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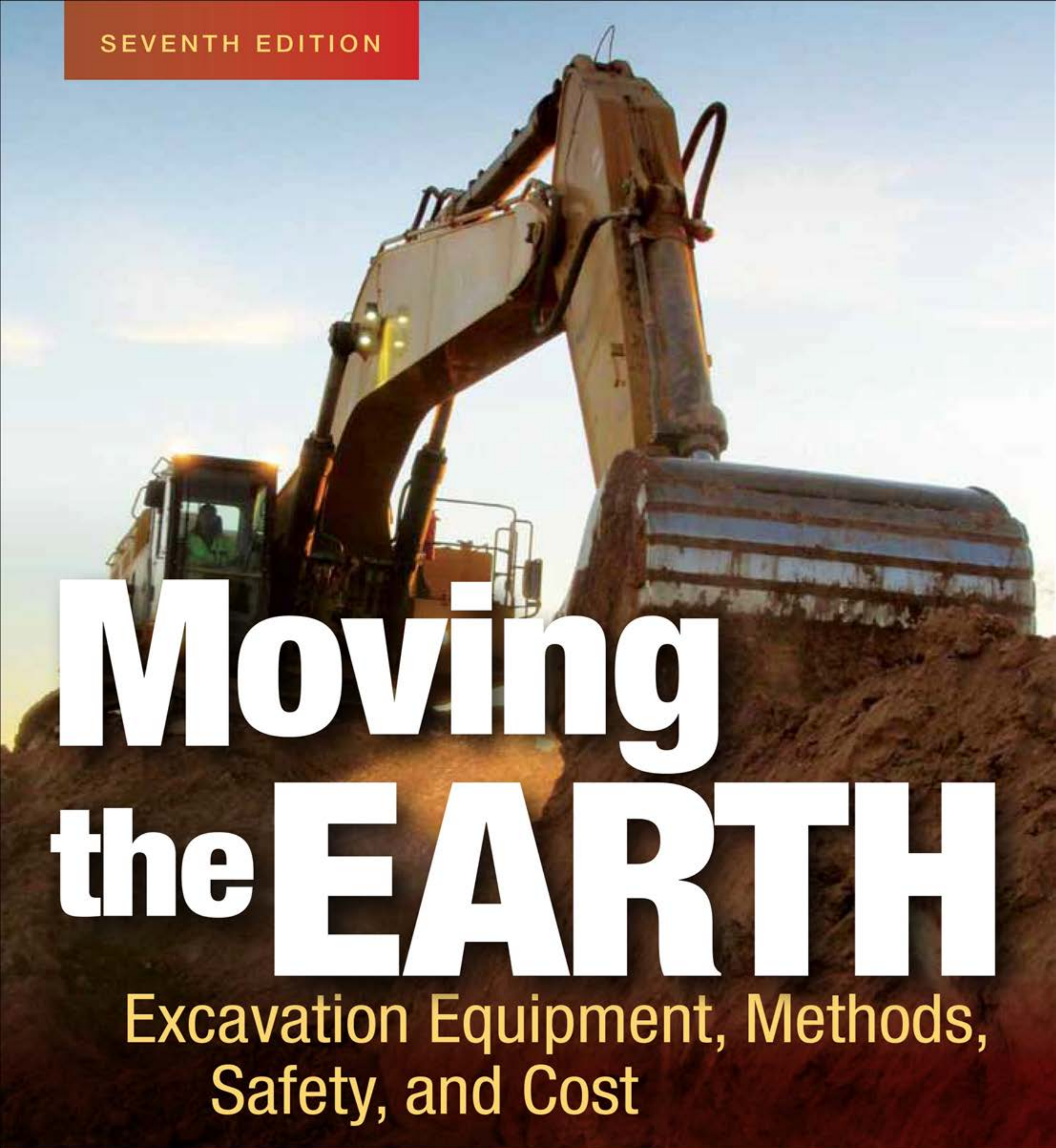

Moving the EARTH

Excavation Equipment, Methods, Safety, and Cost

ROBERT L. **SCHMITT** | CLIFFORD J. **SCHEXNAYDER**
AARON **COHEN** | HERBERT L. **NICHOLS, JR** | DAVID A. **DAY**

Mc Graw Hill Education

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PREFACE TO THE SEVENTH EDITION

Construction techniques and equipment are constantly evolving. This seventh edition of *Moving the Earth* captures many of the machine advances and technologies showcased at the 2017 CONEXPO-CON/AGG, together with the experiences of the author team as we visited projects both in the United States and internationally since publication of the sixth edition. Most machines work in combination with others, such as an excavator loading trucks, so the text emphasizes the importance of thinking in terms of linked systems. Because machine technology continually evolves, a contractor must stay abreast of machine improvements to remain successful in determining the most economical grouping of machines.

This edition describes in detail how to investigate equipment productivity, understand linked system productivity, and perform step-by-step calculations to determine system productivity. Skill in work task analysis, together with familiarity with appropriate machine applications, is imperative to successfully completing an earthwork project. Machines are designed for specific tasks and are economical only when used in the proper manner.

Important changes have been made to this edition:

- Calculating machine ownership and operating costs is presented in detail.
- Earthwork quantity takeoff and development of earthwork estimates are consolidated in a single chapter.
- Soil and rock are explained in terms of their engineering properties.
- Machine power is described based on rolling and grade resistance to movement.
- Operational capabilities of machines by type characteristics are detailed, and methods for calculating productivity with sample calculations are presented. (Based on best professional practices, we have tried to present standard formats for analyzing production.)

To improve the organization and presentation of concepts, all chapters have undergone revision or consolidation. Numerous photographs are now used to illustrate the latest equipment and methods. Safety concerns are highlighted when discussing specific machines. Construction equipment is manufactured globally in a dynamic market setting, so we have searched worldwide for the latest ideas and trends in machine technology.

Many individuals and firms have supplied information and illustrations for this work, and we owe them a great debt of gratitude. Others have freely given of their time to explain important machine concepts; their kindness is sincerely appreciated. However, full responsibility for all content rests with the author team.

We solicit comments on this edition.

Robert L. Schmitt, P.E.
Clifford J. Schexnayder, P.E.
Aaron B. Cohen, CPC

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CHAPTER 1

TOOLS AND TASKS— PRIDE AND REALITY

Men and machines, moving earth and rock, transform a project plan into reality. This book describes the fundamental concepts of machine utilization and how to economically match machine capability to specific earth-moving requirements. Because careful planning is of critical importance to a contractor's ability to survive in the marketplace, the second objective of this book is to explain how to plan the execution of earth-moving tasks.

REALITY

Reality or myth, the constructor who moves the earth with big machines is an illiterate character with muddy boots and a hard hat covering an even harder head. But there is also a glorious side: the constructor who moves the earth is a proud craftsman. The truth is somewhere between illiterate and pride, for an uncertain Mother Nature may bless you with sunshine or rain (Fig. 1.1), and those who work moving the earth are gamblers with guts and a developed skill for mastering the vagaries of nature. All successful earthmovers soon come to possess a humbleness and respect for the awe and unknown quantity of Mother Nature.

Before William S. Otis, working for the Philadelphia contracting firm of Carmichael & Fairbanks, built the first practical steam shovel excavating machine in 1837 (Fig. 1.2), all movement of the rock and soil was a challenge. Men many centuries before were dreaming of machines to move the earth. Giovanni Fontana in 1420 diagramed his dream of a mechanical dredging machine. The "Yankee Geologist," as Otis's machines were called, was his mechanical answer to moving the earth on an 1838 railroad project south of Boston, Massachusetts. Development of the steam shovel was driven by a demand for an economical mass excavation machine to support the era of railroad construction. Similarly the Cummins diesel engine was developed in the early 1900s as the road-building phase of earthwork construction began. In the short-term future, the basic machine frame will not change, but productivity, accuracy, and utility should improve because of enhancements. Machines will possibly evolve into mobile counterweights driven by an energy-efficient and environmentally friendly power plant. Machines may become mobile counterweights, simply a work platform for an array of hydraulic tools. Basic engineering tenets of leverage, torque, tension, and force will be boldly built into early three-dimensional machinery following the lead of William Otis.

FIGURE 1.1 A dozer in the throes of Mother Nature's mud.

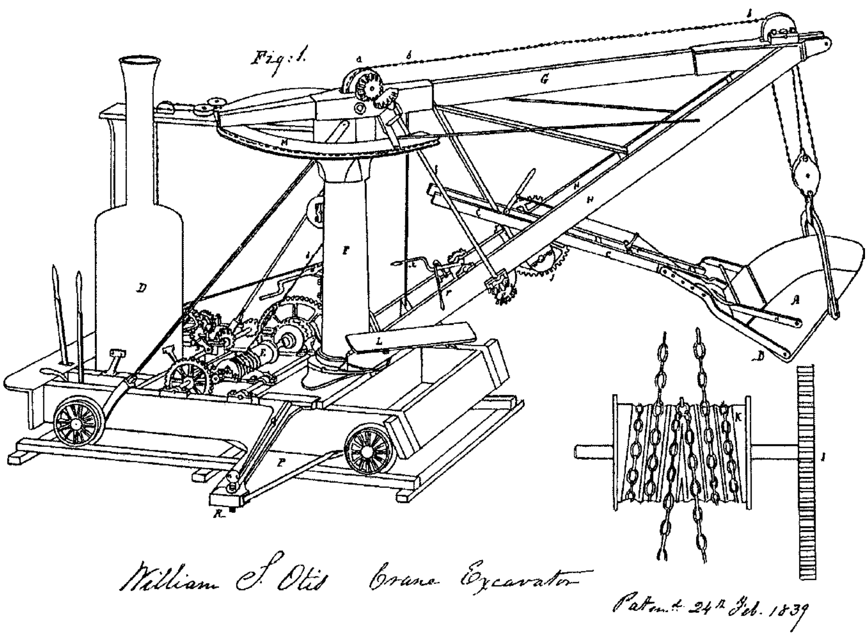

FIGURE 1.2 The William S. Otis steam shovel patent drawing.

Another part of folklore describes the proud earthmover as rolling in high profits and a consumer of large quantities of hard drink. And again the reality is very different. The high contractor failure rate quickly disproves the first notion, and for those who fail to carefully plan their earth-moving operations and monitor financial performance, maybe the drink is the result of despair. To overcome the vagaries of nature, all who succeed with a profit belong to a fraternity steeped in attention to careful planning and the deployment of superior cost analysis tools. Preparing accurate cost estimates is part of every successful earthmoving project won by competitive bidding. Still, for every contract awarded, a group of four or five other earth-moving contractors will say the price was too low! There may be mud on the boots, but the triumph of bringing a job in on time and budget goes to those who

- Understand machine capabilities
- Appreciate the physical characteristics of rock and dirt, both in its natural state and when manipulated
- Prepare detailed work plans
- Spend time studying contract language
- Carefully read cost reports

These are the subjects this text will scrutinize and explain in detail.

EARTH-MOVING EQUIPMENT

One of the most obvious problems in constructing a project is how to transport and manipulate rock and dirt. Machines provide the economical solution to this problem. The proof of how well the planner understands the work to be accomplished and selects appropriate machines is revealed by counting the money when the contract is completed. Did the company make a profit or sustain a loss?

From the time man first decided to build a simple structure for protection from the elements, to the inspiring construction achievements of the Pyramids, the Great Wall of China, the temples at Angkor Wat in Cambodia, and up until the middle of the nineteenth century, earthwork was accomplished by the muscle of man and beast. When New York State began excavating the Erie Canal on July 4, 1817, men bent to the task of digging the trench by the strength of their arms. The first mechanization—earth-moving machines—came with railroad construction in the late 1830s. The steam shovel transformed how projects were planned and executed.

The Bucyrus Foundry and Manufacturing Company came into being because of railroad building. Between 1885 and 1897 approximately 70,000 miles of railway were constructed in the United States. Later the Bucyrus shovels would be one of the key machines responsible for the Americans' success in completing the Panama Canal.

Internal Combustion Engines

By 1890 many companies had begun experimenting with gasoline engine–powered carriages using Nikolaus Otto's patented four-cycle gasoline engine. The Best Manufacturing Company (the predecessor to Caterpillar, Inc.) demonstrated a gasoline tractor in 1893. The first application of the internal combustion engine to excavating equipment occurred in 1910 when the Monighan Machine Company of Chicago shipped a dragline powered by an Otto engine to the Mulgrew-Boyce Company of Dubuque, Iowa. Henry Harnischfeger brought out a gasoline engine–powered shovel in 1914. C. L. "Clessie" Cummins, working out of an old cereal mill in Columbus, Indiana, developed his diesel engine in the early 1900s, and after World War I, the diesel engine began to appear in excavators. Warren A. Bechtel built a reputation as a successful railroad grading contractor. He pioneered the use of motorized trucks, tractors, and diesel-powered shovels in construction.

The Boulder Dam project (later named the Hoover Dam) was a colossal proving ground for construction equipment and techniques. With R. G. LeTourneau's development in the Nevada desert of welded equipment and cable-operated attachments, the use of bolted connections for joining machine pieces together came to an end. LeTourneau, fostering innovations in tractor/scraper design, made possible the machines later used to build airfields around the world during World War II. At the massive Hoover Dam project, sophisticated aggregate production plants were introduced, as well as the use of long-flight conveyor systems for material delivery.

Significant Developments

Torque converter A fluid-type coupling that enables an engine to be somewhat independent of the transmission.

After World War II, the interstate highway program caused a road building surge. Because of mandated design grades, there was a need to move very large quantities of rock and dirt. To support a road-building effort requiring large-scale movement of earth, scrapers increased in capacity from 10 to 30 cy. With the development of the **torque converter** and the power shift transmission, the front-end loader began to displace the old cable-operated "dipper" stick shovels. But the three most important developments were high-strength steels, nylon cord tires, and high-output diesel engines.

1. *High-strength steels*. Up to and through World War II, machine frames had been constructed with steels in the 30,000- to 35,000-psi yield range. After the war, steels in the 40,000- to 45,000-psi range with better fatigue properties were introduced. The new high-strength steel made possible the production of machines having greatly reduced overall weight.
2. *Nylon cord tires*. The utilization of nylon cord material in tire structures made larger tires with increased load capacity and heat resistance a practical reality. Nylon permitted the number of plies to be reduced with the same effective carcass strength.
3. *High-output diesel engines*. Manufacturers developed new ways to coax greater horsepower from a cubic inch of engine displacement. Compression ratios and engine speeds were raised, and the art of turbocharging was perfected.

BEING COMPETITIVE

This book introduces the engineering fundamentals for planning, selection, and utilization of equipment used for moving rock and dirt. It enables one to analyze operational problems and to arrive at practical solutions. It is about the application of engineering fundamentals, and the use of analysis to plan earth-moving activities and to make decisions based on economic comparisons of machine choices.

A contractor's ability to win contracts and to perform them at a profit is determined by two vital assets: people and equipment. To be competitive, the equipment must be competitive,

FIGURE 1.3 An equipment loading-hauling-compaction spread.

both mechanically and technologically. Old machines, which require costly repairs, cannot compete successfully with new equipment, having lower repair costs and higher production rates.

In most cases, a piece of equipment does not work as a stand-alone unit. Individual pieces of earthmoving equipment work together as a unit: a loader or excavator and dump trucks. When the truck dumps its load, the material is then spread by a dozer and densified by compaction equipment. This group of machines working together is commonly referred to as an *equipment spread* (Fig. 1.3). The operational productivity of each machine must match the capability of the other machines in the spread. For production efficiency, the machines must mesh together like gears.

Optimization in the management of an equipment spread is critical for a contractor, both in achieving a competitive pricing position and in accumulating the corporate operating capital required to finance the expansion of project performance capability. This book explains the fundamental concepts of machine utilization, which economically match machine capability to specific project requirements.

There are no unique solutions to the problem of selecting a machine to move material. All machine selection problems are influenced by external environmental conditions imposed by nature and the contract (a project must be completed on time or a late penalty is charged from the contractor). To appreciate how environmental conditions influence the utilization of heavy construction equipment, one must understand the mechanics of how the construction industry operates.

The success of earth-moving operations can set the tone for the entire project. Earth-moving is the first visible task, and without its success and profitability, an atmosphere of doom can loom over subsequent tasks. There may be added pressure for later tasks to make up for earth-moving losses. Owner relations can be strained because of early change orders. An understanding and intermingling of project management principles and machine capability is paramount.

THE CONSTRUCTION INDUSTRY

By the nature of the product, each earthwork project proceeds under a unique set of production conditions, and those conditions directly affect equipment selection. Whereas most manufacturing companies have a permanent factory where raw materials flow in and finished products flow out in a repetitive, assembly-line process, those who perform earthwork carry their factory with them from job to job. At each new site, the builder proceeds to set up and produce a one-of-a-kind project. If the work goes as planned, the job will be completed on time and with a profit.

Equipment-intensive projects present a great financial risk. Many projects involving earthwork are bid on a unit-price basis, and there can be large variations between estimated and actual quantities. Some projects require an equipment commitment greater than the contract amount. Such a situation forces a contractor into a continuing sequence of jobs to support long-term equipment payments.

Additional risk factors facing contractors in equipment-intensive work include their financing structure, construction activity levels (the amount of work being put out for bid), labor legislation and agreements, and safety regulations. Project size and weather-dependent outdoor work can contribute to long project durations. Projects requiring two or more years to complete are not uncommon in the industry. Subsurface conditions often differ from those anticipated. Utility interference always complicates earth-moving operations—consider the frequency of news reports where a construction crew has disturbed a gas main or fiber-optic line.

Government-initiated actions that seriously affect the operating environment of the construction contractor are labor legislation and safety regulations. In each of these areas, many regulations affect a contractor's operations. These actions can directly influence equipment decisions. Sound and emissions are issues receiving greater regulatory attention, and some owners are limiting machine noise levels through contract clauses. Newer emission requirements have forced equipment manufacturers to reorient their research and development programs.

SAFETY

The rate of personal injury and death resulting from construction work is too high. Of all major industry classifications, construction has one of the poorest safety records. The construction industry employs nearly 6.4 million people—roughly 6% of the American workforce. However, according to the National Safety Council, the industry has about 23% of the deaths and 10.3% of the injury accidents every year. Several of the major causes of deaths and injuries are earthwork equipment and task related: being struck by a machine, being caught in between equipment, and trench excavation cave-ins. The keys to better work site safety are first leadership, then programs, followed by the incentives to create a safe industry.

In 1970, Congress enacted the Williams-Steiger Act, more commonly referred to as the Occupational Safety and Health Act (OSHA). The act provides a comprehensive set of safety rules and regulations, inspection procedures, and safety record-keeping requirements. It also permits states to enact their own OSHA legislation as long as the state legislation is at least as stringent as the federal legislation. The OSHA rules and regulations are published in the *Federal Register*. Construction and Health Regulations, Code of Federal Regulations, Part 1926, pertains specifically to construction contractors and construction work. The act provides both civil and criminal penalties for violations of OSHA regulations. Contractors must maintain a current, up-to-date file of OSHA regulations and work proactively to comply with OSHA requirements.

THE CONTRACTING ENVIRONMENT

Construction contractors work within a unique market situation. The job plans and specifications supplied by the client dictate the sales conditions and product but not the price. Almost all work in the equipment-intensive earthwork fields of construction is awarded on a bid basis, through either open or selective tender procedures. Under the design–bid–build method of contracting, the contractor states a price after estimating the cost based on a completed design supplied by the owner. But there is often a risk component concerning payment: Is the work to be performed lump sum, all quantity risk on the builder, or will the quantities be measured and the work paid on a unit price basis? The offered price includes overhead, project risk contingency, and the desired profit.

Design–build contracts, where the contractor has control of the project design are becoming more popular. In the case of transportation projects with a total value under \$10M, 25% of the projects awarded in recent years were let design–build best value. With a design–build project, the contractor must state a guaranteed price before the design is completed. This adds another element of risk, because estimating the quantities of materials required to complete the project becomes very subjective. But the advantage to the contractor is that the design can be matched in the most advantageous way to the contractor's construction skills and equipment fleet.

Complicating this matter is the fact that the owner dictates the terms of the contract and the project delivery method, not the contractor. On most projects, the contractor is better suited to control the risk associated with this decision. This risk is inherently built into bids in the form of contingencies for each of the individual bid line items. Not infrequently, however, the range between the high and low bids is much greater than these factors would justify. A primary cause of variance in bid prices is a contractor's inability to estimate costs accurately.

Two quick measures—contract volume and contract turnover—indicate the financial strength of the firm. Contract volume refers to the total dollar value of awarded contracts (under contract) *at any given time.* Contract turnover measures the dollar value of work a firm completes during a specific *time interval.* Contract volume is a guide to the magnitude of resources committed at any one time, as well as to possible profit if the work is completed as estimated. But contract volume alone fails to answer any timing questions. A contractor, who, with the same contract volume as the competition, is able to achieve a more rapid project completion, and therefore a higher capital turnover rate while maintaining the revenue-to-expense ratio, will be able to increase the firm's profits. Contractors who finish work ahead of schedule usually make money. Overhead to support direct construction activities is typically time based. Simply put, the less time to build, the lower the overhead cost.

PLANNING EQUIPMENT UTILIZATION

Each piece of construction equipment is specifically designed to perform certain mechanical operations. The task of the earthwork builder is to match the right machine or combination of machines to the project task. Considering individual tasks, the quality of performance is measured by matching the equipment spread's production against its cost. Production is work done; it can be the volume or weight of material moved, the number of pieces of material cut, the distance traveled, or any similar measurement of progress. To estimate the equipment component of project cost, it is necessary to first determine machine *productivity.* Productivity is governed by engineering fundamentals. Chapter 5 covers the fundamentals controlling machine productivity. Each level of productivity has a corresponding cost associated with the effort expended. The expenses experienced through machine ownership and use, and the method of analyzing such costs are presented in Chap. 2.

Although each major type of equipment has different operational characteristics, it is not always obvious which machine is best for a particular project task. After studying the plans and specifications, visiting the project site, and performing a quantity take-off, the planner must visualize how to best employ specific pieces of equipment to accomplish the work. Is it less expensive to make an excavation with scrapers or to top-load trucks with a hoe or shovel? Both methods will yield the required end result, but which is the most economical for the given project conditions?

To answer this question, the planner develops an initial plan for employment of the scrapers and then calculates their production rate and the subsequent cost. The same process is followed for the top-load operation. The equipment spread with the lowest estimated total cost to move the material, including mobilization of the machines to the site, is selected for the job.

To perform such analyses, the planner must consider both machine capability and methods of employment. In developing suitable equipment employment techniques, the planner must have knowledge of the material quantities involved, which is the focus of Chap. 3. If it is determined that different equipment and methods will be used as an excavation progresses, then it is necessary to divide the quantity take-off in a manner compatible with the proposed equipment utilization. The person performing the quantity take-off must calculate the quantities in groups by material type or condition (dry earth, wet earth, rock). It is not just a question of estimating the total quantity of rock or the total quantity of material to be excavated. All factors that affect equipment performance and choice of construction method, such as location of the water table, clay or sand seams, site dimensions, depth of excavations, and compaction requirements, must be considered when making the quantity take-off.

The normal operating modes of the particular equipment types are discussed in Chaps. 6 to 11 and 13 to 15. No two projects are exactly alike; therefore, it is important to consider each project with a completely open mind and review all possible options. Moreover, machines are constantly being improved and new equipment being introduced.

Heavy equipment is usually classified or identified by one of two methods: functional identification or operational identification. A bulldozer used to push a stockpile of material could be identified as a support machine for an aggregate production plant, a grouping that could also include front-end loaders. The bulldozer could, however, be functionally classified as an excavator. In this book, combinations of functional and operational groupings are used. The basic purpose is to explain the critical performance characteristics of a particular piece of earth-moving equipment and then to describe the most common machine applications.

The efforts of builder and equipment manufacturers, daring to develop new ideas, constantly push machine capabilities forward. As equipment capabilities change, the importance of careful planning and execution of earthwork operations increases. New machines enable greater economies. The central focus of this book is to improve the ability of those engaged in “Moving the Earth” to match specific machines to individual project situations.

CHAPTER 2
COMPANY AND MACHINE COST

Cash flow is vital to any construction business. A contractor expends the client's funds, then, in turn, provides a valued service in the form of a constructed project. Contractors must be good stewards of this money and be able to track their expenses to build while simultaneously receiving and making payments. Payments for material invoices, weekly payroll, and subcontractor draws can complicate the accounting of money. Running a construction business with the associated buying and selling of machines requires solid accounting practices.

Two important accounting documents used to monitor a company's financial performance are the balance sheet and the income statement. The balance sheet is a snapshot of financial health at a particular moment in time. A company's income statement shows all of the money a company earned (revenues) and all of the money a company spent (expenses) during a specific period, usually the fiscal year. The income statement provides a map of how a company is changing and the pace of change.

A correct and thorough understanding of the costs resulting from equipment ownership and operation provides companies a market advantage that leads to greater profits. Ownership cost is the cumulative result of those cash flows an owner experiences, whether or not the machine is productively employed on a project. Operating cost is the sum of those expenses an owner experiences by using a machine on a project. There are three basic methods for securing a particular machine for project use: (1) buy, (2) rent, or (3) lease.

CONSTRUCTION COMPANY ACCOUNTING

Tracking the Money

Accounting
The practice of recording, classifying, reporting, and interpreting the financial data of an organization.

There are three types of **accounting**: (1) generally accepted accounting principles (GAAP accounting) for financial statements (lots and lots of rules), (2) management accounting (no rules) used in running the firm, and (3) tax accounting. This chapter will discuss the first two and leave the tax aspect to accounting professionals who are constantly trying to understand the tax laws that politicians and bureaucrats can dream up and continually change.

Accounting is the process of recording, classifying, reporting, and interpreting the financial data of an organization. One of the main purposes of accounting is to aid decision makers in choosing among alternative courses of action—management

Cost accounting The phase of accounting that deals with collecting and controlling the cost of producing a product or service.

accounting. Effective management of a construction company requires proper **cost accounting** and the availability of current and accurate cost information. For information to be useful, there must be consistent use of accounting principles from one period to another (e.g., a method of recording and reporting information).

Financial statements communicate useful monetary information and are the result of simplifying, condensing, and aggregating transactions. No one financial statement provides sufficient information by itself, and no one item or part of each statement can summarize the information. The most important accounting document used to monitor a company's earnings is the income statement. The balance sheet shows the company's overall financial health and potential for future growth. The income statement shows the sources of a company's production costs, other expenses, and income.

Income Statement

A company's income statement is a record of its earnings or losses for a given period. This can be thought of as a moving picture of company performance. It shows all of the revenue a company earned and all of the costs and expenses a company experienced during a specific period, usually the fiscal year. It also accounts for the effects of some basic accounting principles such as depreciation.

The income statement provides a record of a company's performance across time. Most importantly, the income statement tells if operations are yielding a profit. It provides a map (Fig. 2.1) of how a company is changing and the pace of change. It is essential for management to know how to analyze different elements of this important document.

Operating income (revenue) does not include interest earned. Nor does it include income generated outside the normal activities of the company, such as income on investments. Operating income is particularly important because it is a measure of profitability based on a company's operations. In other words, it assesses whether or not the core operations of a company are profitable. It ignores income or losses outside a company's normal domain. Earnings before taxes are the sum of operating and nonoperating income. Net earnings or net income (loss) after taxes is the proverbial bottom line. It is the amount of profit a company makes after all of its income and all of its expenses.

Retained Earnings. Retained earnings is the amount of equity from profits that a company has accumulated through all of its transactions since the beginning of the firm. If the company continually makes substantial profits, it is a stable company, or if it is like the Low Bid Corporation [see "Income (loss) from operations" in Fig. 2.1], there are major problems and the viability of the company is clearly threatened. In addition to gross profits that are way too thin, it appears that Low Bid is carrying way too much general and administrative expenses. These could include unnecessary travel, a company airplane, entertaining clients, or even unnecessary estimating cost caused by attempting to bid everything that comes along. Estimating can range from 0.1% to over 0.2% of the bid price, and work must be won to recover this cost.

LOW BID CONSTRUCTION CORPORATION
STATEMENT OF INCOME AND RETAINED EARNINGS

	For the Years Ended December 31,		
	2015	**2014**	**2013**
Revenue (Notes 10 and 16)	$174,063,148	$163,573,258	$210,002,272
Cost of revenue (Note 10)	169,404,787	158,935,103	200,070,826
Gross profit	4,658,361	4,638,155	9,931,446
General and administrative expenses (Notes 1 and 10)	8,062,623	6,777,840	6,671,035
Income (loss) from operations	(3,404,262)	(2,139,685)	3,260,411
Other income (expense):			
Interest income	319,797	646,480	668,928
Interest expense	(485,937)	(250,996)	(209,872)
Other income (expense)	377,840	(115,246)	211,119
	211,700	280,238	670,175
Income (loss) before income taxes	(3,192,562)	(1,859,447)	3,930,586
Income tax benefit (expense)	668,631	284,861	(1,590,480)
Net income (loss) (Note 17)	$ (2,523,931)	$ (1,574,586)	$2,340,106
BEGINNING RETAINED EARNINGS	$3,090,214	$4,664,800	$4,664,800
ENDING RETAINED EARNINGS	$566,283	$3,090,214	

Notes

10. Related Party Transactions:

Management believes that the fair value of the following transactions reflect current amounts that the Company could have consummated transactions with other third parties.

Revenue:

During the years ended December 31, 2015 and 2014, the Company provided construction materials to various related parties in the amounts of $108,112 and $26,556, respectively. Included in accounts receivable at December 31, 2015 and 2014 are amounts due from related parties, in the amounts of $27,337 and $15,132, respectively.

Professional Services:

During the years ended December 31, 2015, 2014, and 2013, a related party rendered professional services to the Company in the amounts of $14,573, $23,342, and $7,944, respectively. During the years ended December 31, 2015, 2014, and 2013, the Company paid $30,000, $30,000, and $5,000, respectively, to outside members of the board of directors.

Subcontractor/Supplier:

Various related parties provided materials and equipment used in the Company's construction business during the years ended December 31, 2015, 2014, and 2013, in the amounts of $4,114,319, $535,694, and $65,441, respectively. Included in accounts payable at December 31, 2015 and 2014 are amounts due to related parties, in the amounts of $1,046,908 and $154,861, respectively, related to supplies.

FIGURE 2.1 Sample income statement.

Royalties:

During the years ended December 31, 2015, 2014, and 2013, the Company paid a related party mining royalties in the amounts of $390,144, $328,310, and $182,061, respectively. Included in accrued liabilities December 31, 2015 and 2014, are amounts due to related parties, in the amounts of $30,464 and $49,983, respectively, related to royalties.

Commitments:

The Company leased office space in the state on a month-to-month basis, at a rental rate of $840 per month, from a related party of the Company. The lease terms also required the Company to pay common maintenance, taxes, insurance, and other costs. Rental expense under the lease for the years ended December 31, 2015, 2014, and 2013 amount to $9,240, $10,080, and $10,080, respectively.

16. Significant Customers:

For the years ended December 31, 2015, 2014, and 2013, the Company recognized a significant portion of its revenue from four Customers (shown as an approximate percentage of total revenue):

	For the Years Ended December 31,		
	2015	2014	2013
A	21.9%	17.5%	26.2%
B	12.5%	16.3%	28.7%
C	9.6%	23.0%	17.2%
D	14.7%	6.1%	5.8%

At December 31, 2015 and 2014, amounts due from the aforementioned Customers included in restricted cash and accounts receivables are as follows:

	For the Years Ended December 31,	
	2015	2014
A	$3,809,567	$2,968,786
B	$6,255,403	$1,855,666
C	$350,962	$1,124,196
D	$2,218,976	$762,181

17. Stock Option Plan:

In November 2008, the Company adopted a Stock Option Plan providing for the granting of both qualified incentive stock options and nonqualified stock options. The Company has reserved 1,200,000 shares of its common stock for issuance under the plan. Granting of the options is at the discretion of the Board of Directors and may be awarded to employees and consultants. Consultants may receive only nonqualified stock options. The maximum term of the stock options are 10 years and may be exercised as follows: 33.3% after one year of continuous service, 66.6% after two years of continuous service, and 100% after three years of continuous service. The exercise price of each option is equal to the market price of the Company's common stock on the date of grant.

FIGURE 2.1 (*Continued*)

Balance Sheet

A company's balance sheet (Figs. 2.2 and 2.3) describes its financial position at a specific date—a single point in time. This is like a snapshot picture of the financial condition. Because it is a single-point-in-time representation, it is sometimes referred to as a position statement. It is prepared at least once per year, but it may also be presented quarterly, semiannually, or even monthly. The balance sheet provides information on what the company owns (its assets), what it owes (its liabilities), and the value of the business to its owners (equity). The name *balance sheet* is derived from the fact that these accounts must always be in balance. Assets must always equal the sum of liabilities plus owner's equity. If liabilities exceed assets, the owner experiences a negative equity, or in simple terms, suffers a loss.

CONSOLIDATED BALANCE SHEET
(Thousands of dollars)

December 31,	2016	2015
ASSETS		
Current assets		
Cash	$ 11,330	$ 10,025
Short-term investments, at cost, which approximates market	8,620	14,738
Accounts receivable including retentions $44,943 and $65,064	208,007	182,319
Refundable federal income taxes	—	11,225
Costs and earnings in excess of billings on uncompleted contracts	192,727	164,232
Equity in joint ventures	96,655	82,311
Real property held for development and sale at the lower of cost or market	45,163	33,000
Other	11,462	7,790
Total current assets	573,964	505,640
Investments and other assets		
Equity in affiliated enterprises	9,815	16,349
Marketable securities, at cost, market $9,667 and $10,741	259	259
Other investments, at cost, which approximates market	41,318	15,896
Notes receivable and other assets	18,024	8,959
Total investments and other assets	69,416	41,463
Property and equipment, at cost		
Land	2,596	2,566
Buildings, ways, and wharves	164,322	148,900
Construction and other equipment	223,144	212,186
Total property and equipment	390,062	363,652
Less accumulated depreciation	(140,169)	(123,702)
Property and equipment—net	249,893	239,950
Total assets	$893,273	$787,053

The accompanying notes are an integral part of the financial statements.

FIGURE 2.2 Sample balance sheet showing the assets portion.

December 31,	2016	2015
LIABILITIES AND STOCKHOLDERS' EQUITY		
Current liabilities		
Short-term and current portion of long-term debt	$ 72,742	$ 29,350
Accounts payable and accrued expenses	228,115	200,761
Billings in excess of costs and earnings on uncompleted contracts	66,982	70,846
Advances from clients	19,687	32,076
Income taxes		
Currently payable	11,462	3,476
Deferred	6,047	46,866
Dividends payable	3,236	2,672
Total current liabilities	408,271	386,047
Non-current liabilities		
Deferred income taxes	43,666	20,611
Deferred income and compensation	15,513	15,602
Accrued workmen's compensation	27,973	23,189
Long-term debt	103,611	76,063
Total non-current liabilities	190,763	135,465
Commitments		
Stockholders' equity		
Common stock, par value $3.33⅓, authorized 20,000,000 shares, issued 10,616,391 shares	35,388	35,388
Capital in excess of par value	74,056	73,273
Retained earnings	196,764	170,421
	306,208	279,082
Less cost of treasury stock, 802,878 and 899,744 shares	(11,969)	(13,541
Total stockholders' equity	294,239	265,541
Total liabilities and stockholders' equity	$893,273	$787,053

FIGURE 2.3 Sample balance sheet showing liabilities and stockholders' equity part.

Assets. Assets are economic resources that are expected to produce economic benefits for their owners. They are presented first on the balance sheet (Fig. 2.2). The assets of a construction company are usually money (cash); receivables; equipment; and plant, property, and materials used to construct projects. A company's good name, or *goodwill,* is also considered an asset where the actual value is realized when the company is purchased, acquired, or merged by another.

Many construction companies have contractual obligations that significantly outweigh their physical assets. For example, a company may have $500 million in ongoing prime contracts and separate subcontract work, while their physical assets may only total $100 million. For this reason alone, the contractor must understand how the assets of the active contractual obligations are counted so that the company remains profitable.

Compared to other types of businesses, construction companies typically have less in the way of physical assets. A manufacturing business will have a large investment in buildings and machinery, and may even at times carry significant inventory of raw material with which to produce the product or an inventory of completed products that have not been sold. These are physical assets a lender relies on as collateral against a loan to the company.

A construction company, by comparison, conducts its business on property owned by someone else and only needs to actually possess a small office for corporate management. A heavy construction company might have a fleet of equipment, which represents substantial assets, but many times such equipment is leased or rented so it does not belong to the construction company. The one exception would be a construction company that produces concrete and asphalt. Many of these companies own their quarries from which they get the raw aggregate for their product. Quarries with their aggregate reserves represent significant asset holdings. In the case of contractors owning property for quarry mining, the reserve ore also represents an asset holding that is realized as the quarry is excavated and the product is sold. Therefore, because the value of actual physical assets possessed by a construction company is usually minimal, lenders must carefully look to the continuing operational performance of the company when evaluating the risk of a loan.

> In reading a balance sheet, it is important to remember that property and equipment are recorded at cost and not the price at which an asset may be sold or the cost to replace the asset.

Current Assets. Current assets are cash or other balance sheet accounts that can be changed into cash within a year. They are usually presented in the order of their liquidity:

- *Cash* is the most basic current asset.
- *Cash equivalents* are not cash but can be converted into cash so easily that they are considered equal to cash. Cash equivalents are generally highly liquid, short-term investments such as U.S. government securities, commercial paper, and money market funds. Short term is generally defined as converting or maturing into cash within 90 days if it is to be considered cash.
- *Accounts receivable* represents money that clients (project owners) owe to the firm for services rendered or for goods sold (e.g., producers of asphalt and concrete) and includes retentions receivable.
- *Inventory*, in the case of a construction firm, is the material kept on hand for use in construction of projects.

Long-Term Assets. Many assets are economic resources that cannot be readily converted into cash. Common examples might be real estate holdings, facilities, and equipment. A sale of these assets may take a year or longer. These long-term, or “other,” assets are expected to provide benefit for future operations.

- *Fixed assets* are tangible assets. Generally, fixed assets refer to items such as equipment, vehicles, plant, buildings, and property. On the balance sheet, these are valued at their cost. Depreciation is subtracted from all classes except land.

Liabilities. Liabilities are obligations a company owes to outside parties. They represent the rights of others to money or services of the company. Examples include bank loans, debts to suppliers, debts to employees, debts to subcontractors, and both deferred taxes and taxes currently payable to government entities. On the balance sheet, liabilities are generally broken down into current liabilities and long-term liabilities.

Overbilling
Placing a higher value on work performed early in the project and lower values on work to be completed near the end of the project, so the contractor does not experience an out-of-pocket cash flow to finance the work.

- *Current liabilities* are those obligations that are to be paid within the year, such as accounts payable, interest on long-term debts, and taxes payable. The most pervasive item in the current liability section of the balance sheet is accounts payable. Also note that "**overbillings**" are recognized as a current liability (see "Billings in excess of costs and earnings on uncompleted contracts" in Fig. 2.3).
- *Accounts payable* are debts owed to subcontractors and to suppliers for the purchase of goods and services on an open account.
- *Long-term debt* is a liability of a period greater than 1 year. It usually refers to loans made to the company. These debts are often paid in installments. These could include loans to purchase vehicles and equipment and mortgage payments for buildings and land. If this is the case, the portion of the principal to be paid in the current year is considered a current liability. Pending litigation from construction claims against the company also represents a long-term debt. These potential claim losses require special evaluation by tax accountants.

Because current liabilities are usually paid with current assets, it is important to examine the degree to which current assets exceed current liabilities. This difference is called *working capital*. Working capital is the difference between short-term assets and liabilities. It is one of the most important measures of a company's financial health and the ability to make payments on time, whether it be the weekly payroll or supplier invoices.

Owner's Equity. Owner's equity, or the net worth of the company, is the excess of assets over liabilities. It represents what the owners have invested in the business plus accumulated profits, which are retained in the company, from ongoing operations. Losses will reduce owner's equity. The formulation of the report's balance is shown by Eq. (2.1):

$$\text{Equity (net worth)} = \text{Total assets} - \text{Total liabilities} \tag{2.1}$$

Considering the balance sheet asset and liability information contained in Figs. 2.2 and 2.3, it is possible to calculate the net worth of the company without knowing exactly the types of equity that the company owners possess (Table 2.1).

At the bottom of the balance sheet in the "stockholders' equity" section (Fig. 2.3), the composition of the private investor equity is presented. Retained earnings is that part of equity resulting from earnings in excess of losses.

Liquidity and Working Capital. Management must study the balance sheet to measure a firm's liquidity, financial flexibility, profit generation ability, and debt payment ability. Financial flexibility is the ability to take effective actions to alter the amounts and timing of cash flow in response to unexpected needs and opportunities.

TABLE 2.1 Net Worth Calculations

	Dec. 31, 2016	Dec. 31, 2015
Total assets	$893,273	$787,053
Total current liabilities	408,271	386,047
Total noncurrent liabilities	190,763	135,465
Total liabilities	599,034	521,512
Net Worth	294,239	265,541

Bonding companies (sureties) will also carefully study the company's balance sheet before issuing a bond. The picture that the balance sheet reveals concerning the company's stability will therefore affect the surety's decision concerning the bonding limit (volume of work) of the construction company. Without the ability to secure a bond, the amount of work a company can undertake is limited.

Bonding companies typically use ratios to break down the balance sheet and ratios provide more pronounced indicators of financial health. Ratios make it possible to make comparisons of key balance sheet line items. This would not be possible when only viewing exclusive line items. For example, the working capital ratio (current assets divided by current liabilities) is an important and common measure of a company's financial health. Surety bonding companies like to see a working capital ratio of at least 1.2 to buffer cash flow during standard operations. The goal is to maintain a margin between assets and liabilities throughout the project and among multiple ongoing projects.

The analysis of a balance sheet can identify potential debt payment problems. These may signify the company's inability to meet financial obligations. Liquidity is the quality that an asset has of being readily convertible into cash—and cash is necessary for paying the bills. Working capital [Eq. (2.2)] is simply the amount that current assets exceed current liabilities. The relative amount of working capital is an indication of short-term financial strength.

$$\text{Working capital} = \text{Current assets} - \text{Current liabilities} \tag{2.2}$$

Working capital is the cash that flows into, through, and out of a construction company. It flows through the company (a circulatory system) as operations are conducted. This flow of working capital through the company is a lifeblood cycle, and without the "blood" the company dies. The flow of cash includes (Fig. 2.4):

1. Clients (project owners) input *contract revenues*.
2. A major portion of this revenue stream flows out of the company as direct costs to pay *direct project costs:* subcontractors, material suppliers, the contractor's labor force, and other expenses.
3. Part of the remainder is used for job *overhead costs* (this cost is allocated to and absorbed by all jobs to keep the direct cost items working).
4. The remainder is classified as gross profit (operating profit).
5. Nonjob overhead—general and administrative (G&A)—**expenses** are then deducted.

Expenses
Goods or services consumed in operating a business.

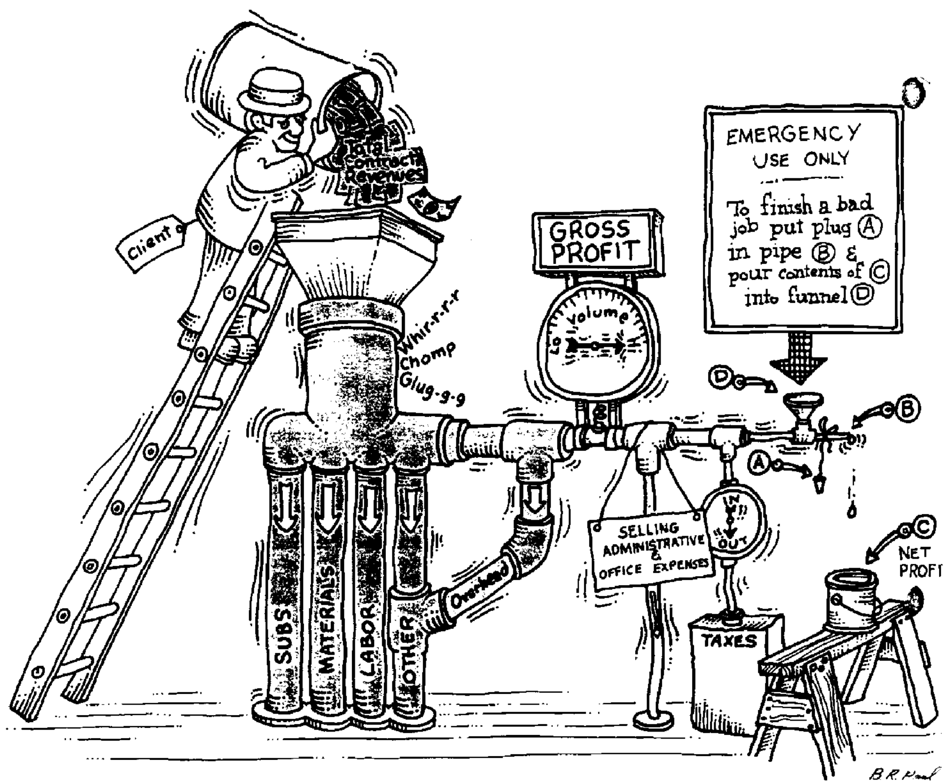

FIGURE 2.4 Flow of funds through a construction company.

6. Finally, a small portion makes it through as *income* to the company. But this is not the portion that the company gets to keep, because taxes must be paid on income.
7. However, if there is even one bad project (total cost is greater than the contract amount), profits from profitable projects must be used to complete the work (pay direct cost).

If the company operates profitably, it should generate a cash surplus. If it does not generate surpluses, it will eventually run out of cash and pass away. From the data presented in the balance sheet for Low Bid Construction Corporation (Fig. 2.5), it is clear the contractor developed a problem with liquidity and working capital in 2017 (Table 2.2). The Low Bid Corporation was forced to use up much of the past profits (retained earnings).

Recognizing its problem, Low Bid has made a provision in the assets part of the 2017 balance sheet to generate needed working capital. See the "Assets held for sale (Note 1)" row in the Assets section of Low Bid's balance sheet (Fig. 2.5). A note that accompanies the balance sheet states "in order to improve working capital, the Corporation executed a definite agreement to sell certain assets. Accordingly, $3,213,484 of assets consisting of inventories and equipment has been classified as assets held for sale on the balance sheet."

LOW BID CONSTRUCTION CORPORATION
CONSOLIDATED BALANCE SHEETS

	December 31, 2017	December 31, 2016
Assets (Note 9):		
Current Assets:		
Cash and cash equivalents (Notes 1 and 2)	$ 2,228,506	$ 1,822,598
Restricted cash (Notes 1, 2, and 16)	2,401,548	1,783,005
Accounts receivable, net (Notes 1, 3, 10, and 16)	21,377,904	14,297,564
Prepaid expenses and other	404,780	749,708
Inventory (Note 1)	3,365,750	4,288,235
Income tax receivable (Notes 1 and 11)	—	774,000
Costs and estimated earnings in excess of billings on uncompleted contracts (Notes 1 and 4)	5,294,054	9,828,009
Total Current Assets	35,072,542	33,543,119
Property and equipment, net (Notes 1, 5, 8, and 12)	15,267,791	18,111,506
Assets held for sale (Note 1)	3,213,484	—
Deferred tax asset (Notes 1 and 11)	1,957,923	873,441
Refundable deposits	55,110	176,565
Goodwill, net (Note 1)	—	1,500,733
Mineral rights and pit development, net	533,608	1,180,666
Claims receivable (Notes 1, 4, and 14)	5,968,026	—
Other assets	80,558	—
Total Assets	$ 62,149,042	$ 55,386,030
Liabilities and Stockholders' Equity:		
Current Liabilities:		
Accounts payable (Notes 6 and 10)	$ 27,025,984	$ 17,606,113
Accrued liabilities (Notes 7 and 10)	1,811,998	2,289,698
Notes payable (Note 8)	1,685,634	1,604,399
Obligations under capital leases (Note 12)	1,118,055	1,041,921
Billings in excess of costs and estimated earnings on uncompleted contracts (Notes 1 and 4)	4,625,657	6,054,814
Total Current Liabilities	36,267,328	28,596,945
Deferred tax liability (Notes 1 and 11)	2,718,734	2,272,700
Notes payable, less current portion (Notes 8 and 9)	9,484,479	7,674,608
Obligations under capital leases, less current portion (Note 12)	2,964,195	3,603,540
Total Liabilities	51,434,736	42,147,793
Commitments and contingencies (Notes 9, 10, 12 and 14)		
Stockholders' Equity:		
Preferred stock — $.001 par value; 1,000,000 shares authorized, none issued and outstanding (Note 13)	—	—
Common stock — $.001 par value; 15,000,000 shares authorized 3,559,438 issued and outstanding (Notes 13 and 17)	3,601	3,601
Additional paid-in capital	10,943,569	10,943,569
Capital adjustments	(799,147)	(799,147)
Retained earnings	566,283	3,090,214
Total Stockholders' Equity	10,714,306	13,238,237
Total Liabilities and Stockholders' Equity	$ 62,149,042	$ 55,386,030

FIGURE 2.5 Balance sheet, Low Bid Construction Corporation (the numerous notes that accompanied the balance sheet are not shown here).

TABLE 2.2 Liquidity Analysis for Low Bid Construction Corporation

	Dec. 31, 2017	Dec. 31, 2016
Current assets	$35,072,542	$33,543,119
Current liabilities	36,267,328	28,596,945
Working capital	–1,194,786	4,946,174

Current Ratio. While the magnitude of a firm's working capital, as calculated using Eq. (2.3), provides information about the ability to prosecute the firm's workload, it is also an indication of its ability to pay short-term obligations. There are other financial ratios designed to measure a company's ability to meet these obligations. Ratios provide a means to identify changes in position that are not as apparent when only reviewing the magnitude of values.

Current ratio
The relation of a company's current assets to its current liabilities.

The **current ratio**, Eq. (2.3), is a tool to identify changes in a company's ability to meet short-term obligations.

$$\text{Current ratio} = \frac{\text{Current assets}}{\text{Current liabilities}} \tag{2.3}$$

Financial analysis is the process of tracking changes in a company's financial health. Ratios are method of analysis used to identify where one should look more deeply into a company's financial statements. As a rule of thumb, the current ratio for a construction company should be above 1.3:1.

When the adequacy of working capital is examined, the composition of the company's current assets should be considered. A company with a high proportion of cash to accounts receivable is in a better position to meet its current obligations. The company with a high proportion of accounts receivable must turn those into cash before it can pay the bills. Again using the Low Bid balance sheet (Fig. 2.5), the liquidity deterioration is also reflected by the cash to accounts receivable proportional change (Table 2.3).

TABLE 2.3 Cash to Accounts Receivable Analysis for Low Bid Construction Corporation

	Dec. 31, 2017	Dec. 31, 2016
Current assets—cash	$2,228,506	$1,822,598
Current assets—accounts receivable	21,377,904	14,297,564
Working capital	1:9.6	1:7.8

Working capital *increases* when a company *makes a profit on a job,* sells equipment or assets, or borrows money on a long-term note. Contractors typically resist selling equipment or engaging in long-term borrowing, both of which directly affect working capital.

Working capital *decreases* when the company *loses money on a job,* buys equipment, or pays off long-term debt. Contractors are typically eager to buy equipment and pay off debt.

CONSTRUCTION CONTRACT REVENUE RECOGNITION

In construction accounting, everything follows accounting practices used in other industries except revenue recognition. In most industries, revenue is recognized at the point of sale, because the uncertainties related to the earning process are removed and the exchange price is known. The exception for construction to this general rule of recognition at point of sale is caused by the long-term nature of construction projects. The accounting measurements associated with long-term construction projects are a bit more difficult because events and amounts must be estimated for a period of years, and even good estimates are modified because of owner-desired change orders or unexpected conditions.

There are several different methods a construction company can use to identify revenue, including the cash, straight accrual, completed-contract, and percentage-of-completion methods, but for financial statements, the only recognized method is percentage of completion.

Cash Method of Revenue Recognition

With the cash method, a contractor records revenue when payments for services are received (actual receipts to date) and records costs as bills are paid (costs paid to date). There is never an accurate picture of the company's financial condition or how individual projects are progressing (a profit or loss). Considering the project data in Table 2.4 and using the cash method of revenue recognition, the revenue to date for the project would be

Payments received to date	$630,000
Costs paid to date	$400,000
Revenue to date	**$230,000**

TABLE 2.4 OK Project Financial Data

Project Financial Data	Amount ($)
Contract amount	1,000,000
Original estimated cost	900,000
Billed to date	700,000
Payments received to date	630,000
Costs incurred to date	450,000
Forecasted cost to complete	400,000
Costs paid to date	400,000

Straight Accrual Method of Revenue Recognition

The straight accrual method considers cost as a costs-to-date (even if not yet paid) and revenue as what has been billed to date. Considering the project data in Table 2.4 and using the straight accrual method of revenue recognition, the revenue to date for the project would be

Billed to date	$700,000
Costs incurred to date	$450,000
Revenue to date	**$250,000**

Completed-Contract Method of Revenue Recognition

The completed-contract method should almost never be used and then only when

- The contractor has predominantly very short-term contracts
- The conditions for using the percentage-of-completion method cannot be met
- There are inherent hazards in the contract beyond normal, recurring business risks

Considering the project data in Table 2.4 and using the completed-contract method of revenue recognition, the revenue to date for the project would be zero at this time, because the project has not been completed.

Percentage-of-Completion Method of Revenue Recognition

The percentage-of-completion method should be used when estimates of progress toward completion, revenues, and costs are reasonably dependable, and all these conditions exist:

- The contract clearly specifies the enforceable rights regarding services to be provided and received by the parties, the consideration to be exchanged, and the manner and terms of settlement.
- The owner (buyer) can be expected to satisfy all obligations under the contract.
- The contractor can be expected to perform contractual obligations.

When using the percentage-of-completion method to calculate revenue, it is first necessary to calculate the percentage of work that has been completed:

$$\text{Percentage of completion} = \frac{\text{Cost to date}}{\text{Cost to date} + \text{Cost to complete}} \times 100\% \qquad (2.4)$$

Considering the project data in Table 2.4, the percentage of completion for the project would be

$$\frac{\$450{,}000}{\$450{,}00 + \$400{,}000} \times 100\% = 52.9\%$$

The revenue to date for a project would be

$$\text{Revenue to date} = \text{Percentage of completion} \times \text{Contract price} \qquad (2.5)$$

Therefore, revenue is $52.9\% \times \$1{,}000{,}000 = \$529{,}000$

$$\text{Gross profit} = \text{Revenue} - \text{Cost} \qquad (2.6)$$

Revenue to date	\$529,000
Cost incurred to date	\$450,000
Gross profit to date	**\$ 79,000**

Over/Underbilling

When the OK Project was originally bid, the anticipated profit was $100,000 (Table 2.4, contract amount minus original estimated cost). As the work has progressed, the cost to complete the work has been continually revised. The data in Table 2.4 represents a revised estimated final cost of $850,000 (Table 2.4, cost incurred to date plus forecasted cost to complete: $450,000 + $400,000). The construction company has billed the owner for $700,000, and the actual experienced cost to date is $450,000; this leaves the contractor with $250,000 in cash. For this discussion, the fact that the contractor has not received all $700,000, because the owner is holding 10% retainage, will be ignored. Part of the $250,000 is true gross profit (what the contractor has really earned, $79,000), and part is the overbilling, $171,000. The way to calculate overbilling is by subtracting the revenue to date (percentage-of-completion method) from the billed-to-date amount. This reveals the excess of the billing over the revenue. Such an undertaking demonstrates the amounts of money belonging to the contractor and to the owner.

Billed to date	$700,000
Revenue to date (percentage-of-completion method)	$529,000
Overbilling or job borrow	**$171,000**

Most contractors are not in the banking business, in the sense that they do not have the funds to finance construction of the project for the owner. Contractors, therefore, allocate more profit to those items of work that will be completed early in the project. In the case of a lump-sum project, this is done when the schedule of values is prepared. The total amount of revenue for the total work is the same; it is just that more of the revenue is received on the early items of work. The formula for calculating overbilling is given by Eq. (2.7):

$$\text{Overbilling} = \text{Billed to date} - \text{Revenue} \tag{2.7}$$

Early in a project a contractor can be in an underbilling situation where actual earned revenue is greater than the amount billed to the owner:

$$\text{Underbilling} = \text{Revenue} - \text{Billed to date} \tag{2.8}$$

Assuming that overbillings have been paid, they indicate that the contractor is "borrowing" money from the owner by billing ahead of earned revenue. While overbillings are preferable to significant underbillings, it can pose some difficulties. For example, if the borrowed cash is used for other purposes, it may not be available for payment of job costs when they are incurred later. Overbilling represents a liability from an accounting perspective since the reported value of work has not been fully earned. The contractor has a remaining liability to install work. This excess will translate into deficit spending later in the project as underbilling occurs to balance out the contract price with final payments. Underbilling represents an asset since earned work has not yet been fully paid.

Excessive overbilling for the first half of the project can cause a substantial reduction in payments in the latter half of the project. It is not uncommon for contractors to overbill at a rate of 15% or higher early in the project to establish a positive cash flow for the duration of the project. This effectively eliminates the chance for any borrowing by exercising a bank line of credit for short-term working capital. Although this has a clear cash flow advantage, this positive offset must be met later with an equal reduction in final payments.

Many unit price contracts for heavy/civil construction projects have a *mobilization* line item to offset the early expenses of starting a job. In essence, this provides an overbilling of actual work on the project since no physical work has been accomplished. Mobilization can be classified as an indirect cost item to support direct cost work items since it provides the machines and temporary facilities to build the project, such as the job trailer, security fencing, and traffic control. However, very few unit price contracts have a *demobilization* item to move equipment and temporary facilities from the site, a real cost to the contractor. These demobilization costs can be passed on to the next project with a mobilization line item but only if there is an immediate next project requiring the items.

Managers should look for underbilling late in a project. Significant underbillings *always* indicate problems and the possibility of unapproved change orders that may not get approved or paid. Underbillings indicate that the contractor is allowing the project owner to "borrow" money, in the sense that the contractor has performed work (and incurred expenses) without yet billing for it. Underbillings reduce cash flow for the individual contract as well as other contracts and the general operations of the company. An underbilling can be characterized as an unbilled receivable.

Contract Status Report

A contract status report (work in progress schedule) summarizes the financial position of each project not completely finished, accepted by the owner. It presents a comparison of work accomplished (revenue earned) against costs and a projection of the final financial outcome of each project. Table 2.5 presents the base data required to develop a contract status report. In preparing a contract status report, it is the project manager who usually is responsible for evaluating the accuracy of the estimated cost to complete a project. The contract price is the sum of the original contract amount and all approved change orders.

TABLE 2.5 It Will Cost You a Million Construction Co. Contract Financial Data

Contract	Contract Price ($)	Cost to Date ($)	Total Amount Billed to Date ($)	Estimated Cost to Complete ($)
School 1	1,000,000	450,000	700,000	400,000
School 2	1,000,000	450,000	400,000	400,000
Store 1	1,000,000	450,000	600,000	500,000
Store 2	1,000,000	450,000	450,000	460,000
Hospital	1,000,000	475,000	525,000	575,000
	5,000,000	2,275,000	2,700,000	2,335,000

The first step in developing a complete contract status report is to calculate a new or current (at the present point in time) estimate of the total project cost. Summing the cost to date of each project with its re-estimated cost to complete does this (col. 2, Table 2.6). Once that is done, it is possible to use Eq. (2.4) (cost to date as a ratio of projected total cost) to calculate the percentage complete of each project (col. 5, Table 2.6). Additionally once the current (new) estimate of the total project cost is calculated, it can be subtracted from the project contract price to obtain a current estimated profit/loss at completion (col. 3, Table 2.6). By multiplying the estimated profit at completion by the percentage complete, profit to date is obtained (col. 6, Table 2.6). Note in Table 2.6 that in the case of the Hospital project,

TABLE 2.6 "It Will Cost You a Million Construction Co." Contract Status

Contract	Contract Price ($)	Current Estimated Total Cost ($)	Estimated Profit at Completion	Cost to Date ($)	Percentage Complete	Total Profit (Loss) Recognized to Date ($)	Estimated Cost to Complete ($)
	(1)	(2)	(3)	(4)	(5)	(6)	(11)
School 1	1,000,000	850,000	150,000	450,000	53	79,500	400,000
School 2	1,000,000	850,000	150,000	450,000	53	79,500	400,000
Store 1	1,000,000	950,000	50,000	450,000	47	23,500	500,000
Store 2	1,000,000	910,000	90,000	450,000	49	44,100	460,000
Hospital	1,000,000	1,050,000	–50,000	475,000	45	–50,000	575,000
	5,000,000	4,610,000		2,275,000			2,335,000

a loss is projected at project completion. An expected loss must be recognized in the period when the loss is identified—the total expected loss.

Table 2.7 presents the complete status report with revenue and over/underbillings recognized. Project managers are expected to analyze and explain the progress of their projects. If the project manager fails to forecast a cost overrun, the report will show an underbilling. This can be particularly troublesome if the cause of the cost overrun cannot be identified.

TABLE 2.7 Contract Status Report for "It Will Cost You a Million Construction Co."

Contract Description	Contract Price	Current Re-est. Total Cost	Estimated Gross Profit at Completion	Cost to Date	Percentage Complete	Total Gross Profit (Loss) Recog. to Date
Column	(1)	(2)	(3)	(4)	(5)	(6)
Formula		4 + 11	1 – 2		4 ÷ 2	7 – 4 or 5 × 3
School 1	$1,000,000	$ 850,000	$150,000	$ 450,000	53%	$79,412
School 2	$1,000,000	$ 850,000	$150,000	$ 450,000	53%	$79,412
Store 1	$1,000,000	$ 950,000	$ 50,000	$ 450,000	47%	$23,684
Store 2	$1,000,000	$ 910,000	$ 90,000	$ 450,000	49%	$44,505
Hospital	$1,000,000	$1,050,000	–$ 50,000	$ 475,000	45%	–$22,619
	$5,000,000			$2,275,000		

	Amount Earned to Date (Revenue)	Total Amount Billed to Date	Overbillings	Underbillings	Re-est. Cost to Complete	Contract Balance
Column	(7)	(8)	(9)	(10)	(11)	(12)
Formula	5 × 1 or 4 + 6		8 – 7	7 – 8		1 – 8
School 1	$529,412	$ 700,000	$170,588		$ 400,000	$300,000
School 2	$529,412	$ 400,000		$129,412	$ 400,000	$600,000
Store 1	$473,684	$ 600,000	$126,316		$ 500,000	$400,000
Store 2	$494,505	$ 475,000		$ 19,505	$ 460,000	$525,000
Hospital	$452,381	$ 525,000	$ 72,619		$ 575,000	$475,000
		$ 2,700,000			$2,335,000	

Financial Statement Analysis

Comparative statement
A financial statement with data for two or more successive accounting periods placed in columns side by side to illustrate changes.

In and of themselves, very few of the individual figures in a financial statement are exceptionally significant. It is their relationship to other quantities, or the magnitude and direction of change with time (since a previous statement), that is important as an indicator of the company's condition. Analysis of financial statements is largely a matter of studying relationships, changes, and trends. The three commonly used analysis techniques are (1) dollar or percentage change, (2) component percentages, and (3) ratios.

Financial statement/report analysis requires that relationships and changes between items and groups of items be described. A **comparative statement** is an analysis report that shows pairwise changes in statement items for two or more successive accounting periods in a column format on a single statement (Fig. 2.3). As an aid to controlling operations, a comparative income statement is usually more valuable than a comparative balance sheet.

Dollar and Percentage Change

The dollar magnitude (amount) of change from one reporting period to another is significant, but expressing the change in percentage terms adds perspective. The dollar magnitude of change is the difference between the amount of a comparison statement (year) and a base statement (year). The percentage change is computed by dividing the amount of the change between the statements by the magnitude for the base statement. Table 2.8 presents the dollar magnitude and percentage change of Low Bid Construction Corporation's revenue and cost of revenue for the 3-yr period 2014 through 2016.

TABLE 2.8 Analysis of Low Bid Construction Corporation's Financial Situation

	2016	2015	2014
Revenue	$174,063,148	$163,573,258	$210,002,272
Cost of revenue	169,404,787	158,935,103	200,070,826
Dollar change in revenue	$10,489,890	–$46,429,014	
Percentage change in revenue	6.4%	–22.1%	
Dollar change cost of revenue	$10,469,684	–$41,135,723	
Percentage change cost of revenue	6.6%	–20.6%	

Though the company cannot be happy about the decrease in revenue shown by the comparison, one possible cause can be eliminated. Because the percentage changes are approximately the same (e.g., revenue decreases 22.1% and likewise the cost of revenue decreases 20.6%), it seems reasonable to assume that an increase in cost was not the cause of the revenue decrease experienced in 2016.

Component Percentages

Component percentages indicate the relative size of each item included within a total. Each item on a balance sheet can be expressed as a percentage of total current assets, total assets, total current liabilities, or total liabilities. Such a display of total assets illustrates the relative importance of current and noncurrent assets, as well as the relative amount of financing obtained from current creditors, by long-term borrowing, and from the owners.

Table 2.9 presents a component percentage of current assets analysis. The analysis shows that the company is increasing its cash position and decreasing accounts receivable and unbilled receivables (underbillings).

TABLE 2.9 Component Percentage Analysis of Current Assets (Thousands)

Current Assets	2016		2015		2014	
Cash	$67,054	15.7%	$53,215	13.1%	$48,310	10.5%
Accounts receivable	$175,513	41.0%	$187,311	46.3%	$222,341	48.1%
Unbilled receivables	$74,552	17.4%	$74,514	18.4%	$101,564	22.1%
Total current assets	$427,722		$405,014		$459,249	

Ratios

A ratio is the relationship expression of two quantities (items) expressed as the quotient of one divided by the other. To compute a meaningful ratio, there must be a significant relationship between the two items considered. The current ratio [discussed before in Eq. (2.3)] summarizes the relationship between current assets and current liabilities. Besides the current ratio, some other important financial ratios for construction companies are:

$$\text{Quick ratio} = \frac{\text{Cash} + \text{Receivables}}{\text{Current liabilities}} \tag{2.9}$$

The quick ratio measures the short-term liquidity of a company:

$$\text{Debt to worth} = \frac{\text{Total liabilities}}{\text{Total shareholders' equity}} \tag{2.10}$$

The debt ratio measures the firm's leverage. The margin of protection to creditors is higher when the ratio is lower because the owners are contributing the bulk of funds for the business. Properly leveraged contractors have debt-to-worth ratios of 2:1 or less.

$$\text{Receivables to payables} = \frac{\text{Receivables}}{\text{Payables}} \tag{2.11}$$

The suggested range for the receivables-to-payables ratio varies with the type of construction activity undertaken by the firm.

Based on the type of industry being studied, there are rules of thumb for evaluating financial ratios. In the case of construction companies

- Current ratio should be above 1.3:1
- Quick ratio should be above 1.1:1
- Debt to worth should be below 2.0:1
- Receivables to payables (commercial general contractors) should be around 1.5:1

- Receivables to payables (trade/heavy contractors) should be around 2.0:1
- Receivables to payables (labor-intensive trade contractors) should be around 3.0:1

One further rule of thumb concerns a construction company's capacity to do work. A firm's backlog of work should not be more than approximately ten times the company's working capital amount. This is something a surety will consider before granting a bond for new work.

EQUIPMENT COST

Equipment cost is often one of a contractor's largest expense categories, and it is a cost fraught with variables and questions. To be successful, equipment owners must carefully analyze and answer two separate cost questions about their machines:

1. How much does it cost to operate the machine on a project?
2. What is the optimum economic life of and optimum manner to secure a machine?

The first question is critical to bidding and operations planning—or, simply, estimating. The only reason for purchasing equipment is to perform profitable work. This first question seeks to identify the expense associated with productive machine work, and is commonly referred to as ownership and operating costs (**O&O**). It is usually expressed in dollars per equipment operating hour.

O&O
The ownership and operating costs of a machine.

The second question seeks to identify the optimum point in time to replace a machine and the optimum way to secure a machine. This is important because it will reduce O&O cost and thereby lower production expense, enabling a contractor to achieve a better pricing position. The process of answering this question is known as replacement analysis. A complete replacement analysis must also investigate the cost of renting or leasing a machine.

The economic analyses, which answer these cost questions, require the input of many expense and operational factors. These input costs will be discussed first and a development of the analysis procedures will follow.

Equipment Records

Data on both machine utilization and costs are the keys to making rational equipment decisions, but collection of individual pieces of data is only the first step. The data must be assembled and presented in usable formats. Many contractors recognize this need and strive to collect and maintain accurate equipment records for evaluating machine performance, establishing operating cost, analyzing replacement questions, and managing projects. Surveys of industry-wide practices, however, indicate that such efforts are not universal.

Realizing the advantages to be gained, many owners are directing more attention to accurate record keeping. Advances in computer technology have reduced the effort required to implement record systems. Several software companies offer record-keeping packages specifically designed for contractors. In many cases, the task is simply the retrieval of equipment cost data from existing accounting files.

Automation provides the ability to handle more data economically and in shorter time frames, but the basic information required to make rational decisions is still the critical item. A commonly used technique in equipment costing and record keeping is the standard rate approach. Under such a system, jobs are charged a standard machine utilization rate for every hour the equipment is employed. Machine expenses are charged either directly to the individual piece of equipment or to separate cost accounts by equipment type. This method is sometimes referred to as an internal or company rental system. Such a system usually presents a fairly accurate representation of *investment consumption*, and it properly assigns machines expenses. In the case of a company replacing machines at regular intervals and continuing in the construction business, this system allows a check at the end of each year on estimate rental rates, as the internally generated rent should equal the expenses absorbed.

The first piece of information necessary for rational equipment analysis is not an expense but a record of the machine's usage. By the act of undertaking a replacement analysis, it is presumed there is a continuing need for a machine's production capability. Therefore, before beginning a replacement analysis, the disposal–replacement question must be resolved. Is this machine really necessary? A projection of the ratio between total equipment capacity and utilized capacity provides a quick guide for the dispose–replace question.

The level of detail for reporting equipment use varies. At a minimum, data should be collected on a daily basis to record whether a machine worked or was idle. Having the operator or foreman manually record engine hours or miles on the operator's time sheet is a low-cost solution for tracking machine usage and is probably the most common method for accumulating utilization data.

Both independent service vendors and equipment companies offer real-time automatic data collection devices. These GPS/Telematics devices installed on the machine are in many cases the most effective way to collect data. A more sophisticated system will seek to identify use on an hourly basis, accounting for actual production time and categorizing idle time by classifications such as standby, down weather, and down repair.

Most of the information required for ownership and operating, or replacement analyses, is available from accounting records. There should be accounts for machine purchase expense and final realized salvage value as part of the accounting data required for tax filings. Maintenance expenses can be tracked from mechanics' time sheets, purchase orders for parts, or shop work orders. Service logs provide information concerning consumption of consumables. Fuel amounts can be recorded at fuel points or with automated systems. Fuel amounts should be cross-checked against the total amount purchased. When detailed and correct reporting procedures are maintained, the accuracy of equipment costs analysis is greatly enhanced.

Many discussions of equipment economics include *interest* as a cost of ownership. Sometimes the fleet managers make comparisons with the interest rates a bank would charge for borrowed funds or with the rate earned on invested funds. Such comparisons assume these rates are appropriate for an equipment cost analysis. It is not logical to assign different interest costs to machines purchased wholly with retained earnings (cash) as opposed to those purchased with borrowed funds. A single corporate interest rate should be determined by examination of the combined costs associated with all sources of capital funds: debt, equity, and internal.

ELEMENTS OF MACHINE OWNERSHIP COST

Ownership cost is the cumulative result of those cash flows an owner experiences whether or not the machine is productively employed on a job. It is a cost related to finance and accounting exclusively, and it does not include the wrenches, nuts and bolts, and consumables necessary to keep the machine operating.

Most of these cash flows are expenses (outflows), but a few are cash inflows. The most significant cash flows affecting *ownership cost* are machine

1. Purchase expense
2. Salvage value
3. Major repairs and overhauls
4. Property taxes
5. Insurance
6. Storage and miscellaneous

Purchase Expense

The cash outflow the company experiences in acquiring a machine is the purchase expense. It is the total delivered cost (drive-away cost), including amounts for all options, shipping, and taxes, less the cost of pneumatic tires for wheeled machines. The machine will show as an asset on the books of the company. The company has exchanged money (cash or borrowed funds), liquid assets, for a machine, a fixed asset with which the company hopes to generate profit. As the machine is used on projects, wear takes its toll, and the machine can be thought of as being used up or consumed. This consumption reduces the machine's value because the revenue stream it can generate is likewise reduced. An owner tries to account for the decrease in value by prorating the consumption of the investment over the *service life* of the machine. This prorating is known as depreciation.

The difference between the initial acquisition expense and the expected future salvage value is the expense being measured—but to simply prorate this amount will not produce a valid analysis. Such an approach neglects the timing of the cash flows. Therefore, it is recommended that each cash flow be treated separately to allow for a time value analysis and to allow for ease in changing assumptions during sensitivity analyses.

Salvage Value

Salvage value is the cash inflow a firm receives if a machine still has value at the time of its disposal. This revenue occurs at a future date.

Used equipment prices are difficult to predict. Machine condition (Fig. 2.6), the movement of new machine prices (Fig. 2.7), and the machine's possible secondary service applications affect the amount an owner can expect to receive for a used machine. A machine with a diverse and layered service potential commands a higher resale value. Medium-size dozers often exhibit rising salvage values in later years because these can have as many as seven different levels of useful life. Such a machine may first be used as a high-production machine on a dirt spread and later be used infrequently by a farmer.

Historical resale data can provide salvage value prediction guidance and can be fairly easily accessed from auction price books. By studying such historical data and recognizing the effects of the economic environment, the magnitude of salvage value prediction errors can be minimized and the accuracy of an ownership cost analysis improved.

Depreciation
An accounting method used to describe the loss in value of an asset.

Tax Saving from Depreciation. The tax savings from **depreciation** are a phenomenon of the tax system in the United States. (This may not be an ownership

FIGURE 2.6 Salvage value is dependent on machine condition.

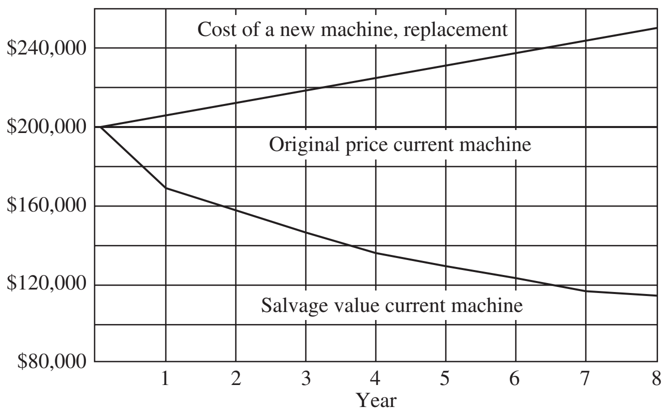

FIGURE 2.7 The movement of new machine prices; cost is one factor affecting salvage value.

cost factor under the tax laws in other countries.) Under the tax laws of the United States, depreciating a machine's loss in value with age will lessen the net cost of machine ownership. The cost saving, the prevention of a cash outflow afforded by tax depreciation, is a result of shielding the company from taxes. This is an applicable cash flow factor only if a company is operating at a profit. There are carry-back features in the tax law, so the saving can be preserved even though there is a loss in any one particular year, but the long-term operating position of the company must be at a profit for tax saving from depreciation to come into effect.

The rates at which a company can depreciate a machine are set by the revenue code. These rates usually have no relation to actual consumption of the asset (machine). Therefore, many companies keep several sets of depreciation numbers: one for depreciation tax purposes, one for corporate earnings tax accounting purposes, and one for internal and/or financial statement purposes. The first two are required by the revenue code. The third tries to accurately match the consumption of the asset based on work application and company maintenance policies.

Under the current tax laws, tax depreciation accounting no longer requires the assumption of a machine's future salvage value and useful life. The only piece of information necessary is basis. Basis refers to the cost of the machine for purposes of computing gain or loss. Basis is essential. To compute tax depreciation amounts, fixed percentages are applied to an unadjusted basis. The terminology *adjusted/unadjusted* refers to changing the book value of a machine by depreciation.

The tax law allows the postponement of taxation on gains derived from the exchange of like-kind depreciable property. If a gain is realized from a like-kind exchange, the depreciation basis of the new machine is reduced by the amount of the gain. However, if the exchange involves a disposal sale to a third party and a separate acquisition of the replacement, the gain from the sale is taxed as ordinary income.

The current tax depreciation law establishes depreciation percentages based on years of machine life. These are usually the optimum depreciation rates in terms of tax advantages. However, an owner can utilize the straight-line method of depreciation or methods that are not expressed in terms of time duration (years). Unit-of-production depreciation would be an example of a non-time–based depreciation system.

Straight-Line Depreciation. Straight-line depreciation is easy to calculate. The annual amount of depreciation D_n, for any year n, is a constant value, and thus the book value (BV_n) decreases at a uniform rate over the useful life of the machine. The calculation equations are

$$\text{Depreciation rate, } R_n = \frac{1}{N} \tag{2.12}$$

where N = number of years

$$\text{Annual depreciation amount, } D_n = \text{Unadjusted basis} \times R_n$$

Substituting Eq. (2.12) yields

$$D_n = \frac{\text{Unadjusted basis}}{N} \tag{2.13}$$

$$\text{Book value year } n, \text{BV}_n = \text{Unadjusted basis} - (n \times D_n) \tag{2.14}$$

Declining-Balance Depreciation. Declining-balance (DB) depreciation methods are accelerated depreciation methods. A DB method writes off larger percentages of machine cost in the early years of its life. In many cases, these methods more closely approximate the actual loss in market value with time. Declining methods range from 1.25 times the current book value divided by the life to 2.00 times the current book value divided by the life (the latter is termed *double-declining balance*). Note that although the estimated salvage value (S) is not included in the calculation, the book value cannot go below the salvage value. The following equations are necessary for using the declining-balance methods.

The symbol R is used for the declining-balance depreciation rate:

1. For 1.25 declining-balance (1.25 DB) method, $R = 1.25/N$
For 1.50 declining-balance (1.50 DB) method, $R = 1.50/N$
For 1.75 declining-balance (1.75 DB) method, $R = 1.75/N$
For double-declining-balance (DDB) method, $R = 2.00/N$

2. The allowable depreciation D_n, for any year n and any depreciation rate R is

$$D_n = (\mathrm{BV}_{n-1}) \times R \tag{2.15}$$

3. The book value for any year n is

$$\mathrm{BV}_n = \mathrm{BV}_{n-1} - D_n, \text{ provided that } \mathrm{BV}_n \geq S \tag{2.16}$$

Since the book value can never go below the estimated salvage value, the DB method must be forced to intersect the value S at time N.

Tax Code Depreciation. The Modified Accelerated Cost Recovery System (MACRS) is a property depreciation system adopted by the Internal Revenue Service (IRS). Under the tax code, machines are classified as 3-, 5-, 7-, 10-, 15-, or 20-yr real property. Most pieces of construction equipment are 5-yr property, including automobiles and light-duty trucks. The appropriate depreciation rates are given in Table 2.10. Note that 1 yr is added to the property life, where a half-year convention is applied to both the first and last years of the equipment life. This implies that the equipment is put into service during the last half of the first year (July through December) and is still in service during the first half of the last year (January through June). MACRS provides for a slightly larger write-off in the earlier years of the cost recovery period since it uses a hybrid of the declining balance at the beginning life and straight line at the ending life. Like the DB method, the MACRS method does

TABLE 2.10 Tax Code–Specified Depreciation Rates for Recovery Period (Half-Year Convention*)

Year	3-yr Property	5-yr Property	7-yr Property
1	33.33%	20.00%	14.29%
2	44.45%	32.00%	24.49%
3	14.81%	19.20%	17.49%
4	7.41%	11.52%	12.49%
5		11.52%	8.93%
6		5.76%	8.92%
7			8.93%
8			4.46%

*Percentages for machines purchased earlier or later in the tax year are different.

not account for salvage value. The full set of depreciation tables showing the MACRS percentages are available in the IRS's free publication 946, *How to Depreciate Property,* available on the Internet at www.irs.gov/publications/p946.

Evaluating Depreciation Methods. Each depreciation method has a unique approach for costing machine life. Tax advantage is usually the key factor when evaluating these methods. If a machine is disposed of before the depreciation process is completed, no depreciation can be recovered in the year of disposal. Any gain, as measured against the depreciated value or adjusted basis, is treated as ordinary income.

The tax savings from depreciation are influenced by

1. Disposal method for the old machine
2. Value received for the old machine
3. Initial value of the replacement
4. Class life
5. Tax depreciation method

Based on the relationships between these elements, three distinct situations are possible:

1. No gain on the disposal—no income tax on zero gain.
2. A gain on the disposal:
   a. Like-kind exchange—no added income tax, but basis for the new machine is adjusted.
   b. Third-party sale—the gain is taxed as income; the basis of the new machine is fair market value paid.
3. A disposal in which a loss results—the basis of the new machine is the same as the basis of the old machine, decreased by any money received.

Assuming a corporate profit situation, the applicable tax depreciation shield formulas are

1. For a situation where there is no gain on the exchange:

$$\text{Total tax shield} = \sum_{n=1}^{N} t_c D_n \tag{2.17}$$

where n = individual yearly time periods within a life assumption of N years
t_C = corporate tax rate
D_n = annual depreciation amount in the nth time period

2. For a situation where a gain results from the exchange
   a. Like-kind exchange—Eq. (2.17) is applicable. It must be realized that the basis of the new machine will be affected.
   b. Third-party sale.

$$\text{Total tax shield} = \left(\sum_{n=1}^{N} t_c D_n\right) - \text{gain} \times t_c \tag{2.18}$$

Gain is the actual salvage amount received at the time of disposal minus the book value.

Basis is a determining factor in making analysis calculations, and the actual salvage derived from the machine directly affects the depreciation saving. To perform a valid analysis, the depreciation accounting practices for tax purposes and the methods of machine disposal and acquisition the company chooses to use must be carefully examined. These dictate the appropriate calculations for the tax effects of depreciation.

Major Repairs and Overhauls

Major repairs and overhauls are included under ownership cost because they result in an extension of a machine's service life. Overhauls are very common when a contractor decides to retain a piece of equipment. They can be considered an investment in a new machine. Because a machine commonly works on many different projects, considering major repairs as an ownership cost prorates these expenses to all jobs. These costs should be added to the book value of the machine and depreciated.

Taxes

In this context, taxes refer to those equipment ownership taxes charged by any government subdivision. They are commonly assessed at a percentage rate applied against the book value of the machine. Depending on location, ownership taxes can range up to about 4.5% of book value. In many locations, there will be no tax on equipment, just user fees. Over the service life of the machine, taxes will decrease in magnitude as the book value decreases.

Insurance

Insurance, as considered here, includes the cost of policies to cover fire, theft, and damage to the equipment either by vandalism or construction accident. Annual rates can range from 1% to 3% of book value. This cost can be actual premium payments to insurance companies, or it can represent allocations to a self-insurance fund maintained by the equipment owner.

Storage and Miscellaneous

Between jobs or during bad weather, a company will require storage facilities for its equipment. The cost of maintaining storage yards and facilities should be prorated to the machines requiring such shelter. Typical expenses include space rental, utilities, and the wages for laborers or watchmen. These expenses are all combined in an overhead account and then allocated on a proportional basis to the individual machines. The rate may range from nothing to perhaps 5% of book value. These facility storage costs may be difficult to assign to specific pieces of equipment and often find themselves in general and administrative accounts. Either way the machine overhead is costed; it may be best accounted in an equipment ledger with dollars, and then prorated to individual machines based on value. A common approach to avoid storage costs is to keep the machine on the project as long as possible, then mobilize it to the next project. The machine is exposed to the elements, but storage cost is eliminated.

ELEMENTS OF MACHINE OPERATING COST

Operating cost is the sum of those expenses an owner experiences by working a machine on a project. If the engine is turned on or the machine moves, the cost is classified as operating. Typical expenses include:

1. Fuel
2. Lubricants, filters, and grease
3. Repairs
4. Tires
5. Replacement of high-wear items

Operator wages are rarely included under operating costs; this is because of wage variance between jobs. The general practice is to keep operator wages as a separate cost category. Such a practice aids in estimation of machine cost for bidding purposes, as the differing project wage rates can readily be added to the total machine O&O cost. In applying operator cost, all benefits paid by the company must be included—direct wages, fringe benefits, payroll taxes, and insurance. This is another reason wages are separated. Some benefits are based on an hourly basis, some on a percentage of income, some on a percentage of income to a maximum amount, and some are paid as a fixed amount. The assumptions about project work schedule will, therefore, affect wage expense.

Fuel

Fuel expense is best determined by measurement on the job. Good service records contain fuel data by individual machines. This is a consumption record over a specific period and under specific job conditions. Hourly fuel consumption can then be calculated directly. With newer instrumentation technology and telematics, the fuel data can now be captured in real time.

When company records are not available, the manufacturer's consumption data can be used to construct fuel use estimates. The amount of fuel required to power a piece of equipment for a specific period depends on the brake horsepower of the machine and the work application. Therefore, most tables of hourly fuel consumption rates are divided according to the machine type and the working conditions. To calculate hourly fuel cost, a consumption rate is found in the tables (Table 2.11) and then multiplied by the unit price of fuel. The cost of fuel for vehicles used on public highways will include applicable taxes. However, in the case of off-road machines used exclusively on project sites, there is usually no fuel tax. In some locations, a color dye is added to the zero-tax fuel for verification by law enforcement officials. Therefore, because of the tax laws, the price of gas or diesel will

TABLE 2.11 Average Fuel Consumption—Wheel Loaders

	Type of Utilization		
Horsepower (fwhp)	Low (gal/hr)	Medium (gal/hr)	High (gal/hr)
90	1.5	2.4	3.3
140	2.5	4.0	5.3
220	5.0	6.8	9.4
300	6.5	8.8	11.8

vary with machine usage. A common practice to reduce fuel purchase costs is buying in bulk quantity and having portable bulk tanks on the project.

Fuel consumption formulas have been published for both gasoline and diesel engines. The resulting values from such formulas must be adjusted by *time and load factors* to account for working conditions. This is because the formulas are derived assuming that the engine is operating at maximum output. Two working conditions must be considered when estimating fuel consumption: (1) the percentage of time (usually per hour) the machine is actually working (*time factor*) and (2) at what percentage of rated horsepower (*throttle load factor*). When operating under standard conditions, a *gasoline engine* will consume approximately 0.06 gal of fuel per flywheel horsepower-hour (fwhp-hr). A *diesel engine* will consume approximately 0.04 gal per fwhp-hr. Advanced electronic fuel injection systems have a direct effect on fuel consumption rates, and individual manufacturers should be consulted.

Lubricants, Filters, and Grease

The cost of lubricants, filters, and grease will depend on the maintenance practices of the company and the conditions at sites where the machine is employed. Some companies follow the machine manufacturer's guidance concerning periods between lubricant and filter changes. Other companies have established their own preventive maintenance change period guidelines. In either case, the hourly cost is arrived at by (1) considering the operating hour duration between changes and the quantity required for a complete change, plus (2) a small consumption amount representing what is added between changes.

Many manufacturers provide quick cost-estimating tables (Table 2.12) for determining the cost of these items. Whether using manufacturer's data or past experience, notice should be taken about whether the data matches expected field conditions. If the machine is to be operated under adverse conditions, such as deep mud, water, severe dust, or extreme cold, the data values will have to be adjusted.

TABLE 2.12 Lubricating Oils, Filters, and Grease Cost for Crawler Tractors

Horsepower (fwhp)	Approximate Cost per Hour	
	Materials ($)	Labor ($)
<100	0.22	0.15
100 to <200	0.49	0.24
200 to <300	0.65	0.24

A formula that can be used to estimate the quantity of oil required is

$$\text{Quantity consumed gph (gal per hour)} = \frac{\text{hp} \times f \times 0.006 \text{ lb/hp-hr}}{7.4 \text{ lb/gal}} + \frac{c}{t} \tag{2.19}$$

where hp = rated horsepower of the engine
c = capacity of the crankcase in gallons
f = operating factor
t = number of hours between oil changes

With this formula, the quantity of oil consumed per rated horsepower-hour between changes is assumed to be 0.006 lb.

Repairs

Repairs, as referred to here, mean normal maintenance-type repairs. These are the repair expenses incurred on the jobsite where the machine is operated and should include the costs of parts and labor. Major repairs and overhauls are accounted for as ownership cost.

Repair expenses increase with machine age. The U.S. Army has found that 35% of its equipment maintenance cost is directly attributable to the oldest 10% of its equipment. Instead of applying a variable rate, an average is usually calculated by dividing the total expected repair cost for the planned service life of the machine by the planned operating hours. Such a policy builds up a repair reserve during a machine's early life. The reserve will then be drawn down to cover the higher costs experienced later. As with all costs, company records are the best source of expense information. When such records are not available, manufacturers' published guidelines can be used.

Downtime. While downtime is not a repair cost chargeable to a machine, it is often the most expensive part of equipment repair. The production time lost while mechanics and parts are being located and the repair is being accomplished is costly to a project. This cost is usually at its highest rate during the first few minutes or hours of the breakdown, while operating costs are still at a maximum and before the work program has been changed. If the shutdown is a short one and only one machine is affected—for example, if a hose bursts in a self-loading scraper working alone—it causes a loss of production to one unit. The same broken hose on a loader will stop the loader, as well as the string of trucks, dozer, and compacting equipment of the spread. Good maintenance programs with scheduled downtime is the most effective practice for avoiding very costly in-service downtime.

Tires

Tires for wheel-type equipment are a major operating cost because they have a short life in relation to the "iron" of a machine. They require replacement one or more times during a machine's life. In addition, they will need repairs. Repair and replacement costs are greatly affected by care and conditions of use. Proper tire selection and good maintenance and work practices often add substantially to profits.

Good tire management includes:

1. Buying tires of the proper size, strength, tread, and speed rating for the job.
2. Using tires only for purposes, loads, and speeds for which they are designed.
3. Maintaining tires at proper pressure and in good condition.
4. Keeping excavation areas, haul roads, and fills smooth and free of spillage.

Tire cost will include repair and replacement charges. These costs are very difficult to estimate because of the variability in tire wear with project site conditions and operator skill. Tire and equipment manufacturers both publish tire life guidelines based on tire type and job application. Manufacturers' suggested life periods can be used with local tire prices to obtain an hourly tire cost. Always remember, guidelines are based on good operating practices and do not account for abuses such as overloading haul units.

Tires are about a third of a truck's operating cost. Poor management practices can abuse the tires.

Replacement of High-Wear Items

Certain items on machines and trucks such as cutting edges, bucket teeth, body liners, and cables have very short service lives in relation to machine service life. The cost of repeatedly replacing these items can be a critical operating cost. By using either past experience or manufacturer life estimates, the cost can be calculated and converted to an hourly basis.

All machine operating costs should be calculated per working hour. When the working hour is the standard, it is easy to sum the applicable costs for a particular class of machines and obtain a total operating hour cost.

MACHINE COST FOR BIDDING

The process of selecting a particular type of machine for use on a construction project requires knowledge of the cost associated with operating the machine in the field. In selecting the proper machine, a contractor seeks to achieve unit production at the least cost. This cost for bidding is the sum of the O&O expenses. O&O costs are stated on an hourly basis (e.g., $135/hr for a dozer) because it is used in calculating the cost per unit of machine production. If a dozer can push 300 cubic yards (cy) per hour and it has a $135/hr O&O cost, the cost for bidding is $0.45/cy ($135/hr ÷ 300 cy/hr). The estimator/planner can use the cost per cubic yard figure directly in unit-price work. On a lump-sum job, it will be necessary to multiply the cost/unit price by the estimated quantity to obtain the total amount to be charged. Indirect costs, such as job overhead and general and administrative expenses, are then added to the direct cost at the bid item level to produce the final bid item amount.

Ownership Cost

The outflow of cash when a machine is purchased and the inflow of money in the future when the machine is retired from service are the two most significant components of ownership cost. The net result of these two cash flows, which defines the machine's decline in value across time, is termed *depreciation*. As used in this section, depreciation is the measuring system used to account for purchase expense at time zero and salvage value after a defined period. Depreciation is expressed on an hourly basis over the service life of a machine. Do not confuse the depreciation discussed here with tax depreciation. Tax depreciation has nothing to do with consumption of the asset; it is simply an artificial calculation for tax code purposes.

Tires will be replaced many times over a machine's service life. Therefore, their cost is not included in ownership cost calculations but is considered as an operating cost.

The depreciation portion of ownership cost can be calculated by either of two methods: (1) time value or (2) average annual investment.

Depreciation—Time Value Method. The time value method will recognize the timing of the cash flows (i.e., the purchase at time zero and the salvage at a future date). The cost of the tires is deducted from the total purchase price, which includes amounts for all options, shipping, and taxes (total cash outflow minus the cost of tires). A judgment about the expected service life and a corporate cost-of-capital rate are both necessary input parameters for the analysis. These input parameters are entered into the uniform series capital recovery factor (USCRF) formula, Eq. (2.20), to determine the machine's purchase price equivalent annual cost.

$$A = P\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right] \tag{2.20}$$

To account for the salvage cash inflow, the uniform series sinking fund factor (USSFF) formula, Eq. (2.21), is used. The input parameters are the estimated future salvage amount, the expected service life, and the corporate cost-of-capital rate.

$$A = F\left[\frac{i}{(1+i)^n - 1}\right] \tag{2.21}$$

where P = a present single amount of money
F = a future single amount of money, after n periods of time
A = uniform *end-of-period* payments or receipts continuing for a duration of n periods
i = the rate of interest per period of time (usually 1 yr)
n = the number of time periods

Sample Calculation: Consider a company with a cost-of-capital rate of 6% that purchases a $300,000 tractor. This machine has an expected service life of 4 yr and will be utilized 2,500 hr per year. The tires cost $45,000. The estimated salvage value at the end of 4 yr is $50,000. The depreciation portion of the ownership cost for this machine using the time value method would be

Initial cost	$300,000
Cost of tires	– 45,000
Purchase price less tires	$255,000

Now it is necessary to calculate the uniform series required to replace a present value of $255,000. Using the uniform series capital recovery factor formula

$$A = \$255{,}000\left[\frac{0.06(1+0.06)^4}{(1+0.06)^4 - 1}\right]$$

$$A = \$255{,}000 \times 0.28859 = \$73{,}591 \text{ per year}$$

Next calculate the uniform series sinking fund factor to use with the salvage value.

$$A = \$50{,}000\left[\frac{0.06}{(1+0.06)^4 - 1}\right]$$

$$A = \$50{,}000 \times 0.\ 22859 = \$11{,}430 \text{ per year}$$