Productivity Improvement

FOR

Construction

Engineering

Implementing Programs
That Save Money and Time



J. K. Yates, Ph.D.



Productivity Improvement for Construction and Engineering

Other Titles of Interest

Constructability Concepts and Practice, edited by John A. Gambatese; James B. Pocock; Phillip S. Dunston (ASCE Technical Report, 2007). Examines constructability and the integration of construction knowledge and experience in the planning, design, procurement, construction, operation, maintenance, and decommissioning phases of a project consistent with overall project objectives.

Managing Gigaprojects: Advice from Those Who've Been There, Done That, edited by Patricia D. Galloway, Ph.D., P.E.; Kris R. Nielsen, Ph.D., J.D.; Jack L. Dignum (ASCE Press, 2013). A stellar group of financial, legal, and construction professionals share lessons learned and best practices developed from working on the world's biggest infrastructure construction projects.

Project Administration for Design-Build Contracts: A Primer for Owners, Engineers, and Contractors, by James E. Koch, Ph.D., P.E.; Douglas D. Gransberg, Ph.D., P.E.; Keith R. Molenaar, Ph.D. (ASCE Press, 2010). Explains the basics of administering a design-build project after the contract has been awarded.

Public-Private Partnerships: Case Studies on Infrastructure Development, by Sidney M. Levy (ASCE Press, 2011). Demystifies public-private partnerships as an innovative solution to the challenges of designing, financing, building, and operating major infrastructure projects.

Quality in the Constructed Project: A Guide for Owners, Designers, and Constructors, Third Edition, prepared by the Construction Institute of ASCE (ASCE Manual of Practice, 2012). Provides information and recommendations on principles and procedures that are effective in enhancing the quality of constructed projects.

Productivity Improvement for Construction and Engineering

Implementing Programs That Save Money and Time

J. K. Yates, Ph.D.



Library of Congress Cataloging-in-Publication Data

```
Yates, J. K., 1955-
```

Productivity improvement for construction and engineering: implementing programs that save money and time/J.K. Yates, Ph.D.

pages cm

Includes bibliographical references and index.

ISBN 978-0-7844-1346-3 (print : alk. paper) — ISBN 978-0-7844-7832-5 (ebook) 1. Building—Super-intendence. 2. Construction industry—Management. 3. Industrial productivity. I. Title.

TH438.Y38 2014 620.0068'5—dc23

2014007427

Published by American Society of Civil Engineers 1801 Alexander Bell Drive Reston, Virginia, 20191-4382 www.asce.org/bookstore | ascelibrary.org

Any statements expressed in these materials are those of the individual authors and do not necessarily represent the views of ASCE, which takes no responsibility for any statement made herein. No reference made in this publication to any specific method, product, process, or service constitutes or implies an endorsement, recommendation, or warranty thereof by ASCE. The materials are for general information only and do not represent a standard of ASCE, nor are they intended as a reference in purchase specifications, contracts, regulations, statutes, or any other legal document. ASCE makes no representation or warranty of any kind, whether express or implied, concerning the accuracy, completeness, suitability, or utility of any information, apparatus, product, or process discussed in this publication and assumes no liability therefor. The information contained in these materials should not be used without first securing competent advice with respect to its suitability for any general or specific application. Anyone utilizing such information assumes all liability arising from such use, including but not limited to infringement of any patent or patents.

ASCE and American Society of Civil Engineers-Registered in U.S. Patent and Trademark Office.

Photocopies and permissions. Permission to photocopy or reproduce material from ASCE publications can be requested by sending an e-mail to permissions@asce.org or by locating a title in ASCE's Civil Engineering Database (http://cedb.asce.org) or the ASCE Library (http://ascelibrary.org) and using the "Permissions" link.

Errata: Errata, if any, can be found at http://dx.doi.org/10.1061/9780784413463.

Copyright © 2014 by the American Society of Civil Engineers. All Rights Reserved.

ISBN 978-0-7844-1346-3 (paper)

ISBN 978-0-7844-7832-5 (PDF)

Manufactured in the United States of America.

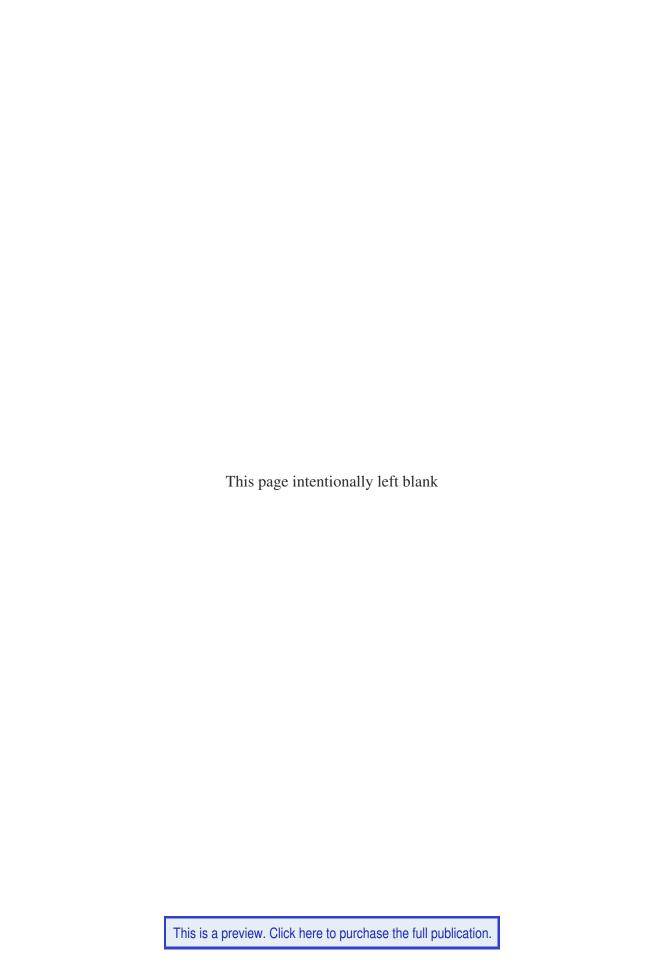
 $21 \ 20 \ 19 \ 18 \ 17 \ 16 \ 15 \ 14 \qquad 1 \ 2 \ 3 \ 4 \ 5$

Instructors: A PDF manual providing worked answers for the problems presented in this book and sample test questions is available at no charge. Contact ASCE by e-mail (pubsful@asce.org) or telephone (1-800-548-2723, domestic U.S.; 1-703-296-6300, international). Ask for Productivity Improvement for Engineering and Construction: Solution Manual and Test Questions, ISBN 978-0-7844-7833-2, Stock No. 47833.

 $\textbf{Cover photo:} \ Reproduced \ with permission. \ Copyright 2014 \ Joseph A. \ Blum. \ josephablum photography. com$

Dedication

To my former students who contributed to this book by providing examples, case studies, figures, and photographs. To the students who over the years continually inspired me to be a better professor and administrator. I am very proud of what all of my former students have accomplished since they graduated from college.



Contents

| Preface |
|---|
| Acknowledgments |
| Chapter 1. Introduction |
| 1.1 Definition of Productivity Improvement |
| 1.2 Global Productivity Rates |
| 1.3 Productivity and Performance Enhancement |
| 1.4 Different Levels of Productivity Measures |
| 1.5 Effects of Productivity Fluctuations |
| 1.6 Organization of the Book |
| 1.7 Summary |
| 1.8 Key Terms |
| 1.9 Exercises |
| 1.10 Optional Project |
| References |
| Chapter 2. Productivity Improvement Programs |
| 2.1 Components of the Productivity Improvement Process |
| 2.2 Reducing Costs and Increasing Production Efficiency |
| 2.3 Benefits of Increasing Production Rates |
| 2.4 Strategic Management Approach21 |
| 2.5 Purpose of Productivity Improvement Programs |
| 2.6 Characteristics of Successful Productivity Improvement Approaches |
| 2.7 Quality Assurance and Quality Control23 |
| 2.8 Lean Construction |
| 2.9 Prefabrication and Modularization |
| 2.10 Summary |
| 2.11 Key Terms |
| 2.12 Exercises |
| References |

viii CONTENTS

| C | Chapter 3. Elements of the Construction Industry | .31 |
|---|--|-----|
| | 3.1 Construction Industry Statistics | .31 |
| | 3.2 The Construction Industry versus the Manufacturing Industry | .32 |
| | 3.3 Construction Productivity Improvement | .34 |
| | 3.4 Construction Industry Project Team Members | .35 |
| | 3.5 Construction Project Development | .37 |
| | 3.6 Project Contract Administration Models | .41 |
| | 3.7 Planning Construction Projects | .44 |
| | 3.8 U.S. and Foreign Labor Statistics | .47 |
| | 3.9 Construction Sectors in the United States | .47 |
| | 3.10 Drivers for Productivity Improvement | .47 |
| | 3.11 Summary | .51 |
| | 3.12 Key Terms | .52 |
| | 3.13 Exercises | .52 |
| | References | .53 |
| | | |
| C | Chapter 4. Human Component of Productivity Improvement | .55 |
| | 4.1 Factors Affecting Worker Performance | .57 |
| | 4.2 Occupational Safety and Health Administration | .59 |
| | 4.3 Workers' Compensation Insurance | |
| | 4.4 Safety Issues Related to Productivity Rates | .62 |
| | 4.5 Preventing Construction Accidents | |
| | 4.6 Causes of Construction Worker Injuries | .72 |
| | 4.7 Construction Failures | .73 |
| | 4.8 Drug and Alcohol Use at Construction Jobsites | .79 |
| | 4.9 Communicating Safety Requirements | .80 |
| | 4.10 Heavy Construction Equipment Safety | .81 |
| | 4.11 Safety Education and Site Safety Programs and Plans | .81 |
| | 4.12 Effects of Tool Use on Performance | .84 |
| | 4.13 Construction Accident Case Studies | |
| | 4.14 Managing Workers and Work Processes | .87 |
| | 4.15 Motivating Workers | .89 |
| | 4.16 Monitoring and Controlling the Human Element | |
| | 4.17 Summary | |
| | 4.18 Key Terms | |
| | 4.19 Exercises | |
| | References | .93 |
| | | |
| C | Chapter 5. Preparing to Conduct Productivity Improvement Studies | .95 |
| | 5.1 Productivity Improvement Team Member Responsibilities | .95 |
| | 5.2 Productivity Improvement Study Interview Guides | .97 |
| | | |

CONTENTS ix

| 5.3 Defining the Scope of Productivity Improvement Studies | |
|---|-----------------|
| 5.4 Potential Work Improvement Areas | 100 |
| 5.5 Scientific Analysis Method | 101 |
| 5.6 Planning Productivity Improvement Studies | 103 |
| 5.7 Learning Curves | 104 |
| 5.8 Effects of Overtime on Productivity Rates | 106 |
| 5.9 Methods for Investigating Productivity Improvement | 108 |
| 5.10 Work Sampling | 109 |
| 5.11 Recording Jobsite Observations | |
| 5.12 Summary | |
| 5.13 Key Terms | |
| 5.14 Exercises | 115 |
| References | 116 |
| Chapter 6. Productivity Improvement Data Analysis Techniques | 117 |
| | |
| 6.1 Occupational Safety and Health Administration | |
| 6.2 Guidelines for Productivity Improvement Meetings | |
| 6.3 Guidelines for Data Presentations | |
| 6.4 Work-Process Analysis Procedures | |
| 6.5 Productivity Rating and Work-Process Analysis Reports | |
| 6.6 Work-Distribution Analysis | |
| 6.7 Recording Work-Process Operations | |
| 6.8 Work-Count Analysis | |
| 6.9 Work-Measurement Methods | |
| 6.10 Systems Engineering Concepts | |
| 6.11 Summary | |
| 6.12 Key Terms | |
| 6.13 Exercises | |
| References | 152 |
| Chapter 7. Evaluating Productivity Improvement Alternatives: Case Stu | dies 155 |
| 7.1 Evaluating and Prioritizing Productivity Improvement Alternative | s 155 |
| 7.2 Case Study 1: Concrete Parking Structures and Police Station | |
| 7.3 Case Study 2: Steel Erection | |
| 7.4 Case Study 3: Highway Interchange Construction | |
| 7.5 Case Study 4: High-Rise Building Stone-Panel Curtain-Wall Instal | |
| 7.6 Summary | |
| 7.7 Key Terms | |
| 7.8 Exercises | |
| References | 910 |