Investigation of the Viability of Designing for Safety

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Abbreviations

CDM	Construction (Design and Management) regulations (United Kingdom)
ISTD	Institute for Safety Through Design
OSHA	U.S. Occupational Safety and Health Administration

Contents

Construction workers historically have experienced more deaths from injuries and more injuries and illnesses requiring time off than workers in any other industry. (The *rate* of fatal injuries is higher in agriculture, mining, and transportation.) In recent years the construction industry has taken many steps to ensure safe working conditions and enable safe work practices, yet construction work remains a hazardous occupation. Addressing safety in the *project design*, before construction begins, has been proposed as an additional method for improving construction worker safety and health.

However, consideration of worker safety is not traditionally part of the project designer's role. This study investigated the viability of addressing construction worker safety and health in the project's design, known as "designing for safety." Research activities included a review of the literature on designing for safety, an examination of the federal Occupational Safety and Health Administration (OSHA) construction standards containing references to design professionals, and a pilot survey of architects and engineers employed as construction design professionals.

Background

U.S. Bureau of Labor Statistics data show that, in 2003, construction workers were about 7% of the nation's workforce but suffered nearly 1,166 deaths from work-related injuries, just under 21% of the total. That same year, 155,400 injuries and illnesses requiring days away from work were recorded in construction, or 9.7% of such cases for all industry. The industry experiences higher rates of deaths from injuries than all other industries, except mining, transportation, and agriculture; compared with all industries, construction has the highest rate of nonfatal injuries and illness requiring days away from work.

In recent years, the construction industry has become increasingly aware of the importance of ensuring worker safety and health on job sites. In addition to a general concern for worker safety and well-being, the interest in improving safety and health is driven by such factors as rising costs and legal liability associated with injuries; a declining number of qualified workers and the need to retain a well-trained, productive workforce; and the recognition that safety improvements can benefit worker productivity and overall project quality.

As the direct employer and the party responsible for a project's construction, the constructor is positioned to promote safe work conditions and enable safe work practices. (In this report, "constructor" refers to the construction firms, contractors, and subcontractors responsible for building a project and employing the construction workers.) The constructor's role is well established in the federal OSHA regulations that place the responsibility for worksite safety and health on the employer. Moreover, the constructor's influence on safety and health has been extensively researched. Best practices have been identified and tools have been developed to help constructors eliminate hazards and ensure safe work practices. Although the industry's overall safety performance has improved, additional efforts are needed to lower the level of risk and further control construction site hazards.

By addressing safety in a project's design, hazards may be eliminated or reduced during construction, thereby enhancing the safety performance of the constructor. For instance, raising the ceiling height in the utility area provides more space and height for trades workers, reducing ergonomic and head-knocker risks (Hecker, Gambatese, and Weinstein 2004). However, addressing worker safety is not traditionally part of the design professional's role, and formal implementation of the concept is not part of standard design practice. Additional investigation and development of the concept are needed to fully realize the benefits of designing for safety.

Study Objectives and Research Methods

The goal of this study was to determine the viability of designing for safety as an intervention for improving construction worker safety and health. The researchers considered viability to be related to the practicality of implementation, given the nature of design practices and the delivery of construction projects. The project sought to assess design professionals' knowledge and acceptance of the design-for-safety concept, and to identify the potential effects of designing for safety on construction project characteristics, such as costs, productivity, and quality. As a small, pilot-level effort, the study was intended to be the starting point for a more comprehensive research project. Three primary activities were undertaken: a literature review, a review of OSHA construction standards containing references to design professionals, and a pilot survey of design professionals. These activities are described below.

Literature review

A literature review identified previous research on a variety of topics related to designing for safety, including its significance to worker safety and health, as well as descriptions of safety-in-design programs, processes, and tools. The findings were used to develop the survey questionnaire and to provide background material for evaluating the survey results.

OSHA standards review

An examination of OSHA construction standards (29 CFR 1926, *Safety and Health Regulations for Construction*, online at www.osha.gov) aimed at identifying provisions for the following:

- The services of a licensed professional engineer or designer that are specifically mandated
- Professional engineer or designer input that is recommended but not mandated
- Design modifications that would mitigate a hazard and thereby eliminate the need for additional on-site safety measures.

The authors conducted a text-based electronic search of OSHA construction standards to identify provisions containing references to "design professional," "engineer," and "designer." Another review sought to identify OSHA provisions for which the required temporary, on-site safety measures could be omitted if a design modification were made, even without specific reference to a design professional. For this effort, the authors evaluated the database of suggested design modifications developed by Gambatese, Hinze, and Haas (1997) and identified OSHA provisions that could be matched with the wording and intent of the design suggestions. The OSHA provisions were then examined to determine whether the design of the permanent structure could be modified to address the safety requirement and thereby eliminate the need for the prescribed temporary safety measure, or to minimize the instances in which the safety measure was required.

Survey of design professionals

The authors surveyed construction design professionals to determine the extent of their knowledge of construction safety, as well as their capabilities in designing for safety and their willingness to implement the concept. The survey sought also to determine designers' perceptions about the feasibility of specific design modifications intended to improve construction worker safety.

The number and type of design firms employed on a project depend on many factors, including the size, complexity, and nature of the project; the intentions and capabilities of the owner; and the availability and cost of design services. One or more firms may be hired to develop a design, each working on the portion related to a particular specialty. Firms may concentrate on a design discipline (design only), or they may undertake both the design and construction (design-build).

Design professionals from both design-only and design-build firms participated in the survey. The participants were employed by firms that design projects in each of the construction industry sectors (residential, commercial, heavy/civil, and industrial). All of the primary design disciplines were represented, including architecture, civil engineering, structural engineering, mechanical engineering, and electrical engineering. These disciplines account for most of the work (based on amount of work and dollar value) undertaken on many projects. Nonetheless, this study does not claim to be an accurate statistical sampling of the profession.

The researchers selected potential survey participants using convenience sampling and random sampling of listings from local telephone directories, the Internet, web-based professional association directories, and personal contacts. The contacted firms were located in western Oregon (Portland and surrounding areas) and northern Florida (Gainesville, Jacksonville, and surrounding areas), where the researchers have established relationships through the construction programs at Oregon State University and the University of Florida.

Given time and funding limitations, the researchers targeted a relatively small sample size. The researchers initially contacted 40 design professionals via electronic mail or telephone to request their participation. The contacted individuals were told that their participation was purely voluntary and that their responses would be kept confidential. Criteria used to select the final participants included willingness and availability, design experience, knowledge about standard design practice, and current employment in the design field. A total of 19 architects and design engineers ultimately participated in the survey.

In-person interviews were selected as the best means of conducting the survey. Such a format allowed the researchers to obtain qualitative information and to explore topics in greater depth, based on the participant's initial responses. Copies of the survey cover letter and questionnaire are attached as annex A.

Literature Review

Approaches to designing for safety

Eliminating the hazard is widely recognized as a far more effective way to improve safety than reducing the hazard or providing personal protective equipment to workers. For instance, Manuele (1997) lists approaches to safety in the following order of decreasing priority and effectiveness:

1. Design to eliminate or avoid the hazard.
2. Design to reduce the hazard.
3. Incorporate safety devices after the fact.
4. Provide warning devices.
5. Institute training and operating procedures.

Andres (2002) developed a similar “safety hierarchy,” presented in order of decreasing effectiveness as follows:

1. Eliminate the hazard.
2. Provide engineering controls.
3. Warn.
4. Train.
5. Provide personal protective equipment.

There is a prevailing belief that the construction industry’s safety problems have been around for too long (Korman 2001). Korman reported on breakthrough approaches to safety that are needed to break the cycle and reduce the number of construction injuries and fatalities. One of the ideas described in Korman’s report is to require and motivate architects and engineers to become involved in worker safety considerations so that safety can be designed into the project.

According to the Institute for Safety Through Design (ISTD), addressing safety in the conceptual or early design stages, rather than retrofitting the design to meet those needs, yields certain measurable benefits. Among the benefits are improved productivity, reduced operating costs, avoidance of expensive retrofitting to correct design shortcomings, and significant reductions in injuries, illnesses, environmental damage, and attendant costs (ISTD 2003). (ISTD, established by the National Safety Council’s Business and Industry division, promotes consideration of safety, health, and the environment in the design of industrial processes, including equipment, products, and facilities.)

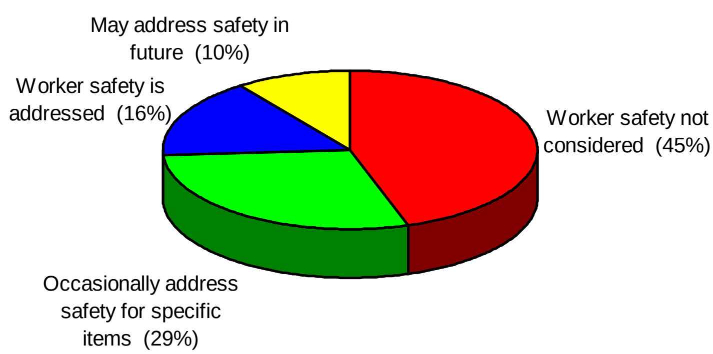
In a survey of general contractors in South Africa, about one-half of the 71 respondents identified the design as a factor that may significantly influence safety and health (Smallwood 1996). Sixty-three of the surveyed contractors stated that there is a need for safety education in universities and technical colleges for architects and engineers.

Implementing the design-for-safety concept

Design firms do not commonly address construction worker safety in their design, according to a 1992 survey (Hinze and Wiegand 1992). Less than one-third of the 23 surveyed design firms addressed safety, and less than one-half of the independent constructability reviews included a review of construction worker safety. ("Constructability" reflects the ease and efficiency with which a project can be built. Constructability is in part a reflection of the quality of the design documents; that is, if the design documents are difficult to understand and interpret, the project will be difficult to build.) The study also found that design-build firms more often addressed safety in project designs than design-only firms.

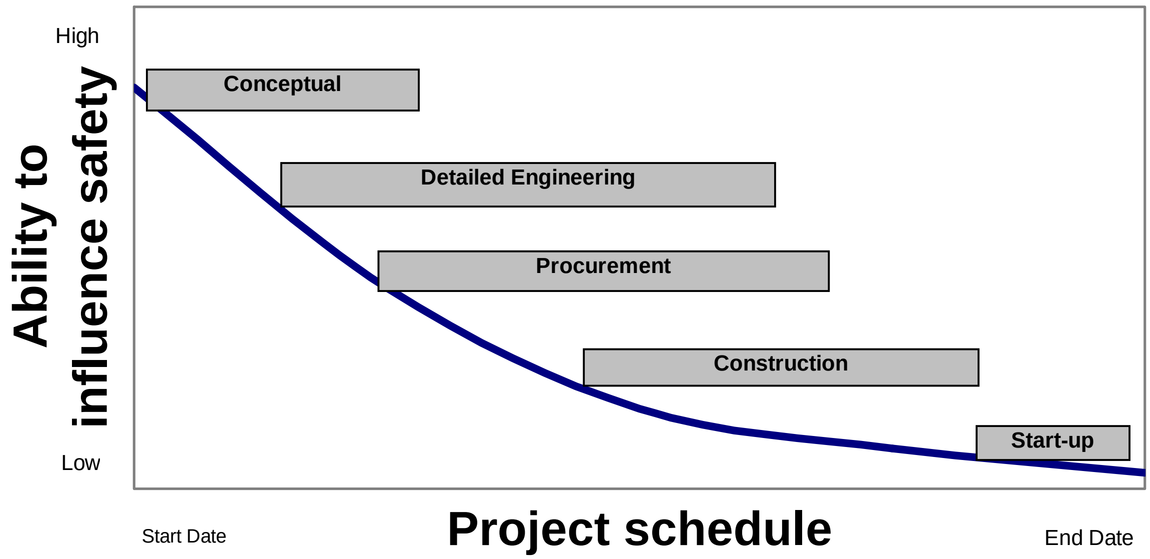
Two construction marketing studies also found that most designers do not address construction worker safety (Hinze 1994a, 1994b). The studies surveyed 377 project owners in the United States. Although these studies had several different areas of focus, the owners were asked if the designers of their projects addressed construction worker safety in their designs. The studies were similar in their finding that many designers did not address construction worker safety (*see* figure 1). Only 16% of the owners surveyed indicated that they considered worker safety in their designs.

Figure 1. Distribution of designer activity in addressing safety (Hinze 1994a, 1994b)



According to Szymberski (1997), the ability to influence the safety of construction workers is greatest in the early phases of a project. Szymberski's time/safety influence curve illustrates this point (figure 2). The curve is based in part on Szymberski's own judgment. He starts with a similar "time/cost curve" that was developed as part of previous research, and replaces "cost" with "safety."

Figure 2. Time/safety influence curve (Szymberski 1997)



Construction worker safety typically is not considered a critical issue by the design team, except in offshore and process industries, such as oil and natural gas processing (MacKenzie, Gibb, and Bouchlaghem 1999). This study found that the following factors affect the safety performance of a project: simplified documentation, improved communication, and improved auditing to ensure implementation of safety features. The study concluded that the detailed design phase is a critical stage for considering safety and that designers do not take enough time to implement safety procedures during the design phase.

Design-for-safety resources, tools, and processes

Designing for safety requires integrating construction process knowledge into the design. However, many designers lack formal training in this area. One way to address this deficiency is for designers to conduct a thorough risk assessment of each design component (Hinze, Coble, and Elliott 1999). Hinze (2000) recommends a holistic approach to design that encompasses the entire life cycle of a building, including construction. This approach can be implemented by including safety considerations in constructability reviews (Gambatese 2000a). A “Life Cycle Safety” project, sponsored by the owner of a new semiconductor manufacturing facility in the Pacific Northwest, involved trade contractors in the programming and design phases (Hecker and Gambatese 2003). The construction knowledge provided by the trade contractors helped identify safety hazards before construction started. A review of project documents and interviews with participants indicated that the approach was effective in providing awareness of safety issues throughout the project.

Another way to implement the concept is to improve the communication and coordination of work between designers and construction foremen, particularly those with excellent safety records (Coble and Haupt 2000). The authors maintain that foremen can make substantial contributions to the design-for-safety effort, provided designers recognize and harness their skills, site experience, and knowledge.

The extent to which design professionals can influence construction site safety depends in part on the design tools available to them. One computer program, "Design for Construction Safety ToolBox," lists project-specific construction safety hazards and suggests design alternatives to eliminate or reduce hazards. (The ToolBox is available from the Construction Industry Institute, www.construction-institute.org.) The database contains more than 400 design practices, based on reviews of construction industry publications and design manuals, as well as interviews with engineers, architects, constructors, and construction managers (Gambatese, Hinze, and Haas 1997).

Legal concerns about designing for safety

Many design professionals fear that addressing construction worker safety in their designs will open them to lawsuits by an injured construction worker or related third party. In a study of 23 design firms, many designers indicated that their lawyers advised them not to address construction worker safety in their projects (Hinze and Wiegand 1992). According to Coble (1997), most design professionals resist implementing the concept because of concerns about increased liability exposure. Gambatese (2000b) reviewed the liability risks associated with implementing design-for-safety knowledge. His findings are outlined in table 1.

Table 1. Designer liability associated with applying design-for-safety knowledge (Gambatese 2000b)

Implementation / Standard Practice	Design-for-safety knowledge is implemented in the facility design	Design-for-safety knowledge is NOT implemented in the facility design
Industry standard practice does NOT incorporate design-for-safety knowledge	**Designer actions:** • Go beyond standard practice. • Fulfill his/her professional duty to take reasonable steps to prevent worker injuries. **Result:** Designer is NOT LIABLE for worker injuries related to the (safe) design as a result of acting with reasonable care.	**Designer actions:** • Are consistent with standard practice. • Do not fulfill his/her professional duty to take reasonable steps to prevent worker injuries. **Result:** Designer is LIABLE for worker injuries related to the design for not acting with reasonable care.
Industry standard practice does incorporate design-for-safety knowledge	**Designer actions:** • Are consistent with standard practice. • Fulfill his/her professional duty to take reasonable steps to prevent worker injuries. **Result:** Designer is NOT LIABLE for worker injuries related to the (safe) design by acting consistent with standard practice and with reasonable care.	**Designer actions:** • Contrary to standard practice. • Do not fulfill his/her professional duty to take reasonable steps to prevent worker injuries. **Result:** Designer is LIABLE for worker injuries related to the design for not acting consistent with standard practice and with reasonable care.

Note: This table does not address situations in which design-for-safety knowledge is absent.

An abbreviated search of the LexisNexis legal database (keywords “architect,” “construction,” and “safety”) identified one court case addressing a construction design professional’s legal responsibilities concerning worker safety. In that 30-year-old case, the architect was found responsible for the deaths of two construction workers who were killed by hydrogen sulfide gas during the construction of a sludge pit (*Evans v. Howard R. Green Co.,* Iowa Supreme Court, 231 N.W. 2d 907, 1975). It was established that the architect knew of the potential for hydrogen sulfide gas accumulation in the pit, because his design included a plan for dissipating the gas to ensure the safety of the facility’s final occupant. The Iowa Supreme Court found:

- An architect cannot ignore a duty to the general public for harm resulting from negligence in furnishing plans and specifications that result in damage during the work itself.
- An architect may be held liable for negligence for failing to exercise the ordinary skill of the profession, where such negligence results in the erection of an unsafe structure whereby anyone lawfully on the premises is injured (including construction workers).
- An architect’s liability for negligence resulting in personal injury or death may be based on his supervisory activities or defects in the plans.
- The liability of an architect is not limited to the owner who employed him. Architects can be sued by “third parties,” that is, parties with whom they do not have a formal contract.
- The claim brought against the architect in the Iowa case was that of a negligent design only.

An in-depth search of legal cases found that recent court decisions recognize a role for designers in ensuring construction workers’ safety (Behm 2004). These legal findings, when considered in combination with the codes of ethics of professional design organizations, can help motivate design professionals to embrace the concept of designing for construction worker safety.

Legislative actions addressing design for safety

Legislative efforts to give design professionals more responsibility for construction worker safety date back at least to the late 1980s, following the collapse of the L’Ambiance Plaza in Bridgeport, Connecticut, which killed 28 construction workers. Two separate bills introduced in the U.S. Senate would have placed increased safety responsibility on design professionals. Senate Bill 2518, introduced in 1988, would have required the involvement of a professional engineer-architect in planning safety and health on construction sites, with a provision for a permitting system requiring approval by the engineer-architect. Senate Bill 930, introduced in 1989, would have placed responsibility on the constructor to employ a certified safety professional for the safety function, with authority to stop work where there is imminent danger to workers. Neither bill gained enough support for passage.

In the revised safety standards for structural steel erection (29 CFR 1926, Subpart R), which took effect in 2001, OSHA defines the project structural engineer of record as the registered, licensed professional responsible for the design of structural steel framing, whose seal appears on the structural contract document. Also included in this regulation is a design criterion requiring that all columns be anchored by a minimum of 4 anchor rods/bolts. When OSHA proposed this requirement, commenters objected that OSHA was exceeding its authority by imposing such specific design requirements. One commenter stated that buildings are designed only to comply with building codes and related industry standards, in order to assure public safety once the building is occupied. OSHA responded with this statement:

> OSHA, however, strongly believes that it is as appropriate for the Agency to require that avoidable safety hazards be engineered out for the protection of those erecting the building as it is for local jurisdictions to set design criteria for the safety of the building's occupants (OSHA 2001).

The Deputy Director of OSHA's Construction Directorate, H. Berrien Zettler, made this statement about the design professional's role in contributing to worker safety:

> OSHA believes that much could be done to improve safety and health on the work site if we could get designers, engineers, and architects to pay attention from the beginning and design into blueprints measures that would lead to a safer workplace, to think of a construction process and design for that as well as for end use (Korman 1999).

Construction (Design and Management) Regulations—United Kingdom

Current regulations in the United Kingdom place requirements for construction worker safety and health on design professionals. (While other European Union countries have developed design and management regulations, their efforts are not as far along as those in the United Kingdom, and there is less written about their programs.) The U.K.'s Construction (Design and Management) (CDM) Regulations, which took effect in 1995, place a duty on the designer to ensure that any prepared design avoids foreseeable risk to construction workers (MacKenzie, Gibb, and Bouchlaghem 2000). In particular CDM Regulation 13 states that all designers must comply with the regulation (*see* annex B). Designers are subject to fines if they fail to comply with the law.

The design profession in the United Kingdom has been slow in meeting its responsibilities under the CDM regulations (Baxendale and Jones 2000). According to Anderson (2000), designers need more guidance about what they are expected to achieve and about how to complete those goals. Ash (2000) maintains that the goals of the CDM regulations are most often achieved when designers and constructors already work together closely, such as in design-build and construction management companies. According to MacKenzie, Gibb, and Bouchlaghem (2000), the following factors greatly affect designer involvement and success under the CDM regulations:

1. Many designers do not comply with the regulations, which place a duty to ensure that any prepared design avoids foreseeable risk.
2. Designers lack awareness of worker safety and health.
3. Designers lack knowledge of construction materials, processes, and techniques.
4. Designers use off-the-shelf materials without questioning their use, a practice that may lead to the creation of safety hazards.
5. The Health and Safety Executive, which issued the CDM regulations and is comparable to OSHA, must do more to encourage effective communication between designers and constructors at an early stage.

Results of OSHA Standards Review

The text-based electronic search of the OSHA construction standards (29 CFR 1926, *Safety and Health Regulations for Construction*) identified 39 provisions containing the term "engineer" (*see* annex C, section 1). No instances of "design professional" or "designer" were found. The authors also cross-referenced the construction standards with a database of design suggestions developed during previous research (Gambatese, Hinze, and Haas 1997). Each suggestion for modifying the design of a permanent facility was examined and, where applicable, matched to the relevant OSHA provision. Where there was a match, implementing the design modification would remove the hazard and thereby eliminate the need to institute the required safety measure at the job site. The list of the design modifications and corresponding OSHA standards is provided in annex C, sec. 2. The findings of this research are described further in the proceedings of the 2003 Construction Research Congress (Gambatese, Behm, and Hinze 2003).

Results of Survey on Designing for Safety

Characteristics of survey participants

A total of 19 architects and engineers out of the 40 initially contacted participated in the survey. The interviews were conducted between June and December 2002. The participants represented a variety of design disciplines, employment positions, and durations of work experience. Of those interviewed, 8 were architects and 11 were from various design engineering disciplines (table 2). The types of firms they represented were about equally distributed between design-only (9) and design-build (10). The discipline of the designer may not correspond to the primary discipline of the employer. For instance, a designer who is academically trained and licensed as a structural engineer may work for an architectural firm, representing that firm's structural expertise.

Table 2. Disciplines of survey participants

	Number	Percent
Architect	8	42.1
Structural	4	21.1
Civil	3	15.8
Mechanical	2	10.5
Electrical	2	10.5
Total	19	100.0

The design experience of the participants ranged from 3 to 33 years, averaging 21 years (table 3). Only 7 of the 19 participants had any construction experience, defined as hands-on construction work, such as carpentry, roofing, and plumbing (table 4).

Table 3. Design experience of survey participants (in years)

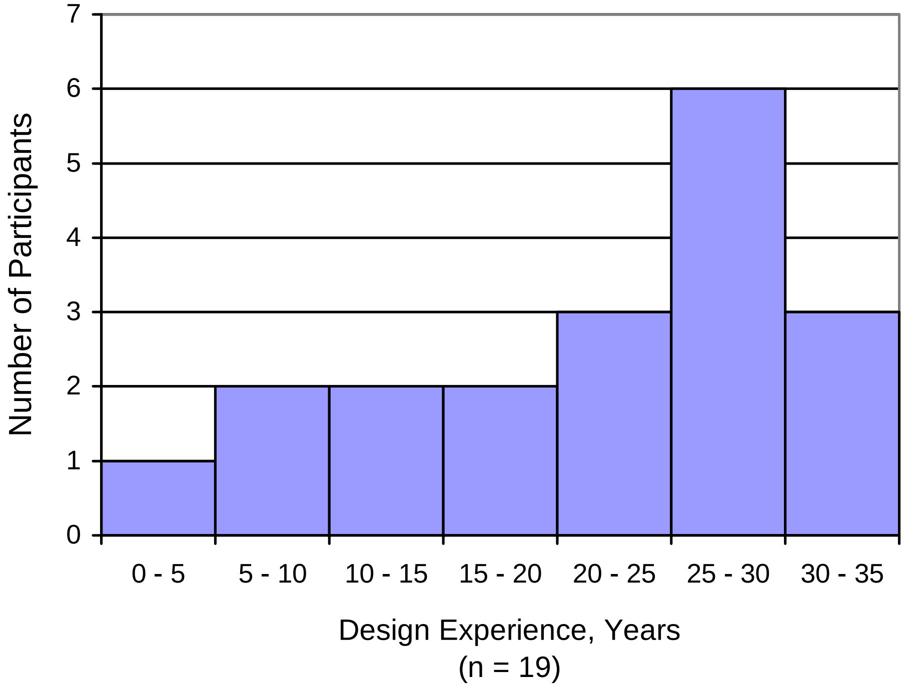


Table 4. Construction experience of survey participants (in years)

Total annual design fee revenue per firm ranged from $75,000 to $500 million, averaging about $155 million per year, according to information provided by 12 of the 19 participants. Six firms had annual design fee revenue greater than $100 million. In 4 firms, all of the revenue came from design services. The other 8 firms provided design and construction services, and the revenues from the two sources were roughly equivalent. The size range reported by these firms is representative of the industry overall. However, this survey does not claim to be an accurate statistical sampling of the industry.

Knowledge of designing for safety

General knowledge of the design-for-safety concept was evaluated using the responses to questions 10, 20, and 25 (*see* questionnaire in annex A). At the beginning of the interviews, the respondents were asked to describe their understanding of the design-for-safety concept. Three of the 19 respondents referred to American Institute of Architects contract documents, which state that safety is the contractor's responsibility. Only one respondent showed an in-depth knowledge of the concept, mentioning topics such as Life Cycle Safety and communication of hazards to constructors, and stating that designing for safety is more than just designing to code requirements. (This participant personally participated in the development and implementation of the Life Cycle Safety process on a project and has spoken on the topic at construction industry conferences.) Four of the 19 respondents indicated that they had heard of the United Kingdom's CDM regulations. Two respondents reported taking coursework that included material on construction worker safety, but not specifically designing for safety.

Implementation of design-for-safety concept

Table 5 summarizes the responses to a variety of questions about designing for safety. Two respondents said they had attended constructor safety meetings, and two mentioned discussing safety as part of constructability reviews. (Constructability reviews implicitly address safety when taking into account the ease and efficiency of building a project, although designers often do not recognize that safety may be one of the factors driving the constructability concern.)

Table 5. Implementation of designing for safety (n = 19)

Survey question	Number (%) answering "yes"
Do you ever make design decisions that improve construction worker health and safety?	9 (47%)
Have you ever had discussions with contractors and/or owners that include the methods/practices employed by the contractor?	8 (42%)
Have you had any discussions with contractors and/or owners that include the features to be included in the design, to ensure construction worker health and safety during project construction?	7 (37%)
Have you ever made modifications to a design in the design phase to eliminate a potential safety risk that would impact construction worker health and safety?	8 (42%)
Have you ever worked with or hired a construction health and safety consultant in the design phase?	3 (16%)
Have you ever been asked to address construction worker health and safety in the design phase?	4 (21%)

The respondents indicated only sparse use of design tools or other processes to help them implement the concept (questions 12, 13, 14, 26, and 28). One respondent mentioned use of the "Design for Construction Safety Toolbox" (Gambatese, Hinze, and Haas 1997). This respondent stated that the client (project owner) provided a safety checklist for use in the design phase. One participant, a structural engineer, pointed out that a revision to the American Institute of Steel Construction's *Manual of Steel Construction* recommends a specific design for steel connections to protect construction workers installing structural steel beams.

Design-for-safety modifications

Nine of the 19 respondents reported making at least one design modification with the intention of reducing safety and health risks to construction workers (questions 16 and 19). One participant cited the use of less hazardous chemicals to comply with green building design certifications. Designing pre-fabricated project components and built-in tie-off points for construction workers were also offered as examples of design-for-safety modifications.

Impacts of designing for safety

Several survey questions sought to obtain participants' views about the possible impacts of designing for safety (questions 15, 24, and 32). ("Impact" was defined broadly to apply to any aspect of a project, the design process, or the construction industry overall, including safety and other project characteristics.) Fourteen participants stated that designing for safety would result in increased project costs, and nine stated that it would lead to schedule delays and lowered productivity (table 6). The impact on construction worker safety was not mentioned, presumably because this outcome was implicit in the survey. Alternatively, failing to mention construction worker safety may reflect the prevailing work priorities for designers.

Table 6. Impacts of designing for safety (n = 19)

Impact	Number (%) citing impact
Increased cost	14 (74%)
Schedule extended/lower productivity	9 (47%)
Decrease in project quality (limits the design creativity)	4 (21%)
Productivity would increase	1 (5%)
"This is a non-question to me because it does not apply"	1 (5%)

Barriers to designing for safety

When asked to list barriers to designing for safety (question 23), seven participants mentioned that designing for safety would interfere with the constructor's means and methods (*see* table 7). Five survey participants mentioned increased liability as a barrier in response to this open-ended question. However, in a different context, when asked if they believed designing for safety increases liability exposure (question 32), many more participants (16 of 19) answered "yes." In other words, when prompted, most of those interviewed saw legal liability as a barrier to designing for safety. By contrast, only four participants answered "yes" when asked if they believed that the nature and culture of the construction industry prevented them from addressing worker safety and health in the design phase (question 34).

Table 7. Barriers and limitations to designing for safety (n = 19)

Barrier or limitation	Number (%) citing barrier
Interferes with the constructor's means and methods	7 (37%)
Increased liability	5 (26%)
Designers have limited or no construction experience/knowledge	4 (21%)
Time constraints/"Have enough to deal with"	4 (21%)
No control over who gets the bid (constructor hired separately)	4 (21%)
Design for occupant, not construction worker	1 (5%)
No motivating force in the design industry	1 (5%)
No code or law; no mechanism for consistency	1 (5%)
Material availability will affect sequencing	1 (5%)
Increased project complexity	1 (5%)
Contractor comes in late in the design process	1 (5%)
Quality of design concepts would be reduced	1 (5%)

Designer interest in designing for safety

Designing for safety is not a standard design practice and typically is not mandated in design contracts in the United States. Thus, implementation of the concept depends, at least in part, on the interest and motivation of the individual designer. The survey posed an open-ended question regarding designers' personal willingness to address construction worker safety and health in the design phase (question 29). Three respondents indicated that they were not willing to implement the concept or not interested in designing for safety (table 8).

Table 8. Personal willingness to design for safety (n = 19)

Response	Number (%) of respondents
Interested / willing	7 (37%)
Neutral response	9 (47%)
Not interested / not willing	3 (16%)

Another way to determine designers' level of interest in addressing safety was to assess their work priorities. The respondents, on average, ranked quality of work their highest priority and construction worker safety as their lowest priority (table 9). This low ranking for worker safety may reflect the prevailing mindset among designers, just as their failure to mention worker safety as an impact of designing for safety (discussed above) possibly implies lack of awareness or motivation to design for safety.

Table 9. Priority of project criteria

Project criteria	Average rank*
Quality of work	1.5
Final occupant safety	2.1
Project cost	2.7
Project schedule	3.8
Aesthetics	4.2
Construction worker safety	5.7

*1 = highest priority, 2 = second highest, and so forth. A **lower** ranking indicates **higher** priority.

Two survey questions (37 and 39) were intended to assess the designers' general interest in and ease with the topic of construction worker safety. Eight of the 19 participants stated that they had been asked to give their opinion about safety (question 37). Most reported that they provided general suggestions while on site and during safety meetings. One respondent stated that, while on a project in Southeast Asia, he felt compelled to speak up about safety because of the extremely dangerous conditions he observed. All but one of the 19 respondents indicated that they felt comfortable talking about construction worker safety and health issues (question 39).

Feasibility of design-for-safety modifications

Table 10 below presents the participants' comments on the feasibility of implementing various design-for-safety modifications (*see* questionnaire in annex A). The proposal for a minimum window sill height of 42 inches to serve as guardrails during construction drew the largest number of objections. Nine respondents opposed the measure and three others felt it was feasible but would have to be requested by the owner.

Table 10. Responses to proposed design-for-safety modifications

Proposed design modification	Responses/comments
Indicate on the contract drawings the locations of existing underground utilities and mark a clear zone around the utilities. Note on the drawings the source of information and level of certainty on the location of underground utilities.	• Already complete this to some extent (10 respondents) • Most do not mark a clear zone or provide a level of certainty for the location of underground utilities • Not part of an architect's work; should be completed in the field (4 respondents)
Design parapets to be 42 inches tall. A parapet of this height will provide immediate guardrail protection and eliminate the need to construct a guardrail during construction or future roof maintenance.	• 5 positive responses; 4 negative • Implementing modification would increase overall costs (5 respondents) • Modification would enhance building aesthetics by hiding rooftop maintenance equipment (3 respondents) • Would diminish aesthetics (1 respondent)
Design columns with holes at 21 and 42 inches above the floor level to provide support locations for lifelines and guardrails.	• Modification is possible (6 respondents) • No added cost (2 respondents) • Would not do this (4 respondents) • Potential concern with the structural integrity by drilling holes in the steel (3 respondents) (Authors' note: This is a valid concern. Drilling holes in the steel decreases the strength of the structural member to resist load. If the column size cannot be increased, the structural integrity could be compromised.)
Design window sills to be 42 inches minimum above the floor level. Window sills at this height will act as guardrails during construction.	• 9 negative responses • Architects, in particular, felt this would hurt quality. • Feasible but must be owner-driven (3 respondents)

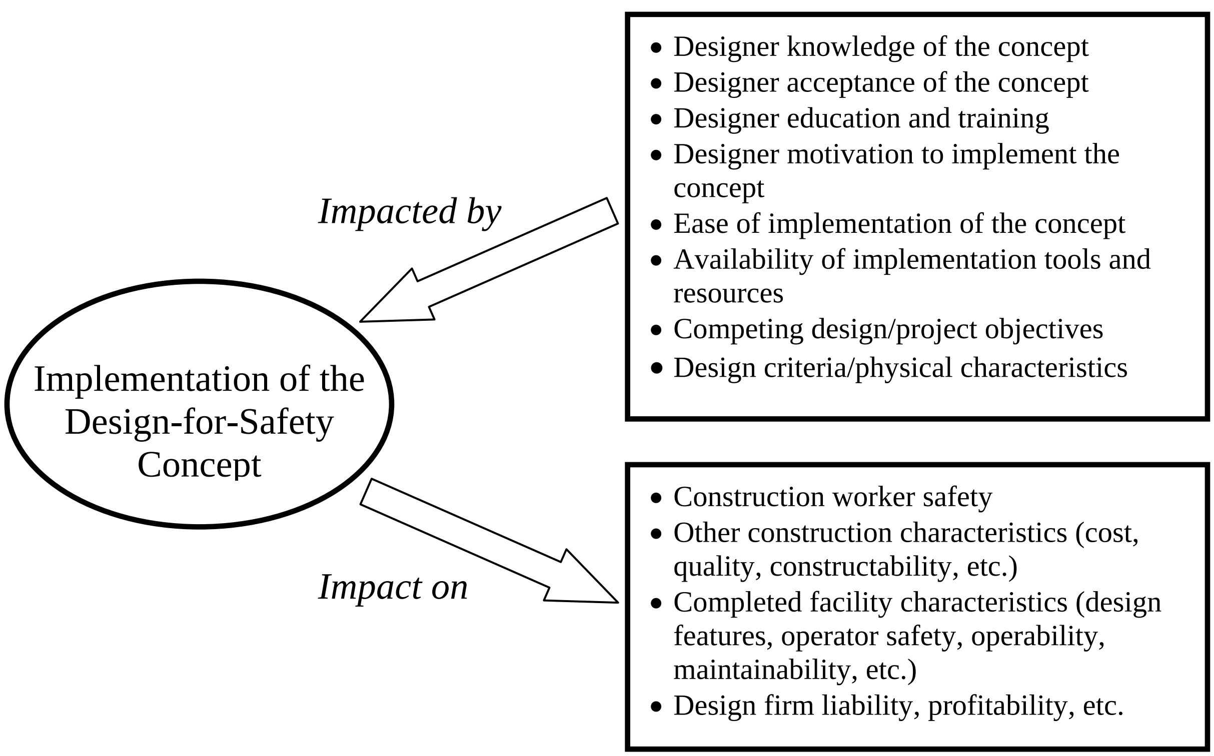
Table 10. Responses to proposed design-for-safety modifications (continued)

Proposed design modification	Responses/comments
Design perimeter beams and beams above floor openings to support lifelines (minimum dead load of 5400 lbs.). Design connection points along the beams for the lifelines. Note on the contract drawings which beams are designed to support lifelines, how many lifelines, and at what locations along the beams.	• Modification is possible (4 respondents); not possible (4 respondents) • Would increase cost (6 respondents); extra time in the design phase (2 respondents) • Not feasible without constructor input (1 respondent)
Provide permanent guardrails around skylights.	• Feasible modification (5 respondents) • Would not implement or is not feasible (7 respondents) • Would increase costs (6 respondents)

Analysis and Discussion

The goal of this pilot study was to determine the viability of implementing the designing-for-safety concept as an intervention for improving construction worker safety and health. The concept is considered viable if it is feasible to implement and effective in producing desired outcomes (*see* table 11). If the concept is, for instance, relatively easy to implement, requires minimal additional resources, and complements other project goals, designers are more likely to implement it.

Table 11. Factors affecting implementation of designing for safety



Note: This table was developed by the authors and is based on their research and experience.

Designer knowledge and acceptance of design-for-safety concept

The researchers used the survey results to assess designer knowledge and acceptance of the design-for-safety concept. At the completion of the survey, each respondent was judged by the interviewer to be either “knowledgeable” or “not knowledgeable” of the concept by evaluating the following:

- The response to question 10: “Describe your understanding of designing for construction worker health and safety.”
- The response to question 25: “In your formal education and training, have you had any coursework that included addressing construction worker health and safety?”
- The interviewer’s qualitative evaluation of the respondent’s overall knowledge of the concept.

Each participant’s level of acceptance of the concept was rated as “negative,” “neutral,” or “positive” by considering the following:

- The respondent’s comments on the feasibility of implementing the suggested design-for-safety modifications (*see* table 10).
- The response to question 10 (describe your understanding of designing for safety).
- The interviewer’s qualitative evaluation of the respondent’s overall acceptance of the concept.

Using these criteria, the researchers found that respondents with previous experience addressing construction safety in the design phase were rated as both more knowledgeable and more accepting of the concept. The researchers found also that participants who specifically cited liability concerns or the nature of the construction industry as barriers to implementation were rated as both less knowledgeable and less accepting of the concept than other respondents.

Outcomes of designing for safety

The designers who participated in the study believe that implementing the design-for-safety concept might increase project costs and diminish productivity and quality. However, the participants tended to focus on the initial design costs and possible increased demand for construction materials, rather than overall project costs. Eliminating the need to install temporary safety measures during construction may result in overall construction cost savings (Gambatese, Hinze, and Haas 1997). Many constructors believe that improving construction safety by any means will result in benefits to other project characteristics in addition to safety (Gambatese, Hinze, and Haas 1997).

Conclusions

The concept of designing for safety is gaining interest in the construction community, but it is not currently part of standard design practice. This pilot study suggests that design professionals have limited knowledge of the concept, which is a major barrier to its implementation. Lack of motivation or willingness to embrace the concept poses another barrier. For instance, the designers participating in the survey, on average, ranked construction worker safety as their lowest work priority (*see* table 9). Concerns about legal liability also pose a significant barrier to designing for safety, according to the study.

Many designers perceive that designing for safety can lead to increased project costs, schedule problems, and diminished design creativity. However, designing for safety in practice has not led to these results, according to a study by Hecker, Gambatese, and Weinstein (2004). In fact, the researchers found that the approach is relatively easy to implement and is effective in reducing hazards to construction workers. For instance, in a construction project that implemented design for safety, raising the ceiling height in the utility area provided more space and height for workers, reducing ergonomic and head-knocker risks, and likely alleviating problems related to congestion, access, and material handling. In the same project, establishing 42-inch parapet heights, creating a walkable ceiling, and designing built-in anchorage points for fall protection reduced risks from falling from heights and may have increased worker productivity (Hecker, Gambatese, and Weinstein 2004; Weinstein, Gambatese, and Hecker 2004). Trade contractors interviewed during the project indicated that the design features improved productivity, but no quantitative comparisons or productivity calculations were made.

Keys to implementation of designing for safety

Putting the design-for-safety concept into practice throughout the construction industry requires substantial changes that will occur only with much time and effort. The following factors are vital to the successful implementation of the design-for-safety concept:

- *A change in designer mindset.* The traditional approach of maintaining a distance from construction worker safety and from the construction process hinders implementation of the design-for-safety concept. Designers need to recognize that their work can directly affect the safety and health of construction workers.
- *Motivated designers.* Many designers need incentives beyond the benefits to worker safety and health, in order to wholeheartedly embrace the practice. Other potential sources of motivation and incentive include the design contract, market forces, knowledge of potential cost savings, professional codes of ethics, building codes, standard design practice, and legislative actions such as regulations that clearly recognize a safety role for designers.
- *Knowledgeable designers.* The lack of safety knowledge among designers should be addressed by providing training on safety-related topics during the designers' formal education and continuing professional development. Alternative designs that enhance safety must be collected and made available for reference. Also, designers need practical guidelines for addressing safety amid the complex array of design processes and regulations they encounter in their work.
- *Constructor involvement.* Constructors and construction workers can help designers recognize potential construction safety hazards and identify a facility's permanent design features that could be modified to minimize such hazards.
- *Mitigation of liability exposure.* Designers will continue to resist designing for safety until their legal concerns are addressed. The construction industry should engage legal

and insurance experts to assist in developing contracts and insurance policies that protect designers from excessive legal liability for incorporating safety features in their designs.

Recommendations

This research indicates that designing for safety is beginning to be recognized as a viable intervention for improving construction worker safety and health. However, the practice is still in its infancy and additional research is needed to demonstrate its effectiveness and to gain widespread acceptance among design professionals. Further study is needed in the following areas:

- *Effectiveness of designing for safety*. Demonstrable evidence will accumulate as more design professionals address worker safety in their projects.
- *Dangers of* <u>*not*</u> *designing for safety*. Case studies of the negative consequences of ignoring worker safety in building designs can help motivate designers to apply the concept in their building projects.
- *Benefits of design modifications.* Cost-benefit modeling can be used to create a database of cost-effective design modifications.
- *Tools and processes.* Design review and assessment tools are needed to assist designers in addressing safety. Research is needed on project delivery methods, design and construction contracts, and errors and omissions insurance.
- *Incorporation of the concept.* Research is needed on how the concept might be incorporated into building codes and standards, sustainability models, and the OSHA construction standards (29 CFR 1926).
- *Education and training.* Academic design coursework should be revised to include design-for-safety content. Also, professional designers, owners, and constructors need further training regarding the principles and applications of designing for safety.

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Annex A. Survey Cover Letter and Questionnaire

Civil, Construction and Environmental Engineering

Oregon State University
202 Apperson Hall
Corvallis, Oregon 97331-2302
Telephone: 541-737-4934 Fax: 541-737-3052

Dear Design Professional:

Oregon State University is conducting a research study of the feasibility of design professionals to address construction site safety through a project's design. The study is titled "Investigation of the Viability of Designing for Safety", and is sponsored by The Center to Protect Workers' Rights (CPWR Small Study No. 01-2-PS). The study involves: an examination of the OSHA standards for construction to determine the provisions that lend themselves to designer input; the development of design details that would capitalize on the identified provisions; and a survey of design professionals to obtain information regarding the barriers and limitations to incorporating safety in the design and the estimated impacts of designing for safety on a project. The outcomes of the study include recommendations for addressing safety in design practice and for further, expanded research on the topic.

As a design professional in the construction industry, we ask for your help with the study by answering some questions about safety in design practices. The interview should take no more than 45 minutes to one hour. To facilitate the interview, we have developed the attached list of questions which relate to your background and experience, current design practices, and design suggestions for improving safety. Your participation in this study is voluntary. Any questions that you may have about the research and your participation will be answered before you are asked to decide whether to participate.

Please answer only those questions that you feel comfortable answering. The information requested is not considered highly personal or sensitive to your, or your firm's, financial standing, employability, or reputation. There are no foreseeable risks associated with participation. Additionally, no direct benefits to study participants are anticipated, except for the possible benefit of gaining knowledge about new research which could be applied to future projects.

Your responses, together with others, will be combined and used for statistical summaries only. The results of this study will be compiled and a summary report will be prepared. **All responses provided will be kept strictly confidential, and summarized data will not identify individual participants or companies.**

You are welcome to keep a copy of this letter and the questions for your records. If you have any questions about this study, please contact John Gambatese, Oregon State University, 202 Apperson Hall, Corvallis, OR 97331 (Tel.: 541-737-8913). If you have any questions about your rights as a participant in this study, please contact the Institutional Review Board (IRB) Coordinator at the Oregon State University Research Office at 312 Kerr Administration Building, Corvallis, OR 97331 (Tel.: 541-737-3437).

Thank you very much for taking the time to participate in this important study.

Sincerely,

John A. Gambatese

John A. Gambatese
Assistant Professor, Construction Engineering Management Program

Questionnaire

SECTION 1: GENERAL INFORMATION

1. What is your title/position? ____________________________

2. What is your typical role on a project team?

3. How many years of experience do you have as a design professional: _____

4. What kind of experience do you have that is related to construction?

5. How many years of experience do you have in construction: _____

6. Design firm discipline: (check all that apply)
   ___Architectural ___Structural ___Civil ___Elect. ___Mech. ___Other

7. Typical types of projects designed: (breakdown in percentages)
   ___Commercial ___Industrial ___Engineering ___Residential

8. Firm size: Total annual design fee billings (approximate): $ ____________

9. What percent of the firm's total revenue comes from: a) design expertise _____%
b) construction _____% c) other _____%

10. Describe your understanding of designing for construction worker health and safety?

SECTION 2: CURRENT DESIGN PRACTICES

11. Do you ever make design decisions that improve construction worker health and safety?
    ____Yes ____No If no, then why not, and skip to question 17.

12. If yes to question 11, do you have a formal process to follow that allows for consideration of construction worker health and safety?
    ____Yes ____No If so, describe the process.

13. What tools (checklists, design databases, use of safety consultants, etc.) have you used to address construction worker health and safety in the design phase?

14. At what point in the design phase is construction worker health and safety addressed?

15. What effect does considering and designing for construction worker health and safety have on the project? (e.g., improved safety, quality, productivity, etc.)

16. What design modifications have you made that reduced health and safety risk to construction workers? Provide specific examples. Review Appendix and discuss feasibility of these design considerations at this time.

17. Have you had any discussions with contractors and/or owners that include: a.) the methods/practices employed by the contractor; and b.) the features to be included in the design, to ensure construction worker health and safety during project construction?
    ____Yes ____No

18. If discussions regarding construction worker health and safety do occur, what typically is the owner/contractor requesting or what are their concerns?

19. Have you ever made modifications to a design in the design phase to eliminate a potential safety risk that would impact construction worker health and safety?
____Yes ____No If yes, give an example.

20. Have you heard of the United Kingdom's Construction (Design and Management) Regulations, passed into law in 1994? ____Yes____No

21. Have you ever worked with or hired a construction health and safety consultant in the design phase?
____Yes____No

22. If yes to question 21, how would you describe the experience in relation to your work – positive, negative, indifferent, and provide any details or suggestions you may have.

23. What barriers or limitations do you see in addressing construction worker health and safety in project design?

24. What impacts do you see in addressing construction worker health and safety in project design? (cost, quality, productivity, schedule, etc.)

25. In your formal education and training, have you had any coursework that included addressing construction worker health and safety? ____Yes____No

26. If yes to question 25, what specifically was included? (tools, chapters, specific courses, conferences, lectures, etc.)

27. Are you aware of any design firms (besides your firm, if applicable) that address construction worker health and safety in the design phase? ____Yes____No

28. Are you aware of any design tools (other than those in listed in Question 13) that could be used to address construction worker health and safety in the design phase?
____Yes ____No If yes, give an example.

29. What is your personal willingness to address construction worker health and safety in the design phase?

30. What priority do you place on the following criteria when designing a project? Please rank with 1 being the highest priority, 2 the second highest priority, and so forth.
____Quality of the work
____Project cost
____Project schedule
____Construction worker safety and health
____Facility occupant safety and health
____Aesthetics
____Other: ______________________
____Other: ______________________
____Other: ______________________

31. If not yet completed at this point in the interview (from Question 16), review Appendix and discuss feasibility of the listed design considerations.

32. Do you believe that addressing construction worker health and safety in the design phase will increase your liability exposure? ____Yes____No

33. Do you believe that <u>not</u> addressing construction worker health and safety in the design phase will increase your liability exposure? ____Yes____No

34. Do you believe that the nature and culture of the construction industry precludes you in any way from addressing construction worker health and safety in the design phase?
____Yes ____No

35. Have you ever been asked to address construction worker health and safety in the design phase?
____Yes____No

36. If yes to question 35, did you? Why or why not?

37. Have you ever been asked your opinion about construction worker health and safety issues?
____Yes ____No

38. If yes to question 37, what was your response?

39. Do you feel comfortable talking about construction worker health and safety issues?
____Yes ____No

40. Why or why not?

QUESTIONNAIRE APPENDIX: DESIGN CONSIDERATIONS

Review these design considerations with the Designer and discuss their feasibility from the standpoints of cost, quality, productivity, scheduling, project administration, contractual, and industry culture.

<u>A – 1: Contract Drawings</u>

1. Indicate on the contract drawings the locations of existing underground utilities and mark a clear zone around the utilities. Note on the drawings the source of information and level of certainty on the location of underground utilities.

2. Review the condition and integrity of the existing structure and indicate any known hazards or deficiencies on the contract drawings.

3. Provide or require the constructor to submit a construction sequence for complicated or unique designs.

<u>A – 2: Electrical Safety</u>

4. Maintain a minimum clearance between the project and existing overhead power lines.

5. Provide electrical/instrumentation system enclosures, which are adequate for the expected environmental/climate conditions.

6. Provide a clear, unobstructed, spacious work area around all permanent mechanical equipment.

<u>A – 3: Fall Protection</u>

7. Design window sills to be 42 inches minimum above the floor level. Window sills at this height will act as guardrails during construction.

8. Design columns with holes at 21 and 42 inches above the floor level to provide support locations for lifelines and guardrails.

9. Design perimeter beams and beams above floor openings to support lifelines (minimum dead load of 5400 lbs.). Design connection points along the beams for the lifelines. Note on the contract drawings which beams are designed to support lifelines, how many lifelines, and at what locations along the beams.

10. Design the parapet to be 42 inches tall. A parapet of this height will provide immediate guardrail protection and eliminate the need to construct a guardrail during construction or future roof maintenance.

11. Provide a guardrail along the perimeter of the tank roof.

A – 4: Skylights

12. Provide permanent guardrails around skylights.

13. Design domed, rather than flat, skylights with shatterproof glass or add strengthening wires.

A – 5: Ladders/Stairways

14. Use consistent tread and riser dimensions throughout the stairway run and the project.

15. Provide access by means of a ladder or stairway when there is a change in elevation of greater than 19 inches.

A – 6: Other Safety and Health Considerations

16. Provide emergency showers and eyewash basins in areas where personnel might come in contact with highly toxic or poisonous materials.

17. Provide adequate illumination on projects to allow for work at night.

18. Allow for a large, unobstructed, open area (limited access zone) below elevated masonry work to minimize the risk of workers being struck by falling objects.

19. Require concrete test results to be verified before removal of the forms and shoring.

20. Require regularly scheduled site housekeeping to ensure a neat, clean work area.

Annex B. Construction (Design and Management) Regulation No. 13 (United Kingdom)

The following is an excerpt from Construction (Design and Management) Regulations (1994), Statutory Instrument 1994, No. 3140, HMSO, online at http://www.hmso.gov.uk/si/si1994/Uksi_19943140_en_2.htm#mdiv13.

Requirements on designer:
13.—(1) Except where a design is prepared in-house, no employer shall cause or permit any employee of his to prepare, and no self-employed person shall prepare, a design in respect of any project unless he has taken reasonable steps to ensure that the client for that project is aware of the duties to which the client is subject by virtue of these Regulations and of any practical guidance issued from time to time by the Commission with respect to the requirements of these Regulations.

(2) Every designer shall—

(a) ensure that any design he prepares and which he is aware will be used for the purposes of construction work includes among the design considerations adequate regard to the need—

(i) to avoid foreseeable risks to the health and safety of any person at work carrying out construction work or cleaning work in or on the structure at any time, or of any person who may be affected by the work of such a person at work,

(ii) to combat at source risks to the health and safety of any person at work carrying out construction work or cleaning work in or on the structure at any time, or of any person who may be affected by the work of such a person at work, and

(iii) to give priority to measures which will protect all persons at work who may carry out construction work or cleaning work at any time and all persons who may be affected by the work of such persons at work over measures which only protect each person carrying out such work;

(b) ensure that the design includes adequate information about any aspect of the project or structure or materials (including articles or substances) which might affect the health or safety of any person at work carrying out construction work or cleaning work in or on the structure at any time or of any person who may be affected by the work of such a person at work; and

(c) co-operate with the planning supervisor and with any other designer who is preparing any design in connection with the same project or structure so far as is necessary to enable each of them to comply with the requirements and prohibitions placed on him in relation to the project by or under the relevant statutory provisions.

(3) Sub-paragraphs (a) and (b) of paragraph (2) shall require the design to include only the matters referred to therein to the extent that it is reasonable to expect the designer to address them at the time the design is prepared and to the extent that it is otherwise reasonably practicable to do so.

Annex C. Results of OSHA Construction Standards Review[1]

Section 1: OSHA Provisions Addressing Design Professionals

This section lists OSHA construction standards (29 CFR 1926) that contain the term "engineer," obtained through an electronic text-based search of the standards online at www.osha.gov.

Engineer

Subpart L – Scaffolds

1926.451(d)(3)(i)
1926.451(f)(5)
1926.452(a)(10)
1926.452(b)(10)
1926.452(c)(5)(iii)
1926.452(c)(6)
1926.452(i)(8)

Subpart M – Fall Protection

Appendix C – Personal Fall Arrest Systems – Non-Mandatory Guidelines for Complying with 1926.502(d)
Appendix E – Sample Fall Protection Plan – Non-Mandatory Guidelines for Complying with 1926.502(k)

Subpart N – Cranes, Derricks, Hoists, Elevators, and Conveyors

1926.550(a)(1)
1926.550(g)(4)(i)(A)
1926.552(a)(1)
1926.552(b)(7)
1926.552(c)(17)(i)

Subpart P – Excavations

1926.650(b)
1926.651(i)(2)(iii)
1926.651(i)(2)(iv)
1926.652(b)(3)(iii)
1926.652(b)(4)
1926.652(b)(4)(i)
1926.652(b)(4)(ii)(C)
1926.652(c)(3)(iii)
1926.652(c)(4)
1926.652(c)(4)(i)
1926.652(c)(4)(ii)(B)
1926.652(d)(3)
Appendix B – Sloping and Benching
Appendix D – Aluminum Hydraulic Shoring for Trenches
Appendix F – Selection of Protective Systems

Subpart Q – Concrete and Masonry Construction

1926.703(b)(8)(i)
1926.705(a)
1926.705(k)(1)
1926.705 Appendix – Lift Slab Operations

[1] OSHA has not verified the accuracy of either listing provided in this annex.

Subpart R – Steel Erection

1926.751 – Definitions
1926.755(b)(1)
1926.756(a)(1)
1926.756(b)
1926.757(a)(7)
Appendix A – Guidelines for Establishing the Components of a Site-Specific Erection Plan – Non-Mandatory Guidelines for Complying with 1926.752(e)

Section 2: Suggested Design-for-Safety Modifications and Corresponding OSHA Provisions

This section lists OSHA provisions that may be addressed through design-for-safety modifications. The authors developed this table by examining and cross-referencing OSHA provisions with the database of suggested design modifications developed by Gambatese, Hinze, and Haas (1997).

Note: Some of the design suggestions, such as requiring a fire control plan, address safety practices rather than building design alterations. Depending on the type of project and contract delivery method, these provisions can be addressed by the designer in the design documents.

Subpart C – General Safety and Health Provisions

OSHA Provision	Design Suggestion
1926.24	Require the submittal of a fire control plan, or require that the fire department be contacted to discuss plans for fire protection services during construction.
1926.25	Require regularly scheduled site housekeeping.
1926.35	Require the submittal of a job-site safety survey and plan and an emergency action plan.
1926.35	Provide for evacuation drills and egress routes; expedite installation, testing, and turnover of fire systems.

Subpart D – Occupational Health and Environmental Controls

OSHA Provision	Design Suggestion
1926.52	Specify mechanical and HVAC equipment that does not produce high noise levels while operating.
1926.56	Provide adequate illumination on projects during work at night.
1926.59	Provide the constructor with a list and the location of toxic substances and other hazardous materials which may be located on the site.

Subpart G – Signs, Signals, and Barricades

OSHA Provision	Design Suggestion
1926.200(a)	Provide signs, lights, alarms, etc. as necessary to ensure safety near exposed equipment.

Subpart J – Welding and Cutting

OSHA Provision	Design Suggestion
1926.352(e)	Require the submittal of a fire control plan, or require that the fire department be contacted to discuss plans for fire protection services during construction.

Subpart K – Electrical

OSHA Provision	Design Suggestion
1926.403	Provide a clear, unobstructed, spacious work area around all permanent mechanical equipment.
1926.403	Ensure that all electrical circuits are sufficiently identified throughout their length.
1926.403	Provide electrical/instrumentation system enclosures which are adequate for the expected environmental/climate conditions.
1926.403	Ensure that electrical/instrumentation systems located in hazardous areas meet the hazard classification requirements.
1926.407	Ensure that specified materials of construction are appropriate for the flammability hazards which may be encountered on the work site (for electrical equipment and wiring only).

Subpart L – Scaffolds

OSHA Provision	Design Suggestion
1926.451(e)(5)	Use a maximum ramp slope of 7 degrees.

Subpart M – Fall Protection

OSHA Provision	Design Suggestion
1926.501	Design window sills to be 42 inches minimum above the floor level. Window sills at this height will act as guardrails during construction.
1926.501	Provide a guardrail along the perimeter of the tank roof.
1926.501	Use access doors that automatically provide a guarded opening when the doors are opened.
1926.501(b)(4)(i)	Provide permanent guardrails around skylights.
1926.501(b)(4)(ii)	Design domed, rather than flat, skylights with shatterproof glass or add strengthening wires.
1926.501(b)(4) iii	Place skylights on a raised curb.
1926.502	Design perimeter beams and beams above floor openings to support lifelines (minimum dead load of 5400 pounds.). Design connection points along the beams for the lifelines. Note on the contract drawings which beams are designed to support lifelines, how many lifelines, and at what locations along the beams.
1926.502	Provide permanent guardrails around roof openings.
1926.502	Design the parapet to be 42 inches tall. A parapet of this height will provide immediate guardrail protection and eliminate the need to construct a guardrail during construction or future roof maintenance.
1926.502	Provide a guardrail around roof accesses and roof work areas.
1926.502(b)	Design columns with holes at 21 and 42 inches above the floor level to provide support locations for lifelines and guardrails.
1926.502(d), Appendix C, (H)(1)	Design and schedule eye-bolts or other connections used for window maintenance so that they can be constructed as early as possible and used during construction.
Non-mandatory Guidelines for 1926.502(k)	Provide or require the constructor to submit a construction sequence for complicated or unique designs.

Subpart P – Excavations

OSHA Provision	Design Suggestion
1926.650	Design the foundation for the soil variations within the site. Consider the soil classifications outlined in 29 CFR 1926.650.

Subpart Q – Concrete and Masonry Construction

OSHA Provision	Design Suggestion
1926.703(e)	Require results of concrete tests to be verified before removal of the forms and shoring.
1926.706	Allow for a large, unobstructed, open area (limited access zone) below elevated masonry work to minimize the risk of workers being struck by falling objects.

Subpart R – Steel Erection

OSHA Provision	Design Suggestion
1926.752(e)	Provide or require the constructor to submit a construction sequence for complicated or unique designs.
1926.754(e)(3)(iv)	Provide permanent guardrails around skylights.
1926.754(e)(3)(iv)	Design domed, rather than flat, skylights with shatterproof glass or add strengthening wires.

OSHA Provision	Design Suggestion
1926.760(d)(2)	Design perimeter beams and beams above floor openings to support lifelines (minimum dead load of 5400 pounds). Design connection points along the beams for the lifelines. Note on the contract drawings which beams are designed to support lifelines, how many lifelines, and at what locations along the beams.
1926.760(d)(3) and App. G to Subpart R	Design columns with holes at 21 and 42 inches above the floor level to provide support locations for lifelines and guardrails.

Subpart T – Demolition

OSHA Provision	Design Suggestion
1926.850(a)	Review the condition and integrity of the existing structure and indicate any known hazards or deficiencies on the contract drawings.

Subpart V – Power Transmission and Distribution

OSHA Provision	Design Suggestion
1926.956(c)(1)	Indicate on the contract drawings the locations of existing underground utilities and mark a clear zone around the utilities.
1926.956(c)(1)	Note on the drawings the source of information and level of certainty on the location of underground utilities.
1926.950	Maintain a minimum clearance between the project and overhead power lines as outlined in 29 CFR 1926.950

Subpart X – Stairways and Ladders

OSHA Provision	Design Suggestion
1926.1051(a)	Provide access by means of a ladder or stairway when there is a change in elevation of greater than 19 inches.
1926.1052(a)(3)	Provide for a uniform stair slope on all stairways.
1926.1052(a)(3)	Use consistent tread and riser dimensions for all stairway runs.
1926.1052(c)(1)	Provide at least one handrail or stairrail along stairways with 4 or more risers, or which rise more than 30 inches in height, whichever is less.
1926.1052(c)(2)	Avoid designs using spiral stairways. If spiral stairways are called for, provide a handrail to prevent stepping on areas where the tread width is less than 6 inches.
1926.1052(c)(4)	Design intermediate vertical members on stairrails and guardrails to be at most 19 inches apart.
1926.1052(c)(7)	When the top edge of a stairrail system also serves as a handrail, the height of the top edge should be between 36 and 37 inches from the upper surface of the stairrail to the surface of the stair.
1926.1052(c)(7)	Design the height of handrails to be between 30 and 37 inches from the upper surface of the handrail to the surface of the tread.
1926.1052(c)(11)	Provide a minimum clearance of 1-1/2 inches along the top and sides of the toprail.
1926.1053(a)(1)(ii)	Design ladders to be vertical, or not exceeding 15 degrees forward, and straight throughout their length.
1926.1053(a)(16)	Design the step-across distance between the center of the step/rung and the nearest edge of a landing to be between 7 and 12 inches. Provide a landing platform if more than 12 inches.
1926.1053(a)(25)	For through-ladder extensions, omit steps/rungs within the extension. Flare the extension side rails to provide between 24 and 30 inches clearance between the side rails.
1926.1053(a)(27)	Design the side rails of through or side-step ladders to extend at least 42 inches above the top level or landing platform.
1926.1053	Design ladder steps/rungs to be spaced between 10 and 12 inches apart, parallel, level, and uniformly spaced throughout the ladder.
1926.1053(a)(6)	Design ladder steps/rungs to be corrugated, knurled, dimpled, coated with a skid-

OSHA Provision	Design Suggestion
	resistant material, or treated to minimize slipping.
1926.1053(a)(12)	Specify that wood ladders NOT be coated with an opaque material.
1926.1053(a)(20(i)	Design horizontal bands to be fastened to the side rails of rail ladders, or directly to the structure for individual-rung ladders.
1926.1053(a)(20)(ii)	Design vertical bars to be on the inside of the horizontal bands and fastened to them.
1926.1053(a)(20(v)	Design horizontal bands to be spaced at intervals not more than 4 feet apart between centerlines.
1926.1053(a)(20)(vi)	Design vertical bars to be spaced at intervals not more than 9.5 inches apart between centerlines.
1926.1053(a)(20)(iv)	Keep the inside of the cage clear of projections.
1926.1053(a)(20)(iv)	Design cages to extend at least 27 inches, but not more than 30 inches, from the centerline of the step or rung, and not less than 27 inches wide.
1926.1053(a)(20)(vii)	Design the bottom of the cage to be between 7 and 8 feet above the point of access to the bottom of the ladder. Flare the bottom of the cage not less than 4 inches between the bottom horizontal band and the next higher band.
1926.1053(a)(20)(viii)	Design the top edge of the cage to be a minimum of 42 inches above the top of the platform, or the point of access at the top of the ladder.
1926.1053(a)(18)	Provide ladder cages, wells, or other safety devices where the length of climb is less than 24 feet but the top of the ladder is at a distance greater than 24 feet above lower levels.
1926.1053(a)(19)(iii)	If the total length of a climb equals or exceeds 24 feet, provide a cage or well, and multiple ladder sections, each section not to exceed 50 feet. Offset each ladder section from adjacent sections, and provide landing platforms at intervals of 50 feet maximum.
1926.1053(e)(24)	Design individual step/rung ladders to extend at least 42 inches above an access level or landing platform either by the continuation of the rung spacing as horizontal grab bars or by providing vertical grab bars that have the same lateral spacing as the vertical legs of the ladder rails.
1926.1053(a)(11)	Design ladders to prevent injury from punctures or lacerations, and prevent snagging of clothing.
1926.1053(a)(26)	Provide a minimum perpendicular clearance of 7 inches between ladder rungs, cleats, or steps, and any obstruction behind the ladder, except that the clearance for elevator pit ladders may be no less than 4.5 inches.
1926.1053(a)(25)	Provide a minimum perpendicular clearance of 30 inches between the centerline of ladder rungs, cleats, or steps, and any obstruction on the climbing side of the ladder. If obstructions are unavoidable, clearance may be reduced to 24 inches provided a deflection device is installed to guide workers around the obstruction.
1926.1053(a)(1)(iii)	Design ladders to be capable of supporting at least two loads of 250 pounds each concentrated between any two consecutive attachments.
1926.1053(a)(1)(iii)	Design each step or rung to be capable of supporting a load of at least 250 pounds applied in the middle of the step or rung.
1926.1053(a)(1)(iii)	Design ladders for any anticipated loads caused by ice buildup, wind, rigging, and impact loads resulting from the use of ladder safety devices.
1926.1053(a)(4)(i)	Provide a minimum clear distance of 16 inches between the sides of individual step/rung ladders, and between the side rails of adjacent ladders.
1926.1053(a)(17)	Provide ladder cages or wells around ladders which have greater than 15 inches clear width to the nearest permanent object on each side of the centerline of the ladder.
1926.1053(a)(21)	Design the well to completely encircle the ladder.
1926.1053(a)(21)	Design the inside face of the well on the climbing side of the ladder to extend between 27 and 30 inches from the centerline of the step/rung.
1926.1053(a)(21)	Design the inside width of the well to be at least 30 inches.
1926.1053(a)(21)	Design the bottom of the well above the point of access to the bottom of the ladder

OSHA Provision	Design Suggestion
	to be between 7 and 8 feet.
1926.1053(a)(21)	Keep the inside of the well clear of projections.

Subpart Z – Toxic and Hazardous Substances

OSHA Provision	Design Suggestion
1926.1101	Specify materials that do not contain asbestos or other known hazardous substances.

29 CFR 1910 – General Industry Standards

OSHA Provision	Design Suggestion
1910.21	Provide for warning signs that describe the allowable floor loading.
1910.23(e)	Provide continuous toeboards along the length of guardrails.
1910.23(e)	Use a uniform railing height throughout the project.
1910.23(e)	Use steel instead of wood for railings in areas where welding or other potential fire sources are present.
1910.23(e)	Design handrails and the top rails of a stairrail system to withstand at least 200 pounds applied within 2 inches of the top edge in any downward or outward direction, at any point along the top edge.
1910.24(g)	Provide a minimum 2 feet-6 inches by 2 feet-6 inches landing area at the top and bottom of ladders. Coordinate the layout of the landings with the structure design to eliminate tripping hazards.
1910.27(d)(2)(iii)	Locate the first step/rung between 6 and 12 inches above the bottom landing, and the top step/rung at the level of the top landing.
1910.38(g)(2)	Provide a covering, or extend the roof line over exterior stairs, ramps, and walkways.
1910.146	Provide ventilation systems in mechanical rooms and confined spaces which are temperature, oxygen depletion, or refrigerant controlled.
1910.146	Provide disconnection switches which are readily accessible.
1910.151(a)	Provide emergency showers and eye-wash basins in areas where personnel might come in contact with highly toxic or poisonous materials.
1910.252(a)(5)	Provide guards around fan inlets/outlets and exhaust ports.
1910.252(a)	Provide guards around equipment to protect workers from moving parts.