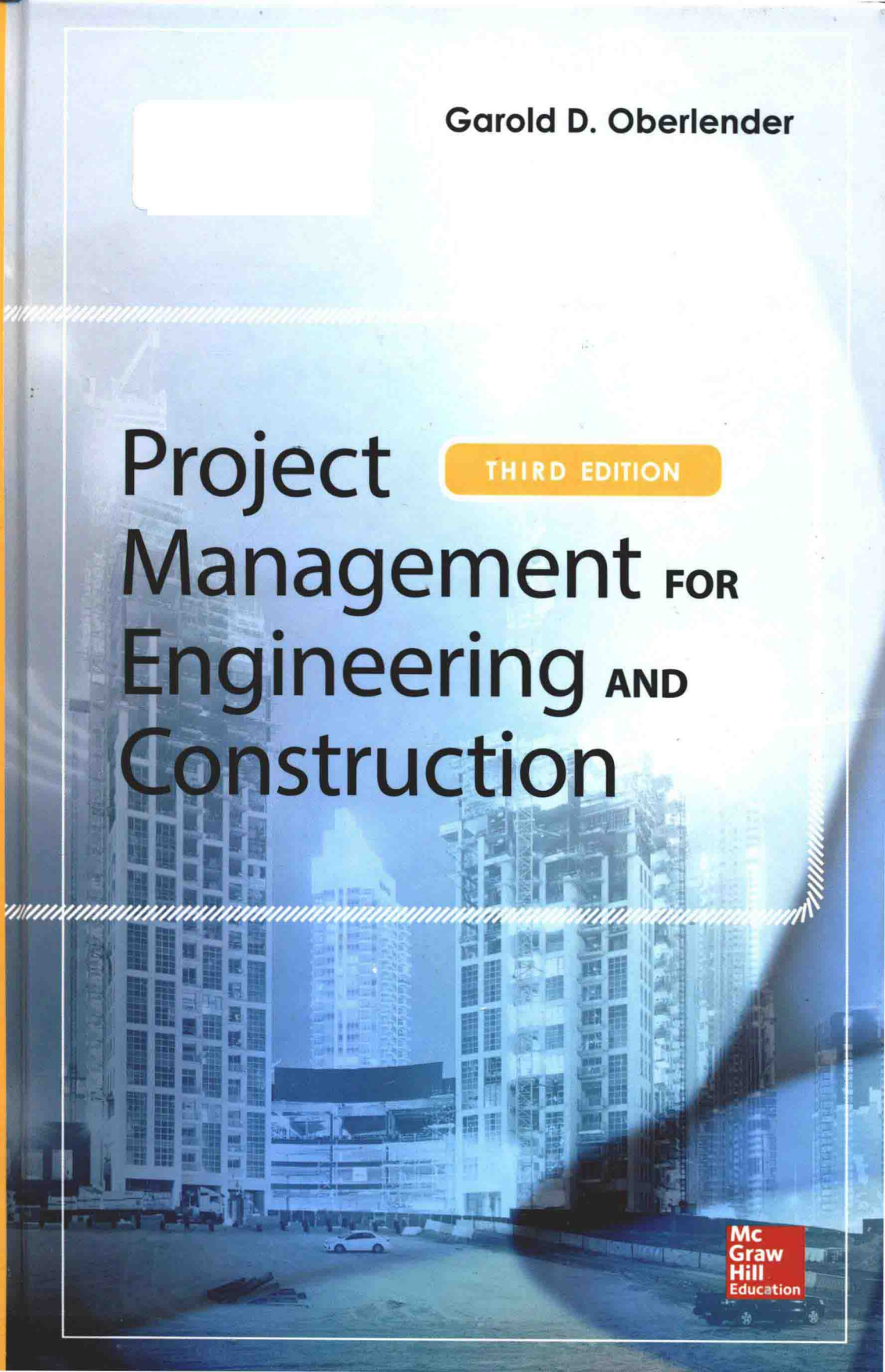
Garold D. Oberlender

Project Management for Engineering and Construction

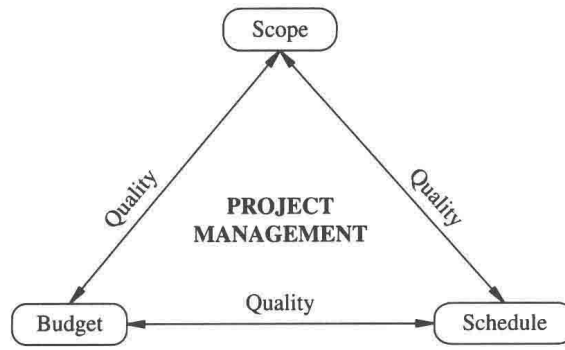
THIRD EDITION



Mc Graw Hill Education

Project Management for Engineering and Construction

Garold D. Oberlender, Ph.D., P.E.
Professor Emeritus of Civil Engineering
Oklahoma State University



Third Edition

Mc Graw Hill Education

New York Chicago San Francisco Athens
London Madrid Mexico City Milan
New Delhi Singapore Sydney Toronto

Project Management for Engineering and Construction, Third Edition

1 2 3 4 5 6 7 8 9 0 DOC/DOC 1 2 0 9 8 7 6 5 4

ISBN 978-0-07-182231-2
MHID 0-07-182231-3

This book is printed on acid-free paper.

Sponsoring Editor
Judy Bass

Editing Supervisor
Stephen M. Smith

Production Supervisor
Lynn M. Messina

Acquisitions Coordinator
Amy Stonebraker

Project Manager
Anupriya Tyagi,
Cenveo® Publisher Services

Copy Editor
Megha Saini,
Cenveo Publisher Services

Proofreader
Nitin Goswami

Art Director, Cover
Jeff Weeks

Composition
Cenveo Publisher Services

ABOUT THE AUTHOR

GAROLD D. OBERLENDER is professor emeritus of civil engineering at Oklahoma State University, where he served for 35 years as coordinator of the graduate program in construction engineering and project management. Prior to joining the faculty at Oklahoma State University, he lived nine years in the Dallas area and worked in the engineering and construction industry. He holds B.S., M.S., and Ph.D. degrees in civil engineering.

In addition to authoring this book, Dr. Oberlender is the coauthor with Robert L. Peurifoy of *Estimating Construction Costs,* Sixth Edition, and *Formwork for Concrete Structures,* Fourth Edition. His books are adopted by universities around the world and widely used by practicing civil engineers.

Dr. Oberlender is a fellow member of the American Society of Civil Engineers (ASCE) and has been inducted into the National Academy of Construction (NAC). He is also a fellow member of the National Society of Professional Engineers (NSPE). He has served as chairman of the Construction Engineering Division of the American Society for Engineering Education (ASEE). Currently he is a writer of construction engineering PE exam questions for the National Council of Examiners for Engineering and Surveying (NCEES).

Dr. Oberlender is frequently an invited speaker on the subject of project engineering and management by companies in industry and professional and technical organizations in the United States and other countries. He served on the Academic Council of the Construction Industry Institute (CII) and was principal investigator for several CII research teams. He was selected for the CII Outstanding Researcher Award for his research on improving early estimates.

In addition to his teaching and research, he maintained a consulting engineering practice for engineering and construction projects in the petrochemical and electrical power industries. Dr. Oberlender is a registered professional engineer in Oklahoma and Texas and a member of numerous honorary societies, including Chi Epsilon, Tau Beta Pi, Sigma Xi, and Phi Kappa Phi.

Preface

This book presents the principles and techniques of managing engineering and construction projects from the initial conceptual phase, through design and construction, to completion. It emphasizes project management during the early stages of project development because the ability to influence the quality, cost, and schedule of a project can best be achieved during the early stage of development. Most books discuss project management during construction, after the scope of work is fully defined, the budget is fixed, and the completion date is firm. It is then too late to make any significant adjustments to improve the quality, cost, or schedule of the project.

Although each project is unique, there is certain information that must be identified and organized at the beginning of a project, before any work is started. Numerous tables and graphs are presented and discussed throughout this book to provide guidelines for management of the three basic components of a project: scope, budget, and schedule. Throughout this book, achieving project quality to meet the owner's satisfaction is emphasized as an integral part of project management.

This third edition has a new chapter that addresses risk management. This topic is extremely important because owners, designers, and contractors are all exposed to risk from the start of a project through its completion. Risk assessment, analysis, and mitigation are key factors in project management of engineering and construction projects.

In preparing this third edition, the author has updated example problems in all chapters and added examples in many chapters. New sections have been added, including: ensuring quality in a project, the owner's team, the importance of the estimator, formats for work breakdown structures, design work packages, benefits of planning, and build-operate-transfer delivery methods.

The intended audience of this book is engineers in industry who aid the owner in the feasibility study, coordinate the design effort, and witness construction in the field. It is also intended for students of university programs in engineering, architecture, and construction because

graduates of these programs usually are involved in project management as they advance in their careers.

This book is based on the author's experience in working with hundreds of project managers in the engineering and construction industry. Much of the material in this book is based on formal and informal discussions with these project managers, who are actively involved in the practice of project management. Although the author has observed that no two project managers operate exactly the same, there are common elements that apply to all projects and all project managers. The author presents these common elements of effective project management that have been successfully applied in practice.

The author would like to thank Glenn Barin and Rock Spencer for their careful review, helpful comments, and advice in the development of the new risk management chapter in this third edition. The author would also like to thank the many project managers in industry who have shared their successes, and problems, and who have influenced the author's thoughts in the development of this book.

Finally, the author greatly appreciates the patience and tolerance of his wife, Jana, and her support and encouragement during the writing and editing phases of the third edition of this book.

Garold D. Oberlender, Ph.D., P.E.

Contents

Chapter

1

Introduction

Purpose of This Book

The purpose of this book is to present the principles and techniques of project management beginning in the conceptual phase by the owner, through coordination of design and construction, to project completion. Emphasis is placed on managing the project in its early stage of development, during the owner's study and design. It is presented from this perspective because the ability to influence the overall quality, cost, and schedule of a project can best be achieved early in the life of a project. Most books and articles discuss project management during the construction phase, after design is completed. At this time in the life of a project the scope of work is fully defined, the budget is fixed, and the completion date is firm. It is then too late to make any significant adjustments to improve the quality, cost, or schedule of the project.

Experienced project managers agree that the procedures used for project management vary from company to company and even among individuals within a company. Although each manager develops his or her own style of management, and each project is unique, there are basic principles that apply to all project managers and projects. This book presents these principles and illustrates the basic steps, and sequencing of steps, to develop a work plan to manage a project through each phase from conceptual development to completion.

Project management requires teamwork among the three principal contracting parties: the owner, designer, and contractor. The coordination of the design and construction of a project requires planning and organizing a team of people who are dedicated to a common goal of completing the project for the owner. Even a small project involves a large number of people who work for different organizations. The key to a successful project is the selection and coordination of people

who have the ability to detect and solve problems to complete the project.

Throughout this book the importance of management skills is emphasized to enable the user to develop his or her own style of project management. The focus is to apply project management at the beginning of the project, when it is first approved. Too often the formal organization to manage a project is not developed until the beginning of the construction phase. This book presents the information that must be assembled and managed during the development and engineering design phase to bring a project to successful completion for use by the owner.

The intended audience of this book is students enrolled in university programs in engineering and construction. It is also intended for the design firms which aid the owner in the feasibility study, coordinate the design effort, and witness construction in the field. This book is also for persons in the owner's organization who are involved in the design and construction process.

Arrangement of This Book

A discussion of project management is difficult because there are many ways a project can be handled. The design and/or construction of a project can be performed by one or more parties. Regardless of the method that is used to handle a project, the management of a project generally follows these steps:

Step 1: Project Definition (to meet the needs of the end user)
Intended use by the owner upon completion of construction
Conceptual configurations and components to meet the intended use

Step 2: Project Scope (to meet the project definition)
Define the work that must be accomplished
Identify the quantity, quality, and tasks that must be performed

Step 3: Project Budgeting (to match the project definition and scope)
Define the owner's permissible budget
Determine direct and indirect costs plus contingencies

Step 4: Project Planning (the strategy to accomplish the work)
Select and assign project staffing
Identify the tasks required to accomplish the work

Step 5: Project Scheduling (the product of scope, budgeting, and planning)
Arrange and schedule activities in a logical sequence
Link the costs and resources to the scheduled activities

Step 6: Project Tracking (to ensure the project is progressing as planned)
Measure work, time, and costs that are expended
Compare "actual" to "planned" work, time, and cost

Step 7: Project Close Out (final completion to ensure owner satisfaction)
Perform final testing and inspection, archive documents, and confirm payments
Turn over the project to the owner

These steps describe project management in its simplest form. In reality there is considerable overlap between the steps, because any one step may affect one or more other steps. For example, budget preparation overlaps project definition and scope development. Similarly, project scheduling relates project scope and budget to project tracking and control.

The topic of project management is further complicated because the responsibility for these steps usually involves many parties. Thus, the above steps must all be integrated together to successfully manage a project. Subsequent chapters of this book describe each of these steps.

Chapter 1 defines general principles related to project management. These basic principles must be fully understood because they apply to all the remaining chapters. Many of the problems associated with project management are caused by failure to apply the basic management principles that are presented in Chapter 1.

Chapter 2, Working with Project Teams, presents the human aspects of project management. The project team is a group of diverse individuals, each with a special expertise, that performs the work necessary to complete the project. As leader of the project team, the project manager acts as a coach to answer questions and to make sure the team understands what is expected of them and the desired outcome of the project.

Chapter 3, Project Initiation, presents material that is generally performed by the owner. However, the owner may contract the services of a design organization to assist with the feasibility study of a project. The project manager should be involved at the project development or marketing phase to establish the scope. This requires input from experienced technical people that represent every aspect of the proposed project.

Chapter 4, Early Estimates, presents the techniques and processes of preparing estimates in the early phase of a project. Preparation of early estimates is a prerequisite to project budgeting. For engineering and construction projects, the early cost estimate is used by the owner in making economic decisions to approve the project. The early cost estimate is a key project parameter for cost control during the design process.

Chapter 5, Project Budgeting, applies to all parties in a project: the owner, designer, and contractor. The budget must be linked to the quantity, quality,

and schedule of the work to be accomplished. A change in scope or schedule almost always affects the budget, so the project manager must continually be alert to changes in a project and to relate any changes to the budget.

Chapter 6, Development of Work Plan, applies to the project manager who is responsible for management of the design effort. Generally, he or she is employed by the professional design organization, which may be an agency of the owner or under contract by the owner to perform design services. The material presented in this chapter is important because it establishes the work plan which is the framework for guiding the entire project effort. The information in this chapter relates to all the project management steps and chapters of this book.

Chapter 7, Design Proposals, presents the process of preparing proposals from the design organization to the owner. After the owner has defined the goals, objectives, intended use, and desired outcome of the project, a request for proposals is solicited from the design organization. The design organization must convert the owner's expectations of the project into an engineering scope of work, budget, and schedule.

Chapter 8, Project Scheduling, provides the base against which all activities are measured. It relates the work to be accomplished to the people who will perform the work as well as to the budget and schedule. Project scheduling cannot be accomplished without a well-defined work plan, as described in Chapter 6, and it forms the basis for project tracking, as described in Chapter 9.

Chapter 9, Tracking Work, cannot be accomplished without a well-defined work plan, as described in Chapter 6, and a detailed schedule, as described in Chapter 8. This chapter is important because there is always a tendency for scope growth, cost overrun, or schedule delays. A control system must simultaneously monitor the three basic components of a project: the work accomplished, the budget, and the schedule. These three components must be collectively monitored, not as individual components, because a change in any one component usually will affect the other two components.

Chapter 10, Design Coordination, applies to the project manager of the design organization. The quality, cost, and schedule of a project is highly dependent on the effectiveness of the design effort. The end result of the design process is to produce plans and specifications in a timely manner that meet the intended use of the project by the owner. The product of design must be within the owner's approved budget and schedule and must be constructable by the construction contractor.

Chapter 11, Construction Phase, is important because most of the cost of a project is expended in the construction phase, and the quality of the final project is highly dependent upon the quality of work that is performed by the construction contractors. Most of the books that have been written on project management have been directed toward a