



CONSTRUCTION INDUSTRY INSTITUTE

DESIGN FOR SAFETY



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Research Summary 101-1

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Design for Safety

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Executive Summary

Construction worker fatalities occur at a rate of approximately four per working day, and disabling injuries at a rate exceeding two per minute per working day. The total direct and indirect costs associated with these injuries and fatalities are in excess of \$17 billion per year. Owners must realize that incorporating safety measures in the design phase directly improves safety on the job site, and ultimately leads to lower total installed cost due to fewer dollars spent on mediating hazards and acquiring construction insurance.

In its research, the CII Design for Safety Research Team accumulated a large number of design suggestions that focus on improving construction worker safety. Many of the design suggestions are already being implemented, but no general method is available by which these ideas could be shared among owners, constructors, designers, and architect/engineers.

In response, the research team has created the “Design for Construction Safety ToolBox,” an interactive computer program to aid in planning and designing facilities. The program allows the user to identify potential safety hazards and offers design suggestions that may be used either to control or to eliminate the hazards. ToolBox, as it is called, allows for both the identified hazards and the design suggestions to be documented in a report format. A project history of construction safety design issues and actions is automatically accumulated and can be easily monitored for completeness of review and status of design decisions.

ToolBox can be an important part of pre-project safety planning. The successful implementation of ToolBox will provide numerous benefits, including a reduction of construction worker injuries and associated costs, as well as a reduction in redesign, rebuild, maintenance, and operating costs. Success, of course, greatly depends on owners taking a proactive role to promote safety through design. ToolBox provides owners and others in construction the ability to identify hazards before they become costly accidents at the site.

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Introduction

Safety is a major concern in construction. Compared with other industries, construction has consistently experienced higher fatality and disabling injury rates than all other industries except for mining and agriculture. Increased control of construction site hazards is needed to lower the level of risk and improve worker safety.

The construction industry has typically looked to the constructor for improvements in worker safety. The constructor carries the lead role in worker safety due to the mandate by the Occupational Safety and Health Act, which places the responsibility for safety on the employer. Research has shown that safety on the jobsite is affected by the actions and attitudes of each employee of the general contracting firm (Hinze and Parker, 1978; Hinze and Gordon, 1979; Hinze and Harrison, 1981). It has also been found that worker safety is affected by a general contractor's interaction with subcontractors (Hinze and Tally, 1988).

Owners, realizing that the costs of injuries are ultimately reflected in the cost of construction, have also greatly expanded their role in ensuring worker safety. The rising costs of health care and workers' compensation, as well as the escalation of litigation involving third parties, are not being ignored by owners. Table 1 (Hinze and Appelgate, 1991) reveals that these costs are not trivial.

Table 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

Owners' pre-qualification requirements and the selection of constructors can be based partly on demonstrated safety performance. Owners can also influence jobsite safety through their contractual agreements with constructors. By insisting on addressing safety in the contract, owners increase the probability that constructors will follow outlined safety procedures. Lastly, owners who are proactive in approaching safety on the construction site promote safety awareness throughout the project team.

Until recently, most regulatory and corporate safety programs have relied on hindsight (statistics and accident investigations) to determine where improvements can be made. Although aggressive constructor and owner safety programs are now making progress in reducing the number of on-site accidents, continued improvements can and should be made. The construction industry must now look to other parties involved in the construction process for additional improvement. Another party in the typical general contracting relationship is the design professional. While the constructor and owner have been involved in addressing and improving worker safety, the designer's involvement in construction worker safety has been minimal. Additional efforts by the designer are needed in order to obtain the zero accidents objective.

Designer's Role in Construction Safety

Historically, the design profession has not addressed construction site safety in its scope of work. Designers' lack of involvement may be attributed to their education and training, the existing design tools and standards, the designers' typical role on the project team, and liability exposure. Regardless of the type of project, designer education and training typically focus on safety of the "end user," such as the office worker, motorist, or equipment operator. Rarely do designers receive formal education and training on design approaches that favorably influence construction worker safety.

Today's design tools and standards reflect the designers' education and training. Design codes, such as the Uniform Building Code, typically provide standards that target the safety of the structure's end user. Facility safety for the period of time between the start of construction and the transfer of the completed project to the owner is not specifically addressed in current design resources. No design tools accessible to the public exist that show how design decisions could or should be made for the benefit of improved construction worker safety.

The designers' role in the project team is usually limited to the preparation of the design documents for use by the constructor. In many cases the designer is also called on to verify that the completed work conforms to requirements of the design documents. Although designers are usually given the authority to stop work that does not meet design requirements, they rarely are given further control of the construction site.

Lastly, designers have minimized their involvement in construction site safety in order to limit their exposure to liability for worker injuries. Numerous court decisions extending the responsibility for safety to third parties reveal the courts' willingness and intention to compensate

injured workers for their losses. As a result, and upon subsequent advice from their legal counsel, many designers have deliberately excluded from their scope of work any involvement in construction worker safety.

The construction industry has recently awakened to the need for designer involvement in construction worker safety. It is becoming more evident that safety practices implemented solely by the constructor cannot eliminate all jobsite hazards. Constructors and safety professionals have realized that design is an underlying facet of construction site safety. This awareness of the designer's effect on worker safety has provided the stimulus for research regarding the designer's role in safety.

Study Objectives

This study investigated the designer's role in construction worker safety and led to the creation of a safety design tool. The specific objectives for the CII Design for Safety Research Team were to:

- recommend appropriate hazard identification techniques.
- determine planning and design steps to facilitate risk reduction.
- identify economic evaluation procedures for design options.
- focus on facility planning and design aspects affecting safety in the construction phase, allowing future considerations of start-up, operational, maintenance, and decommissioning phases during conceptual and detailed design.
- produce a “tool box” of design ideas to assist design teams in identifying and mitigating safety hazards.

The research effort began by accumulating design for safety suggestions. This compilation process continued throughout the duration of the research. Development of the design tool commenced with the creation of a prototype at The University of Texas at Austin. Further development of the prototype into the final working program was performed at the University of Washington and continued throughout the research project together with the design suggestion accumulation process.

Throughout the course of the research, reaction to the research topic was positive and encouraging. Construction industry personnel and academic colleagues showed interest in the research and its potential effect not only on construction site safety, but on the

designer's role in safety. Many individuals remarked about the favorable and direct effect it will have on improving worker safety. Numerous calls were received inquiring about the availability of the design tool and its database of design suggestions. Some individuals also contacted the research team members to describe and discuss potential applications of the program within their firm's project management and design processes.

Design for Safety Suggestions

The accumulation of design suggestions involved searching for and developing design ideas and recommendations. These suggestions were to represent current best practices in the industry. A “best practice” is a design idea which, when used, provides an improvement in construction safety. In more general terms, best practices can be seen as the optimum procedures and methods which project teams use to achieve improved construction safety.

The main goal of this effort was to compile as many design suggestions as possible. All suggestions applicable to the design phase of any type and size of project were recorded. Since the relative merits of each design idea must take into account the specific project circumstances, design suggestions were not discarded based on their apparent impact on project cost, schedule, quality, or other design or construction performance criteria. It was deemed that any efforts to overlook or eliminate specific design ideas should be conducted by the designer as specific project objectives are examined.

Design Suggestion Sources

The research effort focused on numerous sources of design suggestions. Previous research and literature citations have indicated that many design suggestions have been developed, and some are routinely implemented by various design firms. An extensive literature search was conducted to identify existing ideas and to integrate related research and industry work. The literature search included reviews of publications from such professional organizations as ASSE, ASCE, AIChE, and CII.