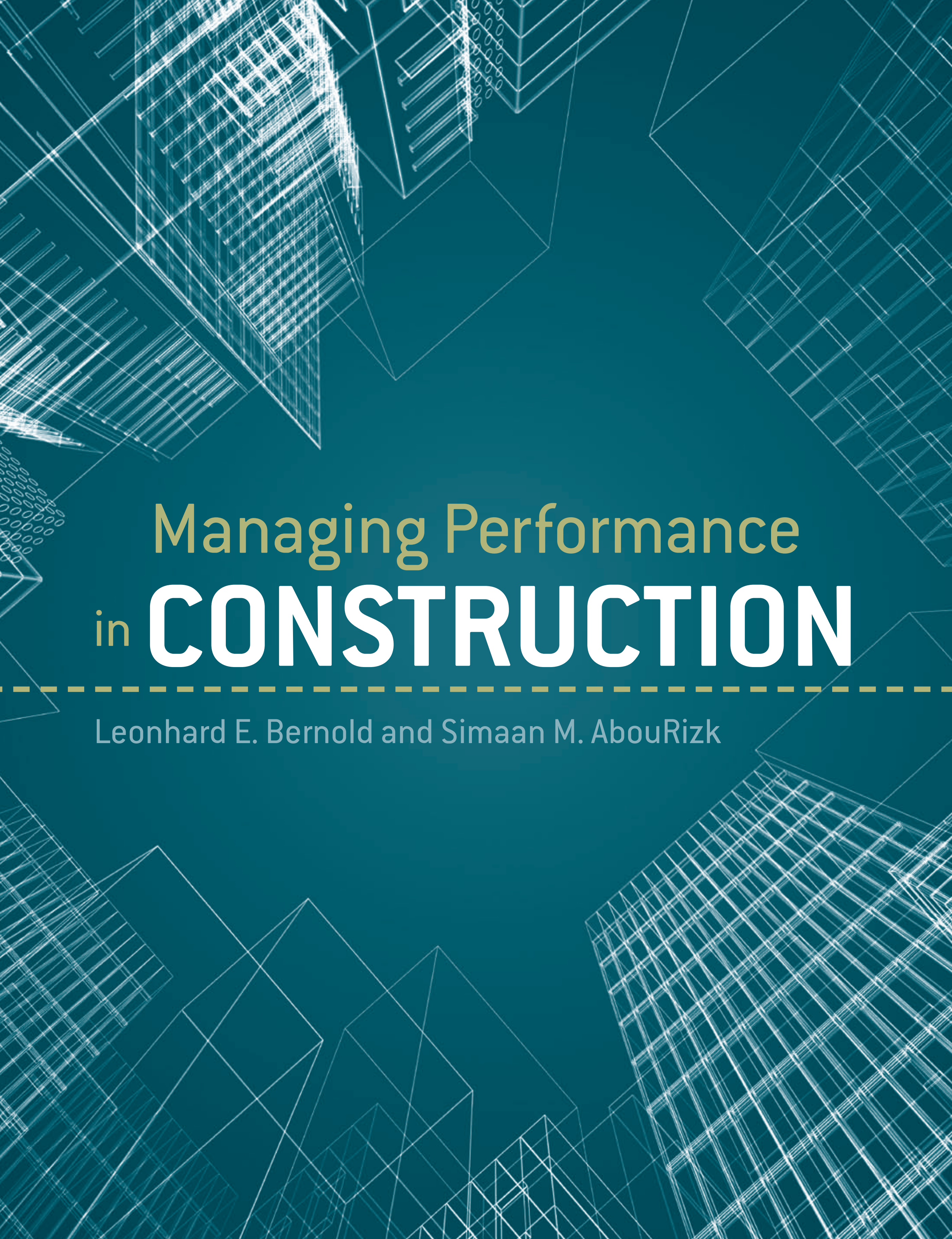

Managing Performance in CONSTRUCTION

Leonhard E. Bernold and Simaan M. AbouRizk

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We would like to dedicate this book
to our families for their continued love and support.
Our gratitude goes to our wives Marilyn and Marleine and
to our five beautiful daughters Elizabeth, Sarah, Hala,
Jenna and Deema

Contents

Preface

I hear and I forget. I see and I remember. I do and I understand.

——Confucius

Addition for construction managers: I think and I innovate.

In 2005, we were offered the opportunity to write this book to present the state-of-practice and knowledge related to the wide range of performance aspects in the construction field. From the outset we felt that a book of this sort should engage the students on many different levels in order to provide a rich set of learning experiences that support one another. For example, we include process simulation software, to provide an opportunity for students and practitioners to gain hands-on experience with modeling and learn how to rapidly evaluate different construction methods and supply-chain configurations. Other important features in the book are pedagogical support of the teaching and learning process, and a companion website, with a wide selection of additional material and supports.

1.1 TAPESTRY OF LEARNING

Deep learning is a complex process, whereby the teacher is both the enabler and facilitator. Einstein once said that one does not understand something until one can explain it to one's grandmother. Obviously, he had more in mind than just parroting what was presented in class. Why would someone's grandmother even be interested in hearing about theories or mathematical formulas? The answer is, only if it is relevant to her and builds on what she already knows. Furthermore, it must be translated into language that she understands.

A textbook does not have to be dry and sterile. This one engages the reader in a conversation, with the intent of stimulating interaction with the teacher. It presents small problems leading the student to follow the thoughts of an experienced engineer, in the same way an apprentice looks over the shoulder of his or her master. Equally important, each reader is recognized as having unique learning

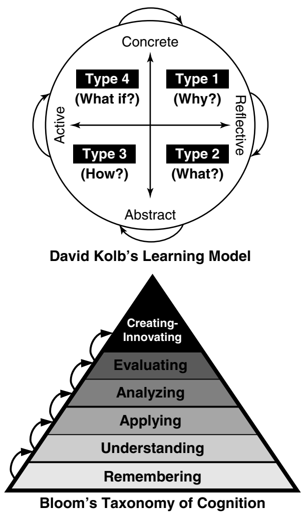

Figure P.1 David Kolb's Learning Model (top); Bloom's Taxonomy of Cognition (bottom)

strengths, as illustrated by David Kolb's learning model, shown at the top of Figure P.1. Various methods and techniques are employed in each chapter to enable all readers to apply their individual learning strengths.

What is the feeling one gets when one really understands new material (before explaining it to grandmother)? One understands the theory behind it, knows how to apply it to solve problems, knows why it is important, and, finally, has an instinctive feeling what would happen if critical variables were changed. In fact, one has visited all four quadrants of Kolb's circle, while scaling Bloom's learning pyramid (bottom of Figure P.1), beginning with memorizing the facts and ending up being able to apply the new knowledge creatively. The teacher is considered the coach, who leads the students through the process of acquiring knowledge via a personal and guided inquiry into the subject. In particular, students will be inspired to tap into their creative and innovative capabilities, and find many opportunities to practice and, ideally, earn well-deserved credits toward their final grades.

The vast majority of engineering students receive very little education related to the historical accomplishments that led to the construction technologies they see almost every day. To fill this vacuum, we add short sidebars to the main text when appropriate in order to provide interesting stories and to encourage an extended inquiry. In the same vein, we "assign" homework and short classroom exercises, which require students to collect, analyze, and evaluate data as additional means for building bridges to the new knowledge they are acquiring. Students can assess how well they understand what they have learned, and detect where their weaknesses are. These activities ensure that students are in control of the learning process, and take an active role. Finally, this book offers a unique opportunity for the teacher to foster reflective learning through journaling

There is no doubt that the most prominent engineer ‘‘journaler’’ lived and worked in the sixteenth century. Who does not admire Leonardo da Vinci’s sketches of lifting cranes and flying machines, and the text and calculations that accompany them explaining how and why the proposed system would work.

Generic Structure of a Class Journal

A. Executive Summary

B. Table of Contents

C. Weekly Journal Entries. Address the following five topics:

1. Weekly review:
   What happened in class?
   What did we have to do?
2. Personal discussion. Reflections about each main subject of the week:
   Why are the new principles and methods important?
   How does the new material relate to what I already know?
   What are real-world problems that I can solve now?
   What helped me most to understand?
3. Special journaling questions relating to the chapter (assigned by the professor)
4. New terms: the meaning of 10 new (to me) terms in construction
5. My favorite sketch/figure/picture that communicates most effectively.

D. Supplementary Materials:

Personal observations

Evaluations

Poems

Newspaper articles

PowerPoint presentations

Websites

Other

Many of the skills that students practice while journaling are among those suggested by the Accreditation Board for Engineering and Technology (ABET): communication, analytic skills, information literacy, lifelong learning, knowledge of contemporary issues, holistic approach to engineering problems, and reflective thinking about professional issues. One of the most satisfying experiences for a teacher is to observe students struggling during a semester, then see them present their journals at its end with pride and a smile, and say, ‘‘This was the toughest thing I did in school, but it will help this class experience guide my future professional life."

1.2 BOOK CONTENTS

The material in *Managing Productivity in Construction* is presented using two integrated media: the traditional textbook and the supporting website, the latter which offers additional supplementary materials for students to explore, if they wish.

Some of the chapters contain features called header problem and/or worked-out problem, positioned at "pressure points." Both features are nontraditional, in that they are embedded in real-world situations that can occur during a construction project. Rather than providing straightforward solutions, they guide readers through problem-solving exercises, requiring them to make assumptions and collect and analyze data; the problems conclude with a discussion of the results, adding a qualitative component and final recommendations to make to a "virtual boss."

Each chapter ends with a chapter review and bibliography. The chapter review includes three components: (1) journal questions, (2) traditional homework problems, and (3) open-ended problem. The journal questions are tailored to each chapter and can be selected by the teacher to amplify the generic outline of a journal.

Managing Performance in Construction covers a wide spectrum of topics in 11 chapters, beginning with the concept of productivity measurements and process modeling. Here is a quick overview of the chapters:

Chapter 1, "Indicators of an Industry in Transition," identifies some of the early indicators of an industry in transition. A major change in the way we design, plan, and even control construction projects will be caused by the industry-wide adoption of the Building Information Modeling (BIM) system. This thrust will be accompanied by the further growth of e-construction management, which will eventually digitally link construction equipment in real time to a project's website. Another major impact on the industry is the drive toward sustainable and ecoefficient construction.

Chapter 2, "Productivity in the Spotlight," describes the many different ways productivity is measured. It details the concept of process productivity in construction, while highlighting the causes of nonproductive work. This chapter also presents the seven types of *muda*, Japanese for "waste," or "wasteful activity," a very effective concept first introduced by Taiichi Ohno, Toyota's chief engineer. In short, a plan has little meaning if it is not accompanied by a method to control the process to meet it. Thus, the chapter introduces scientific methods to measure how well construction is progressing on the most critical level: the production process. Finally, it offers various methods useful in identifying the factors leading to high, as well as poor, productivity.

Chapter 3, "Cornerstones of Efficient Site Operation," begins by quoting the thirty-fourth president of the United States, Dwight D. Eisenhower: "Plans are nothing; planning is everything." This chapter strives to live up to this premise, one that has been uttered by many others.

The disappearance of the medieval Master-Builder who constructed those gigantic cathedrals in Europe caused a long list of problems for construction professionals, key of which was the loss of construction expertise during the design phase. This chapter reviews the emergence of constructability as a critical issue of securing efficiency during construction. It goes on to present the Work Breakdown Structure (WBS) and Organizational Breakdown Structure (OBS) as key elements of integrating the various participants in a project. Finally, Chapter 3 works through several examples that demonstrate how construction processes are tightly linked to the efficiency of the supply chain. Real-world construction examples also are used, to illustrate the importance of planning and implementing highly efficient procedures.

Chapter 4, "Introduction to Simulation and Its Use in Modeling Production Systems," takes as its premise that as the twenty-first century advances, there will be no physical labs, that most experimentation will take place using computer simulation. Experimenting in the real world is often too expensive and impractical, especially in construction. In this chapter, we introduce readers to a new generation of computer simulation systems that facilitate experimenting with complex construction operations with relative ease. Specifically, we introduce Simphony and its simulation templates and show how they can be used in modeling construction systems in general and construction operations in particular. Once a model is built, we can then experiment with it for the purpose of understanding its production structure, its bottlenecks, and the means of improving its productivity.

Chapter 5, "A Case Study: Applying Simulation in Tunnel Construction," assesses, models, and simulates a real-life project. The purpose here is to give the reader as near as possible an actual experience of building large-scale models of complex systems. To that end, we introduce a project that we developed during a consulting assignment, involving the installation of a large water main inside a tunnel over a stretch of approximately 500 meters. The operation we model includes construction of the shafts and the tunnel and the installation of the pipe inside it. We simplify the modeling strategy in this chapter to suit the broad range of readers, then on the website provide the full models so that the advanced reader can further investigate their features.

Chapter 6, "Competencies That Drive the Company," examines the present thinking around the competencies successful workers and managers need to develop. The knowledge and skills necessary today have gone far beyond what was thought sufficient just 30 years ago. The chapter describes how core competences depend, as never before, on the personal and continued initiative of the individual, one who makes lifelong learning a key element of his or her development.

A second section in chapter 6 presents modern methods for assessing the performance of a manager and explains how to turn the evaluation into a tool of constant improvement.

Chapter 7, "Productivity in a Healthy and Safe Work Environment," discusses the many physical and the emotional strains that impact both on-site workers and managers in their offices. Ulcers and insomnia are as destructive to the performance of workers as accidents and overexertion on the construction site. Along with the more traditionally known detrimental effects of working in the open environment, such as extremes in temperature and humidity, the health risks of noise and vibration from tools and equipment will also be reviewed. The mechanisms leading to the epidemic of back injuries in the industry also are presented.

The chapter closes with a look at the increasingly destructive forces of the numerous on-the-job stressors—harassment for example, which, when allowed to smolder, costs companies large sums of money. In some cases, targeted individuals and their families are bullied into an abyss from which many never return. A major part of this interesting topic is dedicated to skills training and the learning curve, brought to life via problems and exercises.

Chapter 8, "The Complexity of Human Motivation," addresses the question of what motivates people to do certain things, a topic of study for over 3,000 years. One of the first who formulized needs-based motivation of humans was the American psychologist Abraham Maslow, closely followed by Yale business professor Victor Vroom and the psychologist Frederick Hertzberg. The theories of each of these men are discussed, and some are applied to solve a problem faced by individuals. Modern efforts to improve job satisfaction, such as job enrichment, are also appraised.

Chapter 9, "Performance Factors of Leaders and Teams," considers the question: "Is a manager also a leader?" Warren Bennis, an American pioneer in leadership studies, once wrote: "The manager asks how and when; the leader asks what and why!" This would imply the answer to the question is no. This chapter looks at the differences between the manager and the leader before delving into some of the known leadership models. The need for leaders to possess emotional intelligence is emphasized; then the focus shifts to the behavior patterns of groups, since a group leader must have special competencies to be successful. Finally, a Worked-Out Problem highlights some of the key issues that commonly emerge when groups are brought together to address a complex issue.

Chapter 10, "Communication: The Nerve System of Construction," is dedicated to examining communication from several different perspectives. Miscommunication has started wars, and lack of effective communication has been cited in many sources as the single most important barrier to overcome to improve productivity in construction.

The chapter begins with an overview of the long and fascinating history of the blueprint, which can be traced back more than 4,000 years. Next, the theory of two-way communication applied to the use of the Internet in construction is presented. This is followed by a discussion of the special needs of construction, and their relationships to different established methods and technologies. The chapter ends with a review of the remarkable opportunities offered today by agent-based communication, balanced by a look at the perils of face-to-face group discussions, addressed using theory and examples.

Chapter 11, "Performance Management," concludes *Managing Performance in Construction* by pulling together all the main topics discussed in the book. It makes the case for moving from a productivity-only focus to measuring business success to assessing performance. Here, performance function is defined as consisting of two factors: productivity and effectiveness. It emphasizes that the short-term focus on the output of the operation neglects the fact that the business consists of many other components, which need to be aligned to the long-term business objects. Thus, the performance of the purchasing department running the supply chain is as critical to the success of the company as the financial department securing critical loans at "effective" conditions. The Balanced Scorecard method is used to demonstrate how to utilize a companywide performance assessment as a basis for continuous improvement. The chapter ends with a top-to-bottom review of supply-chain management as one of the keys to improving future construction performance.

Chapter 1

Indicators of an Industry in Transition

Adam Smith (1723–1790) was once hailing the great opportunities offered by the division of labor. This mechanistic view of work has since been matched with views that stress the needs and goals of humans within a social organization. In many ways, the human relations movement has brought laborers and management closer together. Many of the expected changes in the future will bring employees even closer together, through so far un-mined communication technologies and electronics. Many construction equipment companies around the world are already putting the "smart" communication infrastructure into their equipment that will radically change the way they manage construction projects in the future. For the first time ever, construction managers will know at every second how well the project is performing; more, they will able to supervise the site from anywhere in the world.

1.1 BREAKING INTEROPERABILITY BARRIERS

The Building Information Modeling (BIM) system, a parametric and object-oriented approach to drawing buildings, is being embraced by architects and design engineers. BIM is more than detailed 3D modeling: It attaches functions and features to each object, to identify it as a unique element in relationship to its surroundings. For example, the function attached to a door might be its ability to swing around the hinge point; and its feature would include the make, weight, color, and so on. BIM allows designers and builders to identify all attributes of a building element, such as windows, HVAC ducts or elevators, and makes it easy to conduct interference and constructability checks.

The potential savings in time—to design, distribute the drawings electronically, and switch smoothly between different software packages (e.g., structural analysis)—has captured the attention of many change agents inside large Architectural-Engineering-Construction (AEC) companies. Even more, the structural steel suppliers in the United States have been on the forefront in taking advantage of creating interoperable software systems. Tests demonstrated how last-minute design changes can be transmitted electronically from a design software directly to the fabricators shop equipment. This ability is unprecedented in the construction industry and gives designers and fabricators many opportunities to reduce costs, while ensuring that project objectives are met. This is just the beginning; we can expect more radical changes in the future in the way we bid, supply, and generally manage construction projects. These changes will encourage the industry to adopt an ontology that will become commonplace, not only between architects and construction engineers in the United States, but those around the world. The education of architects and engineers could even be organized around one of the primary strengths of BIM: collaboration. In fact, its support of cross-organizational and global collaboration among project participants is expected to become a major benefit for the industry.

1.2 CONSTRUCTION BECOMES SUSTAINABLE

According to the World Business Council for Sustainable Development (WBCSD), critical aspects of ecoefficiency are:

- Reduction in the material intensity of goods or services
- Reduction in the energy intensity of goods or services
- Less dispersion of toxic materials
- Improved recyclability
- Maximum use of renewable resources
- Greater durability of products
- Increased service intensity of goods and services

Like BIM, ecoefficiency is changing the way we construct, as we seek to produce sustainable, ecofriendly structures. Sustainable buildings are achieved through integrated building design, an approach to design and construction that involves the participation of owners, contractors, suppliers, building users, and design professionals. Notably, the U.S. Green Building Council (USGBC) has, to date, certified more than 20,000 projects using its Leadership in Energy and Environmental Design (LEED) rating system, introduced in 1998. The nonprofit organization promotes buildings that are environmentally responsible, profitable, and healthy places to live and work. LEED awards points for relative efficiency improvements in the use of energy, water, and materials. But LEED covers only the final building, so a special standard has since been added: LEED for New Construction and Major Renovation (LEED-NC). It focuses on safeguarding and conserving water, energy, and the atmosphere, while eliminating the creation of material waste. Green building points can be earned, for example, by recycling old building materials or breaking up concrete on-site to create a permeable ground for rainwater to pass through. Replacing cement with fly-ash, or reducing the amount of cement, also earns points for producing less CO_2.

Low-Impact Development (LID) is also generating a lot of interest, as it addresses one of the main problems facing the United States, the dry-pumping of aquifers, combined with evaporation of large amounts of water. This innovative stormwater management approach uses rainfall as a major resource, rather than a nuisance. It creates opportunities for the rainwater to infiltrate the local ground, to be filtered and stored, instead of being piped away.

Maintaining a sustainable earth means ensuring that the next generation will take over a world in much the same state and with the same amount of resources as in the previous generation. Two building materials that meet this goal extremely well are wood and bamboo. Using wood as a building material will resurrect an old and almost-lost craft, lead to innovation in wood structural design, and reduce the cost of timber by creating global economic incentives to plant different kinds of trees for economic benefits.

Construction and demolition (C&D) waste contributes 25 percent of the total waste stream in the United States, and many landfills have already reached capacity. Instituting stricter new regulations, raising public awareness, and opening new landfills are not always options, or will become expensive to sustain. Therefore, reducing and recycling C&D waste has become paramount. One new concept calls for mining old landfills to recover and recycle decades of C&D waste.

These developments are additional signs that construction will continue to change.

1.3 E-CONSTRUCTION MANAGEMENT

E-business, e-collaboration, e-communication, and wireless communication have made major inroads into many industries. E-business refers to electronic or Internet-based commerce, supply-chain management, customer relations, and companywide communications. The resulting benefits are faster interactions, better prices and delivery terms, and better support from suppliers, who are able to reduce their administrative burden and human error. Although construction is lagging behind in seeing the increased efficiencies and savings that are being reaped by users in other industries, this will undoubtedly change. The benefits of a matured technology that is able to survive the rough construction environment is something the construction cannot afford to pass up.

Similarly, Internet-based project collaboration services have seen steady growth. They offer functions such as team directories, file sharing, document archiving, task management, project scheduling, and current budget status, all accessible by authorized personnel 24/7. These services will further develop to include virtual, live project-site meetings. An inspector on-site will be able to show a problem with his wireless mobile network camera as engineers and suppliers, all connected to the Internet, all review the video and the relevant drawings simultaneously. Internet phone services will provide the audio, to

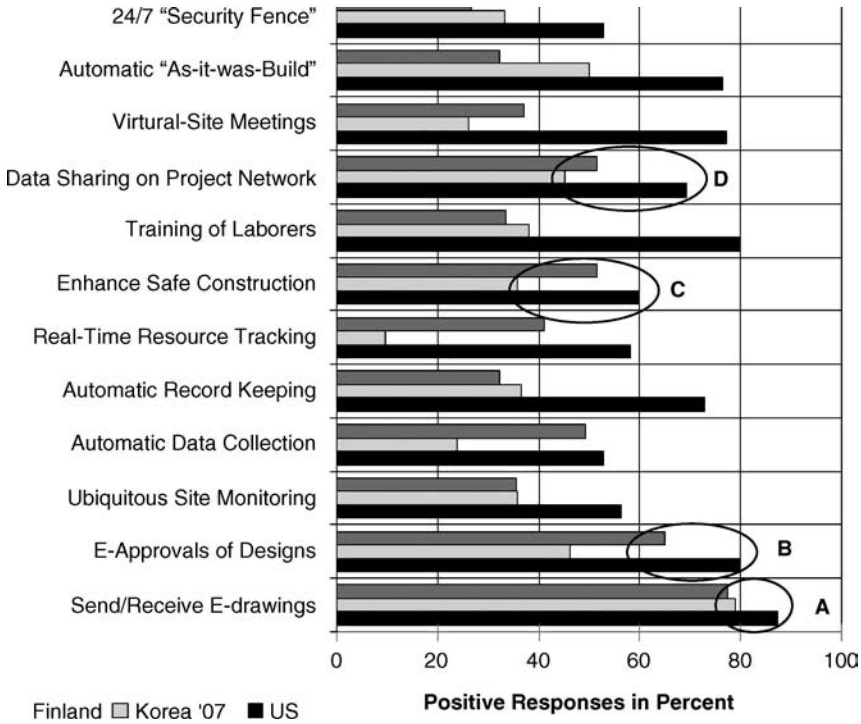

Figure 1.1 Opportunities for Using Web-Based and Wireless Communication

enable brainstorming on a shared whiteboard. These services are all about saving significant amount of time solving a real problem, eliminating weeks of waiting for an answer to a Request for Information (RFI).

Another indicator of future changes was a survey made in 2007 of 300 construction managers from three countries—the United States, South Korea, and Finland—about their beliefs regarding where Web-based wireless communication could provide important benefits. While there were significant differences in their responses, as shown in Figure 1.1, there were also some interesting commonalities.

In general, the 100 American managers, located in different regions of the country, were more optimistic about the use of Web-based communications than their counterparts in Finland and South Korea. Indicated by the labels A, B, C, and D are areas where one or two country representatives have the highest expectations. We point out, however, that A, B, and D are those areas where these services are already being heavily used, and thus are most familiar to the respondents. We already discussed how BIM will facilitate the rapid growth of those same areas. New areas include construction safety as automated sensor systems protect the workers from exposure to hazardous environments. Finally, the American managers thought that Web cameras could change the way laborers are trained, provide automatic "as-it-was-built" updates, and support virtual site meetings.

1.4 LINKING UP TO SMART CONSTRUCTION EQUIPMENT

Change is progressing in the way construction professionals manage, maintain, and protect their equipment. Combining "smart" agent-based software, global positioning systems (GPS), and wireless satellites and local communication systems, vast networks have been created to track and receive information from sensors built into equipment.

Geofencing is one very useful application of what is referred to as *telematics*. With this application, a contractor is able to install a virtual fence around a construction site, which is being monitored by GPS and local positioning tools. Every time a person, vehicle, piece of equipment, or anything else equipped with a hidden or open tag crosses the virtual fence, the incident is automatically recorded, or an alarm notification is sent to an "agent"—such as the local police station. Wireless sensors or tags, such as smart radio frequency identification (RFID) tags, can be integrated into the system to collect data or to send a warning. Thus, for example, equipment rental agencies will be able to automatically track how their units are being treated, and protect them from being operated by an untrained or unauthorized person.

A related change has begun in the way operators run dozers, graders, or scrapers. After equipment manufacturers switched to electronic controls and differential GPS or laser-based systems, real-time 3-D position data of cutting blades are generated electronically. These sophisticated equipment still require human operators, but this, too, will change over time. Having the ability to send commands to hydraulic actuators electronically opens the door for full automation. In other words, for suitable tasks, such as directing the blade of a dozer or grader, the human operator is being replaced with a "smart" and fast-reacting automatic controller. A computer calculates the discrepancy ($\Delta Z(x,y)$) to the desired contour and sends signals to the hydraulic cylinders, which move the blade into the desired position, while the human operator focuses on steering the equipment safely and quickly.

How Global Positioning Systems Work

A global positioning system (GPS) is made up of three parts: (1) 24 satellites, which orbit the Earth every 12 hours on almost the same track; (2) control and monitoring stations on Earth; and (3) GPS receivers owned by users. GPS satellites broadcast signals from space that are picked up and identified by GPS receivers. Each GPS receiver then provides a three-dimensional location (latitude, longitude, and altitude), plus the time. Due to ionospheric and tropospheric distortions of the signals, however, errors may be introduced into the calculation of coordinates of the target receiver. To correct most of these inaccuracies, differential GPS uses the location of a known reference station to constantly recalibrate the coordinates.

Source: www.gps.gov

1.5 HIGHLY SUCCESSFUL ENGINEERING MANAGERS

Managers in engineering and construction spend, on average, 60 percent of their time on managerial tasks and 35 percent on engineering-related work. Further, the majority of the managerial time is spent addressing human resources issues, which requires what is referred to as "soft leadership skills" or "emotional intelligence." Ever since David McGregor published

The Human Side of Enterprise in 1960, in which he introduced his Theory X and Y, managers and employees have started to move away from X toward Y. This change was accelerated by research results that showed that successful managers depend 85 percent on emotional intelligence and 15 percent on technical skills and knowledge. It was also found that 80 percent of managers who fail do so because they lack soft leadership skills. This parallels observations by successful engineer managers, who state that they use only 5 percent of what they learned in college, but had to acquire 85 percent of what they really needed on their own—a large part of which was learning to work with people.

Organizations wishing to systematically improve their performance must expand their knowledge base. In this regard, change is underway in the way knowledge gain is fostered. The main driver of this development is the highly successful 360-degree appraisal, or feedback method, for managers (“360 degrees” refers to the full circle that surrounds an individual working inside a company). It is used to identify, early, key skills that are lacking in an aspiring manager. When an appraisal is done, feedback is solicited organizationwide—from subordinates, peers, and supervisors—and includes a self-assessment. The results are used to direct skills training and continuing education.

Soft skills that are typically needing development in today’s engineers are:

- Synergistic thinking
- Interpersonal communication
- People development—coaching
- Leadership
- Motivation
- Workplace conflict resolution
- Teamwork collaboration
- Change management
- Stress management

A Story of Whats and Whys

Michelle Brink couldn’t believe her eyes as she looked at her computer screen, which displayed the results of several what-if runs she had made with her new process simulation software. She was looking at a possible productivity increase between 20 to 30 percent in laying block and brick, compared to the present method. And the necessary change to achieve it was so minor.

Michelle received a BS in civil engineering three years ago, and has been working for Prime Value Builder, Inc. (PVB) a major developer of single-family homes and town houses. For the first year she worked in scheduling, and then spent a year and a half in estimating, where she received excellent 360-degree performance evaluations. Aspiring to become a construction manager, she was promoted to assistant to Jerry Foresight, a reliable ‘‘old hand’’ in the company.

PVB’s human resources department had been following her career and decided to manage her further growth in the company. First, she was recommended for a continuing education course, called Kaizen management, offered by a major management consultant company. Michelle had never heard of Kaizen management, and so had no clue what to expect. The HR people cautioned her that the course would be tough but that afterward she would be well informed and well prepared to advance her career.

From the first minute she was intrigued as the course first covered the history of management theories, concepts she had heard about but never fully understood. But what most fascinated her was the period following World War II with the rapid introduction, in quick succession, of new management concepts such as the Work Breakdown Structure (WBS) and the Critical Path Method of scheduling, or the Gantt chart. But she was most impressed by what the Japanese car company Toyota had implemented to improve the quality of its cars while at the same time increasing productivity and reducing costs. What was ironic was that the foundation for the ‘‘miracle’’ Japanese management system had been laid by an American, by the name of W. Edward Deming. He had taught them the basics and they listened while he was dismissed by US companies for many years.

The previous day, the class had covered the concept of Just-in-Time (JIT), which Michelle thought was less interesting than what she learned in the second half of the class, which was dedicated to Just-in-Sequence (JIS) delivery. The key to JIS, a very simple concept, was not just that deliveries were coming to the plant on time but that they also were organized in a first-in-first-out (FIFO) manner, meaning that the parts that were needed first were in front or on top of the containers or pallets. This was in direct opposition to the method used to store luggage in airplanes, which operate on a first-in-last-out (FILO) basis.

Later they were introduced to computer simulations of processes. The class was shown how to change delivery times, to account for rush hour, switching JIS off and on, and so on. Then they could watch on the screen as the effects of the changes took place, in terms of production time and productivity.

What struck Michelle was the realization that when ordering brick and block, for example, she currently worried only about ‘‘getting it there’’ before the subcontractor arrived. But by ordering with JIS in mind, that is telling the supplier to put it right where it was needed on the construction site—the blocks could be delivered inside the footprint next to the foundations, or the bricks along the outside wall. Of course, this must be timed so that the bricks

(*continued*)

and blocks were delivered after the foundations had been poured, at which point Michelle realized that a major problem would be communicating the correct locations to the supplier—or, more importantly, to the truck driver delivering the bricks and blocks. She also realized she would have to factor in that their supplier used trucks with long-reach hydraulic crane booms.

To solve these problems, she thought back to a case study they had worked on in class. The delivery trucks in the case study used *telematics*. Once at the correct address, the driver simply accessed a website that directed him, via a live video feed, from the entrance of the site to his destination, using direction arrows overlaid on the screen. The driver was able tosee exactly where to turn and which door to back up to. In fact, the door opened just as he pulled up, and the forklift driver was already there, ready to unload. They were expecting him, since the telematics system had announced when he was entering town.

But Michelle did not anticipate that the supplier was using telematics and PVB did not have a wireless camera on-site. So she considered alternatives she might use. How about colored stakes? The day before delivery, she would put up the stakes at the locations where she needed the operator to unload cubes of bricks or blocks. She would also calculate how many were needed, and space the cubes appropriately. And, she thought, ''If I tell them at the plant to attach coordinating colored paper to the cubes, there is no way the driver will get confused. This has to work!''

Michelle also remembered another lesson emphasized in the Kaizen class: performance measurements as the necessary basis for managing improvements. This motivated her to design a time-and-motion study, to compare performance at a traditionally organized site versus a JIS site. Probably, she thought, she would be able to enlist two of the summer interns to conduct the study, after she trained them how to do it. What an exciting learning experience would this be for them while, at the same time, establishing valuable data to the company.

CHAPTER REVIEW

Journaling Questions

1. Draw up a list of all the concepts and ideas that you do not understand from reading Michelle's story.
2. How will the drive toward sustainable construction affect the way we manage projects?
3. Sketch the communication network for a virtual site meeting to solve a problem detected by a quality control inspector. It should involve the structural engineer, the steel manufacturer, and the architect, each in his or