



# CONSTRUCTION PROJECT SAFETY

John Schaufelberger  
Ken-Yu Lin



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# PREFACE

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Construction continues to be one of the most dangerous occupations in the United States, accounting for about 10% of the disabilities and 20% of the fatalities that occur in the industrialized work force. Most successful construction companies have recognized that safety and health management is a critical strategic issue and have developed comprehensive company safety and health programs. Anyone involved in managing a construction project must understand that job site safety is very important requiring their full attention.

A safe working environment results in increased worker productivity and reduces the risk of injury. Accidents are costly, leading to disruption of the construction schedule and demanding significant management time for investigation and reporting. The indirect costs that result from accidents can be significant and generally are not covered by insurance, thus adversely affecting the profitability of a project.

Project labor cost is greatly influenced by a construction company's safety record. The firm's workers' compensation insurance premium rates are directly related to the company's safety record. Federal and state statutes mandate the implementation of required safe working practices on all construction sites. Failure to comply with these requirements may result in significant fines as well as accidents.

This book was developed to examine construction project safety from the typical phases of a construction project. It was written for use in undergraduate and graduate construction management programs. Most authors approach construction safety from a regulation-based perspective. It was felt that providing a project context for the discussion would enhance student learning regarding how to develop a site-specific accident prevention program by thinking through construction processes and identifying the various hazards that may exist during the different phases of construction.

Fire Station 39 constructed in Lake City, Washington, was selected as the project to be used as a case study throughout the text and serves as the basis for the discussion. The project was a \$3.5 million fire station constructed between April 2009 and March 2010 for the Seattle Fire Department. The project was not so complex that students would need to learn complex construction techniques but instead can focus on project site safety issues.

The book is organized into individual chapters that address major construction safety and health issues. Chapters 1 through 4 discuss the importance of

good job site safety procedures, workers' compensation insurance, accident prevention programs, and the federal Occupational Safety and Health Administration (OSHA) requirements. Chapters 5 through 10 discuss the safety concerns that were addressed during the various phases of constructing Fire Station 39. Each chapter concludes with a set of review questions that emphasize the major points covered in the chapter. Exercises are provided that require application of the principles discussed. Appendix A contains a glossary of terms used in the book, Appendix B is a sample accident prevention program for Fire Station 39, Appendix C contains a construction schedule for Fire Station 39, Appendix D contains the requirements for the 10- and 30-hour OSHA certification, and Appendix E contains selected OSHA standards that relate to Fire Station 39. Selected OSHA standards are contained in Appendix E to provide a reference for students to understand the safety plans discussed in the book. Even though some states may issue their own occupational safety and health regulations, these regulations generally are based on OSHA requirements.

An array of additional resources for both students and teachers are readily available on the book's dedicated website, [www.wiley.com/go/constructionprojectsafety](http://www.wiley.com/go/constructionprojectsafety). While the construction photographs and building information model images presented in the book are black and white, color versions of both the photographs and images can be found on the web site as well as selected construction drawings for Fire Station 39. An instructor's manual containing answers to the review questions and PowerPoint slides is available for teachers on the book web site.

Finally, the authors would like to thank The Miller Hull Partnership and the following individuals for their assistance in the completion of the book: Alan Sutherland, Jason Solie, Caroline Kreiser, Kyle Hughes, and Aran Osborne.

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# INTRODUCTION

## 1.1 NATURE OF CONSTRUCTION OPERATIONS

Other than mining and agriculture, construction project sites are the most dangerous workplaces in the United States. The construction industry accounts for about 10% of the disability injuries and 20% of the fatalities that occur in the industrialized work force, even though construction workers account for only about 8% of the industrial man-hours worked in the United States. The construction industry includes a wide variety of companies, specialized crafts, and types of projects. Projects vary from single houses to multibillion-dollar major infrastructure projects.

Fatality and recordable injury and illness cases within the industry from 2007 to 2010 are shown in Table 1.1. Therefore, construction safety is a very important topic. The ability of a construction company to eliminate or mitigate the risk of accidents is essential in the execution of a successful construction project. Implementing effective safety measures reduces project costs and demonstrates concern for the welfare of

**Table 1.1** Construction Workplace Fatalities and Injuries/Illnesses per 100 Full-Time Workers

|   | 2007 | 2008 | 2009 | 2010 |
|---|------|------|------|------|
| <b>Fatalities</b>   |      |      |      |      |
| Number of fatalities  | 1239 | 1016 | 879  | 802  |
| <b>Rate of Injury and Illness Cases<br/>per 100 Full-Time Workers</b> |      |      |      |      |
| Total recordable cases  | 5.4  | 4.7  | 4.3  | 4.0  |
| Cases involving days away from<br>work, job restrictions, or transfer | 2.8  | 2.5  | 2.3  | 2.1  |
| Cases involving days away<br>from work                                | 1.9  | 1.7  | 1.6  | 1.5  |
| Cases involving day of job<br>transfer or restriction                 | 0.9  | 0.7  | 0.7  | 0.6  |

Source: Bureau of Labor Statistics, "Industries at a Glance," available: <http://www.bls.gov/iag/tgs/iag23.htm>.

people working on or passing by the project. Safety records are often considered by project owners when selecting construction firms to construct their projects.

There are two major aspects of project site safety: (1) *safety of persons working on the site* and (2) *safety of the general public who may be near the project site*. Both aspects must be addressed when developing project-specific safety plans. These plans identify all hazards to be faced by construction workers and the general public during the various phases of construction and measures to be taken to minimize the risk of injury to workers or the public. Examples of construction worker safety measures are requiring the wearing of personal protective equipment (PPE) and placement of barricades around floor openings. Examples of public safety measures are perimeter fences and warning signs to prevent entry into the project site by unauthorized individuals.

The primary causes of construction job site injuries are:

- Falling from an elevation
- Being struck by something
- Trenching and excavation cave in
- Being caught between two objects
- Electrical shock

Many hazards exist on all construction sites: sharp edges, falling objects, openings in floors, chemicals, noise, and a myriad of other potentially dangerous situations. Mitigation measures are required to minimize the potential for injury, and continued training is needed to ensure the entire work force maintains a work safely attitude.

Most construction projects are unique and executed in varied work environments. Construction workers, therefore, are constantly expected to familiarize themselves with new situations that potentially may be hazardous. In addition, the composition of construction project teams varies from project to project, and many craft workers may work for different employers leading to a lack of conformity and continuity. Craft workers may only work on a project site during certain phases of the work and then move to another project site. The continuing change in the composition of the work force on a project presents significant leadership challenges to the project manager, superintendent, and field supervisors.

Another major safety challenge for construction site supervisors is the increased employment of workers for whom English is a second language. Not only do these workers have difficulty reading and understanding safety signage, but they may be unwilling to report unsafe job site conditions or working practices. It is critical that the supervisors be able to enforce good safety practices among all individuals working on a job site. This may require that safety signage be posted in multiple languages and that safety orientations be conducted in multiple languages.

As construction projects are being executed, there is a continuous series of situations in which construction workers and/or the general public may be exposed to risk of injury. It is extremely important for construction leaders to recognize these situations and take action to control or mitigate these job site hazards. Many construction operations occur in excavations below the surface of the ground or in the air above the ground. In many cases, construction activity is exposed to natural



**Figure 1.1** Masonry workers construct a concrete block wall from a vertical scaffold

elements, such as rain, snow, wind, or other climatic conditions. Implementing measures to protect workers and the public is the best way to minimize the potential for injury. This is illustrated in Figure 1.1, which shows construction workers constructing a concrete masonry wall from a vertical scaffold.

Creating a safe work site is a function of the physical conditions of the working environment and the behavior or working attitude of the individuals working on the site. Safety planning must begin during the initial planning for a construction project along with the development of a cost estimate and project schedule. The initial safety plan needs to outline how safety will be managed on the project, including roles and responsibilities of project participants, resources available, anticipated hazards and mitigation measures, training requirements, and safety equipment needs. Requiring everyone on the project site to wear appropriate PPE may impact worker productivity, and the purchase of appropriate safety equipment may impact project costs.

## 1.2 IMPORTANCE OF SAFE PRACTICES

A disabling injury or a fatal accident on a construction project will have a significant negative impact on the execution of construction operations. Accidents cost money, have an adverse impact on worker morale and productivity, and lead to adverse publicity about the project, the construction company, and the project owner. It is the

construction company's responsibility to provide a safe working environment for all construction workers on the project site, including those employed by subcontractors, and to protect the public from harm. This is a significant concern when major construction activity occurs within a facility, such as a hospital, that is in operation.

The primary factors that motivate safe practices on construction sites are:

- Humanitarian concern for workers and the public
- Economic cost of accidents
- Regulatory requirements for work site safety

Each of these factors is discussed in the following paragraphs.

It is a normally accepted principle that an individual should not be injured while working for an employer. This is based on humanitarian concern for the well-being of every individual. In addition to the humanitarian concern, there is a significant adverse economic impact if an accident occurs. Accidents are costly, as will be discussed in the next section, and often result in uncompensable delays in the completion of the construction project.

Congress passed the Occupational Safety and Health Act (the OSH Act) in 1970 establishing mandatory workplace safety and health procedures. These required procedures will be discussed in greater depth in Chapter 4. The act created the Occupational Safety and Health Administration (OSHA) within the Department of Labor to administer the act. OSHA regional and area offices employ inspectors whose duties include visits to construction projects to ensure compliance with mandated safety and health procedures and to assess significant fines for failure to comply with the required procedures. Job safety and health requirements generally consist of rules for avoiding hazards that have been proven by research and experience to be harmful to personal safety and health.

The act authorized individual states to establish their own occupational health and safety requirements as long as the state requirements are at least as effective as the federal requirements. Several states have enacted their own occupational safety and health statutes and employ inspectors to ensure compliance on construction project sites within the state. Failure to comply with statute requirements usually results in significant citations and fines.

Most successful construction companies have recognized the importance of safety management and have developed effective company safety programs that include:

- New employee orientation
- Safety training
- Project-specific accident prevention plans
- Job site surveillance

Good safety practices reduce the cost of doing business because they lead to reduced premiums for workers' compensation and liability insurance and minimize the costs that result from accidents and injuries on a job site. Construction companies, depending upon the type of craft labor that they employ, often pay 10 to 20% of their direct labor costs for workers' compensation insurance premiums, which is a significant cost of doing business. This will be discussed in more detail in the next chapter.

The effectiveness of a construction company's safety program often is a key factor in the ability of the company to become prequalified and allowed to submit a proposal on a project. Project owners do not want unsafe contractors working on their projects, because the owners do not want the negative publicity associated with construction accidents. Unsafe project sites also often lead to citations and resulting fines from state or federal occupational safety and health inspections.

Implementing and enforcing a strong safety program also demonstrate company management's interest in the welfare of individuals working on the job site. The ability of a construction company to deliver a quality project is directly affected by the ability and motivation of the individuals working on the job site, whether they work for the general contractor or for one of the subcontractors. Providing a safe working environment demonstrates management's commitment to the welfare of the workers resulting in the workers wanting to work on the project site and making the project a success.

The DuPont Company has been a leader in developing a safety culture within the company and provides consulting services to companies and organizations that wish to improve their safety performance. Based on their extensive experience with workplace safety, DuPont has developed the following 12-element program<sup>1</sup> for management of employee safety:

- *Management Commitment.* This is a basic component of a successful safety program, and it must be demonstrated in words and action.
- *Policy and Principles.* The company safety policy and principles must be based on the company's values, mission, and vision and must be communicated effectively throughout the organization.
- *Integrated Organizational Structure.* Safety must be integrated as a core value throughout the company, and good safety practices must be enforced by supervisors at all levels.
- *Line Management Accountability and Responsibility.* Company leaders are held responsible and accountable for the safety culture within the company and the safe performance of subordinates.
- *Goals, Objectives, and Plans.* Safety management systems require continued evaluation, identification of challenging goals and objectives, and adoption of a continuous improvement process.
- *Safety Personnel.* Experienced and knowledgeable safety professionals are needed to provide support to supervisors regarding regulatory and technical issues related to good safety management.
- *Procedures and Performance Standards.* High operational standards and aggressive goals are needed to motivate all employees to excel in good safety performance.
- *Training and Development.* A comprehensive training program consisting of orientation, initial training, and refresher training is required to ensure that all company employees have the knowledge to perform their responsibilities safely.

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<sup>1</sup> Charles Soczek, *Implementation of Process Safety Management (PSM) in Capital Projects*, E. I. DuPont de Nemours and Company, Wilmington, DE, 2011.

- *Effective Communication.* Safety information needs to be continuously communicated within the company, on the project sites, and among the external community to improve safety performance.
- *Motivation and Awareness.* Implement incentive programs to recognize employees who make significant contributions to the company's safety performance.
- *Audits and Observations.* Conduct comprehensive safety audits at all levels within the company to monitor safety awareness and performance.
- *Incident Investigations.* Investigate any accidents, near-misses, or other incidents that could have resulted in an injury.

### 1.3 COST OF ACCIDENTS

Accidents and the corresponding damage that they cause to employees, property, and equipment can have a significant adverse impact on the financial condition of a construction company. It is difficult to measure precisely the cost of accidents, but they have a significant adverse impact on employee well-being, productivity, and morale. Direct costs of accidents are those costs covered by insurance, and the cost of the insurance coverage is a function of the insurance underwriter's assessment of the risk posed and the construction company's claims history. Indirect costs are all other costs not recovered through insurance coverage. The indirect costs associated with an accident often are up to four times the direct costs.

The direct costs of accidents include:

- Workers' compensation insurance premium cost
- Liability insurance premium cost
- Equipment liability insurance premium cost
- Legal expenses associated with claim resolution

Workers' compensation insurance is a no-fault insurance that compensates an injured worker for the cost of medical expenses, provides supplemental income if the worker is unable to work, and provides retraining if the worker cannot perform the duties of his or her job. Insurance premiums are based on the risk presented by the craft of the worker, such as roofer, carpenter, or steelworker, and the claims record of the employer. This type of insurance will be discussed in the next chapter.

General liability insurance and equipment liability insurance cover the cost of property damage or personal injury incurred by someone not involved in the project. Premium costs for these insurance policies also are affected by claims history; the more frequent the claims, the higher the policy premium. Depending upon the type of liability insurance policies obtained, legal costs may or may not be included in policy coverage. If not covered by the insurance policy, any legal expenses would be borne by the construction company.

The indirect costs of accidents include:

- First-aid expenses
- Damage or destruction of materials

- Clean-up and repair cost
- Idle construction machinery cost
- Unproductive labor time
- Construction schedule delays
- Loss of trained manpower
- Work slowdown
- Administrative and legal expenses
- Lowered employee morale
- Third-party lawsuits

The indirect cost of an accident generally greatly exceeds the direct cost incurred. In the event of an accident, all project operations typically cease while an investigation is undertaken. Workers on the site are being paid, but little productive work is being performed, leading to unproductive labor and equipment time, which may adversely affect the project budget and construction schedule. Any damaged materials or equipment will need to be replaced, and the project site may need to be cleaned. If work on a project is stopped because a contractor's employee or a subcontractor's employee has an accident, the cost of delaying the project is assumed by the contractor and not the project owner.

## 1.4 CAUSES OF ACCIDENTS

Why do accidents occur on construction project sites? They may result from an unsafe act by a worker or from unsafe job conditions or both. Research into why construction accidents occur has shown that about 90% of accidents on construction sites are due to unsafe behavior and about 10% are due to unsafe job site conditions. Unsafe behavior may result from a worker's state of mind, fatigue, stress, or physical condition. This may involve attempting to do more than he or she is capable of doing, such as picking up a heavy load; engaging in unsafe work activity; or improperly responding to an unsafe situation. Overexertion is a major cause of accidents, because tired workers often are not mentally alert. A major concern in the construction industry today is the aging work force and the greater susceptibility of older workers to job-related injuries.

Some examples of causes of accidents are:

- A person detects a hazardous condition but does nothing to correct it, and an accident may result. An example may be the use of defective equipment, such as a ladder.
- A person disregards a safety policy or procedure, and an accident may result. For example, a worker not wearing gloves may get a sliver when handling lumber.
- An individual may lack proper training in how to perform a specific construction task safely and may undertake performing the work in an unsafe manner.
- An individual may misjudge the risks associated with a specific task and mistakenly choose to perform the task in an unsafe manner.

The following are types of accidents that occur on construction projects in the United States each year:

- A worker is connecting steel structural members on the fourth floor of a commercial building project and falls to the ground.
- A worker is struck in the head by a load being moved by a tower crane.
- A worker is working on a platform that collapses.
- A worker installing a pipe in an open trench is crushed when the sides of the trench collapse.
- A worker installing roofing material slips and falls to the ground.
- An electrical worker installing a circuit breaker is electrocuted.
- A brick mason working on a scaffold falls to the ground.

## 1.5 ROLES AND RESPONSIBILITIES

The effectiveness of a company safety and health program is directly related to management's commitment to safety. Company leaders must establish the safety culture within their companies by emphasizing the importance of safety in meetings and their visits to project sites. They must also ensure that sufficient resources are provided to support a comprehensive companywide safety program that mandates the development of a specific written injury and illness prevention plan for each project site. A company safety and health program should contain the following elements:

- Hazard analysis—assessment of the hazards
- Hazard prevention—actions to be taken to keep workers safe
- Policies and procedures for working safely—rules to be followed by employees and subcontractors
- Employee training—type and frequency of training
- Continual workplace inspection—walk-around inspections of job sites
- Enforcement of company safety policies and procedures—steps to be taken when violations occur

OSHA requires that at least one person on each job site be designated as the *competent person* who is responsible for regular inspections of the site for conformance with required safety practices and procedures. To be considered competent, the individual must be knowledgeable of the various types of work to be performed on the job site as well as all required company and legally mandated safety and health practices and procedures. A competent person may have other duties, but he or she is assigned specific safety enforcement responsibilities for the project site.

Everyone on a project—from senior management to the newest employee—has responsibility for safety:

- Project managers and superintendents are responsible for establishing and enforcing safety policies and procedures, providing necessary resources, and effectively communicating safety and health information to all people working on the site, both the contractor's employees and the subcontractors.



- Field supervisors implement and enforce those safety policies and procedures as well as conduct hazard analysis, employee training sessions, accident investigations, and safety inspections.
- Employees are responsible for following established safety procedures, reporting safety hazards, and participating in safety training and meetings.

Project leaders and field supervisors must set the standard regarding safety on their projects and enforce safety standards at all times. A continual safety awareness campaign that is focused on reducing accidents is necessary. Frequent (at least weekly) job site safety inspections should be conducted to identify hazards and ensure compliance with job-specific safety rules. Every project meeting should address safety. Foremen should conduct daily safety meetings to review the safety aspect of the tasks to be performed that day. They play a critical role in establishing and maintaining a safe job site. Safety is an everyday, hands-on responsibility of all craft labor supervisors on the project.

Supervisors must conduct training to ensure that their workers are knowledgeable of:

- The construction company's safety policies and procedures
- Specific accident prevention plans developed for the project
- Housekeeping procedures to be followed on the project
- Emergency procedures for the project site
- The proper use of all equipment to be employed on the project
- The identification of any hazardous materials to be used on the project and proper procedures for handling them

Safe construction procedures and techniques should be identified for each phase of the work to minimize the potential for accidents. Some of the ways to reduce the risk created by a hazard are:

- Modify construction techniques to eliminate or minimize the hazard.
- Guard the hazard, for example, by fencing in the site.
- Provide a warning, such as back-up alarms on mobile equipment or warning signs.
- Provide special training.
- Equip workers with PPE, such as hard hats and hearing protection.

The hazards associated with each phase of work and selected mitigation strategies should be discussed with both contractor and subcontractor work crews prior to allowing them to start work. Many superintendents require daily safety meetings prior to allowing the workers to start work. These meetings address risks and mitigation strategies for the work to be performed that day. The meetings must address general housekeeping policies, emergency procedures, proper use of equipment, as well as any hazardous materials present and proper handling procedures for these materials.