular principle in previous sections of this chapter. Indoor environment quality has a lot to do with how people feel both physically and emotionally when they spend time in the facility—whether it is their home, or where they work, shop, or play. In a nutshell, indoor environmental quality of a building has to do with the air quality, ventilation, humidity, lighting, noise, and other factors that have significant impacts on the inhabitant's comfort, health, and productivity. Space really matters and it has finally been recognized just how much it can affect a person's ability to perform. In a work environment it can affect such things as absenteeism, output, teamwork, and effectiveness. Who knew that by applying sustainable techniques such as adding more daylighting, or increasing the number of fresh air exchanges, or managing noise levels in the work environment, that you could improve overall worker productivity—and perhaps even profitability.

Optimize Operational and Maintenance Practices

A lot of sustainable systems can be designed into a building to reduce maintenance requirements, and enhance operations, by specifying materials, products and equipment that saves energy, conserves water, and eliminates the effects of toxic chemicals. However, that's not the end of the story. It's important to develop an O&M plan that supports your sustainability goals through the building's entire life cycle. Even when every effort has been made to design and construct a wonderfully sustainable building, we can end up sabotaging the benefits of that effort if we then fail to operate and maintain it properly. Here are some practical guidelines recommended by the National Institute of Building Sciences to optimize operational and maintenance practices:

- ◆ Educate building occupants in the fundamental sustainability principles.
- ◆ Train facility managers and maintenance staff in sustainable practices.
- ◆ Automate and monitor lights, heating, cooling, water, waste, temperature, moisture, and ventilation usage and systems.
- ◆ Reduce waste wherever you can and develop a recycling program.
- ◆ Employ sustainable watering and landscaping practices.
- ◆ Purchase and use safer cleaning products and maintenance services.
- ◆ Support practices that encourage sustainable transportation choices.

Waste in Construction

Although the fundamental principles address almost all issues associated with sustainability as it relates to construction, there's one that I feel isn't covered well enough and warrants its own focus. According to the National Institute of Building Sciences:

Responsible management of waste is an essential aspect of sustainable building. In this context, managing waste means eliminating waste where possible; minimizing waste where feasible; and reusing materials which might otherwise become waste.

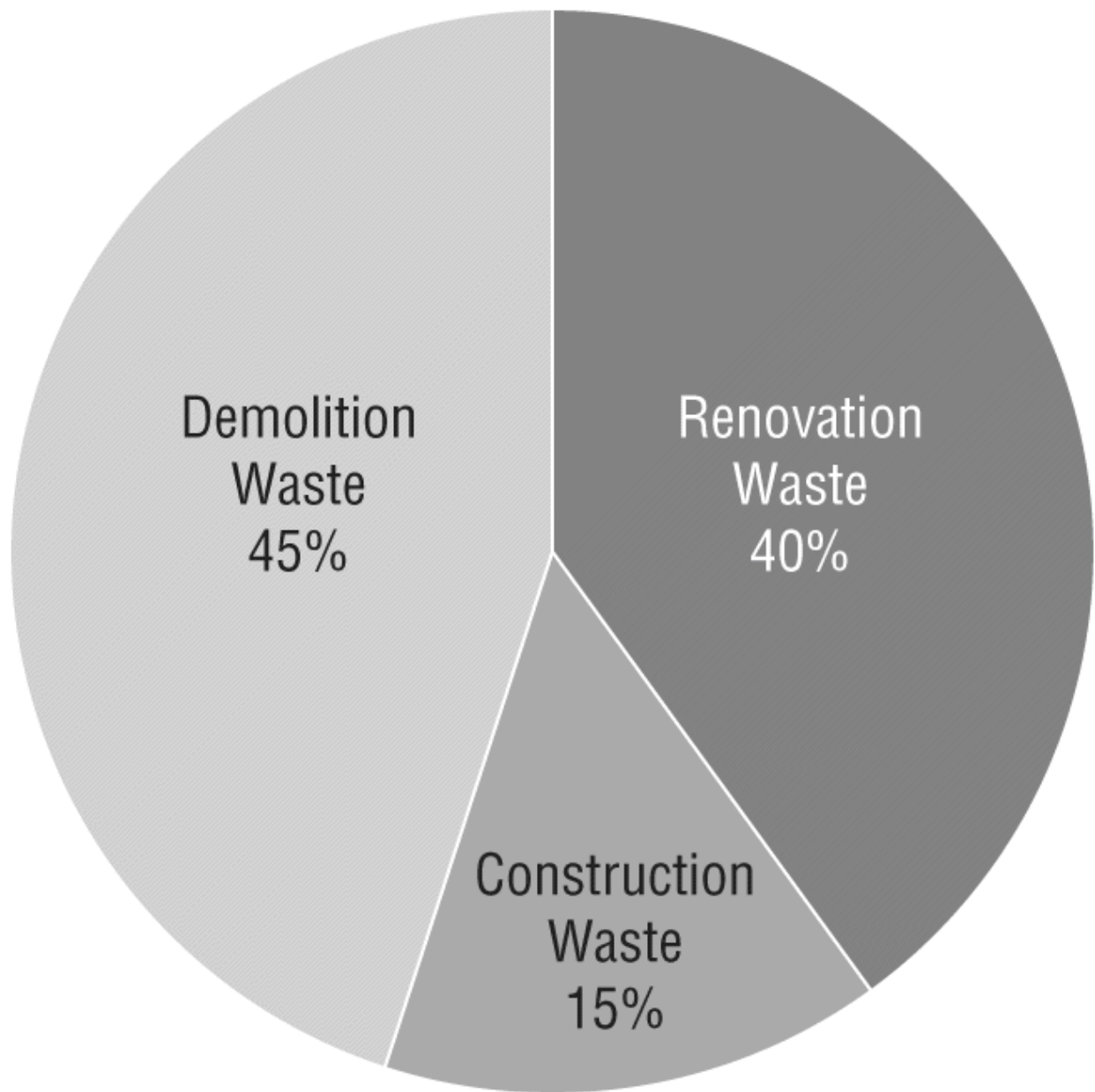
Waste is a major issue in the construction process and has been for a very long time. It is a tremendous challenge, both at the project level and industry-wide. I don't think we can properly address sustainability without tackling the waste issue. Those institutions and agencies that track waste distinguish between demolition waste and waste related to new construction. It may be further categorized as follows:

- ◆ Debris left over from new construction (e.g. material scraps of all kinds, cardboard boxes, packaging)
- ◆ Remodeling/demolition waste and debris from existing buildings (e.g. brick, doors, windows, trim, old wood, insulation, plaster, fixtures, appliances)
- ◆ Debris from large civil works projects such as roads, highways, bridges, tunnels, and railways (e.g. asphalt, concrete, rebar, steel, timber, rubble)

No matter how you categorize it, it's a big issue. Just consider the variety of materials associated with construction debris—concrete, wood, asphalt, gypsum, nails, screws, bolts, asbestos, fiberglass, metals, bricks, concrete block, light fixtures, wiring, equipment, glass, plastics, doors, windows, plumbing fixtures, trees, stumps, dirt, rock, etc. Is it any wonder that building demolition and construction is the largest single source of waste in the entire trash producing spectrum?

NOTE

New construction projects average 3.9 pounds of waste per square foot of building area. For example, almost 98 tons of waste is generated when constructing a 50,000-square-foot building. Building demolition averages about 155 pounds of waste per square foot, so a 50,000-square-foot demolition project would yield a whopping 3,875 tons of debris.



So, what do we do with all of this waste? Hauling and dumping the debris in landfills is still the most prominent disposal method for construction waste. Unfortunately, our landfills are overloaded and this is not a sustainable solution. The better solution is to reuse or recycle construction waste whenever possible. There are many building materials that can be easily recycled such as concrete, plastics, tile, lumber, metals, masonry products, carpet, insulation, and more. The benefits of recycling have been known for some time. A good win-win example is using recycled concrete as a base material for new roadways or driveways. In addition to saving money, if

recycled right on site, the pollution involved in trucking in new material can be eliminated. Recycling does take some planning and extra effort to sort and collect the various different types of materials, but many construction companies are now making this a priority. And, depending on your location, there are now several types of recycling facilities and services that process construction debris. With new construction in particular, it is now quite easy to develop a reliable recycling program right on the jobsite. On the other hand, demolition is a bigger challenge. However, if we choose to *deconstruct* a building, instead of demolish it, then we have a chance to salvage many materials for reuse. Items such as boards and lumber, decorative trim, hardware, light fixtures, stair parts and railings, windows, and doors are not only pretty easy to salvage, but in some cases, they can be sold at a premium. We see the reuse option applied much more in the residential sector, but it can also be used for light commercial projects as well.

deconstruct

To selectively dismantle a building, component by component, in order to salvage materials for reuse or recycling. It differs from demolition whereby a building is cleared to the ground in the most expedient manner possible.

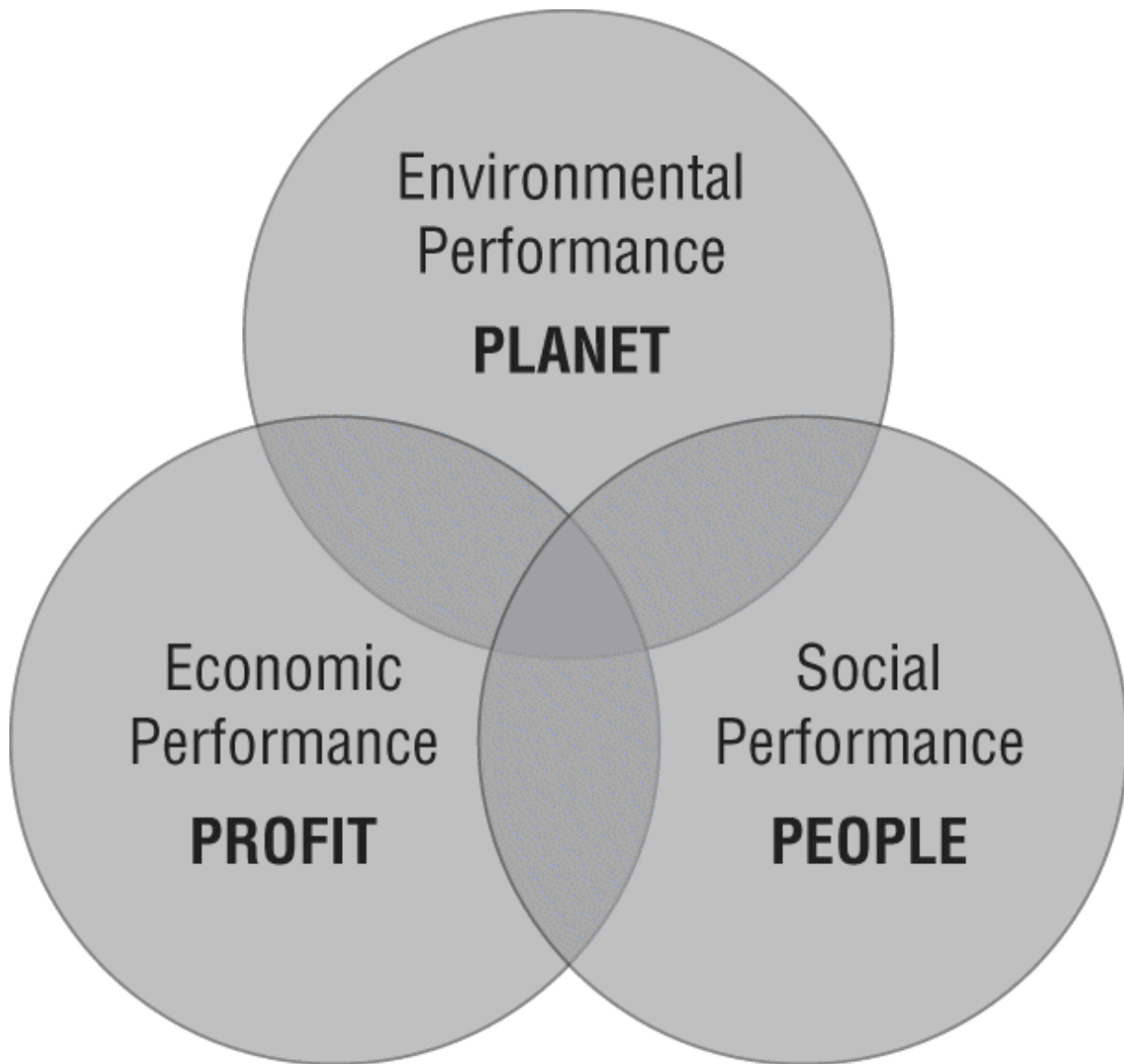
Of course, we can always address the construction waste issue right at the design stage, by eliminating it in the first place—or at least minimizing it. For example, during design, an attempt should be made to coordinate stated dimensions with standard sizes of materials to eliminate the need to cut or trim materials to fit. When dimensions are designed in 2-foot increments, it's much easier to get full use of such things as standard 4 ft x 8 ft sheet goods, or standard-length lumber milled in 2-ft increments. Any time you see an odd-number dimension on a set of plans, you know there is going to be waste in some materials. The more odd-number dimensions, the more waste. Unfortunately, not all elements of design lend themselves to a nice neat 2-ft increment, so we can't eliminate all waste. But, we can certainly do better, starting at the planning and design stages.

Triple Bottom Line

Thus far in this chapter, we have focused on sustainability from an energy, health, and environmental perspective, and this is generally how most people, including the consuming public, understand sustainability. However, in the mid-1990s, a business author by the name of John Elkington came up with an approach to sustainability from a corporate responsibility perspective. This sustainability model is called the *Triple Bottom Line* or TBL framework. Elkington believed that businesses should begin to measure the health and performance of their organizations by something other than the traditional measurement of profit. He believed that businesses should measure their overall success by considering environmental and social factors, as well.

triple bottom line

Measuring business success by the financial performance of the organization as well as environmental and social factors.

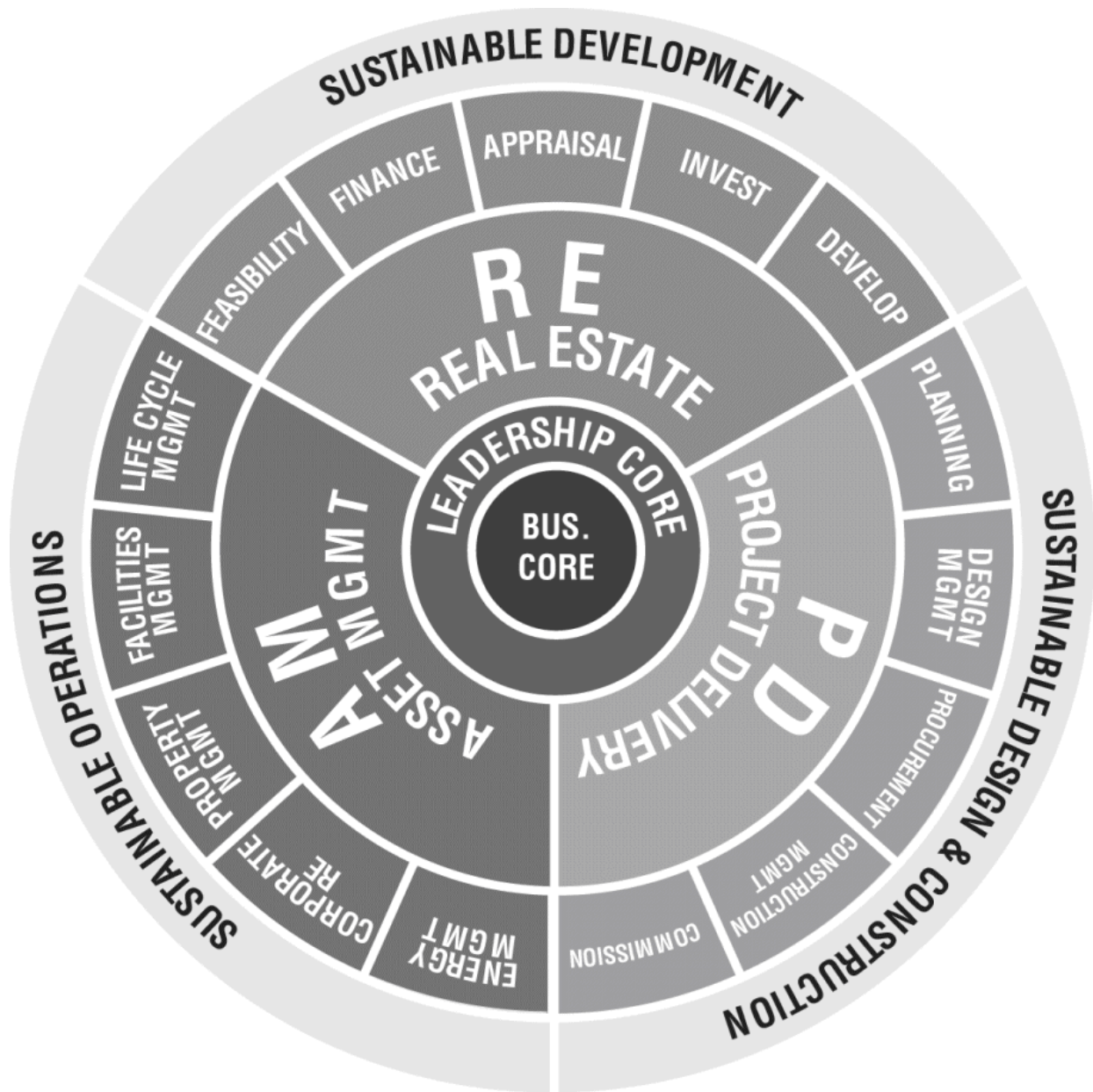


Triple Bottom Line Sustainability

Educating the Next Generation

Understanding the impact of the construction business on all of society is very important as we educate and prepare the next generation of participants and leaders in the industry. At the Burns School of Real Estate and Construction Management, where I serve as the director, we define sustainability from a TBL perspective. The Burns School is one of only a few Construction Management programs that reside in a College of Business. And we are the only

program that looks at both the “build side” and the “business side” of construction through a real estate and built environment lens. We believe that to be truly sustainable, new construction and new development projects must perform environmentally and socially, as well as economically. The construction industry’s traditional single measure of profitability is not enough. The principles of this more holistic perspective are at the heart of our construction management program. It is expressed in what we call teaching the full life cycle of the built environment. We believe that teaching the fundamental core competencies associated with real estate and the transactional side of the built environment, as well as all aspects of project delivery (project planning, design management, commissioning, asset management, etc.), and not just construction management, is the best way to mitigate risks, generate value, eliminate waste, and develop sustainably. Understanding the relationships between real estate, project delivery, and asset management from a triple bottom line perspective is what makes Integrated Project Leaders, as referenced back in [Chapter 6](#). And that’s what we are out for at the Burns School at the University of Denver.



Going Beyond Green

As a construction industry we have done a pretty good job identifying various economic and environmental factors of performance. We can point to meeting budgets and hitting profit targets for our economic measures. Likewise, we can brag on how much less energy our buildings are consuming because of the selection of energy saving materials and equipment that went into our projects. However, it isn't so easy to come up with the social benefits that our projects may bring to a community.

Several years ago, I spoke before a group of young members of the industry identified as the Emerging Leaders Forum, which is a subgroup of the Associated General Contractors (AGC). There was about 105 members in the audience. I asked if they could identify how their last project contributed to the community from an economic perspective. Everyone shared how their projects had been profitable, and how those profits led to individuals having jobs and good salaries, which meant that they could purchase homes and rent apartments, buy groceries from local merchants, etc. I then asked how their projects had performed environmentally, and most could tell me about some water saving, or energy conserving, or waste reducing feature that had been built into the project. But when I asked how their project had performed socially, the room went silent. No one raised their hand. So, I randomly called on someone to inquire further. The young man I called on revealed that his last project was a bridge that created a shortcut across a congested traffic area. He shared how the project had made money for his company, as well as all of the subcontractors and vendors who had supplied goods and services in the completion of it. He could also describe in detail the many conservation measures that were taken to enhance the public health and environment of the community. But when I asked about what difference the project made from a social perspective he was stumped. And then I asked if there was anyone in the room who traveled that new bridge, and a different young man raised his hand. I then asked what difference that bridge had made in his daily life. He stated that he now could get home to his family about 35 minutes earlier than before the bridge was built. And when I asked, about what specific difference that extra 35 minutes made in his life, he shared, with a tear in his eye, that now he was able to make it home in time to be at most of his daughter's soccer games. How do we ever measure this kind of impact? It's difficult, but we need to find ways to assess our projects' performance beyond just profit and environmental impacts. Here are a few different ways that we might begin to think about our triple bottom line performance as an industry.

Economic performance In addition to profits, we can also assess economic performance from an income or expenditure perspective, or from a tax perspective, or employment

perspective. Measuring a variety of aspects associated with the economic health of a neighborhood or community is a good way to assess the impact of the built environment on its surroundings. Specific examples include:

- ◆ Personal income
- ◆ Employment opportunities
- ◆ Job training
- ◆ Job growth
- ◆ Unemployment rates
- ◆ Business growth
- ◆ Tax revenues to municipalities

Environmental performance It is very important to limit the impact that building and development have on our ecosystems and natural resources, and on our planet in general. These environmental factors are often the easiest to incorporate into any sustainability plan. Here are examples of the common types of measurements we often include:

- ◆ Air quality
- ◆ Water quality
- ◆ Water usage
- ◆ Electricity consumption
- ◆ Fossil fuel consumption
- ◆ Recycling trends
- ◆ Hazardous waste quantities
- ◆ Air and water pollutants
- ◆ Health impacts

Social performance Social performance is the toughest of the TBL variables to measure. Social dimensions of a community could include measurements associated with education, access to social resources, health care and well-being, quality of life, and

social capital. The examples listed below are a small sampling of potential variables that can be easily related to new facilities, building projects, and the built environment:

- ◆ Poverty rates
- ◆ Public assistance usage
- ◆ Home ownership
- ◆ High school drop-out rates
- ◆ College or community college graduation rates
- ◆ Crime statistics
- ◆ Life expectancy
- ◆ Diverse labor force participation
- ◆ Average commute times
- ◆ Public transportation use
- ◆ Obesity rates

There are many positive things that come as a result of a healthy and robust construction industry—jobs, services, access, commerce, security, etc. When we build a new health clinic or a new transit station, or a new school, or a new manufacturing facility, or a retail outlet, or a new bridge, we rarely think about its impact on a community and the people who live there, from all aspects of sustainability—but perhaps we should.

Sustainability Standards

The majority of students graduating from community colleges and four-year university programs where construction management is being taught are most likely pretty familiar with the Leadership on Energy and Environmental Design (LEED) program, developed by the U.S. Green Building Council (USGBC). As you learned in [Chapter 1](#), LEED is a voluntary, market-driven building-rating system that evaluates environmental performance over a building's life cycle. The program is designed to encourage project teams to pursue LEED certification for their buildings. According to the USGBC website:

LEED is the most widely used green building rating system in the world. Available for virtually all building, community and home project types, LEED provides a framework to create healthy, highly efficient and cost-saving green buildings. LEED certification is a globally recognized symbol of sustainability achievement.

<https://new.usgbc.org/leed>

The LEED program, first developed in 1993, with a mission to promote sustainability-directed practices in the construction business, is pretty impressive. Its widespread acceptance and use account for a number of notable highlights. Here are just a few shared by the USGBC:

- ◆ Over 2.2 million square feet of building space is LEED certified every day.
- ◆ There are more than 90,000 projects participating in LEED, with at least 32,500 of those being commercial projects.
- ◆ LEED is in 165 countries and territories and works for all building types anywhere.

LEED Certification

Under the LEED program, buildings are evaluated against certification standards. According to the USGBC, all building types

and all building phases, including new construction, interior fit-outs, operations and maintenance, and core and shell projects may achieve LEED certification.

For a building to earn LEED certification, it must to earn points by meeting certain criteria. Based on the total number of points achieved, a project then achieves one of four LEED rating levels. The lowest level of certification is called Certified and the highest is identified as Platinum:

LEED Designations	
Designation	Description
BD+C Building Design and Construction	For new construction or major renovations; includes new construction, core & shell, schools, retail, hospitality, data centers, warehouses & distribution centers, and health care.
ID+C Interior Design and Construction	For complete interior fit-out projects; includes commercial interiors, retail, and hospitality.
O+M Building Operations and Maintenance	For existing buildings that are undergoing improvement work or little to no construction; includes existing buildings, schools, retail, hospitality, data centers, and warehouses & distribution centers.
ND Neighborhood Development	For new land development projects or redevelopment projects containing residential uses, nonresidential uses, or a mix. Projects can be at any stage of the development process, from conceptual planning to construction.
Homes	For single family homes, low-rise multifamily (one to three stories) or mid-rise multifamily (four to six stories); includes homes and multifamily low-rise and multifamily mid-rise.
Cities and Communities	For entire cities and sub-sections of a city. Using the Arc performance platform, LEED for cities projects can measure and manage their city's water consumption, energy use, waste, transportation, and human experience.
LEED Recertification	Applies to all occupied and in-use projects that have previously achieved certification under LEED – including BD+C and ID+C, regardless of their initial rating system or version.
LEED Zero	Available for all LEED projects certified under the BD+C or O+M rating systems, or registered to pursue LEED O+M certification. LEED Zero is for projects with net-zero goals in carbon and/or resources.

- ◆ The Certified designation requires earning 40–49 points.
- ◆ Silver certification requires earning 50–59 points.
- ◆ Gold certification requires 60–79 points.
- ◆ Platinum requires earning 80-plus points.

There are seven different categories in which an applicant can pursue points toward achieving certification for their projects. These categories are identified by the USGBC as follows:

- ◆ **Location and transportation**—This category rewards thoughtful decisions about building location, with credits that encourage compact development, alternative transportation, and connection with amenities, such as restaurants and parks.
- ◆ **Sustainable sites**—This category rewards decisions about the environment surrounding the building, with credits that emphasize the vital relationships among buildings, ecosystems, and ecosystem services.
- ◆ **Water efficiency**—This section of the program addresses water from an efficiency-first point of view for indoor use, outdoor use, specialized uses, and metering.
- ◆ **Energy and atmosphere**—This category approaches energy from a holistic perspective, addressing energy use reduction, energy-efficient design strategies, and renewable energy sources.
- ◆ **Materials and resources**—This credit category focuses on minimizing the embodied energy and other impacts associated with the extraction, processing, transport, maintenance, and disposal of building materials.
- ◆ **Indoor environmental quality**—This category rewards decisions made by project teams about indoor air quality and thermal, visual, and acoustic comfort. Green buildings with good indoor environmental quality protect the health and comfort of building occupants.
- ◆ **Innovation**—The purpose of this LEED category is to recognize projects for innovative building features and sustainable building practices and strategies.

In addition to the environmental benefits of LEED, meeting LEED standards has also proven to save owners money over a project's life cycle. A green building costs less than a normal building because fewer resources are needed or used. LEED buildings save energy, conserve water, generate less waste, and support human health. Furthermore, LEED buildings attract tenants and buyers, cost less to operate and boost employee productivity and retention. Simply put, the value of a property is significantly increased when it is sustainably built and operated.

Although LEED is the predominant sustainability standard recognized in the United States, it's important to know that it is not the only standard that exists. There is now an abundance of green standards, rating systems, and certification programs across the marketplace to help guide contractors and building designers in their efforts to deliver sustainable, high-performance buildings. In addition, *Green Building Inc.* reports that there are nearly 600 green product certifications in the world, and 100 of them are in use in the United States.

NOTE

Building Green is an online membership and peer network for designers, contractors, and sustainability professionals. First established in 1985, Building Green has served as a clearinghouse for information and training associated with healthy and sustainable design and construction techniques and practices. They support project teams that use an integrative process that reduces ecological impact and that maximizes return on investment. <https://www.buildinggreen.com/>.

The Bigger Picture

Starting way back with the Code of Hammurabi, first introduced in [Chapter 1](#), the significance of construction, and its impact on society, was first recognized. Those of us already in construction, or about to embark on careers in construction, have a collective accountability for the health, safety, and well-being of the public. Whoever thinks, “it’s just construction,” doesn’t realize just how important construction is to all of society and civilization. As I stated at the beginning of this book, nothing exists without us—housing, health care, education, transportation, energy, commerce, worship, recreation—none of it exists without construction. And the added accountability associated with constructing roadways, bridges, facilities, and buildings, in a sustainable fashion, just emphasizes even more just how important this industry, and our work is. Just construction? I don’t think so!

Terms to Know

certified wood

deconstruct

energy modeling

geothermal heating

gray water

net-zero building

rapidly renewable material

triple bottom line

daylighting

eco-friendly

environmental-friendly products

green building

life-cycle cost analysis (LCCA)

photovoltaics

renewable energy

wainscoting

Review Questions

1. What is the life cycle of building products?
2. Define life-cycle cost analysis (LCCA).
3. What are the six fundamental principles of sustainable building design?
4. Name three ways we can reduce and optimize energy use.
5. Name four types of green materials.
6. How can construction waste be minimized?
7. What is the triple bottom line?
8. Name four common types of environmental performance measurements.
9. What does the acronym LEED stand for?
10. How do buildings earn LEED certification?

Appendix A

Common Acronyms Used in Construction

The following are some acronyms commonly used in the construction field:

AR: Augmented reality

BIM: Building information model

CAD: Computer-aided design

CD: Construction document

CM: Construction manager

CSI: Construction Specification Institute

DB: Design-build

DD: Design development

ENR: *Engineering News Record*

EPA Environmental Protection Agency

FOR: Field observation report

GC: General contractor

GMP: Guaranteed maximum price

GPS: Global positioning systems

HVAC: Heating ventilation and air conditioning

IFOA: Integrated form of agreement

IPD: Integrated project delivery

IPL: Integrated project leader

LCCA: Life-cycle cost analysis

LEED: Leadership in Energy and Environmental Design

MR: Mixed reality

O/A/C Owner, architect, contractor

OSHA: Occupational Safety and Health Administration

PM: Project manager

PO: Purchase order

PPP: Public-private partnership

QA: Quality assurance

QC: Quality control

RFI: Request for information

RFP: Request for proposal

RFQ: Request for qualifications

ROI: Return on investment

ROM: Rough order of magnitude

SWPPP: Storm water pollution prevention plans

TBL: Triple bottom line

VOC: Volatile organic compound

VR: Virtual reality

WBDG: Whole building design guide

WBS: Work breakdown structure

Appendix B

Answers to Review Questions

Chapter 1

1. What is the name of the stone carvings dating back to the pyramids that contained the first written regulations pertaining to construction, commonly referred to as the first known building code?

Answer: The name of the stone carvings containing what is commonly referred to as the first known building code is the Code of Hammurabi.

2. By what specific measurement is construction used as an economic indicator for the U.S. economy?

Answer: The specific construction measurement used as an indicator regarding the health of the economy in the United States is housing starts.

3. What are the five primary sectors of the construction industry?

Answer: The five primary sectors of the construction industry are residential, commercial, heavy civil, industrial, and environmental construction.

4. What is the name of the organization credited with promoting construction management as a legitimate and unique area of study at four-year universities?

Answer: The organization credited with promoting construction management as a legitimate and unique area of study is the Associated Schools of Construction (ASC).

5. What is the role of the owner on a construction project?

Answer: The role of the owner on a construction project is to develop the program for the building, define the scope of the project, create the budget, and provide the funding for the project.

6. What is the name of the weekly magazine dedicated solely to the construction industry?

Answer: *Engineering News Record* (ENR) is the weekly magazine dedicated to the construction industry.

7. Name three associations affiliated with the construction industry.

Answer: Many associations are affiliated with the construction industry. Three of the best-known associations are the Associated General Contractors, the Associated Builders and Contractors, and the National Association of Home Builders.

8. What does LEED stand for, and what is its purpose?

Answer: LEED stands for Leadership in Energy and Environmental Design. It is a rating system that evaluates a building's environmental performance over its life-cycle.

9. What two construction associations offer voluntary certification programs for construction managers?

Answer: The two construction associations that offer voluntary certification programs for construction managers are the American Institute of Constructors and the Construction Management Association of America.

10. What is lean construction, and from what industry does its concepts stem?

Answer: Lean construction is a philosophy that focuses on adding value with less work and the elimination of waste in the building process. It stems from the manufacturing industry, particularly the Toyota Production System.

Chapter 2

1. Distinguish between construction management as a function and construction management as a project delivery method.

Answer: The construction management function entails various tasks performed by the contractor such as estimating, scheduling, cost control, and contract administration in order to monitor, manage, and control the work of the contract for which the contractor is obligated. Construction management as a project delivery method is a contractual arrangement whereby the construction manager is hired by the owner to provide services to the owner, such as design review, overall scheduling, cost control, value engineering, constructability reviews, and construction coordination. Under CM project delivery, the construction manager may or may not be financially obligated to carry out the construction work itself.

2. Identify at least three characteristics that make the construction project unique from other industry sector projects.

Answer: The construction project is unique in a variety of ways. Each construction project is built as a one-of-a-kind structure or facility. Every construction project is built on a different and unique building site. The building process takes place outside. Much of the work is performed by the human hand. The labor force is by and large made up of transient workers moving from job to job.

3. Name the four primary project values to be managed, monitored, and controlled.

Answer: The four primary project values that need to be managed, monitored, and controlled on a construction project are time, cost, quality, and safety.

4. Why is scope definition so important in the construction process?

Answer: Scope definition is important in the construction process because it describes the extent of the work that is to be performed by the contractor.

5. What is meant by the term *project delivery*?

Answer: Project delivery is the overall structural or organizational framework used to put all the aspects of designing and building a construction project together.

6. Identify the four primary project delivery methods and discuss how they differ contractually.

Answer: The four primary project delivery methods are design-bid-build, design-build, at-risk CM (also called CM/GC), and integrated project delivery. With design-bid-build, the owner has separate contracts with the designer and the contractor. With design-build, there is only one contract between the owner and the design-build entity for both the design and the construction. With at-risk CM, the owner holds two contracts: one with the construction manager/general contractor and one with the designer. Integrated project delivery uses a single multiparty agreement with all three principle parties sharing all risks and rewards

7. Explain how agency CM is different from at-risk CM.

Answer: The difference between agency CM and at-risk CM is in regard to who is responsible for performing the actual work of the contract. Under agency CM, the construction manager has no liability for the construction and acts only as an agent or advisor to the owner. With at-risk CM, the construction manager acts as an advisor to the owner during the design phase and is liable for the construction.

8. What is meant by the term *fast tracking*?

Answer: Fast tracking is a technique used to speed up the completion of a construction project by overlapping the design and construction processes.

9. Name the three basic ways in which a design-build entity may be configured.

Answer: The three basic ways in which a design-build entity may be configured are to have the contractor and the designer create an informal partnership for a project, to have a full-service design-build firm in which the designers and the

contractors work for the same company, or to establish a legal joint venture between designer and contractor for a single project.

10. Identify the 10 functions of construction management.

Answer: The 10 functions of construction management are managing the project team, performing pre-construction services, estimating the project, contract administration, managing job site and construction operations, planning and scheduling the project, controlling project performance, managing project quality, managing project safety, and managing project risks.

Chapter 3

1. Why is open bidding required on public projects?

Answer: Public projects require an open bidding procedure because taxpayer dollars are at stake, and an open bid allows any contractor to submit, reducing the risk of fraud, favoritism, and undue influence and reassuring taxpayers that their tax dollars are being spent properly.

2. Name a tool used to reduce the number of bidders on a public project and increase the quality of the contractor pool.

Answer: The tool used to limit the number of contractors bidding on a public project is the requirement for a prequalification statement.

3. What is the purpose of a labor and materials payment bond?

Answer: A labor and materials payment bond is a guarantee, backed by a surety, that payment for the contractor's labor and materials used on the project will be made.

4. Identify the notice document that informs the public of upcoming construction projects funded with taxpayer dollars.

Answer: The notice document that is used to inform the public about upcoming construction projects is an advertisement for bids. These ads are typically posted electronically through construction project lead services but may be published in newspapers and trade magazines as well.

5. Name the three selection methods used to buy construction services, and identify the solicitation instrument used for each one.

Answer: The three selection methods used to buy construction are low-bid selection, best-value selection, and qualifications-based selection. The solicitation instrument used for low-bid selection is the invitation for bids (or advertisement for bids). The solicitation instrument used for best-value selection is the request for proposals. The solicitation

instrument used for qualifications-based selection is the request for qualifications.

6. Which procurement method is the most commonly used today, and what is the selection criteria used to determine the winner?

Answer: The most common procurement method used today is still design-bid-build. The selection criteria used to determine the winner when using design-bid-build is low price.

7. What is the name of the official document that the owner uses to notify the contractor to start construction?

Answer: The document used to officially inform the contractor to proceed with the contract is called a *notice to proceed*.

8. Name the two primary selection criteria categories considered when using the best-value method.

Answer: The two primary selection categories considered with the best-value procurement method are price (quantitative factors) and qualification factors such as design, management, or past performance.

9. Describe how the weighted criteria evaluation process works.

Answer: Weighted criteria is a form of best-value selection in which maximum point values are preestablished for qualitative and price components and award is based on high total points earned by the proposers for both components.

10. List at least three factors that are commonly considered before deciding to bid on a construction job.

Answer: There are many factors to consider when deciding whether to bid on a job. Some of these factors include location of the project, size of the job, who the architect or owner is, and the technical complexity of the project.

Chapter 4

1. What two major components make up the contract documents?

Answer: The two major components that make up the contract documents are the drawings and the project manual.

2. When did architects first begin to use drawings to communicate their design intent?

Answer: It was during the Renaissance when architects first started to use drawings instead of models to communicate design intent.

3. What does CAD stand for?

Answer: CAD stands for computer-aided design.

4. There is a particular way in which the drawings are organized in a set of drawings. Identify the order of drawings in a typical set of plans.

Answer: A typical set of drawings is ordered with the civil drawings first, then the architectural, then the structural, then the mechanical, and finally the electrical drawings.

5. What is the difference between a plan view and a section view in a set of drawings?

Answer: A plan view represents a horizontal cut through the structure, and a section view represents a vertical cut through the structure.

6. Name the four primary sections of a project manual.

Answer: The four primary sections of a project manual are the bidding documents, the general conditions, the supplemental conditions, and the technical specifications.

7. The CSI MasterFormat is broken down into how many divisions?

Answer: There are 50 divisions to the MasterFormat.

8. Under which CSI division would you find building insulation?

Answer: You would find building insulation under Division 07, Thermal and Moisture Protection.

9. Name the four basic types of construction contracts.

Answer: The four basic types of construction contracts are the lump-sum contract, cost-plus-fee contract, guaranteed maximum price (GMP) contract, and unit-price contract.

10. Under a guaranteed maximum price contract, what happens if the actual cost is less than the guaranteed maximum contract price?

Answer: If the actual cost of the project is less than the guaranteed maximum contract price, the owner benefits from 100 percent of the savings unless there is an arrangement to split the savings with the contractor.

Chapter 5

1. Name the four fundamental stages of the construction management process after the design stage.

Answer: The four fundamental stages of the construction management process are pre-construction, procurement, construction, and post-construction.

2. What are the five distinct stages of the design process?

Answer: The five distinct stages of design are programming and feasibility, schematic or conceptual design, design development, construction documents, and as-builts.

3. How does the quality of the design drawings impact the quality of the construction?

Answer: The construction contract calls for the contractor to build the project in accordance with the plans and the specs. If the plans, specs, or overall design is flawed or something is missing, then the contractor is obligated to perform as instructed or to bring the flaw or defect to the attention of the architect by processing a change order. Either way, the owner is left with paying the price for the error and is usually not happy.

4. In relation to construction, what is meant by the term *due diligence*?

Answer: Due diligence is the process of identifying any problems associated with the project early on so that those problems can be factored into the decision making that occurs during the pre-construction stage.

5. What are the two procurement instruments used to buy out the construction job?

Answer: The two procurement instruments used to buy out the construction job are subcontracts and purchase orders. Subcontracts are used to buy labor, and purchase orders are used to buy materials and equipment.

6. Name at least three positions that make up the members of the on-site construction management team.

Answer: Three positions that make up the on-site project team are superintendent, assistant superintendent, and field engineer.

7. What occurrence marks the official end of the project?

Answer: The official end of the project occurs when the architect releases a certificate of substantial completion.

8. What is the name of the tool used to keep track of and manage the completion of all of the loose ends, minor repairs, adjustments, and missing items at the end of the project?

Answer: A punch list is used to manage all of the loose ends, minor repairs, adjustments, and missing items at the end of the project.

9. What is value engineering, and what is its purpose?

Answer: Value engineering is the process of analyzing the design, products, and materials associated with the project to determine whether the proposed application, installation, or execution is the best approach or solution. The purpose of value engineering is to optimize resources to achieve the greatest value for the money being spent.

10. Why is it important to have a clear distinction between the project punchout and the warranty period?

Answer: It is important to have a clear distinction between project punchout and warranty because the completion of punchout denotes substantial completion of the project. If work items continue to get added to the punch list, it will be very difficult to clearly mark the end of the project.

Chapter 6

1. Name three key members of the project team.

Answer: The three key members of the project team are owner, principle design firm, and general contractor.

2. List at least three common factors that will influence your ability to trust or not trust members of your team.

Answer: The common factors that influence trust on a team are history and experience, competence and ability, similarities and differences, relative power and authority, and character.

3. How is vulnerability-based trust related to accountability within the team?

Answer: With vulnerability-based trust, all team members should be aware of each other's tasks and deliverables. Team members should authentically ask each other how things are going and respond honestly. Each team member should use this information to help each other as needed for the success of the individual team member and the overall project.

4. According to Fernando Flores, what are the five basic speech acts?

Answer: The five basic speech acts include declaring, requesting, promising, assessing, and asserting.

5. Define committed listening and committed speaking.

Answer: Committed listening is listening intently to another person to make sure that you clearly understand what they mean by the words they are speaking without judging, assessing, or negating what they are saying. Committed speaking is speaking with intention and purpose, using words specifically to clearly convey your exact meaning.

6. Give three examples of effective listening.

Answer: Examples of effective listening are to stop talking, give others an extended chance to talk, hear their whole question/comment, paraphrase to assure your understanding,

show respect and concern, withhold evaluation, be patient, and project positive listening energy.

7. Give three examples of effective speaking.

Answer: Examples of effective speaking are to ask for specifics and/or clarification, get examples, avoid broad statements which do not allow core understanding, watch for nonverbal cues, facial expressions and eye contact which are clues for understanding, review and summarize, rephrase what you determined to be key information, clarify what needs to be done now or “by when.”

8. How does low-bid mentality challenge the ability for the AEC industry to make cultural shifts?

Answer: Low-bid mentality challenges the ability for the AEC industry to make cultural shifts because when low price drives the entire project delivery process, there’s no room for any real value generation or innovative solution finding to optimize our clients’ returns on investment.

9. What is the basic difference between management and leadership?

Answer: The basic difference between management and leadership is that we manage things and lead people.

10. Define the role of the Integrated Project Leader (IPL).

Answer: The role of the Integrated Project Leader (IPL) is to be the individual who has primary accountability with leading the design-build team. The IPL may take the place of the traditional project manager or the project manager may be subordinate to the IPL.

Chapter 7

1. When does the pre-construction phase take place?

Answer: When using integrated project delivery methods, the pre-construction phase takes place before design is complete and construction begins.

2. What are three ways owners can benefit from alternative project delivery methods?

Answer: The three ways owners can benefit from alternative project delivery methods are lower project costs, improved schedule, greater value, higher quality, less waste, greater efficiencies, and more innovation.

3. Define pre-construction services.

Answer: Pre-construction services are the anticipatory planning, analytical, and evaluation activities that occur before construction begins, often during the design phase when at-risk CM or design-build is employed as the project delivery method.

4. List the five most common pre-construction services.

Answer: The five most common pre-construction services are feasibility studies, constructability reviews, conceptual estimating, value engineering, and life-cycle cost analysis.

5. How do feasibility studies benefit the owner?

Answer: Feasibility studies help the owner at an early stage consider how successful the project will be for its intended purpose. The construction manager will help the owner uncover both the positive and negative outcomes of the project before they proceed with the investment and capital expenditure.

6. Who should perform the constructability review?

Answer: All members of the construction team: project managers, senior personnel within the construction company, superintendents, foremen, trades personnel, subcontractors, facility and maintenance personnel, and specialty contractors should perform the constructability review.

7. What are two benefits of using conceptual estimating?

Answer: Two benefits of using conceptual estimating are that it helps clients and architects track the impacts of design as it develops and it gives the owner cost certainty much earlier in the design process.

8. How are cost models developed?

Answer: Cost models are developed from previously built projects where actual costs are known and archived to create a “historical cost, or model cost database,” which can then be used to extrapolate estimates for similar projects.

9. How can value be added to a project in terms of benefits and cost?

Answer: Value can be added to a project by improving benefits and reducing cost, maintaining benefits and reducing cost, improving benefits and maintaining cost, increasing benefits and increasing cost.

10. Define life-cycle cost.

Answer: Life-cycle cost is a cost analysis that provides long-term cost projections for a particular building investment over its useful life cycle.

Chapter 8

1. What is a construction estimate?

Answer: A construction estimate is a summary of probable quantities and costs of materials, labor, equipment, and subcontracts to complete a project, including taxes, overhead, and profit, based on the best available information at the time.

2. Name the four primary categories of costs in the construction estimate.

Answer: The four primary categories of costs in the construction estimate are materials, labor, equipment, and subcontracts.

3. How are construction estimates typically organized?

Answer: Typically, construction estimates are organized according to either the CSI MasterFormat, which utilizes 50 divisions.

4. What type of estimate would we probably do if we were meeting with a client for the first time and they wanted to get a rough idea about their project cost?

Answer: The type of estimate that would most likely be presented to a client who was seeking a rough idea of cost for a new project would be a rough order of magnitude (ROM) estimate.

5. Identify the four preparation steps taken to start the estimating process.

Answer: The four preparation steps taken to start an estimate are to review the plans and specs, to develop a query list, to attend the prebid meeting, and to visit the site.

6. What are general conditions?

Answer: General conditions are the same thing as indirect costs and represent the expenses incurred in order to deliver and manage the materials, labor, equipment, and subcontracts employed on any given job. Supervision, cleanup, temporary

utilities, and security fencing are all examples of general conditions.

7. What unit of measure is typically employed for pricing general conditions?

Answer: The unit of measure typically applied to general conditions is a unit of time such as hour, day, week, or month.

8. What is a scope sheet?

Answer: A scope sheet identifies all of the items of work to be performed under a specific trade heading or work category such as masonry or siding.

9. Identify at least four characteristics exhibited in a quality estimate.

Answer: There are many characteristics displayed in a quality estimate, including correct quantities, accurate labor hours, correct pricing, accurate calculations, completeness, clear paper trail, proper overhead, and proper profit.

10. When will you know the true accuracy of your estimate?

Answer: You will know the true accuracy of your estimate when the project is complete and all the costs and expenses have been added up.

Chapter 9

1. What is partnering?

Answer: Partnering is a team-building technique to establish a set of common goals and objectives for the project and develop a mutually acceptable protocol for communication and conflict resolution through a formal agreement.

2. How does the contractor receive clarification from the architect regarding details of the design?

Answer: The contractor receives clarification from the architect regarding details of the design by processing a formal request for information (RFI) in writing.

3. What is the purpose of a submittal?

Answer: Submittals provide a means by which the architect and owner can confirm the intent of the design.

4. What is a shop drawing?

Answer: A shop drawing is a special kind of submittal, usually required when a building material must be fabricated from scratch. The drawing includes details, dimensions, and the configuration of the item being fabricated.

5. What is the name of the document that establishes the template for measuring work progress as it relates to requests for payment?

Answer: The name of the document that establishes the template for measuring work progress as it relates to requests for payment is a schedule of values.

6. What is the name of the document that formally and officially authorizes a payment to the contractor?

Answer: The document that authorizes payment to the contractor is called an application and certificate for payment.

7. What are liquidated damages?

Answer: Liquidated damages are an amount of money that is assessed to the contractor for a failure to meet a specified

completion date.

8. What is retainage?

Answer: Retainage is a certain percentage of money owed to the contractor that is held back by the owner to encourage completion of the project.

9. Identify two instances when a change order might need to be initiated.

Answer: A change order would be required to correct a detail of the design that contained an error or omitted information or would be required when an owner wants to add scope to the project.

10. Name three alternatives to traditional litigation for resolving construction contract disputes.

Answer: Three alternatives to traditional litigation for resolving construction disputes are mediation, the minitrial, and arbitration.

Chapter 10

1. Identify at least three issues that the superintendent must be concerned with when trying to manage construction operations.

Answer: Three issues that the superintendent must be concerned with when trying to manage construction operations are subcontractor coordination, material and equipment deliveries, and productivity.

2. When scheduling subcontractors for the job, you should try to follow three fundamental rules. What are they?

Answer: When scheduling subcontractors for the job, the three fundamental rules that you should try to follow are to resist bringing subcontractors onto the job until you are 100 percent ready for them; to make sure that once you bring them on the job, they have everything they need to proceed; and to pay all subcontractors promptly upon completion of their work.

3. What does it mean to order something on will-call?

Answer: A will-call acts as a confirmation of an order that has been placed prior to the date it is actually due for delivery. The will-call generally occurs the afternoon before the scheduled delivery and confirms or denies that the delivery date is still a go.

4. Identify at least three factors that can negatively impact construction productivity.

Answer: Factors that negatively impact construction productivity are crowded work spaces, poor coordination of work activities, poor supervision or lack of supervision, an inexperienced or poorly trained workforce, not having the proper tools and equipment, adverse weather conditions, confusing plans and specs, changes in the work plan, and inefficient job site layout.

5. Identify at least three environmental issues that might interfere with the project schedule and cause unexpected delays on the job.

Answer: Environmental issues that can interfere with the construction schedule and cause unexpected delays on the job are encountering soil erosion problems, encountering endangered species on-site, having to protect vegetation on-site, trying to protect and preserve wetlands during construction, and discovering historical or cultural artifacts while excavating.

6. What is a laydown area?

Answer: A laydown area is a designated storage area within the construction site that is used for sorting out large orders such as the structural steel.

7. What types of information should be shown on a site logistics plan? Name at least four items.

Answer: The types of things that should be shown on a site logistics plan are the location of the field office, the location of the temporary utilities, the location of the storage trailers, the location of the laydown area, the location of the portable toilets, the location of dumpsters, on-site parking areas, the security fencing, and the entrance and exit gates.

8. Why is it important for the job superintendent and the other members of the on-site team to keep project diaries?

Answer: It is important to keep a project diary because there is so much information that must be communicated back and forth among the project participants, and there is a great opportunity for misunderstandings, confusion, and things falling through the cracks. The diaries help to keep straight all of the communications, conversations, and activities.

9. Why is it important to accurately report hours and cost codes on time cards?

Answer: It is important to accurately record hours and cost codes on time cards because they provide the payroll clerk with all of the information needed to calculate wages and distribute paychecks. They also provide fundamental information needed to track and monitor productivity and labor expenditures.

10. Identify the way in which the construction industry has increased overall owner involvement in the construction process.

Answer: The construction industry has increased overall owner involvement in the construction process through a variety of collaborative software programs that establish intranet sites. These programs allow the owner to take part in a variety of project communications and may have a webcam linked to them.

11. What does SWPPP stand for and what is its purpose?

Answer: SWPPP stands for *storm water pollution protection plan*, and its purpose is to document how the contractor will manage erosion and prevent pollution of lakes, rivers, wetlands, and coastal areas by runoff water and sediment from the building site.

Chapter 11

1. What are the two most common types of schedules used in construction?

Answer: The two most common types of schedules used in construction are the Gantt chart (or bar chart) and the network diagram.

2. Name the two techniques used to create a network diagram.

Answer: The two techniques used to create a network diagram are the activity-on-arrow method and the activity-on-node method.

3. Precedence diagramming is another name for which type of network diagram?

Answer: Precedence diagramming is another name for the Precedence Diagram Method (PDM) of network diagramming.

4. What is a look-ahead schedule, and how is it used?

Answer: Look-ahead schedules are developed by superintendents and trade foremen to coordinate the work and activities over a relatively short period of time, usually two- to four-week intervals. They are often hand-drawn and are distributed to the specific trades involved.

5. What are the three stages of network diagram development?

Answer: The three stages involved in developing a network diagram are the planning stage, the sequencing stage, and the scheduling stage.

6. Name the three different types of activities that are included in the typical schedule, and give an example of each.

Answer: The three different types of activities that are included in the typical schedule are production activities (for example, installing siding), procurement activities (for example, ordering windows), and administrative activities (for example, obtaining the building permit).

7. What is the critical path, and why is it important from a project management standpoint?

Answer: The critical path is the continuous chain of activities with the longest (combined) overall duration in the network diagram. The critical path is important from a management standpoint because the critical path determines the project duration, and any delay in any activity along the critical path results in a delay in the overall project.

8. What is float, or slack, in the schedule?

Answer: Float is the amount of time that an activity's start can be delayed before it impacts the project's planned completion.

9. What are the three scheduling calculations that you must perform in order to determine the project duration and the critical path?

Answer: The three calculations that must be performed to determine the project duration and the critical path are the forward pass, the backward pass, and the total float calculations.

10. After you complete a forward and backward pass, how do you know which activities are on the critical path?

Answer: The activities that have no total float will be the activities on the critical path.

Chapter 12

1. What are the seven fundamental steps included in the project control cycle?

Answer: The seven fundamental steps included in the project control cycle are (1) develop the project plan, (2) establish the project benchmarks, (3) monitor the project performance, (4) identify performance deviations, (5) evaluate corrective options, (6) make adjustments as needed, and (7) document, report, and evaluate results.

2. What are the two essentials of an effective project control system?

Answer: The two essentials of an effective project control system are information and a good reporting system.

3. Name three sources where you might gather field information needed to develop your project controls.

Answer: Three sources of field information needed to develop project controls are material invoices, time cards, and subcontractor billing statements.

4. It is important to receive accurate and complete information from the construction job site. Name two specific construction management functions where this information is used.

Answer: Field information is used to detect variances between the actual and planned performance of a project regarding cost, time, and productivity. It is also used to develop the historical estimating databases and productivity factors used when creating the project estimate and schedule.

5. What is a cost code, and how is it used in project controls?

Answer: A cost code is a reference number assigned to each work activity identified in the project estimate and schedule. This code is often based on a CSI division number and another number identifying type of cost. Cost codes are used to track all items of work contributing to the overall project costs including

materials, labor, equipment, subcontracts, and overhead. All job information regarding cost is tracked via these cost codes.

6. Name at least three factors that can impact project performance.

Answer: Numerous factors can impact project performance: weather, quality of the workforce, inadequate tools and equipment, defective materials, and overcrowded job sites are just a few.

7. What is an escalation clause, and how is it used in the construction contract?

Answer: An escalation clause is a special clause, usually negotiated into the construction contract when there is suspicion that some pricing component of the estimate is in a high state of flux. The clause allows for adjustments to be made to the estimate based on current pricing of the suspected component.

8. What is the riskiest element of project planning and project control?

Answer: The riskiest element of project planning and project control is in estimating productivity.

9. What does it mean to crash the schedule?

Answer: Crashing the schedule means to compress the overall schedule by accelerating certain activities within it so that they finish sooner, thereby shortening the overall schedule.

10. Regarding project controls, what does it mean to forecast in construction management?

Answer: To forecast means to predict the final cost and schedule outcomes on a project while the work is still in progress. Construction managers forecast final cost and completion dates on a regular basis throughout the construction process.

Chapter 13

1. What are the three fundamental objectives of a quality management plan?

Answer: The three fundamental objectives of a quality management plan are to do things right the first time, to prevent things from going wrong in the first place, and to continually improve the construction process.

2. What is the difference between quality control and quality assurance?

Answer: Quality control addresses quality at the project level and deals with conformance to the plans and specs through submittals, mock-ups, shop drawings, inspections, and testing. Quality assurance addresses quality at the process level and deals with policies and procedures associated with hiring, training, safety, subcontracting, and procurement.

3. Name three quality control mechanisms typically mandated by the construction contract that are used to check for conformance to the plans and specifications.

Answer: Three quality control mechanisms typically mandated by the construction contract that are used to check for conformance to the plans and specifications are submittals, mock-ups, and shop drawings.

4. Explain the concept behind a zero-punch list.

Answer: The concept behind a zero-punch list is to complete the final walk-through inspection with few or no punch items noted on the list. The idea is to inspect and correct the work as it progresses instead of waiting until it is completed, only to find that the quality is unacceptable.

5. What is an FOR?

Answer: An FOR is a field observation report and involves a process in which employees, subcontractors, and visiting vendors are encouraged to report any work item suspected of being installed incorrectly or failing to meet a quality or safety

standard. Each of these observations is logged by the quality engineer or person in charge of the task, and each item in question is verified or corrected as needed.

6. What is the name of the agency responsible for establishing safety standards and enforcing them through inspections conducted at construction job sites?

Answer: The name of the agency responsible for establishing safety standards and enforcing them through inspections conducted at construction job sites is the Occupational Safety and Health Administration, commonly referred to as OSHA.

7. Identify the four primary components of an effective safety management plan.

Answer: The four primary components of an effective safety management plan are management commitment, job site analysis, hazard prevention and control, and safety and health training.

8. What are the four primary causes of injuries in the construction industry?

Answer: The four primary causes of injuries in the construction industry are falls, being struck by an object, being crushed or trapped, and electrical shocks.

9. Identify at least five items of personal protection equipment that might be utilized by workers on the job site.

Answer: Personal protection equipment includes hard hats, safety glasses, steel-toed shoes or boots, face shields, ear plugs, special suits or coveralls, respirators, gloves, and safety harnesses.

10. What is an MSDS?

Answer: An MSDS is a material safety data sheet. An MSDS must be obtained and maintained for every chemical product that is located on the job site.

Chapter 14

1. Name the six different categories that most risk factors generally fall under.

Answer: The six different categories that most risks generally fall under are prebid risks, design risks, construction risks, political/legal/regulatory risks, financing risks, and environmental risks.

2. What is a contingency?

Answer: A contingency is an amount of money added to an estimate to cover unknown conditions or risk impacts.

3. What is a joint venture?

Answer: A joint venture is a business arrangement where two or more construction companies enter into an agreement for a one-time, single-project commitment and share resources and risks to manage and build the project.

4. Name at least three types of construction risks.

Answer: There are several types of construction risks, including labor availability, quality of labor pool, differing site conditions, site access, property damage and theft, coordination of utilities, adverse weather, labor disputes, safety, and material availability.

5. What is a latent design defect?

Answer: A latent design defect is a flaw in the design that is not known until after the construction is complete and time has passed, allowing for the flaw or defect to show itself.

6. Name at least three prebid risk factors.

Answer: The prebid risk factors are the contract, the owner, the project price, the project time, work/labor issues, the location, and the estimate prep factors.

7. Name one estimate preparation risk factor.

Answer: There are several estimate preparation risk factors. They include the adequacy of the pricing data, familiarity of the

subcontractors, ability to visit the site, confusing or contradictory plans and specs, excessive preparation costs, and insufficient time to prepare the estimate.

8. What two factors must be considered when trying to determine the risk rating for any given risk?

Answer: The two factors that must be considered when determining a risk rating for any given risk is the probability that the risk will occur and the impact if it does.

9. Name the five most common risk mitigation strategies.

Answer: The five most common risk mitigation strategies are risk avoidance, risk transfer, risk abatement, risk transfer, and risk allocation.

10. Give one example of a risk allocation technique that contractors might use on a large, complex project when they think they have exceeded their risk tolerance.

Answer: A contractor might decide to joint venture with another contractor on a large, complex project.

Chapter 15

1. What is a BIM model?

Answer: A BIM model is a digital representation of the physical and functional characteristics of a building displayed as a 3D model.

2. What is the difference between 3D CAD modeling and BIM?

Answer: A BIM model is attached to a database that holds all pertinent information about the objects that make up the project. A 3D CAD model is not linked to any database.

3. How is *virtual reality* different from *augmented reality*?

Answer: Virtual reality is a computer-generated simulation of an artificial three-dimensional environment. It requires the use of special equipment to interact with the created environment, such as goggles or gloves. Augmented reality is different in that it is a technology that superimposes or overlays a computer-generated image on a user's view of the real world, thus providing a composite view.

4. What is the difference between a design-intent model and a construction model?

Answer: A design-intent model focuses on communicating design information through a 3D model. A construction model contains construction-specific information such as cost data and scheduling durations and sequences.

5. What is the difference between the central repository approach and the distributed repository approach to implementing BIM?

Answer: With the central repository approach, all project information can be loaded into one database to create a single BIM model. With the distributed repository approach, the BIM model consists of a collection of separate databases maintained within distinct programs.

6. What is clash detection?

Answer: Clash detection is a process for effectively identifying unintended material or system interferences in a 3D project

model.

7. What are the fourth and fifth dimensions of BIM?

Answer: The fourth and fifth dimensions of BIM are time (or 4D) scheduling and cost (or 5D) estimating.

8. What are the sixth and seventh dimensions of BIM?

Answer: The sixth and seventh dimensions of BIM are sustainability (or 6D) and facility management (or 7D).

9. What does the term *interoperability* mean?

Answer: Interoperability is the capability of a system to interact with other systems without access or implementation limitations or restrictions.

10. Name at least three common ways that contractors use BIM.

Answer: There are at least ten common ways in which contractors use BIM, including for design visualization, design assistance and constructability review, site planning and utilization, 4D scheduling, 5D estimating, integration of subcontractor and supplier data, systems coordination, layout and fieldwork, prefabrication, and operations and maintenance.

Chapter 16

1. What is the life-cycle of building products?

Answer: The life-cycle of building products is how materials are extracted and processed, manufactured and shipped, purchased and used, repaired and maintained, and disposed of.

2. Define life-cycle cost analysis (LCCA).

Answer: Life-cycle cost analysis is a tool used to determine the most cost-effective option among different competing alternatives. Consideration is given to costs associated with the full life cycle of a building or system, from initial purchase to final disposal.

3. What are the six fundamental principles of sustainable building design?

Answer: The six fundamental principles of sustainable building design are to optimize site potential, optimize energy use, protect and conserve water, optimize building space and material use, enhance indoor environmental quality, and optimize operational and maintenance practices.

4. Name three ways we can reduce and optimize energy use.

Answer: Among the ways to reduce and optimize energy use are to reduce heating, cooling, and lighting demand through passive strategies such as daylighting and conservation practices; specify energy-efficient HVAC and lighting systems; utilize and install energy-efficient appliances and products displaying the Energy Star® designation; employ renewable energy sources such as solar heating for hot water, photovoltaics, and geothermal heating systems; optimize building performance by employing energy modeling programs during design and after occupancy and operations; and optimize system control strategies by using programmable thermostats and other occupancy sensors

5. Name six types of green materials.

Answer: Six types of green materials are materials made from recycled content, reclaimed materials, low-emitting materials, certified wood materials, rapidly renewable materials, and locally/regionally sourced materials.

6. How can construction waste be minimized?

Answer: Construction waste can be minimized by recycling, reusing, and eliminating waste in the first place during design.

7. What is the triple bottom line?

Answer: The triple bottom line is measuring business success by the financial performance of the organization, as well as environmental and social factors.

8. Name eight common types of environmental performance measurements.

Answer: Eight common types of environmental performance measurements are air quality, water quality, water usage, electricity consumption, fossil fuel consumption, recycling trends, hazardous waste quantities, air and water pollutants, and health impacts.

9. What does the acronym LEED stand for?

Answer: LEED stand for Leadership on Energy and Environmental Design.

10. How do buildings earn LEED certification?

Answer: For a building to earn LEED certification, it must to earn points by meeting certain criteria. Based on the total number of points achieved, a project then achieves one of four LEED rating levels.

Glossary

addendum

A change or addition to the contract documents issued after the documents have been released but before the bids are due.

add-ons

A term commonly used in construction estimating to describe the taxes, overhead, and profit added to the estimate after all other costs have been calculated.

advertisement for bids

A public notice, usually published in newspapers, trade magazines, and journals, providing information regarding bidding procedures for public projects.

agency CM

A construction management project delivery option in which the construction manager acts in the owner's best interests at every stage of the project, from design through construction. The construction manager offers advice and project management services to the owner but is not financially responsible for the construction.

architectural programming

The research and decision-making process initiated by an owner, usually with the help of an architect or other programming specialist, that identifies the basic needs of the client and the parameters of the project to be designed and ultimately built by a construction professional. (Also see *program*.)

as-built drawings

Record drawings completed by the contractor and turned over to the owner at the end of the project identifying any changes or adjustments made to the conditions and dimensions of the work relative to the original plans and specifications.

at-risk CM

A project delivery option where the construction manager serves as a consultant to the owner in the development and design phases of the project and then as the general contractor during the construction phase.

augmented reality

A technology that superimposes or overlays a computer-generated image on a user's view of the real world, thus providing a composite view.

back charge

An amount of money charged against a subcontractor for work that the general contractor performed because the subcontractor failed to do so.

backward pass

A scheduling technique used to calculate an activity's late start and late finish.

base isolators

Large shock absorbers typically made of alternating layers of rubber and steel (or lead) attached to a building's foundation to allow movement of the structure without causing damage.

best value

Any selection process where proposals contain both price and qualitative components and where the award is based on a combination of price and qualitative considerations.

BIM model

A digital representation of the physical and functional characteristics of a building displayed as a 3D model, with the added capability to integrate a whole array of design and construction data related to cost, schedule, materials, assembly, maintenance, energy use, and more.

brownfield sites

Properties that are abandoned or underused because of historic environmental contamination.

callback

A request from an owner that a contractor return to the job site to correct or redo some item of work.

capital expenditure

Funds used by a company to acquire, upgrade, build, and maintain physical assets such as property, buildings or equipment. Capital expenditures can include everything from repairing an air conditioning system, to putting on a new roof, to

purchasing a piece of equipment, to adding onto an existing building, or constructing a brand-new facility.

capital project

A long-term investment project to build upon, add to, or improve a capital asset.

central repository approach

The concept that all project information can be loaded into one database to create a single building information model.

certified wood

Wood harvested from responsibly managed forests, and certified as such by a third-party evaluator.

change order

Requests made by the owner to add or subtract features to the scope of the project resulting in changes to the contract.

claim

An issue that occurs during construction and remains unresolved after the job is complete.

clash detection

A process that utilizes a BIM 3D model to analyze interferences in the design by resolving conflicts among the various material and structural systems.

closed bid

Used with private projects and is not open to the public. Bidding is by invitation only, via an invitation for bids, to a selected list of contractors.

cofferdam

A temporary watertight enclosure erected to prevent water from seeping into an area, allowing construction to take place in the water-free space.

commissioning

A process of testing and checking all equipment and systems within the facility at the end of a project to assure proper functioning and operation. It may also include the training of owner personnel in the operation and maintenance of the equipment.

commitment management

The practice of being aware of each team member's tasks and deliverables, checking in with them periodically, and helping when needed for the success of the project.

committed listening

Listening intently to another person to make sure that you clearly understand what they mean by the words they are speaking without judging, assessing, or negating what they are saying.

committed speaking

Speaking with intention and purpose, using specific words to clearly convey your exact meaning.

concrete washout station

A temporary container installed on a construction site to collect all water runoff from the washing of trucks, tools, and equipment associated with concrete. The container may be prefabricated and delivered or built on-site.

constructability reviews

A design review process in which experienced contractors and construction managers work with designers to ensure that the details of the design actually can be built in an efficient and cost-effective manner. The process entails review of materials, application, installation techniques, field execution, and building systems.

construction management

The planning, scheduling, evaluation, and controlling of construction tasks and activities to accomplish specific objectives outlined in the contract documents.

construction model

A building information model, typically prepared by a contractor, that links construction-specific information, such as work breakdown structures and cost data, to project elements in the 3D model.

contingency

An amount of money added to an estimate to cover unknown conditions or risk factors.

contract documents

The drawings, conditions, terms, and specifications setting forth the requirements for constructing the project.

contract indemnification

Provisions in a contract that provide protection against possible financial loss, damage, or liability.

cost code

A reference number used to track cost and schedule information on materials, labor, subcontracts, equipment, overhead, and fees throughout the project control process.

cost control

A continuous monitoring process used to track the variances between actual performance and planned performance on a project, specifically concerning cost and time.

cost model

The working budget to guide the design process by allocating budget limits to the various elements or systems of the design.

crashing the schedule

To take steps that accelerate activities in the schedule, resulting in an earlier completion date.

critical path

The longest path through a network diagram schedule, which includes those activities that have zero days of float. The critical path determines the overall project duration.

curtain wall

An exterior cladding system that is supported entirely by the frame of the building, rather than being self-supporting or load-bearing.

daylighting

Rather than relying solely on electric lighting during the day, daylighting brings indirect natural light into the building by placing windows, skylights, light shelves or other openings and reflective surfaces so that during the day natural light provides effective internal lighting.

decommissioning

The process of shutting down a building and removing it safely from operational use.

deconstruct

To selectively dismantle a building, component by component, in order to salvage materials for reuse or recycling. It differs from demolition whereby a building is cleared to the ground in the most expedient manner possible.

design-bid-build

A project delivery method in which the owner holds two separate contracts for design and construction. This method is often referred to as the *traditional* project delivery method.

design-build

A project delivery method in which there is only one contract between the owner and a design-build entity. The design-builder is responsible for both the design and the construction of the project. This method is often referred to as *single-source* project delivery.

design-intent model

A building information model prepared by an architect, primarily intended to communicate architectural design information.

digitizer

An electronic pen-shaped stylus or mouse curser used in conjunction with software to assist in the quantity takeoff task in estimating.

distributed repository approach

The concept that the BIM consists of a collection of separate databases maintained within distinct programs that can communicate in a way that allows them to exchange at least some of their data.

dry shacks

Facilities that may be constructed on-site or brought in as modular units equipped with tables and storage lockers. They provide a dry place for workers to eat their lunch and change their clothes. Union agreements often require that the contractor provide a dry shack on-site.

due diligence

Obligation of the contractor, usually written into the contract, to complete the construction project with reasonable care and avoid harm.

earned value analysis

A technique used in construction to determine the estimated value (earned value) of work completed to date on a project and comparing that to the actual work completed on the project.

eco-friendly

Earth-friendly, or not harmful to the environment. This term most commonly refers to products that contribute to green living that help conserve resources like water and energy.

emotional intelligence

The capacity to be aware of, control, and express one's emotions, and to handle interpersonal relationships judiciously and empathetically.

energy modeling

A computer simulation of a building used to determine or estimate its energy usage.

environmentally preferred products

Products that have a lesser or reduced effect on human health and the environment when compared to competing products that serve the same purpose as defined by the EPA's Greening of the Government Executive Order 13101.

escalation clause

Usually negotiated into the construction contract when there is suspicion that some pricing component of the estimate is in a high state of flux. The clause allows for some fluctuation in the contract price based on the current pricing of the suspected component.

fast tracking

A practice utilized to speed up a job by overlapping the design phase and the construction phase of a project. This is often applied in design-build or construction management project delivery.

feasibility study

An analysis conducted at the very early stages of a project to help the owner determine if it is a good idea to invest their time and money to follow-through with the project or whether an alternative solution should be pursued.

field observation report (FOR)

A report used to track questionable quality and safety performance on the job site. Employees, subcontractors, and visiting vendors are encouraged to report any work item suspected of being installed incorrectly or failing to meet a quality or safety standard. Each of these observations is logged by the quality engineer or person in charge of the task, and each item in question is verified or corrected as needed.

forecasts

Periodic predictions stated in reports as to the final cost and schedule outcomes on a project while the work is still ongoing.

forward pass

A scheduling technique used to calculate an activity's early start and early finish. The forward pass must be completed before the project duration can be determined.

Gantt chart

Considered revolutionary when Henry Gantt first published this planning tool around 1910, a type of bar chart that illustrates a project schedule. It displays the start and finish dates of the various activities of a project.

geothermal heating

Heat extracted from the earth that exceeds the heat on the surface of the earth.

green building

The practice of designing, constructing, and operating buildings to maximize occupant health and productivity, use fewer resources, reduce waste and negative environmental impacts, and decrease life-cycle costs. Green building is at the heart of sustainability.

gray water

Gently used water from sinks, showers, tubs, and washing machines. It is not water that has come into contact with feces, either from the toilet or from washing diapers. Sewage water is referred to as black water and cannot be recycled or reused.

guaranteed maximum price (GMP)

A contract methodology in which the contractor is reimbursed for actual costs of materials, labor, equipment, subcontracts, overhead, and profit up to a maximum fixed-price amount. Any

costs over the maximum price shall be borne by the contractor. Any savings below the maximum price will revert to the owner. This type of contract is often implemented when design is less than 100 percent complete.

hologram

A projected object that appears as something real, but instead of being made of physical matter, a hologram is made entirely of light.

infrastructure

The basic roadways, bridges, and railroad networks that support a community or society.

integrated form of agreement (IFOA)

A multiparty agreement that includes the owner, design professional, and constructor as signatories to the same construction contract. This unique legal relationship is also referred to as an IFOA.

integrated project delivery (IPD)

Any project delivery method that contractually engages the contractor responsible for constructing the project at the beginning of the design process. Both design-build and at-risk CM are considered IPD models.

integrated project leader (IPL)

A title intended to clearly distinguish the primary accountability associated with leading a design-build team. Although every organization is different, an IPL may take the place of a traditional project manager in design-build, or the project manager may be subordinate to the IPL.

integrative thinking

The ability to face constructively the tension of opposing ideas and, instead of choosing one at the expense of the other, generate a creative resolution of the tension in the form of a new idea that contains elements of the opposing ideas but is superior to each.

interoperability

The capability of a system or program to interact with other systems or programs without access or implementation limitations or restrictions.

invitation for bids

A notification sent to a selected list of contractors, furnishing information on the submission of bids on a private project.

joint venture

When two or more construction companies enter into an agreement for a one-time, single-project commitment and share resources and risks to manage and build the project.

land development

Changing the landscape to alter landforms, subdivide existing property, or changing current property usage for new purposes.

land entitlement

The legal process of obtaining approvals from a governing municipality to allow for the development of a certain building type.

latent design defect

Defects or flaws in design details that are not known until after the construction is complete and time has passed, allowing for the flaw or defect to show itself.

laydown area

A designated area on the building site where large orders can be stored and sorted in an organized manner so that the parts can be easily identified for use on the project.

lead time

The amount of time it takes for a product or equipment to be delivered to the job site. Products that have a long delivery time are called *long-lead-time items* and require special planning considerations.

lean principles

Principles that stem from the Toyota Production System (TPS) and focus on creating more value for customers with less work and the elimination of waste. These principles are now being applied to the construction industry.

life-cycle cost

Long-term cost projections for a particular building investment over its useful life cycle.

life-cycle cost analysis

A tool used to determine the most cost-effective option among different competing alternatives. Consideration is given to costs associated with the full life-cycle of a building or system, from initial purchase to final disposal.

liquidated damages

A daily amount of money paid by the contractor to the owner for each day that the project fails to meet the completion date specified in the contract. Not all contracts contain a liquidated damages clause.

material safety data sheet (MSDS)

An information sheet documenting pertinent chemical information on various products used in construction.

mixed reality

Is the merging of the real world with virtual objects to produce new environments and visualizations where physical and digital objects co-exist and interact in real time. The object is anchored in the existing real environment.

mock-up

Physical models or small samples constructed to allow the architect and owner to review the appearance and function of materials, colors, textures, and other aesthetic features before incorporating them into the actual project.

multiple prime

A contracting methodology in which the owner bypasses the use of a general contractor and enters into multiple separate contracts with trade or specialty contractors for the various sections of the work associated with the project, such as concrete, framing, mechanical, and electrical work. Each of the specialty contractors involved becomes a prime contractor on the project.

network diagram

A common type of construction schedule, also called the *critical path method* (CPM), that depicts a continuous chain of activities showing both activity durations and the relationship of the activities. There are two types of network diagrams: activity-on-arrow (AOA) and activity-on-node (AON).

network logic

The order in which activities are sequenced in the network diagram relative to their interdependent relationships.

net-zero building

An energy-efficient building where, on a source energy basis, the actual annual delivered energy is less than or equal to the on-site renewable exported energy.

notice to proceed

The owner's official notification to the contractor to start work on the project. The contractor may or may not begin on the exact day of the notice but is authorized to proceed in whatever manner deemed appropriate.

Occupational Safety and Health Administration (OSHA)

The federal agency responsible for establishing safety standards for construction and all other industries in the United States. The agency also has the authority to enforce those standards through rigorous inspections at the job site and to issue citations to and assess fines against any contractor or subcontractor for violating these standards.

open bid

A competitive bidding requirement for all public projects. An open bid is one that is advertised publicly and allows any qualified contractor to submit a bid on the project.

open book philosophy

A practice of information transparency among all the project parties that benefits the client by leading to open dialogue, a better understanding of the design, and its impact on budgets and schedules.

partnering

A team-building technique, calling upon the parties to the construction contract to establish a common set of project goals and objectives and develop a mutually acceptable protocol for communication and conflict resolution through a formal agreement.

perspective drawing

A three-dimensional drawing representing width, length, and height of a structure.

photovoltaics

Devices that generate electricity directly from sunlight via an electronic process that occurs naturally in certain types of material called semiconductors.

precedence diagram

A graphic presentation of a schedule depicting project activities on a node with an arrow that depicts the dependencies that exist between the activities.

pre-construction services

Anticipatory planning, analytical, and evaluation activities that occur before construction begins, often during the design phase when at-risk CM or design-build is employed as the project delivery method.

preparatory inspection

Inspections, sometimes called *pre-inspections*, that are designed to check progress and make sure that everything is ready for the next stage of construction.

prequalification

The process in which an owner, based on minimum financial, management, and other qualitative data, determines whether a construction firm is fundamentally qualified to compete for a certain project, or class of projects.

price proposal

The part of a design-build proposal that stipulates the price at which the design-builder will provide the design and construction services necessary to complete the project.

procurement

Acquisition of goods and services.

program

A written statement that identifies and describes an owner or end user's needs and requirements for a facility. Every design starts with a program. (Also see *architectural programming*.)

progressive design-build

A qualifications-based design-build application where the design-builders is selected primarily on qualifications, followed by a process whereby the owner then progresses toward a design and contract price with the delivery team.

project delivery

A comprehensive process by which a building, facility, or structure is designed and constructed.

public-private partnership

A business venture approach whereby a public sector authority and a private enterprise join forces and combine resources to deliver government projects aimed at serving the public good.

punch list

The minor adjustments, repairs, and work items that must be done before substantial completion can be achieved. The list is prepared jointly by the owner, architect, and contractor. The architect confirms completion of each item on the list.

quality assurance

A quality management approach that addresses quality at the process level and deals with policies and procedures associated with hiring, training, safety, subcontracting, and procurement.

quality control

A quality management approach that addresses quality at the project level and deals with conformance to the plans and specs through submittals, mock-ups, shop drawings, inspections, and testing.

quantity surveyors

Individuals who are responsible for counting up and calculating all of the quantities of materials, labor, and equipment necessary to build a construction project.

query list

A list of questions and needed clarifications compiled by an estimator as he or she reviews the plans and specs during the estimating process.

rapidly renewable materials

Natural, non-petroleum-based building materials made from agricultural products that are typically harvested within a 10-year or shorter cycle.

reliable promising

Developed by the LCI, reliable promising and personal commitment making show respect for people and build trust among team members. Reliable promising creates ownership and

responsibility, and helps shift the culture from one of “holding people accountable” to a culture of “being accountable.” Reliable promising reduces rework, defects, and waste—and increases productivity.

renewable energy

Energy from sources that are naturally replenishing such as solar, wind, and geothermal power.

request for information (RFI)

A written request for clarification regarding the plans or specifications. The requests are usually made by subcontractors through the general contractor to the architect.

request for proposals (RFP)

A solicitation document, written by the owner, requesting pricing and a technical solution for design and/or construction services.

request for qualifications (RFQ)

A document issued by the owner prior to an RFP to solicit contractor or design-builder qualifications. The RFQ may be used by the owner to shortlist potential proposers, or it may be used by itself as the final competitive submittal employed in qualifications-based selection.

responsive bid (or proposal)

A bid or proposal package that meets all of the requirements of the solicitation instrument.

retainage

A certain percentage of money owed to the contractor for work progress that is held back by the owner to encourage completion of the project.

return on investment

A financial ratio used to calculate the benefit an investor will receive in relation to their investment cost.

rework

A term used to describe defective construction work that must be redone or corrected.

schedule of values

A budget template established early on in the project against which progress payments are measured. The schedule

summarizes the total project cost by the various divisions of work.

scope of work

The parameters defining the overall extent of work to be included in a construction contract. The project scope is commonly communicated through construction plans and written specifications.

scope sheet

Similar to a work package, a scope sheet describes the items of work to be performed under a particular trade heading. It often accompanies a subcontractor's bid or a request for quotation.

self-performed work

Construction work that is performed with the general contractor's own forces or labor. This is work that is not subcontracted.

shop drawing

A supplemental drawing to the plans and specifications, prepared by subcontractors, vendors, or fabricators, that details methods, materials, and models of a product or installation associated with the project.

short-interval schedules

Also called *look-ahead schedules*. They focus on a short period of time and a limited scope of work. They usually plan work for a two- to four-week time period.

shortlisting

Narrowing the field of offers through the selection of the most qualified proposers on the basis of qualifications.

site logistics plan

A layout plan identifying the placement of all temporary facilities needed during the construction stage of the project, such as the office trailer, crane, storage, security fencing, dumpsters, and portable toilets.

slip form

Concrete forms that rise up the wall as construction progresses.

specifications

The written instructions from an architect or engineer accompanying the project plans pertaining to the quality of

materials and workmanship required for the project.

stereoscopic projection

A 3D video display or view of a computer-generated building information model. Stereoscopic 3D is not the same thing as augmented, virtual, or mixed reality.

strategic foresight

A planning-oriented practice based on the study of futures and statistics.

straw wattles

An erosion control product made of compacted straw or other materials such as geotextile fibers, bound into a tight, tubular roll that comes in 10- to 25-foot lengths. These are often specified in an SWPPP.

submittals

Data, samples, details, colors, and product literature required by the terms of the contract to be presented to the architect by the contractor for approval prior to ordering and installation.

substantial completion

The point at which all punch list work has been completed and the owner can occupy or take possession of the new facility.

tailgate safety meeting

Weekly safety meetings held at the job site and usually conducted by the superintendent. Also called *toolbox safety meetings*.

takeoff

A term commonly used in the construction industry to describe the process of measuring the plans to quantify materials, labor, and equipment.

teaming enterprise

Finding ways to establish a reciprocal working environment among your most trusted and aligned business and trade partners to create efficiency and effectiveness.

technical proposal

The part of a design-build proposal that contains the conceptual design for the project. It may also include information regarding schedule, team makeup, and overall management plan for the project.

time and materials

Another name for a cost-plus-fee contract. These are the two cost factors that are reimbursed under a cost-plus-fee contract. Time equates to the cost of the labor, and materials equate to the cost of the building products used in the construction.

total float

The amount of leeway available to start or complete an individual schedule activity before it affects the planned project completion.

Total Quality Management (TQM)

A recognized quality control and quality assurance program based on continuous quality improvement practices.

transmittal

A tracking document that serves as a cover notification to any communication, submittal, or shop drawing being transmitted among the project participants.

triple bottom line

Measuring business success by the financial performance of the organization as well as environmental and social factors.

unforeseen conditions

Unknown physical conditions at the site that were not anticipated by the owner or the contractor.

value engineering

A process in which various alternative approaches are evaluated and considered regarding design, product selection, or building system in an effort to provide the most efficient, cost-effective solution possible relative to value in response to the desires of the owner.

variance

The cost or time difference between the actual project performance and the planned project performance.

virtual construction

A computerized environment where contractors and their teams can simulate, analyze, and plan the construction of a building project before the actual construction process begins in order to head off problems in the field before they occur.

virtual design and construction

The act of visually assessing, analyzing, and managing all work on a construction project in a 3D virtual environment before building the project and performing any work on-site, in the real world. The design and construction team can work together collaboratively to plan, design, coordinate, and construct a project before they begin building anything in the field.

virtual reality

A computer-generated simulation of an artificial three-dimensional environment. Requires the use of special equipment to interact with the created environment such as goggles or gloves.

vulnerability-based trust

Establishing honesty among team members through authentic check-ins and providing the support needed to make sure all team members, and thereby the project, succeed.

wainscoting

The lower part of the walls of a room, when finished in a material different from the upper part, such as wood paneling.

weighted criteria

An evaluation method used in best-value selection in which maximum point values are assessed for qualitative and price components of a proposal. Contract award is based on the highest total points earned.

will-call

Acts as a verbal confirmation of an order that has been placed prior to the date it is actually due for delivery. The will-call, generally made by the superintendent, occurs just before the scheduled delivery date.

work breakdown structure (WBS)

A tool used by estimators to organize the work of a contract in a hierarchical fashion.

work package

Detailed items of work bundled together under a particular trade. This is also called a *bid package*.

working drawings

The final detailed drawings used for construction. These are also called *construction documents* or *contract documents*.

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