

CONSTRUCTION INDUSTRY INSTITUTE®

THE OWNER'S ROLE IN CONSTRUCTION SAFETY

UNIVERSITY OF FLORIDA

JIMMIE HINZE

XINYU HUANG

THE OWNER'S ROLE IN CONSTRUCTION SAFETY

by
Jimmie Hinze
and
Xinyu Huang
University of Florida

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The Owner's Role in Construction Safety

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EXECUTIVE SUMMARY

The construction industry has long been regarded as one of the most dangerous industries, primarily due to its history of poor safety performance. This is despite the fact that dramatic improvements have been made in the safety performance of the construction industry in the past decade. The improvements are due, in varying degrees, to the efforts of owners, contractors, subcontractors, and designers. While past safety studies have investigated the roles of contractors, subcontractors, and designers, the owner's impact on construction safety has not been thoroughly studied.

The owners of projects are the primary consumers of construction services, the sources of project finances, and, in many cases, the end users of the facilities. They regularly play a key role in project development. Traditionally, owners have not been directly involved in construction safety, primarily to avoid economic losses and legal entanglements resulting from injuries. With the increase of accident costs and legal cases involving owners as the third-party defendants, owners have come to realize that they cannot ignore safety.

In this study, the owner's role in construction safety was investigated. The relationship between project safety performance and the owner's influence was examined, with particular focus on the project context, selection of safe contractors, contractual safety requirements, and the owner's proactive involvement in safety management. A questionnaire survey sent to owners with large construction budgets and interviews

conducted on projects with large worker hour exposures were the two means of data collection for the study. Statistical analysis shows that there is a strong relationship between project safety performance and owner involvement. Practices of owners that favorably impacted project safety performances were identified, including:

- **Project context:** Project characteristics related to better safety performance include petrochemical projects, private projects, open-shop projects, projects with design-build contracts, projects of fairly large or small size (not medium size), projects working one shift, and projects working five or less workdays per week.
- **Careful selection of safe contractors:** Owners aggressive in safety use proactive criteria to evaluate and select contractors. These criteria include the contractor's total recordable injury rate (TRIR) on past projects, qualifications of the contractor's safety staff, qualifications of the contractor's project management team, and the assessed quality of the contractor's overall safety program.
- **Contractual safety requirements:** Contractual safety requirements should clearly convey the owner's emphasis on safety and the owner's expectation of a safe project. Five contractual requirements were identified as being leading (safety promoting) indicators, and they are listed as follows:
 - Contractor must place at least one full-time safety representative on the project
 - Contractor must submit the résumés of key safety personnel for the owner's approval
 - Contractor must provide specified minimum training for the workers
 - Contractor must submit a site-specific safety plan
 - Contractor must submit a safety policy signed by its CEO
- **Owner's proactive involvement in the safety practices of projects:** The owner's direct involvement in the safety process during construction is perhaps the most important role that the owner can play to favorably impact project safety performance. The key measurements employed by the owners with better safety performances are identified as:
 - Owners set their expectations on safety from the very beginning of a project, especially the zero-injury objective;
 - Owners impose requirements on the safety programs developed by contractors and emphasize specific items, including: emergency plan (medical and hazardous materials), daily JSA (job safety analysis) conducted on the project site, and a mandated substance abuse program;

- Owners monitor near miss rates and the safety inspection records on the projects, besides other types of injury statistics (TRIR, lost-time injury rate, etc);
- Owners maintain accident statistics by contractor on their projects, and also include the contractor's injury statistics in their own accident records;
- Owners participate in the safety recognition program and financially support the program;
- Owners actively participate in safety training and orientation and verify the comprehension of the training (such as by testing);
- Owners assign a full-time safety representative on site with various responsibilities including: enforcing safety rules; reviewing safety performance on site and submitting reports to the home office; monitoring pre-task analysis programs; participating in safety recognition programs; and participating in safety and/or tool box meetings.

Based on a statistical analysis, a model to demonstrate how owners can help improve safety was established. A scorecard was developed to assess the owner's level of involvement in safety and this scorecard tested on several projects.

It was concluded that the owner's involvement significantly influences project safety performance. Better project safety performances are achieved when owners set safety objectives, select safe contractors, and participate in safety management during construction.

CHAPTER 1 INTRODUCTION

With peak levels of employment reaching eight million workers, the United States construction industry has the dubious distinction of perpetually being one of the industries with the worst injury and fatality records. The mining industry and the agriculture industry are the only industries that have worse records than the construction industry. While the actual incidence of construction worker injuries has declined over the past three decades, the number of injuries and fatalities is still at an unacceptable level (Hinze, 1997). According to the Census of Fatal Occupational Injuries (CFOI, 2003), an average of 1,115 workers were killed annually on construction sites from 1995 to 2000, which accounted for nearly 20% of all industrial fatalities in the United States. This number is a disproportionate distribution of construction worker fatalities since construction workers account for only 7% of the industrial workforce. While many strides have been made to reduce the incidence of injuries, there is considerable room for improvement. The industry is trying to find new ways to improve safety performance.

In the construction industry, most construction projects involve the participation of owners, designers, and contractors. The owners (also called facility clients, or project buyers) of projects are the primary consumers of construction services, the sources of project finances, and, in some cases, the end users of the facilities. Owners include both public and private entities. Some owners obtain the services of a construction firm to build a facility with virtually no interaction between the owner and the construction firm during the construction process. Other owners play varying roles during the construction

phase, with some being closely involved with the construction effort during every stage of project execution.

Generally, an owner of a project will require various objectives to be satisfied by the designer and contractor (Hinze, 2001). The owner defines the scope of a project to become a reality, which requires the services of several parties. First, the designer will develop the guidance document for building the project. The contractor will then follow by executing the construction of the project.

Typical objectives required by the owners include, but are not limited to the following: when a particular project should be finished; what quality requirements the project must satisfy; the owner's cost of the project; and possibly the safety standards that must be met during project construction. The roles of some of the parties are shown in the organizational chart for a general contract agreement in Figure 1-1. In all types of contract agreements, the owner is at the top position of the project organization. Essentially, the owner has the overall authority on the project.

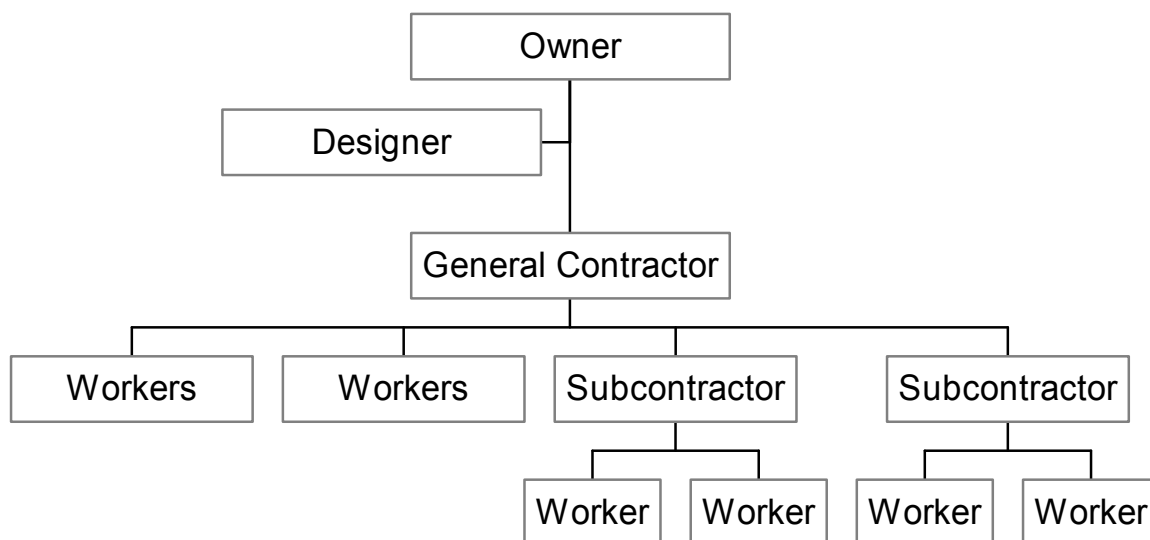


Figure 1-1. The organizational chart of a typical general contract agreement

Traditionally, safety responsibilities have rested solely on the shoulders of contractors. Owners and designers have held the view that they should not get involved in construction worker safety for fear of incurring increased liability exposure. However, in the past decades more and more parties to the construction process have come to realize that zero accidents is an attainable objective, but only through the concerted efforts of all parties involved in the construction process. Owners, A/E firms (also called designers), and contractors/subcontractors have different roles in preventing accidents to achieve an injury-free worksite (Hinze, 1997; Gambatese, 1996; Toole, 2002). The contractor is undoubtedly the pivotal party to control jobsite safety. Strategies and approaches taken by contractors to improve project safety have been thoroughly investigated in past research studies (Levitt and Samelson, 1993; Hinze, 1997; Hinze, 2002). Subcontractor safety influenced by the general contractor in various sizes of projects was investigated by Hinze and Figone (1988, for small and medium projects), and Hinze and Talley (1988, for large projects). Designers can reduce safety hazards in the working environment by considering worker safety issues in their design decisions. Hinze and Gambatese (1996) gathered various “best practices” for designers to address safety issues in their designs and developed a safety design tool to help designers eliminate hazards when making decisions. Today, more and more owners have come to realize that the costs of construction accidents are ultimately their own financial burden, and that they cannot with certainty shield themselves from the legal liabilities associated with worker injuries. As a result, many owners are taking more active roles in construction safety. This begins with the selection of safer construction firms and can also be observed in the safety provisions included in the construction contract. Owners

will continue to influence safety performance by the nature of their involvement during the construction process.

Despite all the research that has been conducted with the various parties to the construction process, little prior work has examined the specific role played by project owners in promoting safety performance. How owners regard their role in safety and how they attempt to exert their influence in the construction process have not been previously examined in detail. This study is focused on the investigation of the impact of owners on construction safety.

CHAPTER 2 LITERATURE REVIEW

Accident Facts

Accident data prepared by the Bureau of Labor Statistics (2003) show that the construction industry has performed much worse than the average of all industries (see Figure 2-1). Although the statistics have improved dramatically in the 1990's, accident rates in the construction industry are still 50% higher than that of all industries, lagging all industries by about 10 years. An alarming fact is that the number of fatalities in the construction industry has increased in the past decade (see Figure 2-2).

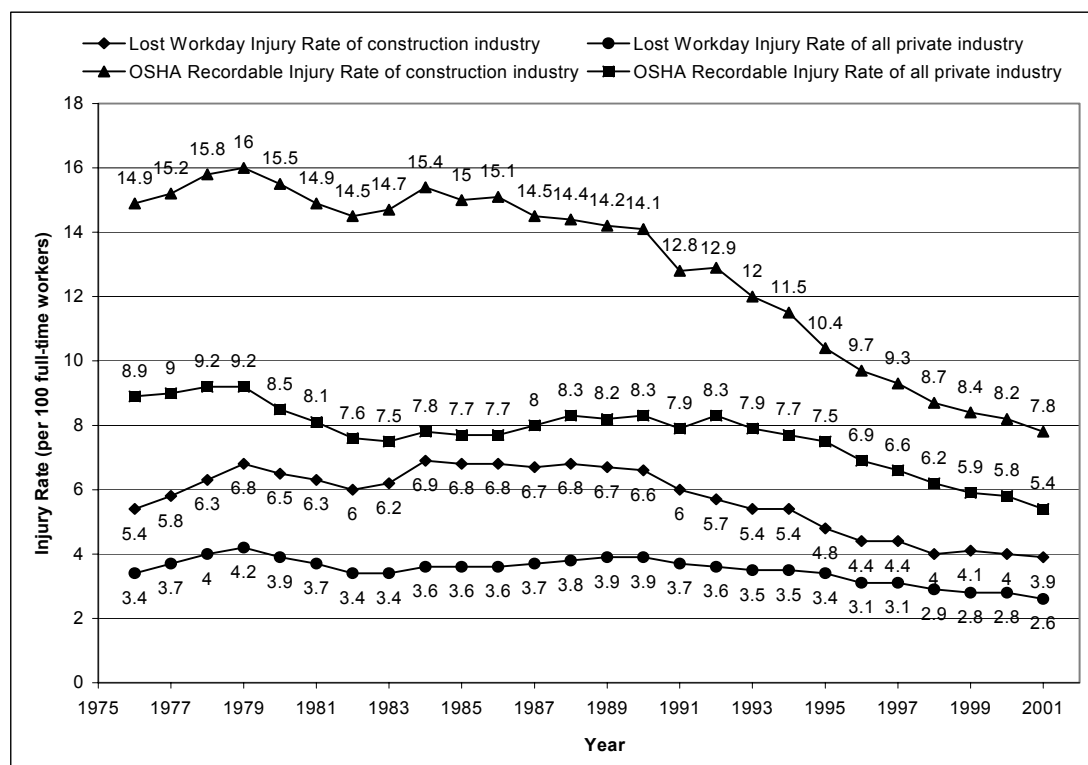


Figure 2-1. Injury rate of construction and all private industry

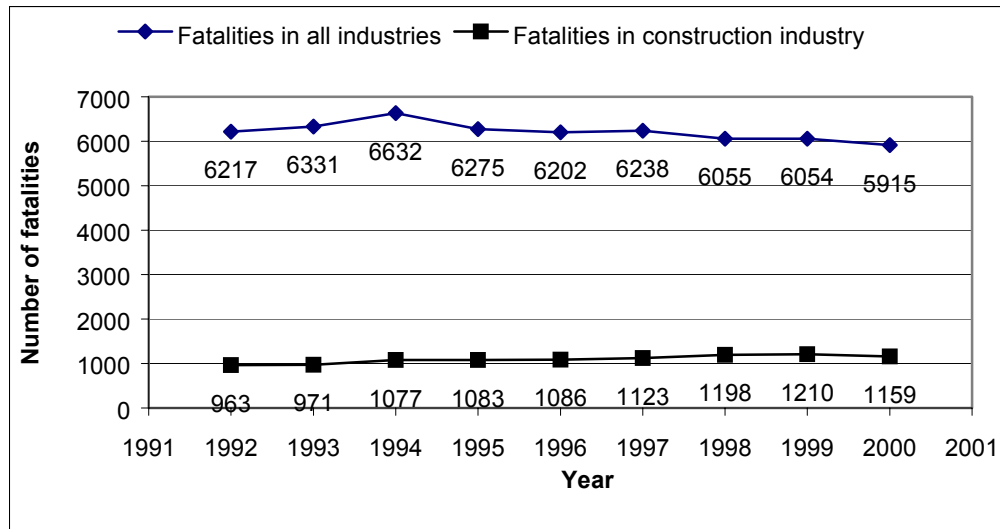


Figure 2-2. Fatalities in construction industry and all industries

Figure 2-3 shows the major types of construction accidents that have occurred in the past decade, based on the analysis of all serious injuries and fatalities investigated by OSHA. Falls, struck-bys, electric shocks, caught-in-or-betweens, and other are the major causes of injuries, although the relative proportion of each type has changed somewhat in recent years (see Figure 2-4).

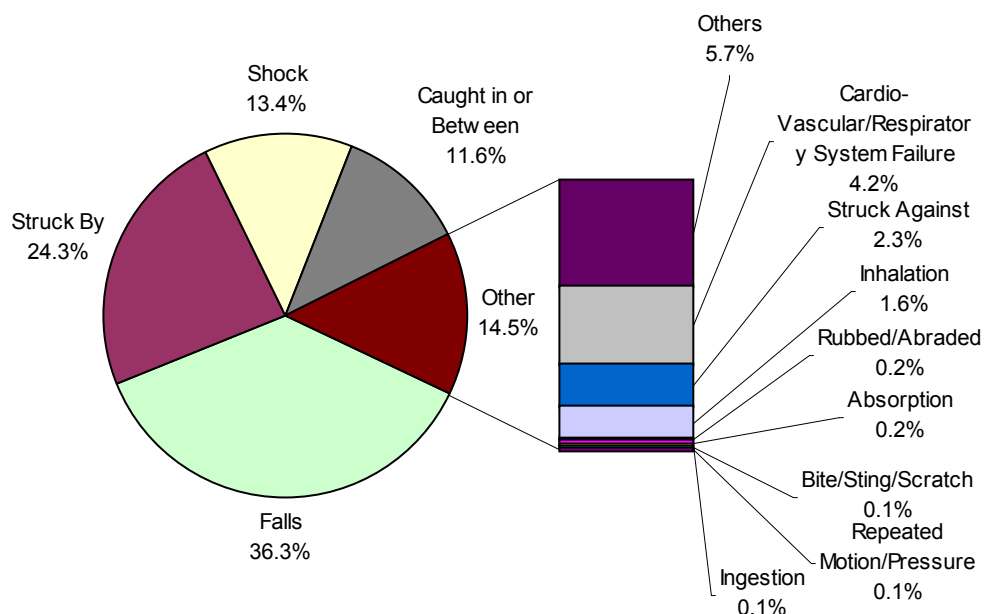


Figure 2-3. Causes of construction fall accidents investigated by OSHA (01/90-10/01)

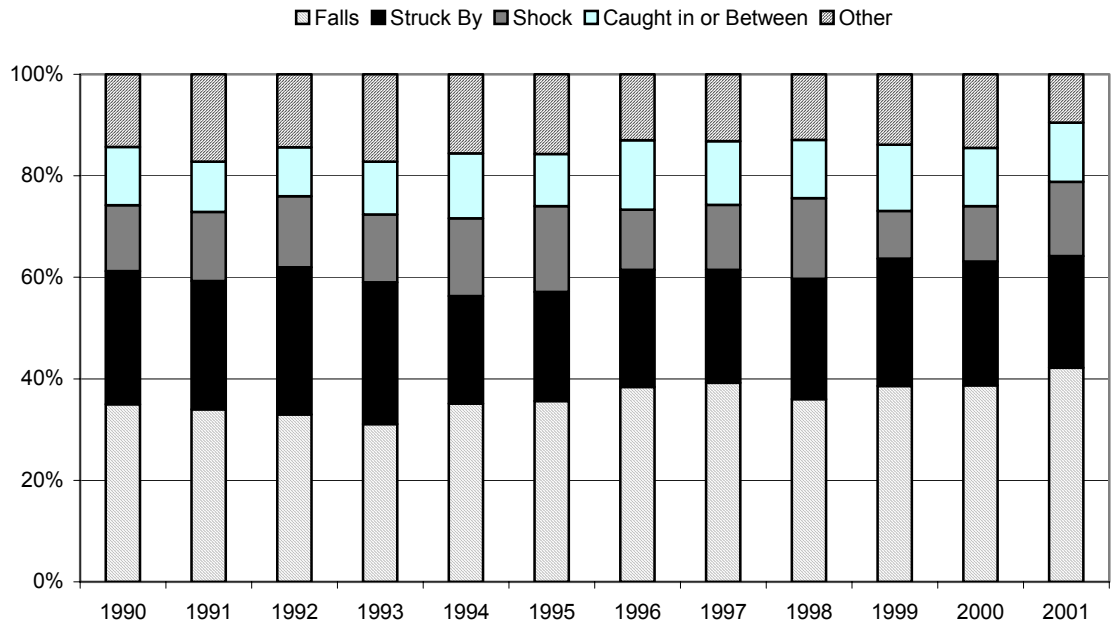


Figure 2-4. Breakdown of OSHA investigated accidents in construction (01/90-10/01)

Owners' More Active Involvement In Safety

With a higher proportion of injuries, the construction industry has long been regarded as a dangerous industry. With an average employment of approximately 7% of the industrial workforce, the construction industry has generally accounted for nearly 20% of all industrial worker fatalities (CFOI, 2003). The research conducted by Everett and Frank (1996) concluded that the total costs of construction accidents accounted for 7.9-15.0% of the total costs of new, non-residential projects. A more recent but unpublished research by Coble and Hinze (2000) showed that the average worker's compensation insurance costs could be conservatively estimated as constituting 3.5% of the total project cost.

Safety performance of the construction industry did improve during the 1990's (see Figure 2-1). As suggested by Hislop (1999), perhaps the most significant factor attributed to this improvement is the increased management commitment to safety. Management has been motivated to make a greater commitment to safety, based on its

increased awareness of the impact of the high costs of worker's compensation payments, the higher dollar value settlements in lawsuits, the increased amounts of OSHA fines for safety violations, and the adverse impacts of poor safety performance on the corporate image.

In order to reduce and eventually eliminate construction accidents, researchers have explored techniques to fulfill the “zero injury objective” through the concerted efforts of all parties involved. The involvement of owners has been regarded as an essential requirement for this objective. For example, in the research conducted by Liska et al. (1993), it was found that an important prerequisite attributed to excellent safety performance was the involvement of the owner not only in pre-project planning including financially supporting the contractor's safety program, but also in the day-to-day project safety activities. In the construction accident causation model developed by Suraji et al. (2001, see Figure 2-5), construction accidents are caused by different responses to certain constraints and the environment on construction projects. In the model, owner (client) responses are the actions (or inactions) of the owner in response to constraints during the development of a project brief (Duff, 2000). These include, for example, reducing the project budget, adding new project criteria, changing project objectives, and accelerating the design or construction efforts of the project. All these elements will play an essential role in accident occurrences.

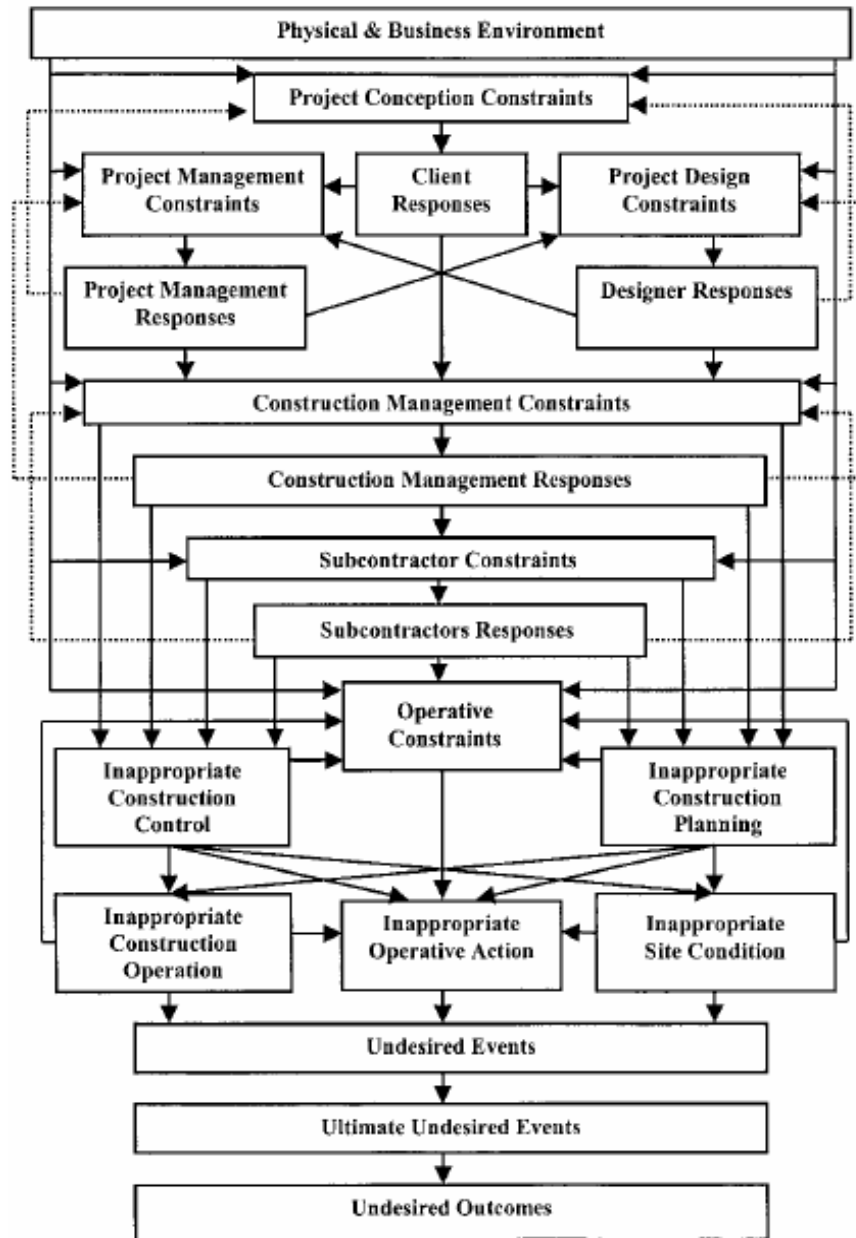


Figure 2-5. Construction Accident Causation Model: Constraints and Responses

In the past, there was a reluctance of owners to become involved in matters related to construction safety issues for the fear of added liability exposure (Sikes et al., 2000). However, since the 1980's more and more owners, especially owners with larger construction budgets, have voluntarily expanded their role in ensuring worker safety. A series of studies conducted at the University of Washington in the early 1990's

demonstrated that owners' concern for construction safety was increasing (Hinze, 1997).

The major reasons include the following:

- The rising costs of health care and workers' compensation are not being ignored by owners (see Table 2-1).

Table 2-1. Average Cost of Construction Site Injuries

Type of injury	Job Costs		Estimated Liability Costs	Total Cost to Employer
	Direct	Indirect		
Medical Only	\$520	\$440	\$240	\$1,200
Lost Work Day	\$6,900	\$1,600	\$16,500	\$25,000

(Hinze and Appelgate, 1991)

- Owners realize that the costs of injuries are ultimately reflected in the cost of construction (Gambatese, 2000b).
- Litigation involving third parties has escalated in the past three decades. For example, in the case of Phillips v. United Engineers & Constructors, Inc., and Plasteel Products Corp., 500 N.E. 2d 1265 (1986), owner was sued but was not held responsible for a worker's fall from catwalk during steel erection. In another case Rigatti v. Reddy, 723 A.2d 1283 (1999), the owner was similarly cleared of being responsible for a roofer's fall. In the case of Stark v. Rotterdam Square, 603 N.Y.S.2d 347 (1993), the owner of a mall was held liable for injuries suffered by a roofer when he fell through a hole cut into the roof.

Because of these types of lawsuits, many owners have come to realize that reducing the frequency and severity of construction injuries is the only sure way of reducing their potential liability for worker injuries (Levitt and Samelson, 1993).

Since the early 1980s, several efforts have been undertaken to formally require owners to participate in construction site safety. A major effort to expand safety legislation resulted after 28 workers died in the tragic collapse of the L'Ambiance Plaza Building in Bridgeport, Connecticut (Godfrey, 1988). This accident became the driving force behind U.S. Senate Bill 2581 to amend the Occupational Safety and Health Act to "require all construction projects to be supervised by . . . a professional engineer-architect designated by the owner and registered in the state where the construction is to be

performed” (ASCE, 1988). Opposition to this bill from a large segment of the construction industry ultimately resulted in its failure.

Although these legislation efforts failed in the U.S., the liability of owners in the United Kingdom was specified by the Construction (Design and Management) Regulations 1994 (CDM), in which the owner’s main duties are contained in Regulations 6, 10, 11 and 12 (Holt, 2001). In CDM, a owner is defined as “any person for whom a project is carried out, whether carried out by another person or in-house.” CDM imposed criminal liability onto the owner who ignores construction safety and where this results in an accident. Each project owner has a responsibility for safety on the project. In cases where there are multiple owners, the owners can appoint an agent or another owner to carry out the owner’s duties, and then have to make a declaration to the enforcing authority (the Health and Safety Executive) that the transfer of duties has been made.

Under CDM, the owner must do the following:

- Appoint a Planning Supervisor and a Principal Contractor for each project, being satisfied that these "duty holders" are competent and have the resources to perform their duties adequately.
- Not permit the construction work to start unless a health and safety plan, which complies with the safety regulations, is in place for that project.
- Provide the planning supervisor with information about the state or condition of the premises where the work is to be carried out. This is information which is relevant, and which the owner either has or could get after making reasonable inquiries.
- Verify that any designer or contractor that is appointed directly is competent for the task and has allocated sufficient resources to it.
- Make the health and safety file available for inspection by anyone who may need information to comply with legal requirements. The owner will sell or pass on the file to a future owner or a person acquiring the interest in the property of the structure to which it refers.

The trend is clear that owners are getting more concerned about construction safety, but many owners are confronted with the problem of how to effectively influence project safety. For example, a safety campaign supported by the owner was conducted during the construction of the Øresund Link between Denmark and Sweden. Primarily, the safety campaign consisted of a comprehensive information campaign aimed at promoting positive attitudes towards safety among the employees, and a specific campaign aimed at the behavioral aspects to increase the level of safety when performing routine work at the construction site (Spangerberg, 2002). In the end, the results of the campaign did not satisfy the owner's expectations of low injury rate, which led people to question what techniques by the owner can effectively improve construction safety.

Therefore, it would be essential to investigate the current techniques employed by owners to achieve good safety performances on construction sites, and if possible establish the effect the techniques on the resultant safety performance.

How Owners Take Their Role In Safety

Owners can actively impact construction safety by selecting safe contractors, addressing safety issues in design, and participating in safety management during construction (Hinze, 1997). To the extent possible, the owners, through their project representatives, should participate with the contractors in all project safety activities, including but not limited to new employee orientation, safety meetings, audits and accident investigations, training, incentive programs and other safety related programs (Gambatese, 2000b).

One of the earlier studies on the owner's role in construction safety by Levitt et al. (1981) reached the conclusion that construction owners who selected or prequalified contractors based on safety performance, and/or who got involved in construction safety

management, had fewer accidents on their projects. The owner's involvement in construction safety management not only reduces the number and severity of accidents but probably also reduces the owner's total liability exposure.

The American Society of Civil Engineers (ASCE) moved to the forefront in the trend to involve owners in safety following the issuance of ASCE's Policy Statement 350 on construction site safety in 1998. The statement outlines ASCE's belief that "improving construction site safety requires attention and commitment from all parties involved." The policy states that safety should be addressed "for each project on a project specific basis," and that owners should "take an active role in project safety." Various ways owners can actively address safety were given in the policy, including the following:

- Assigning overall project safety responsibility and authority to a specific organization or individual (or specifically retaining that responsibility) that is qualified in construction safety principles, rules, and practices appropriate for the particular project.
- Including prior safety performance as a criterion for contractor selection.
- Designating an individual or organization to monitor safety performance during construction.
- Designating in the contract documents those parties responsible for the final approval of shop drawings and details.

Gambatese (2000b) summarized various ways in which owners can actively address safety, including the following:

- Establish a clear position on safety.
- Ensure that safety is addressed in project planning and design.
- Consider safety performance when selecting a contractor.
- Address safety in the construction contract.
- Assign safety responsibility during construction.
- Participate in project safety during construction.

Establish And Communicate Attitudes Towards Safety

All owners have a legal and moral responsibility to insist on the safe performance of their construction contractors and to use reasonable care to prevent contractors from injuring others on the site. Owners should understand that their involvement in construction safety management not only reduces the number and severity of injuries, but is also likely to reduce the owners' total liability. In addition, the owner should realize that safe performance is generally related to lower costs, better quality work, improved productivity, adherence to schedule, reduced exposure to bad publicity, and minimal disruption of the work being performed. As Hinze (1997) stated, owners whose objectives are to avoid injuries are likely to have a proactive and more direct involvement in construction operations. Therefore, the first step of the owner's involvement in safety is commitment, especially management commitment, to create an injury-free project. Each owner in the survey conducted by Levitt and Samelson (1993) stated the belief that active involvement in construction safety, done properly, served to reduce rather than increase the firm's potential liability for construction accidents.

The owner's position on safety should be clearly communicated to the project team at the beginning of the project and to all team members joining the project during the construction phase (Gambatese, 2000b). During project development, owners should convey their commitment to safety to the contractors through various means, including devising incentives for safety and by implementing sanctions for failing to support the owners' safety initiatives.

Consider Safety In Contractor Selection

Traditionally, selecting safe contractors was recognized by many owners as the most effective way to guarantee safety performance on their projects. Criteria for

selecting safe contractors have been extensively investigated in the past. Levitt and Samelson (1993) stated that screening contractors in terms of their expected safety performance is an easy and effective way for construction owners to enhance construction safety. Levitt and Samelson (1981) suggested that the criteria must be (1) predictive of safe project performance; (2) equally applicable to different construction firms; and (3) objective. Possible selection measures were EMRs, OSHA recordable injury rates, and management safety accountability. Findings from the research that are indicative of safety accountability include the following:

- ❑ Who in the organization receives and reviews accident reports, and what is the frequency of distribution of these reports? (Frequent reports, detailed by operating units, and reviewed by the president of the firm would be an indication of high company accountability for safety.)
- ❑ Frequency of safety meetings for field supervisors.
- ❑ Compilation of accident records by foremen and superintendents and the frequency of reporting. (Contractors who categorize their accident statistics by superintendent and foremen, rather than by larger units, have a more detailed accountability system.)
- ❑ Frequency of project safety inspections and the degree to which they involve project managers and field superintendents.
- ❑ Use of an accident cost system allocating or assigning responsibility to individual foremen and superintendents, as well as project managers.

Certain safety criteria during the selection of contractors suggested by Hinze (1997), and Hinze and Godfrey (2003) include the following:

- Injury incident rates (including lost workday injury rates, OSHA recordable injury rates, first aid injury rates, and etc.)
- Job site safety inspections
- Behavior based worker observations
- Experience modification rates (EMR)
- Loss ratios of workers' compensation
- Records of OSHA citations and fines
- Litigation related to injuries
- Performance records of key personnel

- Project safety plans
- Contractor qualification safety surveys
- Worker's conception surveys

Contractual Safety Arrangements

Owners must also make sure that contractors recognize their contractual responsibility to perform safely (Levitt and Samelson, 1993). Contractually, most owners have the contractor indemnify them from any losses or liabilities resulting from injuries, but it is also essential to include specific and thorough safety requirements in the construction contract. The requirements might include the following (Gambatese, 2000b):

- The requirement that the contractor abide by all applicable safety laws and regulations;
- A delineation of the responsibility for safety on the jobsite;
- The submission of a written contractor safety program before work begins;
- A requirement for implementing a substance abuse program; and
- The submission of an emergency plan and accident reporting procedure.

Questionnaires sent to owners and contractors (Business Roundtable, 1982) were used by Stanford University to identify safety requirements owners placed on construction contractors and specific practices of owners to emphasize safety with contractors. The responses are arranged in decreasing order of use by the respondents.

Require use of a system of permits for potentially hazardous activities.

1. Require the contractor to designate a responsible supervisor for safety coordination on the job site.
 - ☐ Provide the contractor with safety guidelines that must be followed.
 - ☐ Discuss safety at owner-contractor meetings.
 - ☐ Periodically discuss safety audits of the contractor operations.
 - ☐ Require immediate reporting of contractor accidents.

- ❑ Stress safety as part of the contract during pre-bid walk-arounds.
- ❑ Investigate contractor accidents.
- ❑ Maintain statistics of contractor accidents.
- ❑ Conduct periodic safety inspections.
- ❑ Set goals for construction safety.
- ❑ Consider safety in prequalifying contractors for bidding on projects.
- ❑ Set up a construction safety department to monitor contractor safety.
- ❑ Set safety guidelines in the body of the contract.
- ❑ Be involved in orientation sessions alerting workers to safety hazards on the job.

An owner, to be actively involved in construction safety, might consider several contractual issues. Many of the issues relate to the safety obligations placed on the contractor. Hinze (1997) suggested that contract provisions may include the following requirements:

- Submittal of a project-specific safety plan
 - Job hazard analysis
 - Regular safety meetings with supervisory personnel
 - A designated project safety coordinator
 - Mandatory reporting of accidents, safety inspections, and safety meetings
 - Inclusion of subcontractors in the safety program
 - Compliance with the owner's safety guidelines
 - Establishment of an effective worker orientation program
- As the major binding document between the owner and contractor, the contractual

arrangement (lump-sum or cost reimbursable) will also impact how safety will be addressed on the project. One reason that the contract type should be considered when addressing project safety is that the contract essentially determines how the owner will make payment to contractors to compensate them for their services on the project, and therefore, can impact the relationship between owner and contractor (Dagostino, 2002).

As safety can be obtained only through the concerted efforts of different parties (owner, contractor, and designer), the nature of their relationships can be expected to impact safety. For example, if the contractor has a close, long-term relationship with the owner, they will generally use cost reimbursable contracts (cost plus). Thus, safety investments will be reimbursed by the owner to support the contractor's efforts. This arrangement encourages the contractor to spend the necessary funds on safety.

Address Safety During Design And Constructability Review

Design decisions can dictate the structure, elements, materials and even the construction methods to be used on the project. For example, the selection of forming systems, cycle times, sequences, equipment, and design of temporary structures are significantly impacted by the design of the permanent construction. Therefore, designers are very influential, perhaps unknowingly, in impacting the way safety issues will be addressed during construction. Consideration of construction worker safety by designers (hereinafter also called A/E) can lead to a reduction in injuries and associated costs during the construction phase (Hinze and Wiegand, 1992; Gambatese, 1998; Gambatese 2000a). Toole (2002) stressed that the A/Es are in the best position to implement specific safety design recommendations, thereby preventing less safe conditions on the site. Also, A/Es may be best able to identify questionable structural situations such as temporary loadings on the permanent structure or temporary work platforms, provided they are explicitly requested to do so and possess all of the data necessary to perform the analysis. One reason why the Corps of Engineers has had particularly low injury rates on their construction projects is that it coordinates the design with erection procedures and coordinates their efforts on safety (MacCollum, 1995). Although the involvement of design professionals in construction site safety has been minimal to nonexistent on many

projects, when they are involved their influence can be significant, and can help reduce accident occurrence. This influence has favorable cost implications for the projects (Gambatese, 2000a. see Figure 2-6).

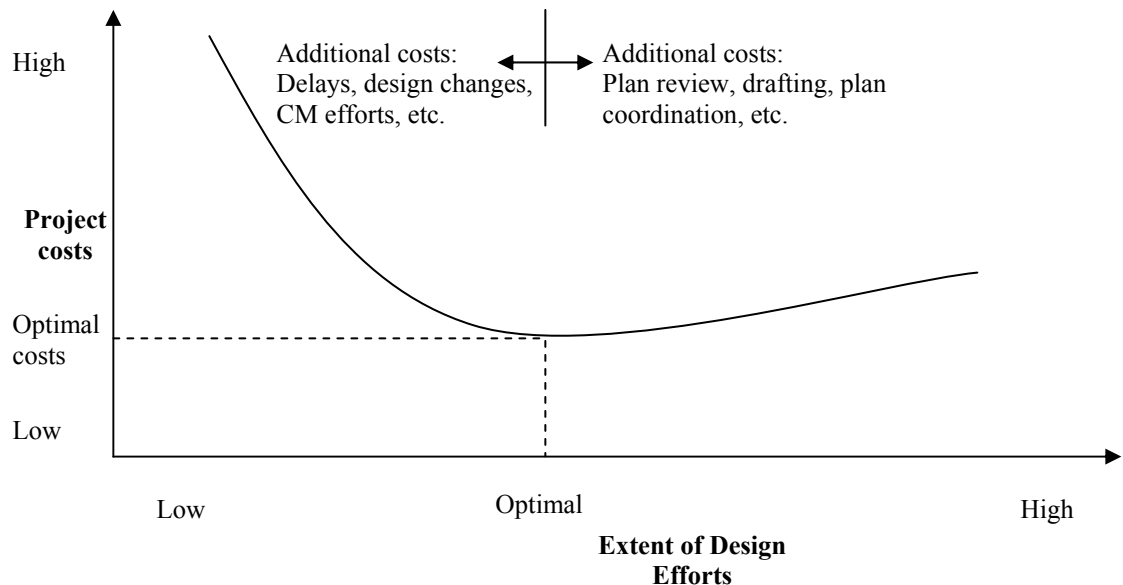


Figure 2-6. Relationship between Design Effort and Project Cost

In the past, design professionals typically would distance themselves from the responsibility for the safety of the construction workers. The reasons include their lack of safety education and training, the lack of safety design tools, their restricted role on the project team, and an attempt to limit their liability exposure (Gambatese, 1996).

However, with the unacceptable injury and fatality rates, the construction industry has concluded, “The need for changes in attitude does not stop at educating erectors to work more safely. It has to go back to the architect and engineer who should not only ask themselves if it can be built, but can it be built safely.” (Baggs, and Cunningham, 1988)

In the UK, the Construction (Design and Management) Regulations 1994 place duties on designers and owners to make assessments of the impact of the proposed design on the life cycle safety of the facility, including the construction workers, maintenance

personnel, and the facility occupants (Holt, 2001). Although a similar U.S. bill to expand the designer and owner responsibilities on construction safety did not pass, the OSHA standards are certainly not foreign to designers, which is a potential source of designer liability. This occurs not solely by assuming the contractor's responsibilities for the means or methods of the construction process, but through the understanding of their duty as designers to help provide a safe workplace which is basic in their review of the contractor's work product (Coble and Blatter, 1999). In response to the needs of the industry, some architects started to work as construction managers on small projects and thus coordinated the construction and design efforts to reduce accidents and costs (McKee, 1994). MacCollum (1995) ranked the methods used for reducing safety risks according to their priority and effectiveness, including the following:

- Design to eliminate or minimize the hazards;
 - Guard the hazards;
 - Give warnings;
 - Provide special procedures and training; and
 - Provide personal protective equipment.
- He further suggested that the design team should include at least one safety

professional, and should develop and implement a hazard prevention plan for each project.

Owners can impact designers and contractors through their proactive participation in construction safety issues. In the construction accident causation model developed by Suraji et al. (2001, see Figure 2-5), designer responses to project design constraints (which may arise from the owner) can in turn place constraints on the construction process. This may result in a chain reaction effect on accident causation. For example, the constraints imposed by the owner may include the following:

- Accelerated design program

- Inadequate design budget
 - Conflict of objectives or demands of other projects
- Designer response is the action or inaction by designers to respond or react to the

constraints existing during the project design stage. These include the following:

- Increased design complexity
- Sublet part of design process
- Reduction in design resources
- Reduction in quality of components
- Ignore legal liabilities

Therefore, owners can take an active role in design for safety through:

- Setting their expectations in the design phase that construction safety is one of their major concerns and is to be built into the project design;
- Addressing safety issues as early as the feasibility study and conceptual design phases and integrate safety into the objectives of the project;
- Actively participating and coordinating the efforts of the designer and the contractor through regular safety/constructability reviews of the project design; and
- If possible, awarding the contract to an engineering and construction company to help promote safety performance.

Participate In Safety During Construction

In the research conducted by Levitt and Samelson (1993), it was found that the owners with the safest construction projects tended to use many of the following strategies with their contractors:

- Stress safety as part of the contract during the pre-job walk-around. This gives contractors the opportunity to include all safety-related items in their bids and lets contractors know early that the owner is serious about safety.
- Require short-term permits, rather than ongoing permits, for hazardous activities. This means that contractors must check daily or more frequently to ensure that any planned hazardous activities are coordinated with other contractors and with the owner's own plant work force.
- Conduct safety audits of the contractor during construction. The owner's or construction manager's safety staff conducts these audits to ensure compliance with the owner's safety requirements and with all state and federal safety regulations. They are aimed at systems and procedures rather than at specific hazards.

- Conduct periodic safety inspections.
- Require safety training of all project employees.
- Maintain statistics on the contractor's safety performance.
- Set goals for construction safety. Project-wide safety goals should be set, along with specific goals for contractors who need special attention because of past poor performance or particularly hazardous work operations.
- Include general safety guidelines in the body of the contract.
- Set up a construction safety department to monitor contractor safety.
- Require immediate reporting of all worker accidents. Immediate rather than periodic reporting gives the owner more time to intervene and ensure that the contractor has corrected any identified hazards before others can be injured by them. Such notification can also serve to initiate consultations with the contractor's senior management, if needed.
- Investigate the contractors' accidents. The owner's involvement in investigating the contractors' accidents gives the owner valuable insights about generic safety hazards on the project, as well as additional insights about the contractors' organization and capabilities in the area of safety.
- Always include safety on the agenda at owner-contractor meetings.
- Provide contractors with special safety guidelines they must follow.
- Require the contractor to assign safety coordination responsibility to someone on site.
- Reimburse the contractor's safety costs in full.

The following is a sample of best practices suggested by Gambatese (2000b) that an owner can implement:

- Adjust the scheduling of different activities or construction phases that would otherwise occur at the same location and be performed simultaneously.
- Provide a list and location of toxic substances and other hazardous materials that are located on the site.
- Do not allow schedules that contain sustained overtime or night work.
- Impose a ceiling on the number of workers on site or in a particular area.

- Confirm that the contractor knows of the potential hazards of all construction materials and their proper storage and disposal.
- On renovation or retrofit projects, provide the contractor with complete and updated as-built drawings of the existing structure.
- Conduct a pre-construction meeting with the contractor (including all subcontractors) to discuss safety issues.
- Consider involving OSHA in planning for project safety prior to starting construction.

Gambatese (2000b) also suggested that owners should:

- Establish a clear position on safety. The owner's position on safety should be clearly communicated to the project team at the beginning of the project and to all team members joining the project as part of the construction phase. The position can be written in the project documents and contracts, and verbally communicated in project team meetings during design and construction. The actions of all members of the owner's organization during the course of the project must reflect and reinforce the established position.
- Ensure that safety is addressed in project planning and design. Thus, owners must provide the initial impetus, by requesting or even requiring, by contract terms, that designers consider construction site safety in their designs.
- Consider safety performance when selecting a contractor.
- Address safety in the construction contract. There are numerous clauses that could be included in a contract to promote safety.
- Assign safety responsibility during construction. The responsibility for overseeing safety on a construction project should be held by a competent organization or individual.
- Participate in project safety during construction. Perhaps the most effective way an owner can influence safety is through jobsite participation. Another common means by which owners can be involved in safety is by requiring the submittal of regular safety reports. Reports can be requested that provide information on the results of jobsite inspections, a listing of all injuries, safety meeting minutes, and investigations of major accidents.

Hinze (1997) summarized some unique owner practices as the following:

- Placing company representatives on every construction project
- Conducting safety meetings with the contractors
- Requiring the contractors to adhere to owner-developed safety practices

- Providing specialized safety training for the contractor personnel
 - Requiring all workers to go through safety orientation
 - Reviewing each contractor's safety program
 - Conducting regular audits of contractor safety performance
 - Implementing safety incentive programs on all construction projects
- The participation of owners in safety during construction is an integral part of the

efforts of many owners, but it is far from the sole participation of owners in safety.

Safety involvement of owners often starts at the very beginning of the project, and lasts throughout the life cycle of the facility. Owner involvement in safety includes selecting safe contractors, addressing safety in design, including safety requirements in the construction contract, and being actively involved in project safety management.

Total Safety Culture And Behavior-Based Safety

When participating in construction safety management, proactive owners generally implement initiatives that promote safety. The concept of total safety culture and behavior-based safety management are among the latest safety management initiatives that will be introduced.

Originally, people believed that accidents were a result of pure chance, and could happen to anyone at any time, and some people were more likely to suffer an accident than others. This was referred to as the accident proneness model (Cooper, 1998). In the past, the prevailing influence of this approach meant that most accidents were blamed solely on employees rather than on the work processes, poor management practices or a combination of these. Recent studies have found no solid evidence to show that certain people were more likely to be involved in accidents, and thus concluded that accident proneness was essentially related the individual's propensity to take risks (Hinze, 1997).

The most famous accident causation model is the Domino model suggested by Heinrich (1959, see Figure 2-7). The model shows that an accident is the result of a

series of events related to the social environment and heredity, personal failings or mistakes, physical hazards and unsafe behavior. These events, if permitted to occur in continuity, result in an accident, which may result in injuries and damages. Any accident is prevented by breaking the chain (or removing a domino) of the series of events at any location. While it is generally understood that most accidents are preceded by a series of events, it is common practice to place most of the attention on the action that occurred immediately before the accident. A more proactive approach would be to focus on the "upstream" activities or events that set the series of events in motion.

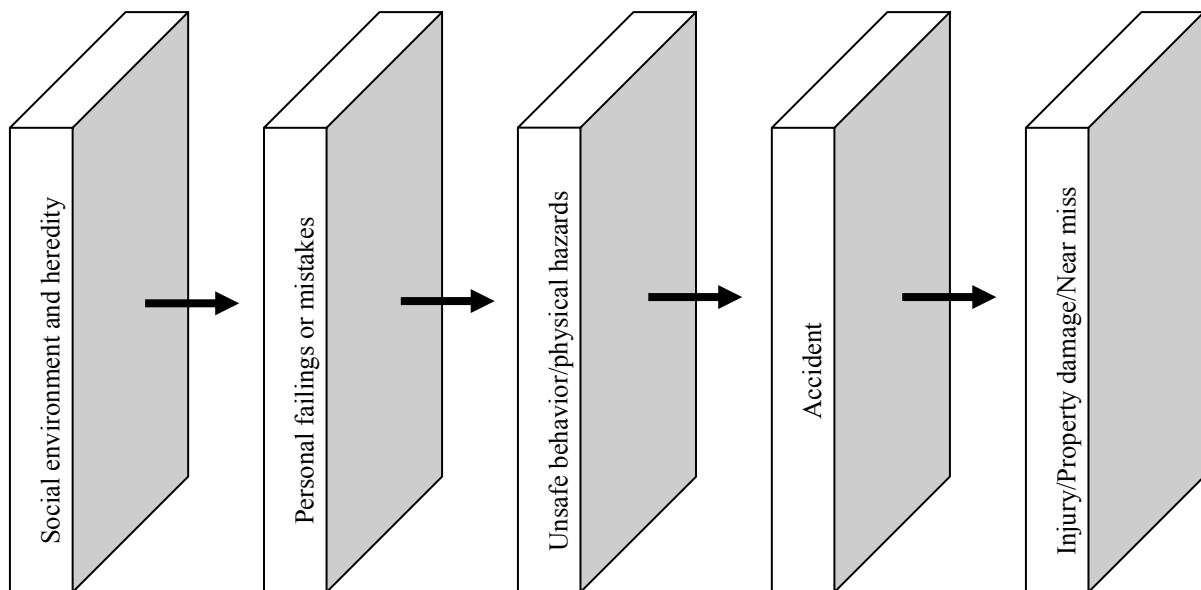


Figure 2-7. Domino accident causation model suggested by Heinrich (1959)

Many other theorists used Heinrich's domino theory as the starting point for their own work. For example, in 1971 Weaver modified the original theory to propose that the last three dominos in the sequence were caused by management omissions (Cooper, 1998). In essence, Weaver's model placed the immediate responsibility for accidents squarely on the shoulders of poor supervision and line management, instead of the injured workers.

Today, as the zero injuries objective is accepted and sought by many owners and contractors, total safety culture (TSC) and behavior-based safety (BBS) have become the popular approaches being implemented by many proactive firms. The basic logic of these approaches is to prevent construction accidents by continually addressing the very front-end of the accident chain – the culture and habits. Safety management is based on the scientific approach that is focused on the psychology and the behavior of workers.

Geller (2001) summarized the essence of TSC as the following:

- Promotes a work environment based on employee involvement, ownership, teamwork, education, training, and leadership.
- Builds self-esteem, empowerment, pride, enthusiasm, optimism, and encourages innovation.
- Reinforces the need for employees to actively care about their fellow coworkers.
- Promotes the philosophy that safety is not a priority that can be reordered, but is a value associated with every priority.
- Recognizes group and individual achievement.

He further pointed out that total safety culture requires continual attention to three domains environmental factors (including equipment, tools, physical layout, procedures, standards, and temperature), personal factors (including people's attitudes, beliefs, and personalities), and behavior factors (including safe and at-risk work practices, as well as going beyond the call of duty to intervene on behalf of another person's safety). In a total safety culture:

- Everyone feels responsible for safety and does something about it on a daily basis;
- People go beyond the call of duty to identify unsafe conditions and at-risk behaviors, and they intervene to correct them;
- Safe work practices are supported intermittently with rewarding feedback from both peers and managers;

- People “actively care” continuously for the safety of themselves and others;
- Safety is not considered to be a priority, but it is a value. This change in philosophy is based on the premise that priorities can change but values cannot.

Weinstein (1997) proposed another approach toward total safety culture through incorporating Total Quality Management with safety. He suggested a Total Quality Safety Management System which is achievable through the implementation of Total Quality Management Principles, Process Safety Management Guidelines, ISO-9000 Quality Guidelines, and OSHA VPP (Voluntary Protection Program) guidelines. The core of this approach relies on the commitment to and leadership of safety, and the involvement of each individual and each work team in safety.

Cooper (1998) criticized the approach that most accidents were blamed solely on employees rather than the work processes, poor management practices or a combination of all three. He analyzed different theoretical models to explain the accident causation, and supported the argument that the main focus of accident prevention should be shifted away from the worker’s unsafe acts and more onto the organization’s overall management system, particularly in relation to the implementation of the organization’s strategic decisions. Cooper concluded that safety culture should be *the product of multiple goal-directed interactions between people (psychological), jobs (behavioral) and the organization (situational)* (Cooper, 1998, page 17). Viewed from this perspective, an organization’s prevailing safety culture is reflected in the dynamic inter-relationships between members’ perceptions about, and attitudes towards, organizational safety goals; members’ day-to-day goal-directed safety behavior; and the presence and quality of organizational safety systems to support goal-directed behavior.

In recent years, behavior theories are widely used in safety management. The behavior-based safety approach is being utilized more extensively on construction projects. The objective of behavior-based safety is to eliminate unsafe behaviors and encourage safe behaviors through effective management interventions, based on behavior and psychological theories. The core of the behavior-based safety approach is to track both safe and unsafe behaviors of workers. According to Sutherland et al. (2000), the basic premise of the behavior-based safety approach can be stated very simply: *Behavior is determined by its consequences*. That is, people tend to repeat those behaviors that produce 'positive' consequences, and not repeat those that result in either no positive or 'negative' consequences. Therefore, by giving workers with safe behaviors "nice" things or removing negative effects, safety behaviors can be positively reinforced. On the contrary, by giving workers with unsafe behaviors negative feedback or by taking away "nice" things, unsafe behaviors will be punished and eliminated. This is also known as negative reinforcement. Workers who work safely could be rewarded (positive reinforcement), while workers who are unsafe could be punished (negative reinforcement). Management must decide which of these are most appropriate.

Peterson (1988) summarized the most common ways the behavioral scientist has contributed to safety management. The major approaches include the following:

- Survey methodology. Managers concerned about characteristics of their organizations have often used employee attitude surveys to identify problem areas, to assess the effects of organizational change or policies on job satisfaction, and as an index of management performance.
- Selection and assessment of personnel. The contribution of the behavioral sciences, particularly psychology, to improved selection, placement, and assessment of personnel is a most common use.
- Programmed Instruction. This concept includes such sensible elements as behavioral definition of training goals, the analysis of learning tasks into

manageable units, and systematic applications of principles of reinforcement to the learning situation.

- Motivation theory. Intervening safety behavior through motivation techniques is the core of the theory. In the minds of some observers, the impact of the motivation theory and the application of the practices they advocate constitute the major contribution of the behavioral scientists to the construction industry.
- Participative management. Workers would be more fully committed if they had a voice in setting the goals and conditions of their work environment.
- Organizational development. Organizational development is a process of systematic, planned change in an organization. It incorporates a definite philosophy that organizational change should be in the direction of mutual trust, openness in communication, readiness to deal with feelings as legitimate data, and understanding intra- and inter- group relations.

Today, behavior-based safety approaches are widely used by many proactive owners and contractors on their construction projects. The common approaches include safety observations, worker participation (through job safety analysis, safety survey etc.), and safety recognition programs.

Summary

From the literature review, it is apparent that although various recommendations exist, there is still no solid evidence in the previous research to describe how owners can efficiently promote construction safety on their projects, and how to assess the relationship between safety performance and the owner's involvement in project safety. A detailed research study at the project level to evaluate the owner's impact on construction safety has not been conducted. This conclusion gave impetus for conducting this research. Certain aspects to be investigated include the owner's commitment to safety, the selection of contractors, contractual requirements, and the owner's participation in safety management during construction.

CHAPTER 3 RESEARCH METHODOLOGY

Since previous studies and perspectives expressed in the literature suggested that the owner's impact on construction safety can be demonstrated in various ways, this study will focus on the influence of these factors on the safety performance of construction projects. This chapter will describe the research methodology to disclose the relationship of the owners' actions on project safety performance.

Research Design

Research Components

The objective of the study: To compare the effectiveness of several different factors of the owner's involvement in construction safety on project safety performance. In order to identify the relationship between a specific factor and project safety performance, the median safety performances of projects on which owners implement specific safety approaches will be compared with the median safety performances of projects on which owners do not have such an approach.

Universe: All construction projects in North American with U.S. and Canadian owners

Experimental Unit: Any individual construction project

Population: Collection of safety performances of projects in the universe

U-Sample: Collection of construction projects included in the study

P-Sample: Collection of safety performances of projects in the study

Inclusion criteria:

The projects selected in the study should have at least 100,000 worker hours accumulated to provide viable information on safety performance;

1. The projects should be on-going or have been completed within the past two years;
2. The safety personnel of the projects must be willing to participate in the study.

Response Variable: Project safety performance is the response variable in the study. It is measured by the total OSHA recordable injury rate (TRIR) of the project, which is the number of OSHA recordable injuries occurring per 100 full-time workers annually (or injuries per 200,000 worker hours of exposure). TRIR can be easily calculated with the number of OSHA recordable injuries and total worker hours expended on a project.

Factors and levels: Each specific aspect of owner involvement in construction safety can be identified as a factor. Therefore, there are multiple factors included in this study. Based on the results of the literature review and previous study results, the factors of interest can be classified into four categories, as follows:

Project context: the characteristics of the projects, including the following:

- The size of the project as measured by the estimated worker hours expended on the project (quantitative factor);
- The construction effort on the project: whether a new project, renovation project, maintenance project, or shutdown/turnaround/outage project (qualitative factor);
- The type of the project: whether a manufacturing project, a petrochemical project, a civil work, a residential project, a utility project, or a commercial project (qualitative factor.);
- The labor relationship of the project: whether the labor on site is union, open shop or merit shop (qualitative factor);
- Type of owner for the project: whether public or private (qualitative factor);
- Basis for contract award, whether the contractor is selected through competitive bidding or not (qualitative factor);

- Type of contract arrangement used on the project: whether general contract, multiple primes, design-build, C.M. at risk, or C.M. agency contract (qualitative factor);
- Type of contract used on the project: whether lump sum contract or cost plus contract, similar to a time and materials (T&M) contract (qualitative factor);
- Firm providing the workers' compensation insurance on the project, whether the owner (OCIP), the project (PCIP), the general contractor (CCIP), or if each employer provides their own insurance coverage (qualitative factor);
- Number of work shifts per day: whether one, two, or three (quantitative factor);
- Number of workdays per week: whether four, five, six, or seven (quantitative factor);
- Number of workers at the peak level of employment on the project (quantitative factor);
- Total estimated monetary value of the project (quantitative factor);
- Percent of workers on site that do not speak English (quantitative factor);
- Number of subcontractors awarded on the project (quantitative factor);
- The prime contractor's commitment to safety, as evaluated by the owner's site personnel (quantitative factor);

Selection of contractor: the factors related to safety that owners consider when selecting contractor(s) to execute their projects, including:

- Whether or not the owner uses a preferred list when selecting a contractor (qualitative factor);
- Whether or not safety performance is a consideration in contractor selection (qualitative factor);
- Measurements used to evaluate safety performance of a contractor including TRIR, EMR, safety personnel qualifications, project team qualifications, quality of overall safety program, the OSHA log, and OSHA inspection history (qualitative factor);

Contractual safety arrangement: the safety requirements that are included in the contract between the owner and contractor. This category will include different safety

management techniques that contractually must be employed by the contractor. They are typically qualitative factors.

Owner's involvement during project execution: the practices of the owner during the project execution to improve safety, including:

- Responsibilities of owner's site safety representative (qualitative factor);
- Implementation of a safety observation program on the project (qualitative factor);
- Specific items that must be included in the contractor's safety program (qualitative factor);
- Means of addressing injury statistics on the project: whether by project, by contractor, or blended with owner's safety performance statistics (qualitative factor);
- Treatment of near misses: whether recorded and investigated, or recorded without further investigation (qualitative factor);
- Owner support of project safety, specifically whether extra funds are provided to promote safety (qualitative factor);
- Owner participation in an OSHA Voluntary Protection Program (VPP) (qualitative factor);
- Whether or not a nurse or EMT is provided for the construction site by the owner (qualitative factor);
- Extent of owner involvement in the safety training program (qualitative factor);
- Implementation of a safety recognition/reward program on the project, and the level of the owner's involvement (qualitative factor);
- Distribution of a safety newsletter on the project (qualitative factor);
- Use of safety lunches to promote safety (qualitative factor);
- Incorporation of safety in the design of the project (qualitative factor);

Most of the factors are qualitative factors, and a few are quantitative factors. For each qualitative factor, the **parameters** of interest are:

ξ_Y = the true median TRIR of all projects where the owners employed the safety technique

ξ_N = the true median TRIR of all projects where the owners did not employ the safety technique

The statistics of interest are:

$\overline{M}_Y$ = The observed median TRIR of all projects where the owners employed the safety technique

$\overline{M}_N$ = The observed median TRIR of all projects where the owners did not employ the safety technique

Thus, the objective of this study could be achieved by **testing the hypothesis** (H_0 : $\xi_Y = \xi_N$ vs. H_a : $\xi_Y < \xi_N$) for each qualitative factor. This is a one-tail test, since TRIR can be expected to be less when the owner implements a safety approach or when the project possesses a specific characteristic identified in the literature review. The hypothesis testing will be further discussed in chapter 5.

Method Design

This study is a retrospective observational study, in which both response variable and factor levels are observed from the samples selected. Personal interviews based on a questionnaire were used to collect most of the data necessary for the study on each project selected. This is one of the methods frequently used in studies on construction projects. Since construction projects generally cost millions of dollars, and they are often under the influence of many different factors, it is not practical to conduct a prospective experimental research study. The interview was therefore employed to obtain as much information as possible.