

THIRD EDITION

CONSTRUCTION ESTIMATING USING EXCEL

STEVEN PETERSON

 Pearson



Construction Estimating Using Excel

This page intentionally left blank



Construction Estimating Using Excel

THIRD EDITION

Steven J. Peterson
MBA, PE



330 Hudson Street, NY NY 10013

Vice President, Portfolio Management: Andrew Gilfillan
Portfolio Manager: Tony Webster
Editorial Assistant: Lara Dimmick
Senior Vice President, Marketing: David Gesell
Field Marketing Manager: Thomas Hayward
Marketing Coordinator: Elizabeth MacKenzie-Lamb
Director, Digital Studio and Content Production: Brian Hyland
Managing Producer: Cynthia Zonneveld
Managing Producer: Jennifer Sargunar

Content Producer: Faraz Sharique Ali
Content Producer: Nikhil Rakshit
Manager, Rights Management: Johanna Burke
Operations Specialist: Deidra Smith
Cover Design: Cenveo Publisher Services
Cover Art: Shutterstock
Full-Service Project Management and Composition: R. Sreemeenakshi/SPi Global
Printer/Binder: Edward Brothers
Cover Printer: Phoenix Color
Text Font: SabonLtPro

Copyright © 2018, 2012, 2007. Pearson Education, Inc. All Rights Reserved. Manufactured in the United States of America. This publication is protected by copyright, and permission should be obtained from the publisher prior to any prohibited reproduction, storage in a retrieval system, or transmission in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise. For information regarding permissions, request forms, and the appropriate contacts within the Pearson Education Global Rights and Permissions department, please visit www.pearsoned.com/permissions/.

Acknowledgments of third-party content appear on the appropriate page within the text.

Unless otherwise indicated herein, any third-party trademarks, logos, or icons that may appear in this work are the property of their respective owners, and any references to third-party trademarks, logos, icons, or other trade dress are for demonstrative or descriptive purposes only. Such references are not intended to imply any sponsorship, endorsement, authorization, or promotion of Pearson's products by the owners of such marks, or any relationship between the owner and Pearson Education, Inc., authors, licensees, or distributors.

Microsoft®, Microsoft Windows®, and Microsoft Office® are registered trademarks of the Microsoft Corporation in the United States and other countries. This book is not sponsored or endorsed by or affiliated with the Microsoft Corporation.

Library of Congress Cataloging-in-Publication Data

Names: Peterson, Steven J.
Title: Construction estimating using Excel / Steven J. Peterson, MBA, PE.
Description: Third edition. | Boston : Pearson Education, [2018] | Includes index.
Identifiers: LCCN 2016042595 | ISBN 9780134405506 | ISBN 0134405501
Subjects: LCSH: Building—Estimates—Data processing. | Microsoft Excel (Computer file)
Classification: LCC TH437 .P357 2018 | DDC 692/.50285554—dc23 LC record available at <https://lcn.loc.gov/2016042595>

10 9 8 7 6 5 4 3 2 1



ISBN 10: 0-13-440550-1
ISBN 13: 978-0-13-440550-6

DEDICATION

*This book is dedicated to Bill Thiede,
who taught me how to estimate.*

This page intentionally left blank



PREFACE

The second hand of the clock swept rapidly toward the 12, signifying that it was 15 minutes to 1. Fifteen minutes until the bid I was working on was due. I had 10 minutes until our secretary would call for the final price, giving her just enough time to write the number on the bid forms, seal the bid, and turn it in. The bid had been tallied and was ready to go, with the exception of one blank line. The words “Asphalt Paving” along with the blank space to the right glared at me. I had yet to receive a number from my asphalt contractor, who had promised me that he would get me a bid. I called his phone number. No answer! There was only one thing left for me to do. I had to do an asphalt takeoff myself, and I had only 8 minutes left. Quickly I grabbed my scale, turned it to match the scale at the bottom of the drawing ($1/8" = 1'$), and began to determine the quantity of asphalt needed for the parking lot. Cutting corners where I could, scribbling numbers on a piece of scratch paper, and punching the numbers on my calculator, I arrived at the square footage of the asphalt. It wasn't exact, but it was close. I then multiplied the square footage by the estimated cost per square foot for the asphalt. The phone rang as I added my estimated cost for the asphalt to the bid. It was our secretary calling for the bid. I gave her the number, and she read it back to me.

I relaxed for the next 20 minutes, waiting for our secretary to call back with the bid results. The phone rang again and it was our secretary. We had won the bid. As I was enjoying the thrill of victory, I glanced at the plans and the words “Warning: Half Size Drawings” jumped off the page. The thrill of victory turned into a large lump in my stomach as I realized why I had won the bid. I had forgotten to double all my measurements as I measured the asphalt, so I had only 25% of the money I needed to purchase the asphalt for the project. Quickly, and carefully this time, I took off the asphalt again. Indeed, I only had a quarter of the asphalt I needed, and it would take all the profit in the job and then some to pay for it.

By working hard during the buyout process, I was able to get the project back on budget. I did this by finding local subcontractors and suppliers for the items I had bid myself who would do the work for less than I had budgeted. In the end, we made a fair profit on the job, but that does not make up for the money we left on the table because of my error.

The job of an estimator is to forecast as accurately as possible the likely cost of a construction project, as well as the required amounts of materials, labor, and equipment necessary to complete the work. Because of the high degree of uncertainty in estimating these items, estimating is more of an art than a science.

There are three key pillars that support the success of an estimator. The first is an understanding of the construction process—how things are built and how the pieces are put together. The second is an understanding of the fundamental principles of estimating. Estimates that are not based on these fundamental principles are nothing more than wild guesses. The third pillar is experience. For a person to become a good estimator, it is required that he or she develops good judgment on how to apply estimating principles. Will Rogers reportedly said, “Good judgment comes from experience, and a lot of that comes from bad judgment.”¹ The pillar of experience can only be acquired through practice.

The purposes of this book are to: (1) give beginning estimators an understanding of the fundamental principles of estimating, (2) provide beginning estimators with practical estimating experience, (3) give beginning estimators a basic understanding of how to use spreadsheets, such as Microsoft Excel,² to increase their estimating productivity and reduce errors, and (4) give experienced estimators another view on estimating and a chance to improve their estimating skills.

¹Will Rogers as posted on <http://www.brainyquote.com/quotes/quotes/w/willrogers411692.html>; accessed August 5, 2016.

²Microsoft® Excel is a registered trademark of the Microsoft Corporation in the United States and other countries.

This book is divided into five sections. The first section introduces the reader to estimating. The second section introduces the quantity takeoff and teaches the reader how to determine the quantity of materials needed to complete the project. The third section shows how to put costs to the estimate. The fourth section shows how to finalize the bid, incorporate the estimate into the schedule, and buy out the project, and also discusses bidding ethics. The fifth section teaches how to tap into the power of computer spreadsheets—specifically Microsoft® Excel—and demonstrates how spreadsheets can be used to automate estimating functions. It also provides a chapter on estimating methods used to prepare conceptual and preliminary estimates. To provide practice in estimating, three drawing sets are included—a residential garage, a residence, and a retail building.

I hope that you will take the time to carefully read each chapter, work the problems at the end of each chapter, and prepare estimates for the drawings sets included with the book. Doing this will help you begin to gain the experience needed to be a successful estimator.

Feedback on this book can be submitted at: stevenjpeterston9@gmail.com

I would like to thank the following people for providing reviews of the manuscript: Dennis Dorward (Pennsylvania College of Technology), Kristen Gundvaldson (Southeast Technical Institute), Darwin Olson (Anoka Technical College), Mark Steinle (Casper College), James William White (Indiana University–Purdue University Indianapolis), and Manoochehr Zoghi (California State University, Fresno).

STUDENT LEARNING OUTCOMES

During the past few years, higher education has been moving to outcome-based learning, which requires accredited programs to measure their students' ability to meet the required outcomes. Currently, in the United States, there are four accreditation standards for construction management and construction engineering program, which are as follows: (1) American Council for Construction Education (ACCE); (2) ABET—Engineering Accreditation Commission, for construction engineering; (3) ABET—Engineering Technology, for construction engineering technology; and (4) ABET—Applied Science, for construction management. Although each of these standards are different, they all focus on three general outcomes, which can be summarized as follows. Construction management/engineering students should be able to:

- Prepare construction cost estimates. This book includes both a residential and a commercial set of plans. Each chapter, where applicable, includes homework problems related to these plans. By completing the homework problems associated with either the residential plans or the commercial plans, the students

will prepare a complete construction estimate. See the instructor's guide for more information on which problems relate to preparing these estimates.

- Effectively communicate in writing. Chapter 24 covers writing a scope of work and Chapter 28 covers writing proposals and communicating by e-mail. The material in these chapters can be used in part to meet the outcome related to written communication.
- Understand ethics as it relates to estimating. Chapter 31 addresses ethics as it relates to estimating and can be used in part to meet the outcome related to ethics.

NEW TO THIS EDITION

The following is a list of key changes that have been made to this edition.

- The Excel contents have been updated to Excel 2016, the latest version of Excel available at the time of this revision.
- A number of changes have been made to ensure that the material in this book aligns with the ACCE and ABET student learning outcomes.
- The material and equipment costs and labor rates have been updated to reflect the costs at the time of this revision.
- Chapters 33 and 34 have been combined into a single chapter and a chapter covering estimating methods used to prepare conceptual and preliminary estimates has been added as Chapter 34.
- The use of data from RSMean (along with six sample pages from their books) has been added.
- A discussion of the Fair Labor Standards Act, which covers the labor laws dealing with non-exempt employees, has been added.
- A discussion of the Davis–Bacon Act, which covers the pay rates for employees on projects funded by the federal government, has been added.
- The problem sets from Chapters 21 and 22 have been expanded.
- An appendix with sample equipment costs has been added.

DOWNLOAD INSTRUCTOR RESOURCES FROM THE INSTRUCTOR RESOURCE CENTER

To access supplementary materials online, instructors need to request an instructor access code. Go to www.pearsonhighered.com/irc to register for an instructor access code. Within 48 hours of registering, you will receive a confirming e-mail including an instructor access code. Once you have received your code, locate

your text in the online catalog and click on the Instructor Resources button on the left side of the catalog product page. Select a supplement, and a login page will appear. Once you have logged in, you can access instructor material for all Pearson textbooks. If you have any difficulties accessing the site or downloading a supplement, please contact customer service at: <http://support.pearson.com/getsupport>

DISCLAIMER

Microsoft and/or its respective suppliers make no representations about the suitability of the information contained in the documents and related graphics published as part of the services for any purpose. All such documents and related graphics are provided “as is” without warranty of any kind. Microsoft and/or its respective suppliers hereby disclaim all warranties and conditions with regard to this information, including all warranties and conditions of merchantability, whether express, implied or statutory, fitness for a particular purpose, title and non-infringement. In no event shall Microsoft and/or its respective suppliers be liable for any special, indirect or consequential damages or any damages whatsoever

resulting from loss of use, data or profits, whether in an action of contract, negligence or other tortious action, arising out of or in connection with the use or performance of information available from the services.

The documents and related graphics contained herein could include technical inaccuracies or typographical errors. Changes are periodically added to the information herein. Microsoft and/or its respective suppliers may make improvements and/or changes in the product(s) and/or the program(s) described herein at any time. Partial screen shots may be viewed in full within the software version specified.

The sample Excel spreadsheets in this book are to provide the reader with examples of how Excel may be used in estimating, and as such, are designed for a limited number of estimating situations. Before using the spreadsheets in this book, the reader should understand the limits of the spreadsheet and carefully verify that the spreadsheets: (1) are applicable to his or her estimating situation and (2) produce an acceptable answer. The reader assumes all risks from the use and/or performance of these spreadsheets. The drawings included with this text are for educational purposes only and are not to be used for construction.

This page intentionally left blank



BRIEF CONTENTS

PART I	Chapter 9
INTRODUCTION TO ESTIMATING 1	THERMAL AND MOISTURE PROTECTION 153
Chapter 1	Chapter 10
THE ART OF ESTIMATING 2	OPENINGS 172
Chapter 2	Chapter 11
OVERVIEW OF THE ESTIMATING AND BIDDING PROCESS 11	FINISHES 181
Chapter 3	Chapter 12
INTRODUCTION TO EXCEL 21	FIRE SUPPRESSION 192
PART II	Chapter 13
THE QUANTITY TAKEOFF 71	PLUMBING 196
Chapter 4	Chapter 14
FUNDAMENTALS OF THE QUANTITY TAKEOFF 72	HEATING, VENTILATION, AND AIR-CONDITIONING (HVAC) 201
Chapter 5	Chapter 15
CONCRETE 84	ELECTRICAL 209
Chapter 6	Chapter 16
MASONRY 107	EARTHWORK 220
Chapter 7	Chapter 17
METALS 115	EXTERIOR IMPROVEMENTS 236
Chapter 8	Chapter 18
WOODS, PLASTICS, AND COMPOSITES 126	UTILITIES 242

	PART III		
-----			Chapter 30
PUTTING COSTS TO THE ESTIMATE 249		THE ESTIMATE AS THE BASIS OF THE SCHEDULE 325	
-----	Chapter 19	-----	Chapter 31
MATERIAL PRICING 250		ETHICS 328	
-----	Chapter 20		PART V
LABOR PRODUCTIVITY AND HOURS 255		ADVANCED ESTIMATING 331	
-----	Chapter 21	-----	Chapter 32
LABOR RATES 264		CONVERTING EXISTING FORMS 332	
-----	Chapter 22	-----	Chapter 33
EQUIPMENT COSTS 276		CREATING NEW FORMS 352	
-----	Chapter 23	-----	Chapter 34
CREW RATES 283		OTHER ESTIMATING METHODS 381	
-----	Chapter 24	-----	Appendix A
SUBCONTRACT PRICING 286		REVIEW OF ESTIMATING MATH 393	
-----	Chapter 25	-----	Appendix B
MARKUPS 290		SAMPLE JOB COST CODES 406	
-----	Chapter 26	-----	Appendix C
PRICING EXTENSIONS 296		SAMPLE LABOR PRODUCTIVITY RATES 411	
-----	Chapter 27	-----	Appendix D
AVOIDING ERRORS IN ESTIMATES 309		SAMPLE EQUIPMENT COSTS 417	
-----	PART IV	-----	Appendix E
FINALIZING THE BID 313		MODEL SCOPES OF WORK 419	
-----	Chapter 28	-----	Appendix F
SUBMITTING THE BID 314		GLOSSARY 425	
-----	Chapter 29	-----	Appendix G
PROJECT BUYOUT 321		INDEX OF DRAWING SETS 432	
		INDEX 433	



CONTENTS

	PART	I

INTRODUCTION TO ESTIMATING		
	Chapter	1

THE ART OF ESTIMATING		
The Estimator		
Types of Estimates		
Bid Package		
Estimating Tools		
Computerized Estimating		
Conclusion		
Problems		
References		
	Chapter	2

OVERVIEW OF THE ESTIMATING AND BIDDING PROCESS		
Planning the Bid		
Pre-Bid-Day Activities		
Bid-Day Activities		
Post-Bid Activities		
Information Flow		
Conclusion		
Problems		
	Chapter	3

INTRODUCTION TO EXCEL		
Conventions Used in This Text		
Workbook Management		

Working with Worksheets 25
Entering Data 30
Formatting Worksheets 35
Writing Formulas 50
Basic Functions 53
Printing 59
Testing Spreadsheets 65
Conclusion 68
Problems 69

PART II

THE QUANTITY TAKEOFF 71

Chapter 4

FUNDAMENTALS OF THE QUANTITY TAKEOFF 72

Performing a Quantity Takeoff 72
Work Packages 73
Communication with the Field 74
Counted Items 76
Linear Components 77
Sheet and Roll Goods 78
Volumetric Goods 80
Quantity-From-Quantity Goods 80
Waste 81
Building Information Modeling (BIM) 81
Conclusion 83
Problems 83
Reference 83

Chapter 5

CONCRETE 84

Forms 84
Reinforcing 85
Concrete 85
Spread Footings 86
Columns 87
Continuous Footings 90
Foundation Walls 95

Beams	97
Slab on Grade	97
Raised Slabs	99
Stairs	100
Sample Takeoff for the Residential Garage	101
Conclusion	104
Problems	104

Chapter

6

MASONRY 107

Block and Structural Brick Walls	108
Brick Veneer	111
Conclusion	112
Problems	112

Chapter

7

METALS 115

Types of Structural Steel	115
Common Shapes for Structural Steel	115
Beams, Girders, and Columns	116
Joists and Joist Girders	118
Metal Deck	120
Steel Trusses	120
Stairs and Handrail	121
Miscellaneous Steel	122
Conclusion	122
Problems	122

Chapter

8

WOODS, PLASTICS, AND COMPOSITES 126

Floor Systems	126
Walls	131
Roof Systems	137
Finish Carpentry	143
Cabinetry and Countertops	143
Sample Takeoff for the Residential Garage	143
Conclusion	145
Problems	145
Reference	152

Chapter 9

THERMAL AND MOISTURE PROTECTION 153

- Waterproofing and Dampproofing 153
- Building Paper and Vapor Barriers 154
- Insulation 157
- Exterior Insulation Finish System 159
- Shingle Roofs 160
- Siding, Soffit, and Fascia 162
- Membrane Roofing 165
- Sample Takeoff for the Residential Garage 165
- Conclusion 168
- Problems 168
- References 171

Chapter 10

OPENINGS 172

- Doors 172
- Windows 173
- Commercial Storefront 174
- Glazing 175
- Hardware 176
- Sample Takeoff for the Residential Garage 176
- Conclusion 177
- Problems 177
- Reference 180

Chapter 11

FINISHES 181

- Metal Stud Partitions 181
- Gypsum Board 182
- Tile 184
- Suspended Acoustical Ceilings 184
- Wood and Laminate Floors 185
- Sheet Vinyl 186
- Vinyl Composition Tile 187
- Rubber Base 187
- Carpet and Pad 188
- Paint 188
- Sample Takeoff for the Residential Garage 188

Conclusion 189

Problems 189

Chapter **12**

FIRE SUPPRESSION 192

Conclusion 194

Problems 194

Chapter **13**

PLUMBING 196

Water Supply 196

Drain-Waste-and-Vent System 196

Fixtures and Equipment 199

Conclusion 199

Problems 199

Chapter **14**

HEATING, VENTILATION, AND AIR-CONDITIONING (HVAC) 201

Residential HVAC Systems 201

Commercial HVAC Systems 204

Conclusion 206

Problems 206

Chapter **15**

ELECTRICAL 209

Residential Wiring 209

Commercial Wiring 210

Sample Takeoff for the Residential Garage 213

Conclusion 216

Problems 216

Chapter **16**

EARTHWORK 220

Characteristics of Soils 220

Swell and Shrinkage 220

Geometric Method 223

Average-Width-Length-Depth Method 224

Average-End Method 224

Modified-Average-End Method 225

Cross-Sectional Method 226
Comparison of Methods 231
Backfill 231
Soils Report 232
Sample Takeoff for the Residential Garage 232
Conclusion 233
Problems 233

Chapter **17**

EXTERIOR IMPROVEMENTS 236

Asphalt and Base 236
Site Concrete 237
Landscaping 237
Sample Takeoff for the Residential Garage 238
Conclusion 239
Problems 239

Chapter **18**

UTILITIES 242

Excavation 242
Bedding 245
Utility Lines 247
Backfill 247
Conclusion 247
Problems 247

PART **III**

PUTTING COSTS TO THE ESTIMATE 249

Chapter **19**

MATERIAL PRICING 250

Shipping Costs 251
Sales Tax 252
Storage Costs 252
Escalation 252
Conclusion 254
Problems 254

Chapter **20**

LABOR PRODUCTIVITY AND HOURS 255

Factors Affecting Labor Productivity 255
Historical Data 257

Field Observations 257
National Reference Books 260
Labor Hours 260
Conclusion 262
Problems 262
Reference 263

Chapter **21**

LABOR RATES 264

Billable Hours 264
Wages 264
Fair Labor Standards Act 264
Davis-Bacon Act 265
Labor Contracts 265
State and Local Employment Laws 266
Cash Equivalents and Allowances 267
Payroll Taxes 268
Unemployment Insurance 268
Workers' Compensation Insurance 269
General Liability Insurance 270
Insurance Benefits 270
Retirement Contributions 270
Union Payments 271
Other Benefits 271
Annual Costs and Burden Markup 271
Conclusion 273
Problems 273
References 275

Chapter **22**

EQUIPMENT COSTS 276

Depreciation and Interest 276
Taxes and Licensing 277
Insurance 277
Storage 277
Hourly Ownership Cost 277
Tires and Other Wear Items 278
Fuel 278
Lubricants and Filters 279
Repair Reserve 279

Leased Equipment 279
Rented Equipment 279
Conclusion 281
Problems 281

Chapter **23**

CREW RATES 283
Conclusion 285
Problems 285

Chapter **24**

SUBCONTRACT PRICING 286
Request for Quote 286
Writing a Scope of Work 287
Historical 288
Bid Selection 288
Conclusion 288
Problems 289

Chapter **25**

MARKUPS 290
Building Permits 290
Payment and Performance Bonds 291
Profit and Overhead 292
Conclusion 294
Problems 294
Reference 295

Chapter **26**

PRICING EXTENSIONS 296
Detail Worksheet 296
Material Costs 296
Labor Costs 297
Equipment Costs 297
Total Cost 298
Summary Worksheet 298
Sample Estimate: The Residential Garage 301
Conclusion 308
Problems 308

Chapter 27

AVOIDING ERRORS IN ESTIMATES 309

- List Cost Codes 309
- Spend More Time on Large Costs 309
- Prepare Detailed Estimates 309
- Mark Items Counted During the Quantity Takeoff 310
- Double-Check All Takeoffs 310
- Include Units in Calculations 310
- Automate with Spreadsheets 310
- Use Well-Tested and Checked Formulas 310
- Double-Check All Calculations 311
- Perform Calculations in Two Ways 311
- Drop the Pennies 311
- Have Someone Review the Estimate 311
- Review Each Cost Code as a Percentage of the Total Cost 311
- Check Unit Costs for Each Cost Code 311
- Compare Costs to Those for Another Project 311
- Allow Plenty of Time 312
- Conclusion 312
- Problems 312

PART IV

FINALIZING THE BID 313

Chapter 28

SUBMITTING THE BID 314

- Bid Submission With Standardized Documents 314
- Writing a Proposal 314
- Writing a Business Letter 317
- Letter Formats 318
- Writing E-Mails 318
- Conclusion 320
- Problems 320

Chapter 29

PROJECT BUYOUT 321

- Subcontracts 321
- Purchase Orders 323
- Contracts for Materials 324

Conclusion 324

Problems 324

Chapter **30**

THE ESTIMATE AS THE BASIS OF THE SCHEDULE 325

Estimating Durations 326

Sample Durations: The Residential Garage 326

Conclusion 327

Problems 327

Chapter **31**

ETHICS 328

Work Ethic 328

Bidding Practices 328

Loyalty to Employer 329

Ethical Dilemmas 329

Conclusion 329

Problems 329

Reference 330

PART V

ADVANCED ESTIMATING 331

Chapter **32**

CONVERTING EXISTING FORMS 332

Creating the Layout 332

Adding Formulas 333

Automating with Macros 335

Testing the Worksheets 340

Adding Error Protection 341

Conclusion 351

Problems 351

Chapter **33**

CREATING NEW FORMS 352

Planning New Forms 352

Setting Up the Spreadsheet 356

Series 358

Naming Cells 361

Adding Dropdown Boxes 362

Referencing Worksheets in a Formula 366

Concatenate 367

Lookup and Vlookup 371
 Proposals 376
 Conclusion 379
 Problems 379

Chapter **34**

OTHER ESTIMATING METHODS 381

Design Process 381
 Delivery Methods 382
 Project Comparison Method 382
 Square-Foot Estimating 386
 Assembly Estimating 389
 And Beyond 391
 Conclusion 391
 Problems 391
 Reference 392

Appendix **A**

REVIEW OF ESTIMATING MATH 393

Lengths 393
 Scaling 394
 Pythagorean Theorem 395
 Areas 396
 Volumes 402
 Conversion Factors 404

Appendix **B**

SAMPLE JOB COST CODES 406

Appendix **C**

SAMPLE LABOR PRODUCTIVITY RATES 411

Appendix **D**

SAMPLE EQUIPMENT COSTS 417

Appendix **E**

MODEL SCOPES OF WORK 419

Footings and Foundations 419
 Framing 419
 Finish Carpentry 420
 Drywall 420
 Floor Coverings 421
 Painting and Staining 421
 Fire Sprinklers 422

Plumbing 422

HVAC 423

Electrical 423

Earthwork and Utilities—Roads and Parking Lots 424

Landscaping 424

Appendix

F

GLOSSARY 425

Appendix

G

INDEX OF DRAWING SETS 432

INDEX 433

PART ONE

INTRODUCTION TO ESTIMATING

- Chapter 1** The Art of Estimating
- Chapter 2** Overview of the Estimating and Bidding Process
- Chapter 3** Introduction to Excel

In this section, you will be introduced to the art of estimating, the estimating process, and Microsoft Excel 2016. These chapters will prepare you for the rest of the book. For those of you who struggle with math or just want to review the mathematical principles used in estimating, a review of estimating math is given in Appendix A.

THE ART OF ESTIMATING

In this chapter you will be introduced to the art of estimating. You will learn what it takes to become a good estimator, the components of a bid package, and the tools used by an estimator. Finally, you will be introduced to computerized estimating.

Estimating is the process of determining the expected quantities and costs of the materials, labor, and equipment for a construction project. The goal of the estimating process is to project, as accurately as possible, the estimated costs for a construction project, as well as the required amount of materials, labor, and equipment necessary to complete the work. The American Institute of Architects defines the work as “the construction and services required by the Contract Documents . . . and includes all other labor, materials, equipment and services provided . . . by the Contractor to fulfill the Contractor’s obligations.”¹ The work is often referred to as the *scope of work*.

Estimating plays a key role in the operation of construction companies. Accurate estimates are needed for a company to be successful in the bidding process while maintaining a reasonable profit margin. If the estimates are too high, the company may starve to death because of the lack of work. If the estimates are too low, the company may lose money and go bankrupt. The estimator is constantly walking a fine line between bidding too low and too high.

THE ESTIMATOR

The estimator is the person responsible for preparing the cost estimates. Large companies may employ an estimating department with one or more full-time estimators. The estimating department is often charged with preparing all of the company’s estimates. In smaller companies,

the project managers or the company’s owner may be responsible for preparing the estimates. Regardless of their job title, employees who are responsible for preparing estimates are estimators. The estimator is responsible for seeing that the estimate accurately determines the quantity of materials, labor, and equipment and incorporates the costs to complete the required scope of work along with a reasonable profit while remaining competitive with other firms in the market. Great skill is required to balance the need to be competitive with the need to be profitable.

To be a good estimator a person must possess the following skills:

- An estimator must have a sound understanding of the construction methods, materials, and the capacities of skilled labor. Because of the great variety of work, it is impossible for an estimator to be versed in all forms of construction. Therefore, an estimator must specialize in one or more areas of construction. An estimator may specialize in a subcontractor trade such as electrical, mechanical, or excavation. An estimator may also specialize in an area of construction such as residential, tenant finish, or highway construction. Because the methods of construction, the preferred materials of construction, and the skill of labor vary from market to market, estimators must also specialize in a specific market area, such as a state or region.
- An estimator must possess the basic skills needed to determine the quantities of materials, labor, and equipment necessary to complete a project. This requires the estimator to read blueprints, understand the design that the architect or engineer has specified, and determine the quantities needed to complete the project. Because much of an estimator’s time is spent working with quantities, estimators must have strong mathematical skills. A review of estimating math is given in Appendix A.

- An estimator must be a good communicator, both verbally and in written form. Part of an estimator's job is to obtain pricing from vendors and subcontractors. To do this, the estimator must convince vendors and subcontractors to bid on projects, communicate what pricing is needed, and—when the company has won the job—communicate the responsibilities of the vendors and subcontractors in the form of purchase orders and subcontracts provided to the vendor, subcontractor, superintendent, and so forth. Estimators may also be required to present estimates to owners—which requires good presentation skills—or prepare proposals—which requires good writing skills.
- An estimator must possess strong computer skills. Much of today's estimating is performed using computer software packages, such as Excel, takeoff packages such as On-Screen Takeoff, and estimating software packages. Estimators also need to be able to prepare contracts, proposals, and other documents using a word processing program.
- An estimator must be detail-oriented. Estimators must carefully and accurately determine the costs and quantities needed to complete the project. Simple mistakes—such as forgetting that the drawings are half-scale or not reading the specifications carefully enough to realize that an unusual concrete mix has been specified—can quickly turn a successful project into an unprofitable job and, in extreme cases, bankrupt a company.
- An estimator must have the confidence to quickly prepare takeoffs and make decisions under pressure. Bid days are hectic. Many vendors and subcontractors wait until the last hour to submit their bids. As the time of the bid closing approaches, the estimator must compare and incorporate new pricing as it is received and fill in missing pricing with limited time and information at his or her disposal. Making a bad decision or failing to make a decision under pressure can cause the company to lose the bid or take an unprofitable job.
- Finally, an estimator must have a desire for constant improvement. One way to do this is to get involved with a professional organization such as the American Society of Professional Estimators (ASPE). Other ways include studying other estimating books and attending seminars. Much of a company's success or failure rides on the abilities of the estimator to obtain profitable work.

Because of the high degree of uncertainty in estimating costs, estimating is more of an art than a science. As with any art, only by practicing can one become a good estimator. One would not expect to become a good pianist after a few lessons. It takes practice. Likewise, becoming a good estimator takes practice. But practice is not enough. Practicing bad estimating skills will only turn a person into a bad estimator. Truly, practice makes permanent.

To be a good estimator, a person must practice using good estimating skills; and for a person to practice good estimating skills, he or she must have a sound understanding of the fundamental principles of estimating. This understanding can only be obtained by studying the art of estimating.

If you want to become a good estimator, it is very important to study and practice estimating. The following is a list of things that you can do as you read this book to become a good estimator:

- Carefully read each chapter. The chapters provide you with explanations of the basic principles of estimating.
- As you read each example problem, check the math with a calculator. This will help you to gain a greater understanding of the estimating principles.
- Many of the quantity takeoff problems can be solved using the five methods (counted items, linear components, sheet and roll goods, volumetric goods, and quantity-from-quantity goods) found in Chapter 4. Be sure that you completely understand each of these methods. As you read each chapter, keep a list of which of the five methods to use for each problem type and how each problem type differs from the general methods covered in Chapter 4.
- When reading the example problems that are based upon the garage drawings that accompany this book, refer to these drawings and see if you can get a similar quantity of materials. Minor differences will occur due to difference in rounding.
- Complete all of the computer exercises and sidebars. Take existing sidebars and customize them to your estimating situation. This will help you to become proficient with Excel.
- Work all of the problems at the end of the chapters. Have your instructor or a fellow estimator look over your solutions. These problems have been provided to give you practice in solving simple estimating problems.
- Prepare complete estimates for the Johnson Residence and West Street Video projects listed in Appendix G. Have your instructor or a fellow estimator look over your estimate. (The loose project drawings are provided in a separate package shrink-wrapped to this text.)

In addition to these things, practice estimating whenever you get the chance. Volunteer to help an estimator with his or her estimate. Ask questions of fellow estimators. Remember, learning to estimate takes time.

TYPES OF ESTIMATES

There are three common types of estimates. They are the conceptual estimate, preliminary estimate, and final or detailed estimate.

The conceptual estimate is an estimate prepared while the project is still in a conceptual state. The conceptual

estimate is used to study the feasibility of a project or to compare two potential design alternatives (for example, a concrete structure versus a steel structure or three stories versus four stories). These estimates are based on a description of the project or on very limited drawings and as such are the least accurate type of estimate.

The preliminary estimate is an estimate prepared from a partially completed set of drawings. A preliminary estimate is often performed when the drawings are 35% to 50% complete and is used to check to see if the proposed design is on budget and to identify changes to the design that need to be made to meet the budget. Preliminary estimates may be performed any time before the bid. Preliminary estimates are more accurate than conceptual estimates because more information about the design is available.

Chapter 34 covers three estimating methods—project comparison, square-foot, and assembly estimating—that may be used to prepare conceptual and preliminary estimates.

Final or detailed estimates are used to prepare bids and change orders, order materials, and establish budgets for construction projects. They are prepared from a complete or nearly completed set of drawings and are the most accurate type of estimate.

Sometimes shortcut methods (methods which produce a close, but less accurate answer) are used to prepare bids in order to bid more projects in less time. This may save time during the bidding process, but can cause cost-control problems for the company. When shortcut methods are used to order materials, the wrong materials or wrong quantities are often delivered to the site, which results in delays and increased construction costs. When a shortcut method produces a quantity within a few percent of the correct answer, it is hard to determine if a quantity overrun is due to poor material use in the field or inaccuracy in the estimating process. Similarly, when a quantity underrun occurs, it is unclear if it is due to good material use in the field or inaccuracy in the estimating process. For cost-control purposes, it is important to have an accurate quantity and cost estimate for all items, including an estimate for both unavoidable and avoidable waste. Unavoidable waste is waste that is a result of the difference between design dimensions and the size of materials. For example, when carpeting a nine-foot by nine-foot room with carpet that comes in 12-foot-wide rolls, you will have a three-foot-wide strip of waste unless it can be used elsewhere. Avoidable waste is waste that can be avoided by good use of materials in the field. It is not uncommon to have one framing crew use 5% more materials to frame the same house as another crew. The extra materials used are avoidable waste. Avoidable waste also includes materials that are damaged or destroyed on the job.

The primary focus of this book is on preparing accurate final or detail estimates, although many of these principles apply to conceptual and preliminary estimates.

BID PACKAGE

Estimates are prepared from bid packages. The bid package defines the scope of work for the construction project. A well-developed bid package includes a set of plans and a project manual.

The plans graphically show building dimensions and where different materials are used. The process of converting the building dimensions and details into estimated quantities is known as the quantity takeoff. The estimator will prepare the bid from the quantity takeoff. Typically, the plans are organized as follows: civil plans, architectural plans, structural plans, mechanical and plumbing plans, and electrical plans. The project manual provides a lot of information for the bidder. The typical project manual includes the following items:

Invitation to Bid: The purpose of the invitation to bid is to invite bidders to bid on the project and give a bidder enough information to decide whether he or she wants to bid on the project. Often, public agencies are required to invite all qualified bidders to bid on the work. This is typically done by posting the invitation to bid in a few predetermined locations (for example, the local library and the public agency's office) and by printing it in the local newspaper. The invitation to bid is also placed at the front of the project manual. The invitation to bid provides a project description, contact information for the owner and design professional (architect or engineer), bid date, restrictions on bidders, expected price range, and the expected duration of the project.

Bid Instructions: Bid instructions are instructions that must be followed to prepare a responsive bid. The goal of the bid instructions is to help the bidders provide a complete bid with all the necessary documents (for example, bid bond and schedule of values). Bidders may be disqualified for not following these instructions, which may result in a bidder losing the job even though he or she was the lowest bidder.

Bid Documents: Public agencies and owners typically use standard forms for the submission of the bid. These forms may include bid forms, bid-bond forms, a schedule of values, and contractor certifications. A sample bid form is shown in Figure 1-1. The bid bond is discussed in the next paragraph. The schedule of values breaks the bid into smaller portions and is used to determine and evaluate the amount of the progress payments. A sample schedule of values is shown in Figure 1-2. Estimators should read these documents carefully and comply fully with their requirements. Bidders can be disqualified for not submitting all of the required bid documents.

Bonds: Bonds include the bid bond, the payment bond, and the performance bond. Bonds are issued

Bid Form

Owner: West Street Video John M. Smith, President P.O. Box 1256 Ogden, Utah 84403	Project: West Street Video 4755 S. West Street Ogden, Utah 84403
---	---

Dear Sirs:

Having carefully examined the bid documents including the plans, specifications, and other related documents; visited the proposed site of the work; and being familiar with other conditions surrounding construction of the proposed project including the availability of material and labor, the undersigned proposes to furnish all labor, material, equipment, supplies, tools, transportation, services, licenses, fees, permits, sales tax, and so forth required by the bid documents for the sum of

\$ _____ dollars (\$ _____).

The undersigned also agrees to complete the work in 150 calendar days.

We acknowledge the following addenda: _____

Enclosed is a _____ (bond or check), as required, in the sum of 5% of the bid.

This bid shall remain good for 60 days after the bid opening.

Respectfully Submitted:

SEAL (if a Corporation)	Company _____
	By _____
	Address _____

	License No. _____
	Date _____

FIGURE 1-1 Bid Form

by sureties. Bid bonds are provided by the contractor at the time of the bid. The bid bond guarantees that the contractor—should he or she be the lowest bidder—will sign the contract and provide the payment and performance bonds. The payment and performance bonds are provided when the contract for the work is signed. The payment bond guarantees that the vendors, subcontractors, and labor will be paid for the work they perform on the project. In the event that the vendors, subcontractors, and labor are not paid on the project, the surety will step in and make the necessary payments. The performance bond guarantees that the contractor will complete the construction project. In the event that the contractor fails to complete the project, the surety will step in and complete the project. Providing payment and performance bonds can increase the costs of the project by 1% to 2%.

Contract: Public agencies and owners often use standard contracts. Estimators should read the

contract carefully and include any costs associated with meeting the terms of the contract in their bid.

General Conditions: Public agencies and owners often use standard general conditions. General conditions affect the cost to complete the work. The general conditions identify the relationships among the owner, design professionals, and the contractor and addresses provisions that are common to the entire project; for example, how changes in the scope of work are to be processed or the need for cleanup. Estimators should read the general conditions carefully and include any costs associated with the general conditions in their bid.

Special Conditions: Special conditions are additional conditions that apply to this specific project. Like the general conditions, the special conditions affect the cost to complete the work. Estimators should read the special conditions carefully and include any costs associated with the special conditions in their bid.

Schedule of Values	
General Requirements	\$ _____
Grading and Excavation	\$ _____
Utilities	\$ _____
Asphalt	\$ _____
Site Concrete	\$ _____
Landscaping	\$ _____
Concrete	\$ _____
Masonry	\$ _____
Rough Carpentry	\$ _____
Finish Carpentry	\$ _____
Cabinetry and Countertops	\$ _____
Insulation	\$ _____
Roofing	\$ _____
Doors and Windows	\$ _____
Finishes	\$ _____
Plumbing	\$ _____
Fire Sprinklers	\$ _____
HVAC	\$ _____
Electrical	\$ _____
Total	\$ _____

FIGURE 1-2 Schedule of Values

Technical Specifications: Technical specifications identify the quality of materials, installation procedures, and workmanship to be used on the project. The specifications also specify the submittal and testing requirements for individual building components. Estimators must read these carefully and understand their implications. Bidding the wrong specification can lead to losing the bid unnecessarily or winning a bid that you do not have sufficient funds to complete. The specifications are typically organized according to the MasterFormat.² The 2004 edition expanded the MasterFormat from 16 divisions to 50 divisions (00 to 49).³ The 2016 MasterFormat is organized as follows:

Division 00: Procurement and Contracting Requirements

Division 01: General Requirements

Division 02: Existing Conditions

Division 03: Concrete

Division 04: Masonry

Division 05: Metals

Division 06: Wood, Plastics, and Composites

Division 07: Thermal and Moisture Protection

Division 08: Openings

Division 09: Finishes

Division 10: Specialties

Division 11: Equipment

Division 12: Furnishings

Division 13: Special Construction

Division 14: Conveying Equipment

Division 21: Fire Suppression

Division 22: Plumbing

Division 23: Heating, Ventilating, and Air Conditioning (HVAC)

Division 25: Integrated Automation

Division 26: Electrical

Division 27: Communications

Division 28: Electronic Safety and Security

Division 31: Earthwork

Division 32: Exterior Improvements

Division 33: Utilities

Division 34: Transportation

Division 35: Waterway and Marine Construction

Division 40: Process Interconnections

Division 41: Material Processing and Handling Equipment

Division 42: Process Heating, Cooling, and Drying Equipment

Division 43: Process Gas and Liquid Handling, Purification, and Storage Equipment

Division 44: Pollution and Waste Control Equipment

Division 45: Industry-Specific Manufacturing Equipment

Division 46: Water and Waste Equipment

Division 48: Electrical Power Generation

Other Inclusions: Other documents such as a soils report and environmental inspections may be included in the project manual. The soils report describes the soil conditions and the water table at the construction site, which greatly affect the excavation costs. Estimators should take this information into account when preparing an estimate for a project.

Included by Reference: Other documents may be included in the specifications by reference. Documents included by reference are not physically attached to the project manual but are treated as if they were. Documents that are often included by reference include standard agency specifications and other readily available standards (for example, American Society for Testing and Materials [ASTM] and American National Standards Institute [ANSI] standards). Estimators need to understand the implication of these standards because they affect how the work is performed or are used to determine compliance with a specification.

ESTIMATING TOOLS

The estimator has a number of tools at his or her disposal to help prepare the estimate. They range from simple paper forms to powerful estimating computer programs. An estimator's tools include the following:

Architect's and Engineer's Scales: Plans are prepared at a reduced scale. Architect's and engineer's scales allow the estimator to measure dimensions from the plans. The architect's scale typically includes the following scales: $1'' = 1'$, $1/2'' = 1'$, $1/4'' = 1'$, $1/8'' = 1'$, $3/16'' = 1'$, $3/32'' = 1'$, $3/4'' = 1'$, $3/8'' = 1'$, $11/2'' = 1'$, and $3'' = 1'$. The engineer's scale typically includes the following scales: 1:10, 1:20, 1:30, 1:40, 1:50, and 1:60. Architect's and engineer's scales are shown in Figure 1-3.

Plan Measurer: A plan measurer or wheel measures the length of a line by rolling the wheel of the measurer along the item to be measured. A plan measurer has the advantage of being able to follow curved lines more easily than an architect's or engineer's scale. Analogue plan measurers

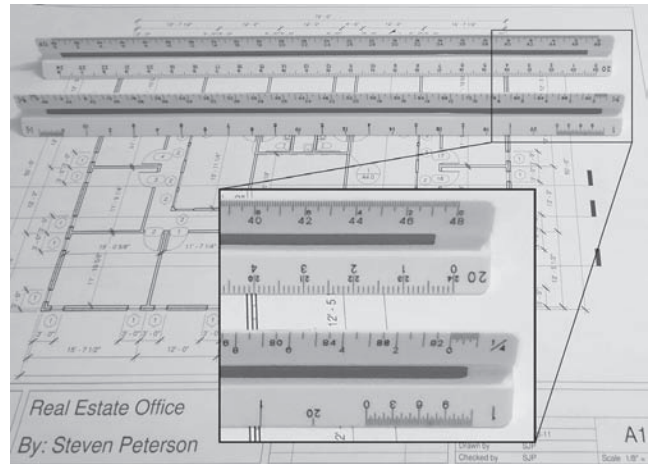


FIGURE 1-3 Architect's Scale (bottom) and Engineer's Scale (top)

have fixed scales, such as $1/2'' = 1'$, $1/4'' = 1'$, and $1/8'' = 1'$; digital plan measurers have more scales available and often include the ability to create custom scales. A digital plan measurer is shown in Figure 1-4.

Digitizer: A digitizer consists of an electronic mat and stylus or puck. The digitizer can measure distances and areas. The digitizer may operate as a stand-alone tool or be connected to a software package. Digitizers have an unlimited number of scales and can perform mathematical functions on distances and areas. A digitizer is shown in Figure 1-5.

Takeoff Packages: The digitizer is being replaced by takeoff packages, such as On Center Software's On-Screen Takeoff and Trimble's Paydirt that allows the user to determine the quantity of material needed from a digital set of drawings. These software packages make determining the length, perimeter, area, and volume quick and easy. On-Screen Takeoff will even allow the user to determine the length of the perimeter, number of tiles, and length of grid needed for a dropped acoustical ceiling by having the estimator trace the



FIGURE 1-4 Digital Plan Measurer

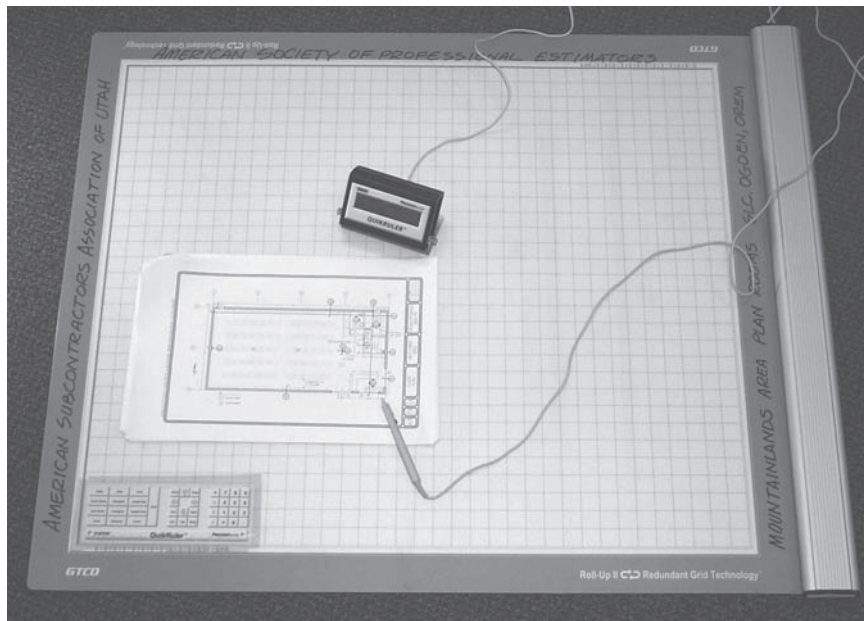


FIGURE 1-5 Digitizer

perimeter of the ceiling. These software packages can be integrated with spreadsheet or other estimating packages.

Building Information Modeling Software: An up and coming trend in the architectural, engineering, and construction (AEC) community is to design buildings using building information modeling (BIM) software, which allows the building to be designed in 3D. Many BIM software packages, such as Autodesk's Revit®, allow estimators to extract quantities from the model.

iPad and Plan Tables: Often the plans and project manuals are available in a digital format, such as pdf file. iPads and larger format plan tables are becoming common tools for the estimator.

Calculator and Paper Forms: In the days before computers, most estimates were prepared by using paper estimating forms and calculators. Some estimates are still prepared in this way, particularly estimates that are prepared in the field; however, with iPads, laptop computers, and portable printers, even paper estimates in the field are being replaced by computerized estimates.

Spreadsheets: With the increased use of computers in the construction industry and spreadsheet programs such as Excel, many companies have converted their estimating forms into computer spreadsheets. Spreadsheets have the advantage of automating the calculations and allowing the estimator to see the effects of minor changes in seconds. Developing spreadsheets for use in estimating is covered in Part V of this book.

Estimating Software: Estimating software packages, such as Trimble WinEst, combines the advantages

of a computer spreadsheet with a database. This automates the estimating even further. Estimating software has the additional advantage of being capable of taking off assemblies as a single item. For example, an estimator can take off a wall assembly that includes the top and bottom plates, the studs, insulation inside the wall, and the finish material on both sides of the wall as a single component. Estimating software also allows the estimator to print the bid information in different formats for different uses with little or no setup.

COMPUTERIZED ESTIMATING

Nothing has revolutionized estimating as much as the advent of computers along with spreadsheets, estimating software, and takeoff packages. If used correctly, computers can reduce the time needed to prepare an estimate and decrease the errors in the estimate. If used improperly, they can increase the number of errors in an estimate and decrease the usefulness of the estimate. There are two dangerous mistakes estimators make when using estimating packages.

The first mistake is to turn the thinking over to the computer so the estimator becomes simply a means of entering data into the software package. This happens when the estimator determines the quantity of a given component and enters it into the computer without giving any thought to job conditions and design requirements that may require this component to be handled in a different way than it is usually handled. For example, a hollow-metal door frame for a pair of doors that must be delivered to the tenth floor of an office building up a small elevator must be constructed in pieces and fabricated on site, whereas most door frames are constructed

as a single member. Computers are good for performing repetitive tasks quickly without error. They are good for handling the mindless and boring tasks such as totaling a column for the umpteenth time. Estimators can make a minor change to an estimate and the computer will calculate the changes to the estimate almost instantaneously.

Another danger of just entering data into the computer is that computer spreadsheets and formulas in estimating packages are developed for a limited number of circumstances based on a set of assumptions made by the writer of the spreadsheet or formula. Whenever the estimator uses the spreadsheet or formula on a situation that is outside the conditions anticipated by the developer, the estimator may get an inaccurate estimate from the spreadsheet or formula. To protect against this, the estimator must have an understanding of the limits and design of the spreadsheet or formula and must make sure the spreadsheet's or formula's response is reasonable.

The second mistake is to create a new spreadsheet or formula and use it without properly testing it. After creating a spreadsheet or formula, the developer should test the spreadsheet or formula to make sure it is working properly, not only on the situation that it was developed for, but on other conceivable situations. In addition, the developer should try to make the spreadsheet or formula mess up and then build in ways to prevent other users from making the same mistakes by building in error-checking procedures.

Excel is the most popular estimating package. In a survey performed by the American Society of Professional Estimators, 29% of the respondents reported using Excel as their estimating software, 22% reported using Timberline (now Sage Estimating), and 25% reported using another estimating software package such as WinEst (by Trimble) and HeavyBid (Heavy Construction System Specialists, Inc.).⁴ Users of estimating packages commonly augment the software package with Excel worksheets to assist in the quantity takeoff and other support functions.

Spreadsheets have the advantage of being inexpensive. Spreadsheet software can be purchased for about \$100 and is often included along with other standard applications—such as word processing—that are sold

as a software package for use in offices. In addition to being inexpensive, spreadsheets are easily adapted to the existing style and estimating procedures of the company. A company that uses paper forms can easily create a look-alike form in the spreadsheet and let the software perform the mundane and tedious calculations. Finally, spreadsheets are easy to create. With a little training and effort, anyone can develop spreadsheets for estimating. Developing spreadsheets for estimating in Excel is covered in Part V of this book.

Estimating software packages are powerful computer software applications that have been developed specifically for estimating. There are a number of packages available, with some packages having been designed for building construction and others for heavy and highway construction that involves large amounts of earthwork. Estimating software packages have the advantage of automating the takeoff process and decreasing the time it takes to prepare an estimate by combining a spreadsheet with a database. The database contains a list of standard items along with their cost, labor productivity, labor rates, equipment costs, and formulas used to calculate the quantities and costs of the individual items. Estimating packages often allow the user to create assemblies—a group of items that are needed to create a component such as a wall—and take off the assembly in a single step. Another feature of estimating packages is that the data can be easily manipulated and printed in different formats.

For example, one can print the costs by line item with the sales tax appearing at the bottom of the report or one can have the sales tax allocated to the individual line items. All these features come at a price. Estimating software packages are more expensive than spreadsheets—often costing thousands of dollars. In addition to the dollar costs, they require a large time investment to set up and maintain the database. The pricing in the database must be kept current with market pricing, materials must be set up, formulas must be written and tested, and assemblies must be created. Companies must perform large amounts of estimating to justify the cost and time commitment involved in using an estimating software package.

CONCLUSION

Successful estimates are the lifeblood of a construction company. Winning bids while maintaining a good profit margin is necessary for a construction company to succeed. Accurate quantities and costs are needed for strong cost controls. To be a good estimator, a person must study and practice sound principles of estimating. Computers have greatly changed the way estimators prepare estimates. Computers and software packages, if used properly, can

increase the productivity of the estimator while decreasing errors. Estimating software includes spreadsheet packages such as Excel, estimating software such as WinEst and takeoff packages such as On-Screen Takeoff.

PROBLEMS

1. Define estimating.
2. Define work or scope of work.