

AN ABSTRACT OF THE THESIS OF

Carl R. Christianson for the degree of Honors Baccalaureate of Science in Construction Engineering Management presented on November 30, 2005. Title: Design for Construction Safety: A Case Study with Architect's Perceptions.

Abstract approved:

John Gambatese

Designing for construction safety is a collaborative process that combines the field experience of builders with the design skills of architects to improve construction safety. Research studies have shown that the design of a project is a factor in approximately fifty percent of jobsite deaths. To reduce this problem it is necessary to have a greater understanding of how designers perceive designing for construction safety, how they take action to implement it on a project, and what are the impacts of the concept on design. To examine these questions, a case study of a renovation project in Oregon was conducted. The majority of the architects interviewed showed interest in learning about the concept and practicing the concept in varying degrees. Implementation for this project primarily involved collaboration to solve specific design and constructability safety issues the Construction Manager/General Contactor (CM/GC) discovered. Impacts on design included increased constructability, awareness of safety hazards, abatement of safety hazards, and collaboration among the design team. The lifecycle benefits of designing for construction safety appear to outweigh the costs on the Project studied. One factor drove implementation of the concept past its barriers: the owner's involvement.

Key Words: Construction Safety, Design, Architect Perception, Case Study

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Design for Construction Safety:
A Case Study with Architect's Perceptions

by
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A PROJECT
submitted to
Oregon State University
University Honors College

in partial fulfillment of
the requirements for the
degree of

Honors Baccalaureate of Science in Construction Engineering Management (Honors Scholar)

Presented November 30, 2005
Commencement June 2006

Honors Baccalaureate of Science in Construction Engineering Management project of Carl R. Christianson
presented on November 30, 2005.

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Carl R. Christianson, Author

ACKNOWLEDGEMENT

This project is would not have been possible without the support and encouragement of Professor John Gambatese and Professor Greg Baker of Oregon State University. Additional encouragement came from the Architects and Construction Mangers that were involved in the case study Project. Gratitude is also due to my friend and editor Julie Ream.

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Design for Construction Safety: A Case Study with Architect's Perceptions

I. INTRODUCTION

Safety Performance of the Construction Industry

The construction industry is a dangerous place to work. In the most recent statistics, 1,224 people died in construction work in 2004 (Census 2004). While the industry consists of about 5 percent of the United States workforce, it is beset with about 21 percent of workplace fatalities (Census 2004). Furthermore, while the total number of fatalities in U.S. work industry is declining, the construction industry has experienced an increase in the number of fatalities (Construction 2001). Statistics from the year 1992-2001 show this trend in Figure 1.

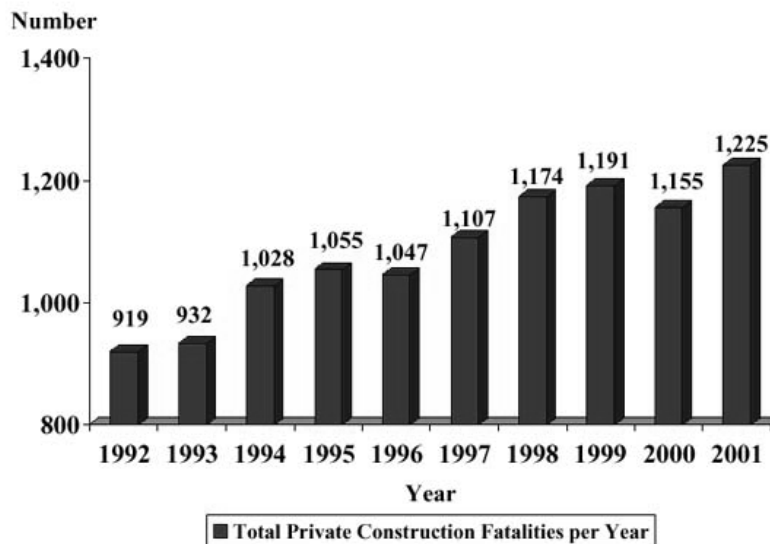


Fig. 1. Fatal work injury counts in the private construction industry, 1992-2001 (Construction 2001)

Construction is the second most dangerous economic sector to work in (Census 2004). There are many hazards that are commonly cited as factors in accidents that are specific to construction. However, when we analyze the distribution of fatalities by event, we see that the biggest difference between construction and the rest of workplace fatalities is the preponderance of falls (see Fig. 2).

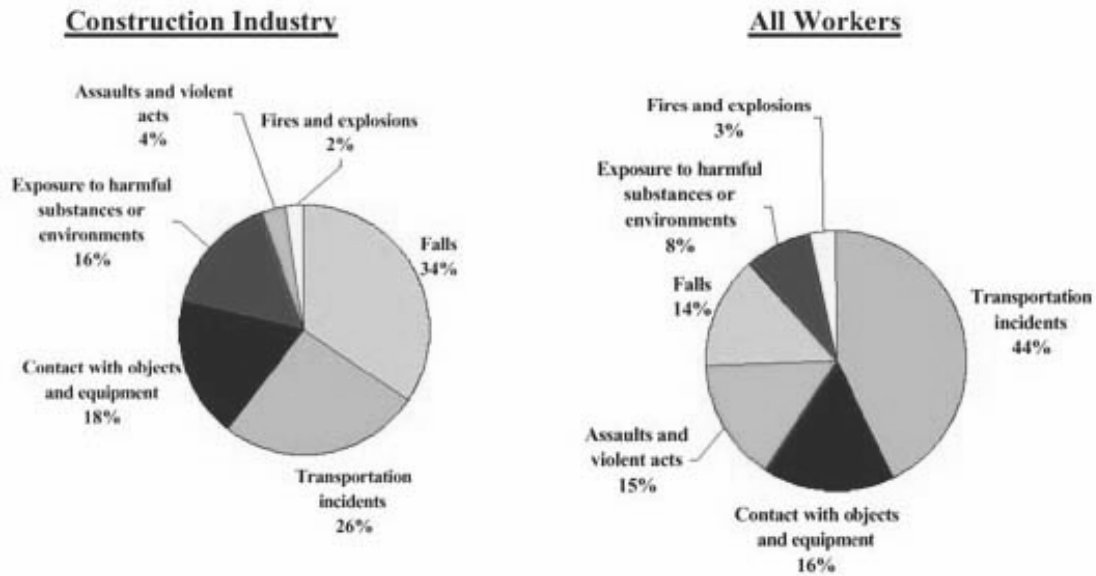


Fig. 2. Distribution of fatalities in the construction industry and to all workers by event, 2001, does not include September 11th terrorist attacks (Construction 2001)

The significantly higher number of falls in construction (34% vs. 14%), as well as the higher levels of exposure to harmful substances or environments (16% vs. 8%), shows areas that are specific to the construction industry. While the construction industry needs to reduce all accidents, it is reasonable to focus on those that are most common.

The most recent data from the Bureau of Labor Statistics (provided in Figure 3) shows construction deaths and parallels the data in Figure 1. The five columns on the right are percentages. It is important to note the majority of the deaths among building contractors and specialty trade contractors are due to falls as was the case for the 2001 data.

Industry(1)	Fatalities		Selected event or exposure(2) (percent of total for industry)			
	Number	Percent	Highway (3)	Homicides	Falls	Struck by object
Total.....	5,703	100	24	10	14	10
Construction.....	1,224	21	12	2	36	12
Construction.....	1,224	21	12	2	36	12
Construction of buildings.....	224	4	11	2	46	13
Heavy and civil engineering construction.....	219	4	17	-	8	21
Specialty trade contractors.....	752	13	10	2	42	9

Fig. 3. Fatal occupational injuries by industry and selected event or exposure, (Census 2004)

It is obvious that action needs to be taken to reduce these accidents. These statistics are known in the construction industry. As a result, most construction firms have safety programs to reduce accidents. In contrast, architects do not have a similar focus on construction accidents and they do not have programs to minimize those accidents.

The Role of the Constructor and the Designer in Safety

It is important to understand the constraints architects face when they design projects today. Currently, there is a distinct boundary between design and construction in the United States. All of the architects interviewed expressed this sentiment to varying degrees. One of the more conservative architects explained the issue succinctly: “Construction safety is primarily the purview of the contractor, in terms of means and methods. Design firms are not covered under their liability insurance for anything related to means and methods, so we must make a clear distinction not to cross that line (Table 1).”

Thus arises one of the more vexing challenges to reducing construction workplace accidents. Since architects are motivated to create unique, attractive structures (to win awards and acquire more jobs), they have an incentive to create “challenging to build” projects. These structures are challenging because they

often require non-traditional methods for constructing them as well as unique sequencing. On occasion, this leads to unsafe work practices by the construction team that all too often cause injuries and accidents.

Creating buildings without aesthetic merit is not the goal, but architects should play some role in creating a project that can be built in a safe manner.

Designing for safety

The responsibility for designers to address construction safety has been implemented in the United Kingdom through the “Construction (Design and Management) Regulations of 1994.” This legislation is commonly known as the CDM regulations. This piece of legislation requires that architects assume some of the liability for construction worker accidents. As a response, architects in the United Kingdom have become much more involved in ensuring construction safety.

These rules stem from a high accident toll in the construction field. High accident numbers in the United States suggest that if governmental regulations work elsewhere, the United States Congress should be encouraged to implement a similar law here. The shift in accident liability has some architectural firms worried.

One of the reasons in favor of changes in the design process is that adding safety features can be done cheaply and with little effort. This is due in part because the engineers are already involved in the structural capacity of the project. Adding additional loads or checking for the ability to support lifelines are both simple tasks at this stage. It is more difficult (and costly) for the contractor to hire an outside engineer after the completion of the design to check if a beam will support a lifeline. Consequently, some contractors do not check these details and by assuming the beam has sufficient strength, they can risk lives. The vast majority of construction workers (and managers) are unable to perform structural analysis to determine the safety of objects around them. As a result, the best time to handle designing for safety is during the design phase with the participation or help of the architect.

One of the other main reasons for the designer's lack of involvement in construction safety is the structure of the contracts. In the traditional design-bid-build (lump sum) format, the architect and the constructor have no contractual obligation to each other. They only have contracts with the owner. The architect guarantees to the owner that their design has been created according to standard practice. The owner then warrants to the builder that the project can be built as designed. The issue with this format is that the timing and lack of formal contract (between the architect and the contractor) forces the constructor to have little or no ability to influence the design to maximize their crew's safety.

A Need to Study Designer Interest and Response to Designing for Safety

(Note: The case study Project, the Owner of the Project, the contracted Architect, and the contracted CM/GC will be capitalized for confidentiality)

In this case study, there is a unique opportunity since the Project studied uses a negotiated contracting format. In this negotiated contract, the constructor is hired to assist in the "preconstruction" phase of the design to benefit the owner. Often this phase will include a focus on shortening the schedule, maximizing access to the site, easing construction of difficult items, reducing project costs, budgeting, solving coordination challenges, and conducting a design review for errors or omissions. The Owner's intent is to involve the builder during this phase of design. This makes it feasible for the Construction Manager/General Contractor (CM/GC) to request the addition of features to the structure that will increase worker safety.

There is good reason for the Owner to be concerned with the safety of construction workers. This project is a unique renovation and will have proportionately greater hazards than a new building. Some of the issues that were reviewed during the design process include: asbestos mitigation, replacement of the building's interior without damaging the historical façade, reinforcement to bring the building up to seismic code, and adding a pitched roof to return the building to its original design intent. Additionally, the building is on a small piece of land with heavy foot traffic around it. Furthermore, the Owner is sensitive to criticism and would likely face significant criticism if there were a major construction accident.

To encourage participation in design for construction worker safety, the Owner required the architect to make a statement during the proposal process indicating how they would address the issue. After hiring the Architect, the Owner began the process of selecting the CM/GC. The Owner asked the construction teams how they would collaborate with the architect to design for construction safety. Part of the following research is to analyze the responses of the architects and the CM/GC to this unusual request.

The intent of this research is to find out what can be done to facilitate designing for construction worker safety. The case study is focused on a building renovation project. The renovation is a \$10 million, three story, 30,000 square foot, educational space with a historical designation in the Pacific Northwest (renovation includes seismic upgrades). The Owner has decided that a safe construction site is a priority. Thus, they have indicated this requirement to the Architect and Construction Manager/General Contractor through the Request for Proposal process. The key questions are whether the Owner's energy directed towards designing for construction safety has in fact changed the design process, the design results, and the barriers that were found along that path.

II. LITERATURE REVIEW

There has been significant prior research into construction safety. In the past decade, some of the research focus has been turned towards designing for construction safety. This change in focus is due to research that “identified the design aspect of projects as being a significant contributing factor to construction site accidents. Designing to eliminate or avoid hazards prior to exposure on the jobsite is also listed as the top priority in the hierarchy of controls common to the safety and health professions” (Gambatese et al. 2005).

In a paper titled, “Viability of Designing for Construction Worker Safety,” Gambatese presents a “pilot study” that addresses the viability of the concept. This study found that many of the designers interviewed were “interested and willing” to consider using the concept in practice. However, the designers had a number of reservations that were addressed in the paper such as the structure of the contracts, a lack of knowledge of the concept, designer education, construction experience among the design team, training, motivation and other competing project priorities. Beyond just the designer’s reservations there are systemic factors that are preventing the concept, these include: changing the designer’s mindset toward safety, establishment of a motivational force to promote designing for safety, increase designer knowledge of the concept, incorporating construction safety knowledge in the design phase...make design for safety tools... and mitigate designer liability exposure (Gambatese et al. 2005). According to the research findings, while there is interest in the industry, it has not become common practice. However, “designing for safety is a viable intervention in construction” (Gambatese et al. 2005).

In Hecker’s and Gambatese’s presentation titled “Collaboration in Design to Promote Construction Safety” (Hecker and Gambatese 2004) they review areas that are challenges to designing for construction safety. They list reasons why designers have traditionally avoided construction worker safety: “OSHA’s placement of safety responsibility, Designer education and training, Lack of safety in design tools, guidelines, and procedures, Designer’s limited role on the project team, Designer’s traditional viewpoint on construction worker safety, and Lack of understanding of the associated liability” (Hecker and Gambatese 2004). The associated liability is a complex topic, “specifically, new safety knowledge exposes the design

professional's significant influence on worker safety" (Gambatese 1998). By avoiding designing for construction safety, designers may actually increase their liability. According to "past legal cases and the concepts of practice standards and professional duty, failure to employ the new safety knowledge may lead to increased liability exposure...within the design-bid-build system of project delivery (Gambatese 1998)." Mitigating the liability issue appears to be a key challenge in implementing the concept.

Hecker and Gambatese further state that, "European research: 60% of construction accidents could have been avoided or had a reduced impact by design alterations or other preconstruction measures" (Hecker and Gambatese 2004). In the presentation, they quote research by Gambatese (2005), which shows that construction worker safety is at the bottom of architects' priority list (see Fig. 4).

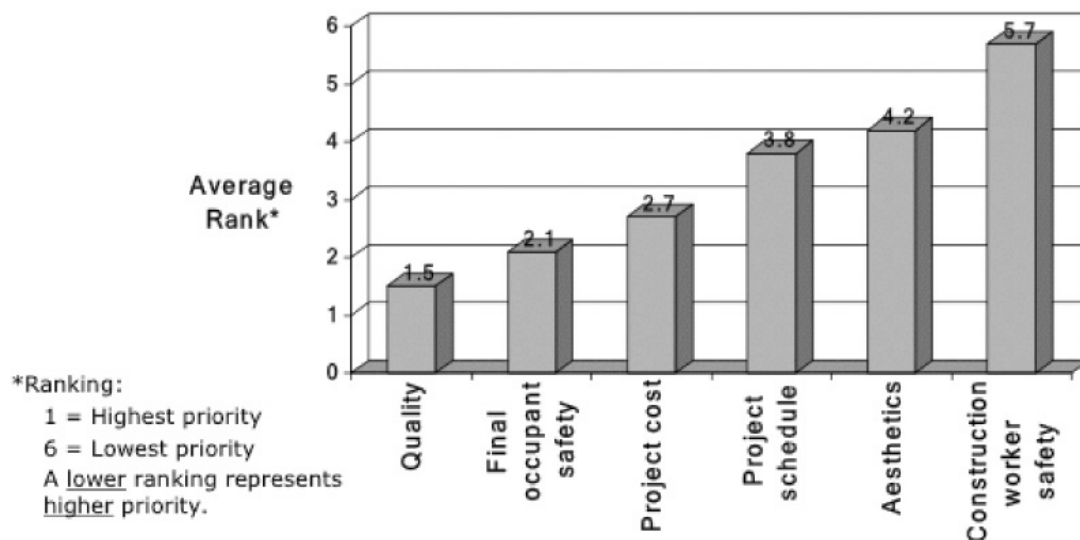


Fig. 4. Survey Results: Priority of Project Criteria (Hecker and Gambatese 2004)

The architect's highest priority is quality, followed by final occupant safety, project cost, project schedule, aesthetics, and lastly construction worker safety (Hecker and Gambatese 2004). This presentation also lists the following keys to implementation:

1. A change in designer mindset toward safety

2. A motivational force to promote designing for safety
3. Designers knowledge of the concept
4. Incorporation of construction safety knowledge in the design phase
5. Designers knowledgeable about specific design for safety modifications
6. Design for safety tools and guidelines available for use and reference
7. Mitigation of designer liability exposure.

One of the keys to implementation of the concept is designing for safety tools. One tool that has been developed is the “Design for Construction Safety ToolBox.” This is a computer program that is based off of the Construction Industry Institute’s best practices (Gambatese et al. 1997). This program helps designers to recognize potential safety hazards in their design and gives suggestions for how to correct them.

In their presentation, Hecker and Gambatese also present analyses of contracting strategies to maximize general contractor and trade contractor involvement in the design process to ensure safe designs for their workers. A list of design for safety examples includes: design in tie-off points for attaching lanyards and other fall protection devices, design floor perimeter beams and beams above openings to support lanyards...note on the contract drawings which beams are designed to support lanyards, how many lanyards and at what locations along the beams, design guardrails around skylights, design upper story windows to be at least 42” above floor level...sills act as guardrails during construction, and use prefabricated components and install as assemblies (Hecker et al. 2004).

Construction Design and Management Regulations

The CDM regulations require designers to follow a mandate to design safe projects (HMSO 2000). However, the instructions are unclear and “research shows that designers are still failing to exploit the potential they have to eliminate and reduce risks on site. [Health and Safety Executive] interventions with designers show that designers are often uncertain of their responsibilities, lack information and training, and produce mountains of generic [Design Risk Assessment] paperwork that adds little value” (CDM 2005).

Toole's paper titled, "Increasing Engineer's Role in Construction Safety: Opportunities and Barriers," creates a bleak outlook on the concept of design for construction safety (Toole 2005). This research references the United Kingdom's CDM regulations to create a list of five main areas where designers could have a significant effect on safety. These areas are: "peer review for safety, create design documents for safety, procure for safety, review submittals for safety, and inspect site operations for safety." Toole lists four main barriers that prevent this from happening. These barriers are: "designer's lack of safety expertise, designers' lack of understanding of construction processes, conflicts with the existing model contract terms, and additional costs incurred by designers" (Toole 2005). Toole hypothetically creates a life cycle cost analysis on performing design for safety costs vs. reduced construction costs (through productivity and lower worker's compensation rates). He suggests that these costs could easily balance out, but states that, "Future research is clearly required to demonstrate that designing for safety can reduce project life cycle costs" (Toole 2005). Toole concludes that, "designers' lack of safety expertise and lack of a deep understanding of construction processes are the least tangible but most significant of the four barriers because they would require the cooperation of the greatest number of organizations. Due to these two sets of barriers, it would be completely ineffective to enact legislation requiring U.S. designers to immediately start performing the five safety-related tasks...the U.S. civil engineering and construction industry as a whole is clearly not ready for legislation similar to the CDM regulations enacted in the United Kingdom nearly ten years ago" (Toole 2005).

Other Previous Related Research

In a paper titled, "Causal factors in construction accidents," researchers at Loughborough University studied the causes of 100 construction accidents. The research led to a number of findings. One was the following: "It was judged that up to half of the 100 accidents could have been mitigated through a design change and it was found that, despite CDM, many designers are still failing to address the safety implications of their designs and specifications (Hide 2003)." Furthermore, the research found that, "The influence from clients on safety appeared limited in the construction sectors predominant in this research (civil engineering, major building, residential). This was, again, despite the responsibilities on clients

imposed by the CDM (Hide 2003).” This study indicates that there is a relationship between designing for construction safety and reduced accidents. Additionally, it suggests a lot of room for improvement.

III. RESEARCH METHODS

Study Goals and Objectives

The goal of this study is to gain a greater understanding of how designers perceive design for construction safety, how they take action to implement it on a project, and the impacts of the concept on design. To meet this goal, selected architects were interviewed to gain their knowledge and opinions of design for construction safety. Secondly, the architects were asked about standard practice for addressing safety in design in the Northwest. Third, the hired Architect for the Project was interviewed during the design process to observe what design for construction safety items were and were not implemented and the reasons for these decisions. Lastly, the Construction Manager/General Contractor's (CM/GC) role in enhancing safety through the design of the project was investigated.

Case Study Project Background

This case study research was split into three questionnaires. The first questionnaire was directed to the four architects who had passed the Owner's "Request for Qualifications" screening process. These architects were directed by the Request for Proposals (RFP) to answer a series of questions to help the selection committee find the best architect for the Project. The RFP included the following design for construction safety question: "2. Describe your design approach for the building renovation contemplated in this project. Specifically describe your approaches to incorporate constructability/sequencing, construction safety, and sustainability/sustainable materials into the design for this project." This question is not commonly included in RFP's for design services. The written responses by the architects are quoted in Table 1.

Table 1. Architect's Proposed (Request for Proposal) Approaches to Safety in Design

Architect:	Approaches to incorporate design for construction safety
The Architect (hired)	" Construction safety is an important aspect of any project but especially on a [Owner's Name] owned building... there are opportunities where the design team can aid the

	project with safety measures...[The Architect] Architects will work with the CM/GC to identify areas of work that would benefit from review and modification for issues of construction safety. For example, with any wood structure controlling field welding to reduce fire hazards is a critical component of construction safety... This issue, among others, will be reviewed with the selected CM/GC to assist in reducing costs, easing complexity of details, and reducing hazards associated with construction." (Page 13)
Architect 2	"Safety will be a top priority in the design criteria...Structural improvements will likely have the greatest impact on construction safety for [The Project]. It is so important for the CM/GC to be involved in the early stages of structural design so they can review proposed systems and begin crafting a strategy that addresses the structural system within their overall safety plan." (Page 12)
Architect 3	"For incorporating considerations relating to constructability/sequencing and construction safety, we would rely heavily on the CM/GC to bring that specific and critical expertise to the team." (Page 14)
Architect 4	Not addressed.

After selecting and hiring the Architect, the Owner proceeded to issue a Request for Qualifications (RFQ) to CM/GC firms. The firms that passed the initial qualifications screening process (known as the shortlist) then submitted written responses to the Owner's Request for Proposals. In the CM/GC's RFP, one question was dedicated to designing for construction worker safety: "Describe your plan to incorporate sustainability, constructability and safety into both the design and construction phases." The following responses by the five construction firms are quoted in Table 2.

Table 2. CM/GC's Proposed (Request for Proposal) Coordination with Architect

CM/GC:	Coordinate with Architect for design for construction safety
The CM/GC (hired)	<p>"During preconstruction we will examine construction type, design elements, hazmat abatement, materials, access, and procurement from a safety point of view" (Page 0)</p> <p>"Life Cycle Safety: [The CM/GC]'s CM/GC Responsibility: Building Safety Into [The Project]: Designing [The Project] for safety is not [The Architect]'s responsibility alone... we can bring a lot to the table. Kevin, Jim, and Mina have hands-on, field experience that lets them see projects through a craftsman's eyes. They will collaborate with [The Architect] to ensure a safe design that will serve the campus well for another 100 years, such as installing permanent tie-off anchors and making mechanical systems easily accessible for facilities staff..." (Page 6)</p> <p>"We will work with [The Architect] to design safety into the project. For example, we will incorporate fall restraints into the design... [The Project] will be a great example of what engineering can bring to the safety design process." (Page 10)</p> <p>"Safety: Design Phase: Safety begins in preconstruction. [The CM/GC] will work with [The Architect] to build safety into the design, "upstream" from the construction process..." (Page 21)</p>

	"Preconstruction safety planning will also focus on: ... Type of construction: a lot of steel means a lot of welding. Bolted connections can reduce the risk of fire... Design elements: roof design (fall restraints incorporated) stair system (concrete tread vs. marble etc.) Access (ADA, elevators, service equipment) Floor Loading-review third floor loading for new library... Materials: Back injuries can be avoided if materials are selected that are either light enough for a worker to lift without strain or can be preassembled in a factory environment and hoisted into place. Safe Access: critical to preventing "slip and fall" accidents for workers..." (Page 22)
Construction Firm 2	"We will work with [The Architect] to insure the design documents reflect and promote a safe approach to constructing the work" (Section 3, Page 4)
Construction Firm 3	Not addressed.
Construction Firm 4	"[The Architect's] Partnership Role as Project Architect: Designs in safety" (Page 4) "Addressing safety in an RFQ or RFP is very rare and much appreciated. Addressing safety in an architect's RFP, as was done at [The Project], is unheard of. Too often Owner's turn a blind eye to safety and regard it strictly as a contractor issue which they do not want to be part of. We applaud your involvement, and support, in keeping our workers, the project team and the public safe during construction." (Page 19)
Construction Firm 5	Not addressed.

The analysis of the architects' and CM/GCs' RFP responses are in the Results section of this thesis.

Development of Questionnaires

The purpose of the first questionnaire was to judge the "openness to" and "knowledge of" design for construction safety among the four Portland, Oregon architects shortlisted for the Project. These interviews were completed about four months after the RFPs were submitted. The survey questions were originally developed and used as part of a previous study on designing for construction safety (Gambatese et al. 2005). However, some of the questions were changed to fit the new context. Those modifications were completed by Dr. John Gambatese and Professor Greg Baker at Oregon State University. The revised questionnaire is attached in Appendix A:. Professor Baker and I performed the interviews at the four architect's offices on April 29, 2005.

This questionnaire consisted of six sections. A summary of the results of this survey is shown in Table 3. Section 1 of the survey asked for general information from the individual interviewed as well as firm specific information. Then the individual was asked about their experience as a design professional, their

construction experience, and their role in the project. For the firm specific questions, we asked about what types of design services and projects the firm takes on, as well as approximate billings and whether or not the firm does any construction work.

Section 2 of the survey referred to the proposal (RFP) that the architect turned in. We asked if the individual was the primary person involved in writing the RFP. Then we asked what their initial reaction was to the RFP question about designing for construction safety, and how they chose to respond. We followed this by asking what they intended to do for construction safety on this project. These answers paralleled the written responses culled from the RFPs (See Table 1).

Section 3 asked the architects if they have general knowledge about the concept of designing for safety of construction workers. The questions we asked included: “Do you have any formal training in this area? Do you know of anyone who is involved in this design? Have you been involved in this type of design? Have you discussed design for safety of construction? How would you rate that experience? Have you hired a consultant to assist on this issue?” Finally, the architects were asked whether they had heard of the United Kingdom’s Construction (Design and Management) Regulations. These questions gave us an understanding of the background of the architects.

Section 4 was focused on current design practices. We asked if the architects had previously made design decisions that improved construction worker safety and health on other projects. Then we asked if the firm had a formal process to follow to address safety in the design. This led to our questions about what tools the firms had to assist on this topic, and if they were aware of other tools. We asked when designing for construction safety should be implemented in a project. We also asked if they had made any design choices that reduced the safety hazards on construction projects.

Section 5 asked about design for safety impacts, barriers, and limitations. This section was very helpful in understanding the reluctance we noticed among most of the architects. We asked what impact design for construction safety would have on a project and what barriers the architects saw in addressing this topic.

Then we asked if the building codes affected the topic. The next question was if addressing construction worker safety would raise liability and conversely if avoiding it would raise liability. We asked if the traditional relationships in construction prevented this design and if personal opinions were affecting the issue. Then we asked if anyone had ever asked for the architect's opinion on this topic, and what their response was. The next question attempted to determine the comfort level of the architect with respect to safety. Finally we asked the architect to prioritize criteria related to cost, quality, schedule, and safety for designing projects.

The last section, Section 6, contained 22 example design suggestions. We divided the list into sections: modifications to contract drawings, electrical safety, fall protection, skylights, ladders and stairs, and other safety and health topics. The architects were asked to provide their opinion about the feasibility of implementing the design suggestions.

The second questionnaire was addressed to the Architect and CM/GC that were hired. This questionnaire essentially asked what measures were proposed for design for construction safety and which measures were actually implemented. These interviews were conducted at about 50% completion of design work. This was approximately six months after the RFP interviews. Prof. Baker and I developed the questions for this follow up interview. I interviewed the Architect and CM/GC by phone.

For the follow up interviews, the main question was whether the emphasis by the owner (through the RFP) had influenced design. We asked three main questions: "What did you plan to implement?", "What have you implemented?", and "Why?" The actual list of questions can be found in Appendix B:. The questions that were directed to the CM/GC's project manager were developed by reviewing their RFP proposal (Table 2). From this text, a number of questions arose around potential design for construction safety areas. These questions asked about implementation of the following: construction type, design elements, floor loading, hazardous materials abatement, materials selection, safe access to the project, and procurement. The next major question arose from the Architects proposal to add permanent tie-offs for construction and maintenance safety. The remaining questions were about barriers, tools, and suggestions for future projects.

A similar procedure was followed to develop questions for the Architect hired for the project. These questions are also shown in Appendix B:. The main questions asked were, “What did you plan to implement for construction worker safety?”, and “What did you actually implement for construction worker safety.” The question about permanent tie-offs was repeated to see a different perspective on this issue. The next question asked if construction safety had any influence on design. Finally questions were asked about barriers, tools, and suggestions for future projects.

Selection of People to Interview

The individuals interviewed were chosen because of their direct involvement in the design for safety process on the Project. For the first questionnaire, all of the architects interviewed were the primary writers of their RFP responses. For the second questionnaire, the Architect’s project manager was interviewed, and the CM/GC’s project manager was interviewed. The intent was to pick individuals who were intimately familiar with their firm’s written responses and the reasoning behind those written responses.

The Interview Process

The format of the interview process was somewhat informal. The first set of interviews was conducted at each of the four architect’s offices (in their conference rooms). Professor Baker asked the majority of the questions and I took extensive notes. The questions were read from beginning to end. After each interview was completed, we compared our impressions of the interest or hesitancy each architect had shown. While not quantitative data, this impression was recorded and is supported up by their responses.

The second questionnaire was e-mailed to the Architect’s project manager and to the CM/GC’s project manager. The Architect’s project manager preferred to respond by e-mail, the CM/GC’s project manager preferred to respond over the phone. The phone-based interview was conducted in a similar manner to the first series of interviews. The questions were asked in order and the CM/GC’s responses were written down.

How the Analysis was Planned

The intent of the analysis was to find out how designers perceive design for construction safety. The responses from the first interviews were recorded in a tabular format to identify trends for each question. By determining the trend as well as the outlying opinions, a sense of the architect's attitudes could be developed. This interpretation of the comments was intended to estimate the common perspective among all of the architects interviewed. The vast majority of the comments and opinions generated from the interviews was not quantitative data. However, a histogram analysis was planned for the question regarding ranking priorities. This question was previously asked in Gambatese et al.'s "Viability of designing for construction worker safety" study. The intent was to verify that the architects interviewed had similar opinions about the priorities (as previously had been shown). A review of the consensus for each question would answer the question about how designers perceive designing for construction safety.

The second questionnaire was analyzed by looking for the attitudes behind their comments. However, this data is more specific to the Project, and so the Architect's and CM/GC's direct actions could be reviewed. The purpose of this analysis was to find how they took action to implement the design for construction safety concept on the Project.

Assumptions and Limitations

A significant assumption in this study was that the individuals we interviewed are a reasonably representative sample for the population of architects in the Northwest. Since there were only four architects interviewed in the first questionnaire, it is not likely to be a statistically significant study. However, the results of the case study related questions were useful. Some error in the data is due to the consistency of the questions and the quality of the note taking. An audiotape of the interviews may have led to a more accurate analysis.

Due to time constraints, a set of interviews of the Owner's representative and the maintenance staff was not

completed. These questions would have addressed the involvement of the Owner in the design for construction safety decisions.

IV. RESULTS

Summary of Data Received

One of the goals of this study was to understand how architects perceive designing for construction safety. The results from the interviews indicate that the architects range from strongly conservative to somewhat progressive on this issue. One of the architects felt that construction safety is absolutely outside of his responsibilities. Two of the four architects were interested in learning more about the concepts and potential applications. The fourth architect was willing to consider the issue and suggested willingness to internalize parts of designing for construction worker safety. This last architect suggested that if the design for construction safety process improved project productivity and safety, and reduced costs, all parties involved would benefit.

The architects described potential advantages of designing for construction safety. Owners might benefit from faster, safer, and less costly projects. Architects might benefit from collaboration to foster better working relationships between constructors and themselves. They could also benefit from additional projects (assuming less costly individual projects implies additional projects for a given amount of investment capital). Constructors could benefit from reduced accidents, reduced risks (both schedule and productivity), and better relationships. The workers could benefit from reduced accidents and higher productivity (thus higher wages).

Analysis of the Data

For the RFP interviews, the results were organized by question from the four architects. Then a common perspective was determined among the interviewees. Some of the responses were polarized; therefore no common perspective could be determined. However, a typical response was found for most of the

questions. These trends are listed in Table 3. To further explain the differing opinions of the architects, some direct quotes are listed under the trends section.

Table 3. Request for Proposal Interview Questions and Results

RFP Interview Results April 29, 2005 Interviewers: Prof. Greg Baker & Carl Christianson		
#	Question	Survey Trends/Consensus
GENERAL INFORMATION		
1	What is your title/position?	Principle, Project Manager, Associate
2	What is your typical role on a project team?	Principle, Project Manager
3	How many years of experience do you have as a design professional?	25
4	How many years of experience do you have in construction?	1.25
5	What kinds of experience do you have in construction, or that is related to construction?	Varies from none to some field experience.
6	What design services does your firm provide?	Architectural
7	What types of projects does your firm typically design?	Commercial, Institutional, Municipal
8	What are your firm's total annual design fee billings (approximate)? \$	\$5 to \$20 Million
9	What percentage of your firm's total revenue comes from design, construction or other sources	100% Design
REQUEST FOR PROPOSALS		
10	Did you participate in putting together your firm's response to the RFP on the renovation project?	Yes
11	If yes, did you participate in developing a response to the question in the RFP on designing for construction safety and health?	Yes

12	What was your initial thought regarding the RFP question when preparing your proposal?	Felt either surprised or unsure how to deal with the question
13	Describe your (or your firm's) thoughts in putting together the response to the question.	Varies: "Construction safety is primarily the purview of the contractor, in terms of means and methods. Design firms are not covered under their liability insurance for anything related to means and methods, so we must make a clear distinction not to cross that line." "Talked to likely CM/GC contractors for the project, considered no welding inside wood building, access to constricted site, stabilizing existing building elements." "The American Institute of Architects says means and methods of construction safety are the contractor's responsibility, we are not in control of that, but we do have a moral responsibility. We considered constructability for the project. For example the plans "must be buildable" and we checked sequencing as part of our responsibility to keep the costs down for the owner." "We skipped the question, it confused us"
14	What did you (or your firm) expect to do in the design, in response to this question?	Varies, some firms were planning to have dialogue to solve this question. This dialogue would be with the contractor over issues such as shoring, connections, and how to build a partnership.
GENERAL KNOWLEDGE OF DESIGN FOR SAFETY CONCEPT		
15	Before proposing on the [The Project], had you heard of the concept of designing for construction worker safety and health?	Mostly no, some firms have some background in design for construction safety. Two of the four firms mentioned that design for construction safety is most prevalent in demo/salvage operations and on job sites with risky site conditions.
16	If you had to define "designing for construction worker safety and health," what would your definition be?	Varies, two firms mention collaboration with the CM/GC. "As planning, how do you construct for workers" "How do you protect workers and build this into planning and sequencing" "Ties to collaboration with contractor" "Finding design solutions to challenges" "Materials are selected to prevent hazardous off gassing etc."
17	In your formal education and training, was anything included on the topic of addressing construction worker safety and health in the design phase of a project?	No "No push to cover this from AIA or owners" "Safety training for the architect states that OSHA is more restrictive than the Uniform Building Code (i.e. ladder cages)."

17a	If yes, what specifically was included (topics, tools, specific courses, conferences, lectures, etc)?	No "We are not aware of tools or conferences etc." One firm mentioned that OSHA does perform consultations for exceptionally hard projects.
18	Are you aware of any other design firms that address construction worker safety and health in the design phase of a project?	No "No, not typically due to liability"
19	Have you ever been asked to address construction worker safety and health in the design phase of a project?	Varies, most firms have experience in addressing construction worker safety. "No, but we address ownership and maintenance issues for permanent facilities staff." "No, but we have addressed some health concerns with material selection."
19a	If yes, did you? Why or why not?	"We did address construction worker safety in recent renovations at Oregon State University and in Portland." "On a recent building we brought in OSHA for O&M and construction issues. We also consider this on CM/GC projects or otherwise complicated design projects." "We have done some design on health side, such as the materials selected." "Yes, the owner's facilities side complains about dangerous materials."
20	Have you had any discussions with contractors and/or owners during the design phase of a project that include: a.) the methods/practices employed by the contractor, and b.) the features to be included in the design to ensure construction worker safety and health during construction?	Mostly yes, firms have some experience with discussions. "Yes, we've had preconstruction conversations, which included roof tie-off points." "Yes, and no, we have limited discussions to the CM/GC process and negotiated contracts."
	If yes, what typically is the owner/contractor requesting, and what are their concerns?	"The owner wants to review safety methods, for example: they want to review asbestos removal sequence." "We see an interest during pre-construction conference", "The owner wants safe roofs for their maintenance personnel, making safety then useful for the contractor." "We did it on our own due diligence."
	If yes, how would you describe the experience in relation to your work – positive, negative, indifferent – and provide any related insights or lessons learned.	We provided consultation services: "Will it be OK with structural engineer?"

21	Have you ever worked with or hired a construction safety and health consultant in the design phase of a project to address construction safety and health concerns?	No
22	Have you heard of the United Kingdom's Construction (Design and Management) Regulations (a.k.a. "CDM Regulations"), passed into law in 1994?	No
CURRENT DESIGN PRACTICES		
23	Do you ever make design decisions in the design phase that improve construction worker safety and health? (This question does <u>not</u> refer to other design factors that may affect construction worker safety such as building codes, OSHA laws, etc.)	Varies between Sometimes and Never "Never, we design something and have a good idea it can be done." "Rarely, mostly it occurs as a by product of the owner's needs"
24	Does your firm have a formal process to follow during design that allows for consideration of construction worker safety and health in project designs?	No
25	What tools (checklists, design databases, use of safety consultants, etc.) do you use to address construction worker safety and health in the design phase?	The firms had no tools except: "The expertise of our field agents"
26	Are you aware of any other design tools that could be used to address construction worker safety and health in the design phase?	No One firm mentioned that this would not be their responsibility: "No, our structural engineers are in tune to deal with issues, we just pass through to them."
27	At what point in the design phase is construction worker safety and health addressed?	Near design documentation (DD) and onward One firm stated that this should be addressed later, "more in CDs"
28	What design modifications have you made in the design phase of a project that reduced safety and health risk to construction workers? Provide specific examples.	Only one firm had modifications they mentioned: "Demolition changes, connections in wood frame construction, and interior installation of windows."
DESIGN FOR SAFETY IMPACTS/BARRIERS/LIMITATIONS		

29	What impact does designing for construction worker safety and health have on a project? (e.g., impacts to cost, quality, schedule, safety, productivity, etc.)	<p>We observed contradictory responses from the architects:</p> <p>"Cost for constructability reasons should go down, Quality? And the schedule should be faster. Productivity should go up"</p> <p>"Cost should go up, aesthetic merit should go down"</p>
30	What barriers or limitations do you see in addressing construction worker safety and health in project design?	<p>All four of the architects cited liability insurance as the main barrier to design for construction safety and health. Two of the architects mentioned a lack of education preventing design.</p> <p>"Liability insurance prohibits designer involvement in means and methods."</p> <p>"Liability increases, contract structure"</p> <p>"We need more education and understanding", "We must not dictate means and methods", "We can achieve safety through the design side and collaboration without dictating worker safety"</p> <p>"Lack of education tied to liability", "Negative impact on aesthetics"</p>
31	Do certain provisions of the building code affect construction worker safety and health?	No, they don't affect construction worker safety
32	Do you believe that addressing construction worker safety and health in the design phase will increase your liability exposure?	<p>Yes</p> <p>However, one architect stated: "No, this might fall under our duty to public safety."</p>
33	Do you believe that not addressing construction worker safety and health in the design phase will increase your liability exposure?	<p>No</p> <p>"No there should be a clear division of responsibility. State law says we can't be sued for means and methods unless we are negligent"</p> <p>"No, none initially, but failure to address this will probably increase our liability in the long run"</p>
34	Do you believe that the traditional relationship between the designer and constructor precludes you in any way from formally addressing construction worker safety and health in the design phase?	<p>Three of the four architects stated no.</p> <p>"Yes, our contractual obligations prevent addressing design for construction safety"</p> <p>"No, as long as we don't have to tell them how to do it"</p> <p>"No, design build often has less collaboration then CM/GC"</p> <p>"No, we can still have collaboration, or should have"</p>

35	What is your personal willingness to address construction worker safety and health in the design phase?	Varies: "My willingness is limited, because that is not our area of expertise - that is the contractor's expertise" "Yes I am willing to address this, but I need a better understanding of how to do that. I need more education." "I am curious to learn more"
36	Prior to today, have you ever been asked your opinion about addressing construction worker safety and health during the design phase of a project?	No
37	Do you feel comfortable talking about construction worker safety and health issues in general? Why or why not?	Yes "No, this is not our area of expertise and we have liability issues" "Yes, but I don't have knowledge of the regulations, but we are seeing more protection now" "Yes, I find it interesting" "Yes, we had to install granite stair treads on a recent project that were very heavy to install and we solved the safety challenges with the CM/GC"
38	What priority do you place on the following criteria when designing a project? Please rank the criteria with 1 being the highest priority, 2 the second highest priority, and so forth.	
	Quality of the work	2.25
	Project Cost	2
	Project Schedule	4
	Aesthetics	1.75
	Facility occupant safety and health	2.75
	Construction worker safety and health	6

	<p>Please review the design for safety suggestions listed below and describe the prevalence and feasibility of implementing the designs on a project from the standpoints of cost, quality, productivity, scheduling, project administration, contractual, and industry culture. For all of the design suggestions, respond with the assumption that the design will be implemented in the design phase. While some traditionally fall in the construction phase, the response should be made as if the designer were implementing the suggestion in some way during the design phase of the project.</p>	
EXAMPLE DESIGN SUGGESTIONS		
<u>Contract Drawings</u>		
39	<p>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.</p>	<p>Yes, all four architects agree on indicating utility locates as part of their duty. Some of the architects would note the source of information. None of the architects would note a clear zone or level of certainty on the drawing (unless there was sufficient reason to believe that the surveyor had made a mistake).</p>
40	<p>Review the condition and integrity of the existing structure and indicate any known hazards or deficiencies on the contract drawings.</p>	<p>Yes</p> <p>"Yes, we already do this to a great extent"</p> <p>"Yes, we would indicate if there were structural integrity or hazardous materials (asbestos) challenges, but we would include a disclaimer"</p> <p>"Yes, would note these, however it is a judgment call, especially if there is a major risk"</p> <p>"Yes we believe that this is in our scope, our due diligence. Furthermore this is part of the design solution"</p>

41	Provide or require the constructor to submit a construction sequence for complicated or unique designs.	<p>Yes, most firms interested for informational purposes, but not willing to review for liability reasons:</p> <p>"We already do this to some extent, but we do not want to have any responsibility for how they want to sequence the work. We would tell the contractor to hire their own engineer for shoring, bracing, sequencing. We don't request a submittal to keep responsibility clear."</p> <p>"No, this is a means and methods issue. We assume it's OK if it has proper engineering effort. We haven't verified submittals of a licensed structural engineer."</p> <p>"No, Not usually, but yes, if it is a historic building, or partial occupation was planned. We would review them like shop drawings."</p> <p>"They would be for information only, not in the stamped submittal process"</p>
<u>Electrical Safety</u>		
42	Maintain a minimum clearance between the project and existing overhead power lines.	Yes, most firms willing to mark existing lines, but they are not willing to mark clearances
43	Provide electrical/ instrumentation system enclosures, which are adequate for the expected environmental/ climate conditions.	Yes, code requires this already
44	Provide a clear, unobstructed, spacious work area around all permanent mechanical equipment.	Yes, but this is required by code and by the owner's demands
<u>Fall Protection</u>		
45	Design windowsills to be 42 inches minimum above the floor level. Windowsills at this height will act as guardrails during construction.	<p>No, harms aesthetics</p> <p>"This idea performs terribly for day lighting. So, the question is 6 months versus 50-year lifespan of the project. We design for the end user."</p>

46	Design columns with holes at 21 and 42 inches above the floor level to provide support locations for lifelines and guardrails.	Mostly yes, but only if asked by the contractor to do so.
47	Design perimeter beams and beams above floor openings to support lifelines (minimum dead load of 5400 lbs. which is the design load for lifelines and lanyards as required by OSHA). 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.	<p>Three of the four architects indicated that they would be willing to do so.</p> <p>"No, this is a challenge for design team to do. The architect is not covered by their insurance, so the owner is liable."</p> <p>Yes, "We would be willing to work with the contractor but would need additional money. We would not be willing to note on the plans which beams are designed to support lifelines. The safety depends on how far structure is along (means and methods)."</p> <p>Yes, "with coordination with the structural engineer"</p> <p>"Yes, as long as it doesn't increase cost"</p>
48	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.	No, this does not make sense financially or for aesthetic reasons.
49	Provide a guardrail along the perimeter of a tank roof.	No, all four architects would only do this if required by OSHA for operations and maintenance (O&M) or at the owner's request.
50	Design special attachments or holes in members at elevated work areas to provide permanent, stable connections for supports, lifelines, guardrails, and scaffolding.	<p>Two of the firms would only do this for maintenance reasons, one of the firms is willing to do this for the contractor if the owner benefits.</p> <p>"Yes, if for maintenance," "We have a firm that specializes in this (meeting maintenance requirements)."</p> <p>No, "Only for maintenance", "Depends on aesthetic"</p> <p>Yes, "if benefits owner (saving costs and faster production)"</p>
<u>Skylights</u>		
51	Provide permanent guardrails around skylights.	<p>No, not necessary for safety</p> <p>"No, not required by code. We would do this if the owner requested it."</p> <p>"It depends on appearance, you can walk on them now, tempered glass is strong"</p>

52	Design domed, rather than flat, skylights with shatterproof glass or add strengthening wires.	No "No, codes require laminated glass, which is very strong and reinforced mullions. The code is worried about the glass falling out in a seismic event (public safety hazard)."
<u>Ladders / Stairways</u>		
53	Use consistent tread and riser dimensions throughout a stairway run and the project.	Three of the four architects already do this for economy of scale reasons. "Yes, right now we do this for design simplicity." "No, we just follow the code."
54	Provide access by means of a ladder or stairway when there is a change in elevation of greater than 19 inches.	Yes, for O&M or Code "Yes, on roof we want a route for maintenance" "Only if code required, or owner requested" "Yes, especially for maintenance"
<u>Other Safety and Health Considerations</u>		
55	Before demolishing and renovating any structure, ensure that an engineering survey is performed by a competent person to determine the condition of the structure, evaluate the possibility of unplanned collapse, and plan for potential hazards.	Yes, architects would require this, but might not be willing to review it. Yes, "the structural engineer is involved, the existing condition needs to be understood or abated." "We could see requiring a stamped one, but not reviewing it (Not a submittal)" "Yes, it is mandatory and depends on the scope of the project"
56	Provide permanent emergency showers and eyewash basins in areas where construction personnel might come in contact with highly toxic or poisonous materials.	No, contractor's responsibility for means and methods. Two of the four architects stated that they would add these only for maintenance or if code required them.
57	Provide adequate permanent illumination on projects to allow for construction work at night.	No, contractor's responsibility No, "would add to lifetime cost of the project."
58	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.	No, "contractor's sequencing issue" or "contractor's risk"

59	Require concrete test results to be verified before removal of the forms and shoring.	<p>Three of the four architects stated that they would not be responsible for issue.</p> <p>"Special inspections are made by the owner. We only review"</p> <p>"We are interested in ultimate strength, not prior to stripping strength"</p> <p>"Yes, we should be required to verify testing results. Right now we provide observation services, but the 3rd party tester is relied upon."</p> <p>No, "this is the special inspector's responsibility. We observe. We recommend the owner require testing prior to removal."</p>
60	Require regularly scheduled site housekeeping to ensure a neat, clean work area.	<p>Two of the four architects stated that this is not appropriate. The other two stated that they would be willing to talk to the General contractor's representative in an observational capacity if this was an issue.</p> <p>One architect stated that he knew of a lawsuit in which photographs (by the architect) were used against the architect for not "preventing errors documented in the photos." Consequently, this architect would "keep quiet."</p>

A number of the architect's comments from the RFP interviews did not specifically apply to the question we were asking. Those responses are listed below along with some background:

- One architect said that they used to have involvement with construction safety: "AIA used to have language that involved the Architect, but we got sued, and now we no longer have involvement."
- Part of the architect's liability challenges is the agency issues that can appear if the architect is perceived by the workers as in control of the situation. If the architect sees a dangerous item on site, he/she must make the call whether the item is an imminent danger and thus require immediate resolution by any means. Otherwise, the architect can only mention it to a supervisor to avoid the appearance of having responsibility for "onsite safety."
- One of the fears of architects in construction safety is that they "don't want to restrict the contractor's direction." For example, if the architect states that a certain beam is for tie-offs it might force the contractor to use the beam even if they have a better plan.
- The research found that the architects were fairly certain that, "factors of safety are higher for maintenance, than construction." This is surprising, but reassuring since most construction firms assume that the design is safe to build.
- "It is a contractual issue between owner and builder, no contract exists between architect and

builder."

- "We analyze how the owner's staff is going to do maintenance; we will include anchors inside if necessary for maintenance."
- "One of our senior architects in the Design Documentation phase with construction knowledge to verify our work to make sure it can be done. We rarely find constructability issues we miss. If a difficult item comes up we communicate with the builder."
- "We can have a discussion, but we can not limit methods, means, sequence in the contract or construction documents, so we don't have liability."
- "Constructability: Simple=Safe=Low Cost"
- "Collaboration worked well on a recent CM/GC project, and got many problems solved."

Review of the RFP trends

The results from the RFP Interviews (Table 3) are important because they show that the architects interviewed are very hesitant to change their processes to promote construction safety. The reasons behind this mindset are complex but seem to be based on four reasons. These reasons are, "limit my liability," "I don't have the education/tools," "this will cost extra," and "this isn't my responsibility."

A review of the architects' answers to our questions in Table 1 duplicates these rationales. The contracted Architect states "Construction safety is an important aspect of any project... Architects will work with the CM/GC," which implies that the Architect is willing to collaborate and try to solve design for construction safety issues. Architect #2 (not hired) also parallels these opinions by stating that, "It is so important for the CM/GC to be involved in the early stages of structural design...begin crafting a strategy that addresses the structural system within their overall safety plan." This statement also suggests a willingness to work collaboratively with the CM/GC. It is important to note that this statement does not say that the architect will be proactive and add items without the input of the CM/GC. Architect #3 (not hired) states that for "constructability/sequencing and construction safety, we would rely heavily on the CM/GC to bring that specific and critical expertise to the team." This statement also suggests a willingness to collaborate, but

not proactively move to enhance construction safety. This last statement also suggests that additional education would be helpful for the architect. The fourth architect (not hired) did not mention construction safety.

A review of the CM/GC responses from Table 2 also shows a willingness to collaborate. The construction firms interviewed potentially have a lot to gain from added influence to the design process. Furthermore, the contracted firm also receives a payment for preconstruction services performed (which would include modifications in the design to make a safer workplace). The CM/GC (hired) has an extensive list of areas for potential design contributions. The written response also suggests a strong willingness to cooperate and contribute. Construction firm #2 (not hired) states that they are willing to “ensure the design documents reflect and promote a safe approach to constructing the work.” This statement is much less specific than that of the CM/GC, but it does promote the collaborative process. Construction firm #3 (not hired) did not mention design for construction safety. Construction firm #4 (not hired) made a very strong supportive statement: “Addressing safety in an RFQ or RFP is very rare and much appreciated. Addressing safety in an architect’s RFP, as was done at [The Project], is unheard of. Too often Owner’s turn a blind eye to safety and regard it strictly as a contractor issue which they do not want to be part of. We applaud your involvement, and support, in keeping our workers, the project team and the public safe during construction.” This is by far the strongest written statement of support among the contractors. Furthermore, it shows that the construction firm might be willing to promote designing for construction safety with other owners. The fifth construction firm (not hired) made no mention of design for construction safety. The positive responses from the contractors suggest that if this idea can gain traction with owners and architects, the contractors will support it.

Out of the 60 questions in the first questionnaire (RFP Interviews), some responses were more useful than others in determining the designers’ perceptions. One of the more helpful questions the architect candidates answered was how construction worker safety and health fit within their other design priorities. The actual question is as follows (see question 38, Table 3): “What priority do you place on the following criteria when designing a project? Please rank the criteria with (1) being the highest priority, (2) the second highest

priority, and so forth.”

This ranking format provided us with a metric that we could analyze to determine an average (mean) score between the architects.

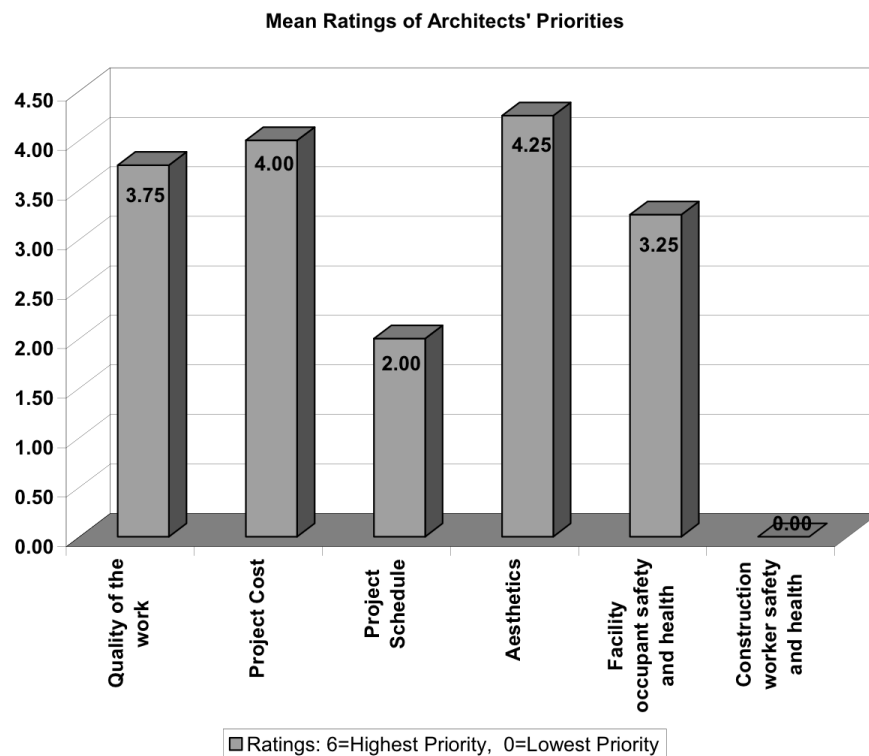


Fig. 5. Mean ratings of the Architects' Priorities

The significance of this chart is that construction worker safety and health is not a priority of the architects we interviewed. Since our sample size of four interviews is not statistically broad enough to extrapolate, we do not feel that it is appropriate to assume that most architects in the general population agree. It is likely that many architects do not thoroughly consider the well being of construction workers as they design. Further, the mean score suggests that some architects have a lukewarm to negative opinion about this topic.

The raw data was scored in the opposite manner, but was inverted to visually show the above result. These

results compare favorably to those from Hecker and Gambatese (2004) (see Fig. 4). The following table (Table 4) shows the mean scores of our data. The answers “program adherence, best value per cost, client and sustainability” were write in answers. It is important that these answers are considered, but we ignored the additional categories because they do not substantially change the priorities in the above chart (Figure 5).

Table 4. Architect’s priorities

Priority	Architect 1	Architect 2	Architect 3	Architect 4	Average
Quality of the work	1	1	3	4	2.25
Project Cost	2	1	4	1	2
Project Schedule	5	5	5	1	4
Aesthetics	4	1	1	1	1.75
Facility occupant safety and health	3	1	2	5	2.75
Construction worker safety and health	6	6	6	6	6

Cost, quality, and aesthetics were tied for priorities among the four architects. Reviewing the comments made during the RFP interviews, we see that cost, aesthetics, and quality are critical factors in determining if an item is pursued in design or not. In the responses to the generic design examples, we see the three priorities conflicting with the design concepts. The architects said that adding safety equipment or barriers adds to the cost of the project or might be “unsightly.”

In the case of contract drawing examples, we found that the architects were willing to implement some changes to enhance construction worker safety. These changes included marking the location of utility lines on their drawings (as determined by utility locating services). The architects also noted that they would be willing to indicate any known hazards or deficiencies of existing structures on the plans. Another opportunity is that some of the architects would be willing to review construction sequences for complicated or unique designs as long as they would not be liable for accidents (similar to shop drawing reviews). They would not indicate a “clear zone” around the utilities. This indication might be fallible and could add liability for which the architect is not protected by insurance. The architects were also against a notation about the level of certainty for the marked location of underground utilities. Presumably, this is also due to liability issues or to the additional costs in collecting this information.

Electrical safety was also an area that the architects were willing to implement the design suggestions. The main reason for this was not for construction safety. These design suggestions are either required by code or by most owners for their operations and maintenance. In a repeat from the contract drawing section, we saw that architects were not willing to mark down clearances for existing overhead lines because of liability.

We devoted a significant number of questions toward fall protection because of the proportionately high number of fall related accidents, as well as the severity of those accidents. The architects were willing to design steel columns with holes at 21” and 42” for OSHA approved cabling. They were also willing to design beams for OSHA fall protection loading, however this task would require additional money. We asked if the architects would be willing to add a guardrail along the top of a tank roof. The consensus was that this would only be possible if the owner asked for it for maintenance. Question number 50 asked if architects would be willing to “Design special attachments or holes in members at elevated work areas to provide permanent, stable connections for supports, lifelines, guardrails, and scaffolding.” The architects were split on this request, however one said that, “Yes, if it benefits the owner by saving costs and faster production.” This progressive outlook on construction safety is encouraging.

On the other fall protection questions, the architects were very hesitant to change a design’s aesthetics for construction worker safety. This parallels the ratings in Fig. 5, which also show aesthetics as a priority of the architects over construction safety.

When we asked the architects about the design suggestions for skylights, they seemed unimpressed. None of the architects felt that additional safety measures were warranted. According to one architect, “you can walk on them now, tempered glass is very strong.” If this is true, it would be unlikely to see architects promote permanent guardrails around skylights for construction safety.

We asked an assorted series of questions about other safety and health considerations. On the permanent

shower and eyewash for construction personnel suggestion, the architects resolutely felt that this was the contractor's responsibility. The same sentiment was repeated for adequate permanent illumination for nighttime construction work and for providing limited access areas under masonry work. The architects did feel that requiring concrete test results to be verified prior to removal of forms and shoring was a good idea. However, the third party tester is usually capable of doing this work and checking. When we review the example design suggestions from the RFP interviews, we see that certain ideas were significantly more favorable amongst the architects than others.

The RFP interviews showed us that many of the architects were interested in construction safety, but due to the liability issues, lack of education, and contractual obligations they are prevented from designing for construction safety.

One of the results of the RFP interviews is the discovery of the "byproduct safety theory." We noticed that the architects were not willing to add features to their design for the safety of the construction workers. However, they were willing to add features for the owner's maintenance crews' safety. Some of these end user features would be beneficial for the construction workers. One of the more progressive architects suggested that if a beneficial tie off for construction workers was necessary, he might try to rationalize adding the tie off for future maintenance needs. In Table 3, question # 50, we see evidence of this line of thought: "Yes, if it benefits the owner (saving costs and faster production)." The question was whether the architect would be willing to design special attachments or holes to provide permanent connections for lifelines, etc. On this line of thought, we see that if costs are outweighed by benefits, the architects are willing to design for maintenance safety with the "byproduct" that the contractor's crews are safer.

Progress Interview Results

The purpose of these interviews was first, to try to identify what the Architect and the CM/GC each planned to implement before starting the project. Second, try to find out what was actually implemented individually or as a team, and why or why not. The interviews were conducted at 90% design completion.

Interview with the CM/GC

The CM/GC's interview was conducted on 17 November 2005 by phone with the project manager. After reviewing the written statements from the CM/GC in the RFP (See Appendix B), the discussion turned to what the CM/GC originally planned to implement. He mentioned one item not in his RFP. This was the improvement to the access of the roof. The building currently has a ship's ladder, which is unsafe to use for maintenance and impossible to use for construction. Since the RFP was written during the schematic design phase, it covered only a few items that would be discussed in the collaboration. The second item he mentioned was the comprehensive, professional engineer approved demolition of the interior of the building. This is planned to be done by creating steel falsework around the exterior of the building to attach to the façade and then removing the interior of the building. This piece of work is very complicated and the details were worked out during collaborative meetings with the Architect. Among other topics in the RFP that the architects mentioned, the construction type had changed to the gutting of the building from the original idea of selective replacement of timber beams. This change was due to the amount of structural steel that was required to bring the building up to seismic code. In the RFP, the CM/GC suggested that they would lobby for steel pan staircases with concrete treads rather than the heavier marble. These stairs are filled in temporarily with plywood and eventually with concrete. The architect agreed to this change due to reduced acoustics rather than safety for construction workers. Under the hazardous materials heading, the CM/GC informed us that due to liability issues, the Owner would be responsible for asbestos abatement in the building. One of the construction safety ideas was to abate all of the asbestos rather than to selectively entomb the materials and risk accidents that might release the fibers. He also mentioned the procedure for bagging and transferring fluorescent tubes to the Owner.

Continuing on to materials selection for the project, the CM/GC said that "it is not practical to select light enough materials to avoid back injuries. Durable materials are still a requirement; the lighter replacements are less durable. We use appropriate hoisting and cranes to avoid lifting injuries. On this project, we are planning to take materials in through the windows with a rough terrain forklift. Inside we will use enough

manpower and appropriate equipment including roustabouts and chain hoists where needed.”

When asked to elaborate on the tie-off discussion, the CM/GC’s project manager stated that since the Owner and Architect decided to add back the gabled roof, the flat roof with tie-offs was no longer a worry. According to the project manager, “most of the work will be done from a boom lift, including the steel work. Since they will all be tied in (to the lift) there will be no exposure and no need for tie-offs or davits.”

Question #5 was about barriers preventing designing for construction worker safety. The project manager stated that the architect does not want to tell us our “means and methods.” This did not completely prevent the discussion of safety. Part of the coordination challenge was “trying to build sensitivity to safety” among the architects. One example of a recent safety challenge on a different project emphasizes this collaborative process. On the other project, the architect called out for handrails to be cantilevered out over the edge of the balcony. This was a construction challenge since the installation would require holding a 500lb rail over the edge of the balcony and then leaning way over the edge and welding the railing on. To come to a reasonable solution, the CM/GC said, “It is better to convince the architect with dollars. If the task is difficult, we just need to educate the architect.” The next question asked about tools that assist the CM/GC on their worker safety design role. He said that the biggest tool they used was personal experience.

Question #6 asked about any other helpful information. The project manager stated that one of the most important tasks in preconstruction is ensuring that “the contractor needs to know the key hazardous exposures, he needs to be aware of the elements” that could hurt his workers. He also noted that during “preconstruction, when we see something with a tough detail, we need to give it some thought. First we need to look at the safety issues and second, we need to look at the cost issues.” Reviewing both these areas allows the CM/GC’s project manager to help in designing safe projects. He said, “We need to look at the challenging pieces of design now while we are in the (inexpensive) design phase.”

Interview with the Architect

This interview was conducted on 18 November 2005 via email with the (hired) Architect's project manager. Here are the results in their entirety (the responses are italicized):

1. What did you plan to implement for "construction worker safety?"

"The Architect and CM/GC discussed the following regarding issues affecting worker safety;

- a) limit or eliminate welding to avoid fire issues on existing wood, worker burns, flammable gases, etc.*
- b) tie-offs for construction & the Owner's maintenance workers.*
- c) Using the permanent structure for temporary bracing."*

2. What have the Architect and the CM/GC actually implemented for "construction worker safety?"

- a) "Initial discussions on this topic revolved around use of bolted connections everywhere possibly to avoid the need of flames, welding, high heat sources, etc near 100 plus year old wood. However, early in the design process this issue disappeared, as the team determined that the best course of action, for the long-term benefit of the Owner, would be to remove the existing structure on the interior and install a new concrete and steel framed interior. However, the design still incorporates the use of bolted connections to the greatest extent possible to reduce welding safety issues. This structure change eliminated a lot of unknown design and construction issues, decreased the required contingency for unforeseen conditions, as well as removed potential hazards from the building that may have otherwise been mitigated or encapsulated in place which would have created worker safety issues during construction and kept materials requiring safety concerns in the future.*
- b) The team discussed using the permanent structure as temporary bracing to reduce cost and reduce contractor/worker risk and safety issues in the use of temporary bracing as well as safety transferring from temporary to permanent bracing. The current design incorporates*

allowances for the installation of the permanent exterior columns and metal stud bracing at the third floor so they may be used by the GC as temporary bracing. However, as the building interior is being fully replaced, the team has placed the temporary shoring design into the scope of the demolition contractor. This will ensure that the responsibility for safety is held by the individuals most affected by its design, and that the highest level of safety will be considered during temporary shoring design. The design team will work with the demolition contractor to incorporate their temporary shoring into the overall scheme of design to insure safety, construction, schedule, and the efficient use of materials, i.e. use of permanent structure as temporary shoring.”

3. What discussions have you had regarding the permanent tie-offs?

“Tie-offs were discussed at certain points in the design phase not only for construction workers during construction but for the Owner’s workers doing general maintenance. As the design developed into essentially an existing skin with new structure, as well as installing a roof with a flat mechanical well, the requirements for permanent tie-offs have changed. The current design was discussed, and based on the following reasons permanent tie-offs were not considered a necessary requirement. Reasons:

- Vehicle rated sidewalks, on the primary facades, that are wide enough to accept a lift capable of getting workers to the cornice / roof line for maintenance and installation.*
- The flat roof mechanical well allows workers to maintain equipment with full height walls around them for protection.*
- Sporadic maintenance of the sloped roofing can be done from a lift from the ground or a rolling stage on the flat roof thus keeping workers behind full guard rail protection without the need to be climbing all over the sloped roof to get around.”*

4. How has construction worker safety been influential on design?

“As architects, we typically don't get involved in the contractor's issues. However, working with the CM/GC and the Owner overall has opened up views and opinions that will help architects understand the GC point of view and day to day issues they face. I don't know if it directly affects design, but working with GCs on these issues creates more team oriented design through understanding the other point of view.”

5. Are there barriers that are preventing designing for construction worker safety?

“Lists or ideas of issues architects & GCs should consider during design would assist in the design process. It is difficult to anticipate what issues the GC has in mind. Typically, architects do not get into any issues regarding contractor safety AND means and methods. Therefore, starting a project with a GC and review issues that the GC typically has concerns about would greatly assist the architect as well as build the relationship between the GC and Architect to the betterment of the project overall.”

6. Are there tools that are assisting you in this task?

“Unfortunately, tools for incorporation and implementation of worker safety through occupant safety don't seem to be available,”

7. Is there anything else you could tell me about that would be helpful for future projects?

“Talking about GC issues and their point of view, their typical day-to-day issues during the design phase will assist in team building between the Architect and the GC. Problems always arise, but if the team foundation is there, solutions always come faster and easier. Conflict will arise, but if the foundation is built, the focus is on SOLVING the problem not determining blame.”

The results of the Architect's follow up interview speak for themselves. However, certain trends do stand out. We see that the CM/GC process is working effectively to solve design for construction safety issues. Many issues that were identified at the beginning of the project were eliminated by changes in the overall design concepts. Still, the evaluation of construction safety during the design has had a positive impact on the case study Project, and may translate into no (or fewer) accidents.

V. CONCLUSIONS

Architect's Perceptions

The goal of this study was to gain a greater understanding of how designers perceive design for construction safety, how they take action to implement it on a project, and the impacts of the concept on design. The results of the interviews show that for most of the architects this is a new and challenging concept. However, three of the four architects were willing to consider designing for construction safety. Those three also stated in their proposals for the case study Project that, "Safety is a top priority..." or "Construction safety is an important aspect..." and went further to say that they would be willing to collaborate with the construction firm. The responses of the construction firms were equally as positive. Three of the five construction firms were willing to work with the architect to ensure the safety of the design. When the architects were interviewed after submitting the proposals, they were more candid about the concept. One architect was worried about liability and interfering with the means and methods of construction and not willing to consider the concept. One firm mentioned liability, but said they had "a moral responsibility," and considered constructability of the plans. One architect went as far as contacting a friend at a construction firm to discover potential design for safety opportunities before writing the RFP response. The last architect was confused and did not answer the question.

When asked about previous experience with the concept, only one architect had experience. Coincidentally, while designing a greenfield project for the same Owner, this architect had called OSHA's consultation service to find a solution for installing a roof over a five-story atrium. The same architect stated that he would also "consider [the concept] on CM/GC projects or otherwise complicated design projects." Most of the designers stated that they had previous preconstruction conversations that involved the safety of the construction workers, but not actual design for construction experience. When asked, none of the designers had heard of the CDM regulations or similar legislation.

One of the questions asked was about what impact (cost, quality, schedule, safety, productivity etc.) the

concept would have on a project. The responses were contradictory. One architect said that “Cost should go up, aesthetic merit should go down.” However, another architect said that, “Cost for constructability reasons should go down. The schedule should be faster. Productivity should go up.” When asked about the barriers/limitations to this concept, all four cited liability insurance as the main issue, and education as the second barrier. This response parallels prior research (Gambatese et al. 2005).

When asked if not addressing the concept would increase liability exposure, three of the architects said “No, there should be a clear division of responsibility.” However, the most progressive of the architects took a different viewpoint, “No, none initially, but failure to address this will probably increase our liability in the long run.” In conclusion, the architects we interviewed see design for construction safety as a collaborative opportunity that is driven by the Construction Manager/General Contractor.

How They Take Action to Implement

There are a number of ways that the architects take action to implement the concept. The main method is to collaborate with the construction firm during preconstruction to find where construction safety is an issue. The architect and constructor team then attempt to find solutions to mitigate safety challenges. Often the architects do not have the in-house resources to do the structural design and in that case, the architect acts as an intermediary between the needs of the contractor and the design of the structural engineer.

The Impacts of the Concept on Design

The impacts of the concept on design are likely to be an increased awareness of constructability and safety. It seems doubtful that architects will be willing to compromise on aesthetics for increased safety. However, not all safety improvements come at a cost in aesthetics, and those that do not may become commonplace in the industry. One example is adding small holes in steel framing to attach temporary railings. This simple action should become industry standard. The drawbacks of the concept on design include increased monetary and schedule cost during preconstruction, these are likely to be earned back during the construction phase if the changes are implemented. The impact of the concept are essentially an increased

awareness of construction safety issues among designers as well as increased collaboration with the contractor which may lead to increased cooperation in other stages of the project.

VI. RECOMMENDATIONS

The research shows that changes in design to benefit construction safety are worthy of consideration by the design team. While some changes may cost more than the added benefit, most seem to be a net win for all parties involved. It is suspected that owners could justify many safety additions in terms of increased productivity and lowered construction worker's compensation costs. Perhaps here lies the crux of the issue. Since architects are paid on a percentage basis of the project cost, they do not always have the same incentives (economic and non-economic) as an owner in making project decisions. It seems that in order to change the current construction practices, it is necessary to have the owners take authority and demand safer construction projects and safer designs.

One of the biggest impacts of designing for safety in construction is the requirement of collaboration between the architect and contractor in the preconstruction phases. This collaboration relies on non-traditional contracting by the owner. By requiring collaboration, the owner receives a better project because the design team has a broader background and can tackle constructability, scheduling, safety, productivity, and procurement through improved design. Furthermore, the team has more experience to leverage during design than the traditional designer-only method.

Recommendations for Future Research

Additional research is necessary to find the best ways to mitigate the liability, education, and means and methods barriers that the architects face. This study did not cover a number of issues in the Project case study. One of the issues is the influence of the Owner on implementation of the design for construction safety concept. The owner in any construction project has a very strong influence on the design criteria and the priorities of the design team. On this Project, the owner indicated that construction safety was going to be a priority through the mention of construction safety in both the designer's RFP and the constructor's RFP. The owner of a project is in the most influential position to promote designing for construction safety. As a result, the Owner significantly impacted the design for the Project, but those impacts were not

researched.

Another area of interest is to see the actual results of the changes in the design. This study could be followed with additional research on the benefits to worker safety during the construction phase of the Project. This research might also attempt to determine if the concept had any impact on other areas, including collaboration, scheduling, and productivity during the construction phase.

One question that remains unanswered is if the owners pushed the safety issue enough. Would additional encouragement provide a safer design, and would the costs outweigh the benefits? One unique design idea that Professor Baker suggested was the creation of a “safety-charette,” that would function similarly to the more common “Eco-charette.” This idea revolves around creating a 1-2 day workshop to study construction safety in design with the help of the owner, the architectural/engineering team, and the construction team. Additional studies could determine the effectiveness of this novel approach.

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VIII. APPENDICES

Appendix A:
Survey of Design Firms regarding Designing for Construction Safety
(RFP Architect Interviews)

Survey of Design Firms regarding Designing for Construction Safety

SECTION I: 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. How many years of experience do you have in construction? _____
5. What kinds of experience do you have in construction, or that is related to construction?
6. What design services does your firm provide? (Check all that apply.)
☐ Architectural ☐ Structural ☐ Civil ☐ Electrical ☐ Mechanical
☐ Other
7. What types of projects does your firm typically design? (breakdown in percentages)
☐ Commercial ☐ Industrial ☐ Institutional
☐ Engineering ☐ Residential ☐ Municipal
8. What are your firm's total annual design fee billings (approximate)? \$ _____
9. What percentage of your firm's total revenue comes from:

a) design	_____%
b) construction	_____%
c) other	_____%

SECTION II: [THE PROJECT] PROPOSAL

10. Did you participate in putting together your firm's response to the RFP on the [The Project] renovation project?
☐ Yes ☐ No
11. If yes, did you participate in developing a response to the question in the RFP on designing for construction safety and health? (See below for question in RFP.)
☐ Yes ☐ No

“Describe your design approach for the building renovation contemplated in this project. Specifically describe your approaches to incorporate the following into the design for this project: a.) Constructability/sequencing; b.) Construction safety; and c.) Sustainability/sustainable materials.”
12. What was your initial thought regarding the RFP question when preparing your proposal?
13. Describe your (or your firm's) thoughts in putting together the response to the question.
14. What did you (or your firm) expect to do (or if interviewing [The Architect], do you plan to do) in the design in response to this question?

SECTION III: GENERAL KNOWLEDGE OF DESIGN FOR SAFETY CONCEPT

15. Before proposing on the [The Project] project, had you heard of the concept of designing for construction worker safety and health?

____ Yes ____ No

16. If you had to define “designing for construction worker safety and health”, what would your definition be?
17. In your formal education and training, was anything included on the topic of addressing construction worker safety and health in the design phase of a project?
 ____ Yes ____ No
- If yes, what specifically was included (topics, tools, specific courses, conferences, lectures, etc)?
18. Are you aware of any other design firms that address construction worker safety and health in the design phase of a project?
 ____ Yes ____ No
19. Have you ever been asked to address construction worker safety and health in the design phase of a project?
 ____ Yes ____ No
- If yes, did you? Why or why not?
20. Have you had any discussions with contractors and/or owners during the design phase of a project that include: a.) the methods/practices employed by the contractor, and b.) the features to be included in the design to ensure construction worker safety and health during construction?
 ____ Yes ____ No
- If yes, what typically is the owner/contractor requesting, and what are their concerns?
- If yes, how would you describe the experience in relation to your work – positive, negative, indifferent – and provide any related insights or lessons learned.
21. Have you ever worked with or hired a construction safety and health consultant in the design phase of a project to address construction safety and health concerns?
 ____ Yes ____ No
22. Have you heard of the United Kingdom’s Construction (Design and Management) Regulations (a.k.a. “CDM Regulations”), passed into law in 1994?
 ____ Yes ____ No

SECTION IV: CURRENT DESIGN PRACTICES

23. Do you ever make design decisions in the design phase that improve construction worker safety and health? (This question does not refer to other design factors that may effect construction worker safety such as building codes, OSHA laws, etc.)
 ____ Always ____ Often ____ Sometimes ____ Rarely ____ Never
- If never, then why not, and then skip to Question 29.
24. Does your firm have a formal process to follow during design that allows for consideration of construction worker safety and health in project designs?
 ____ Yes ____ No
- If yes, describe the process.

25. What tools (checklists, design databases, use of safety consultants, etc.) do you use to address construction worker safety and health in the design phase?
26. Are you aware of any other design tools that could be used to address construction worker safety and health in the design phase?
27. At what point in the design phase is construction worker safety and health addressed?
28. What design modifications have you made in the design phase of a project that reduced safety and health risk to construction workers? Provide specific examples.

SECTION V: DESIGN FOR SAFETY IMPACTS/BARRIERS/LIMITATIONS

29. What impact does designing for construction worker safety and health have on a project? (e.g., impacts to cost, quality, schedule, safety, productivity, etc.)
30. What barriers or limitations do you see in addressing construction worker safety and health in project design?
31. Do certain provisions of the building code affect construction worker safety and health?
☐ Yes, positively ☐ Yes, both positively and negatively
☐ Yes, negatively ☐ No, they don't affect construction worker safety
 If yes, please comment further on specifics.
32. Do you believe that addressing construction worker safety and health in the design phase will increase your liability exposure?
☐ Yes ☐ No
33. Do you believe that **not** addressing construction worker safety and health in the design phase will increase your liability exposure?
☐ Yes ☐ No
34. Do you believe that the traditional relationship between the designer and constructor precludes you in any way from formally addressing construction worker safety and health in the design phase?
☐ Yes ☐ No
35. What is your personal willingness to address construction worker safety and health in the design phase?
36. Prior to today, have you ever been asked your opinion about addressing construction worker safety and health during the design phase of a project?
☐ Yes ☐ No
 If yes, what was your response?
37. Do you feel comfortable talking about construction worker safety and health issues in general? Why or why not?
☐ Yes ☐ No
38. What priority do you place on the following criteria when designing a project? Please rank the criteria with 1 being the highest priority, 2 the second highest priority, and so forth.

<input type="checkbox"/> Quality of the work	<input type="checkbox"/> Facility occupant safety and health
<input type="checkbox"/> Project cost	<input type="checkbox"/> Construction worker safety and health

____ Project schedule
____ Aesthetics

____ Other: _____
____ Other: _____

39. Please review the design for safety suggestions listed below and describe the prevalence and feasibility of implementing the designs on a project from the standpoints of cost, quality, productivity, scheduling, project administration, contractual, and industry culture. For all of the design suggestions, respond with the assumption that the design will be implemented in the design phase. While some traditionally fall in the construction phase, the response should be made as if the designer were implementing the suggestion in some way during the design phase of the project.

EXAMPLE DESIGN SUGGESTIONS

Contract Drawings

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.

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

Electrical Safety

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

Fall Protection

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

9. Design perimeter beams and beams above floor openings to support lifelines (minimum dead load of 5400 lbs. which is the design load for lifelines and lanyards as required by OSHA). 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.

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

10. 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.

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

12. Design special attachments or holes in members at elevated work areas to provide permanent, stable connections for supports, lifelines, guardrails, and scaffolding.

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

Skylights

13. Provide permanent guardrails around skylights.

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

Ladders / Stairways

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

Other Safety and Health Considerations

17. Before demolishing and renovating any structure, ensure that an engineering survey is performed by a competent person to determine the condition of the structure, evaluate the possibility of unplanned collapse, and plan for potential hazards.

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

19. Provide adequate permanent illumination on projects to allow for construction work at night.

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

20. 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.

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

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

☐ Currently do it ☐ Do not currently do it ☐ Feasible in the future

Comments: _____

End-of-Survey

Appendix B:
Follow up questions for the Architect and CM/GC

Thesis Questions for CM/GC's Representative:
Role of "Safety in Design" in the Bidding/Design process:

Purpose: What we'd like to learn, confidentially are:

- What did you plan to implement?
 - What have you implemented?
1. You wrote in your RFP that "During preconstruction we will examine construction type, design elements, hazmat abatement, materials, access, and procurement from a safety point of view, (Page 0)"

Later, the RFP noted more detail on some of these areas:

2. "Preconstruction safety planning will also focus on: ... Type of construction: a lot of steel means a lot of welding. Bolted connections can reduce the risk of fire... Design elements: roof design (fall restraints incorporated) stair system (concrete tread vs. marble etc.) Access (ADA, elevators, service equipment) Floor Loading-review third floor loading for new library... Materials: Back injuries can be avoided if materials are selected that are either light enough for a worker to lift without strain or can be preassembled in a factory environment and hoisted into place. Safe Access: critical to preventing "slip and fall" accidents for workers..." (Page 22)

What did you plan to implement?

What have you helped implement?

How about in the areas that you mentioned in the RFP?

- a. construction type
 - b. design elements
 - c. floor loading
 - d. hazmat abatement
 - e. materials
 - f. safe access
 - g. procurement
3. You also wrote about life cycle safety: "Life Cycle Safety: [Firm's Name] CM/GC Responsibility: Building Safety Into [Building's Name]: Designing [Building's Name] for safety is not [Architect]'s responsibility alone... we can bring a lot to the table. [The project team] have hands-on, field experience that lets them see projects through a craftsman's eyes. They will collaborate with [Architect] to ensure a safe design that will serve the campus well for another 100 years, such as installing permanent tie-off anchors and making mechanical systems easily accessible for facilities staff... (Page 6)" Can you elaborate on the tie-off discussion?

4. On Page 21, you've written about: "Safety: Design Phase: Safety begins in preconstruction. [CM/GC] will work with [The Architect] to build safety into the design, "upstream" from the construction process..." (Page 21)
 - a. How has construction worker safety been influential on design?
 - b. Are there barriers that are preventing designing for your crew's safety?
 - c. Are there tools that are assisting you in this task?
5. Is there anything else you could tell me about that would be helpful for future projects?

Thesis Questions for Architect's Representative:

Introduction: Text from [Architect's] RFP:

" Construction safety is an important aspect of any project but especially on a State owned building... there are opportunities where the design team can aid the project with safety measures...[Architect's Name] Architects will work with the CM/GC to identify areas of work that would benefit from review and modification for issues of construction safety. For example, with any wood structure controlling field welding to reduce fire hazards is a critical component of construction safety... This issue, among others, will be reviewed with the selected CM/GC to assist in reducing costs, easing complexity of details, and reducing hazards associated with construction." (Page 13)

Purpose: What we'd like to learn, confidentially are:

- What [the Architect] had planned to implement for "construction worker safety?"
- ...and what [The Architect] has actually implemented for "construction worker safety."

1. What did you plan to implement for "construction worker safety?"
2. What have [The Architect] & [The CM/GC] actually implemented for "construction worker safety?"
3. What discussions have you had regarding the permanent tie-offs?
4. How has construction worker safety been influential on design?
5. Are there barriers that are preventing designing for construction worker safety?
6. Are there tools that are assisting you in this task?
7. Is there anything else you could tell me about that would be helpful for future projects?

Appendix C:
Data from Request for Qualifications Interviews

Interview Results April 29, 2005 Greg Baker & Carl Christianson					
#	Question:	Firm 1	Firm 2	Firm 3	Firm 4
GENERAL INFORMATION					
1	What is your title/position?	Associate	Principal in Charge, President	Principal	PM
2	What is your typical role on a project team?	Project Management	Principal in Charge, PM	Principal in Charge, PM, Design	Management, Contracts, Relations
3	How many years of experience do you have as a design professional?	27	31	25	17
4	How many years of experience do you have in construction?	0	0	1	4
5	What kinds of experience do you have in construction, or that is related to construction?	"construction administration for architectural team"	Agriculture	Laborer, Sophomore in College	with Disney
6	What design services does your firm provide?	Architectural, Interior Design, Urban planning	Architectural	Architectural, Interior Planning	Architectural
7	What types of projects does your firm typically design? (breakdown in percentages)	Commercial, Institutional, Municipal	Commercial, Institutional, Municipal	Commercial, Institutional, Municipal, Engineering, Industrial, Residential	Institutional, Commercial, Residential
8	What is your firm's total annual design fee billings (approximate)? \$	\$5.5 million	\$8 million	\$15-20 million	\$5.2 million
9	What percentage of your firm's total revenue comes from	85% design, 15% feasibility	100% Design	100% Design	100% Design
THE CASE STUDY PROJECT PROPOSAL					
10	Did you participate in putting together your firm's response to the RFP on the case study renovation project?	Yes	Yes	Yes, "Lead"	Yes

1 1	If yes, did you participate in developing a response to the question in the RFP on designing for construction safety and health? (See below for question in RFP.)	Yes	Yes	Yes	Yes
1 2	What was your initial thought regarding the RFP question when preparing your proposal?	"Constructability is something the architect should address; construction safety to a great extent is not in architect's scope. Sustainability is woven through the design"	"What does this have to do with me?"	"Surprised by construction safety", "hadn't ever been asked about it"	"Thought we had wrong RFP", "Called 'Resource', who also thought it was a mistake"
1 3	Describe your (or your firm's) thoughts in putting together the response to the question.	"Construction safety is primarily the purview of the contractor, in terms of means and methods. Design firms are not covered under their liability insurance for anything related to means and methods, so we must make a clear distinction not to cross that l	AIA says means/methods/safety are contractor's, not in control of that, but has moral responsibility, Considered constructability "must be buildable" and sequencing, Sustainability: dictated by client "middle of road approach"	"It made sense for renovation work, fits with the Owner's strategy.", Renovation challenges/risks were unique, tie to education at the Owner	"Skipped the question, it confused us"
1 4	What did you (or your firm) expect to do (or if interviewing the hired Architect, do you plan to do) in the design in response to this question?	"To some extent - in terms of demo/salvage, we would analyze types of connections with the wood frame construction"	"Sit down with the client and figure out concerns", "Figure out how to work with the hired CM/GC", "How do we partner?"	"Knew CM/GC", "Ties in with dialogue with the contractor to include shoring etc.", "Design/Architect discussion over safety and cost"	"Remove structure to make it safer to build"
GENERAL KNOWLEDGE OF DESIGN FOR SAFETY CONCEPT					

1 5	Before proposing on the Project, had you heard of the concept of designing for construction worker safety and health?	Yes, and no, "To some extent - in terms of demo/salvage, we would analyze types of connections with the wood frame construction"	No, "Mostly OSHA/Contractor items", "Details for savvy low rate contractor"	Yes, "We've seen it on the job site, due to risk in site conditions"	No
1 6	If you had to define "designing for construction worker safety and health", what would your definition be?		"As planning, how do you construct for workers", "How do you protect workers and build this into planning and sequencing"	"Ties to collaboration with contractor", "Finding design solutions to challenges", "Materials are selected to prevent hazardous off gassing etc."	"Better understanding of building, as building is phased in", "Can only be done with the contractor", collaboration
1 7	In your formal education and training, was anything included on the topic of addressing construction worker safety and health in the design phase of a project?	No	No, "Safety training for architect: OSHA is more restrictive than code/UBC on ladder cages"	No, "No push to cover this"	No
1 7 a	If yes, what specifically was included (topics, tools, specific courses, conferences, lectures, etc)?		No Seminars, "OSHA in excess of building code: ex. Ladder Cages"	"Haven't heard of anything", "Not pushed by the industry"	"OSHA does consults for hard stuff, but unique." "We used OSHA for a recent building roof"
1 8	Are you aware of any other design firms that address construction worker safety and health in the design phase of a project?	No, "not typically-due to liability"	No	No	No, "means and methods"
1 9	Have you ever been asked to address construction worker safety and health in the design phase of a project?	Yes	No, but Yes for O&M issues for permanent facilities	No, "have addressed some health concerns with material selection"	Yes
1 9 a	If yes, did you? Why or why not?	"Some on Weatherford, and other renovation projects such as the Pioneer Court House."		"Some on health side, such as the materials selected", "Yes, the facilities side complains about dangerous materials."	"On recent building we brought in OSHA for O&M and construction., "On CM/GC or complicated design projects"

20	Have you had any discussions with contractors and/or owners during the design phase of a project that include: a.) the methods/practices employed by the contractor, and b.) the features to be included in the design to ensure construction worker safety and	Yes, and No, "limited to the CMGC process and negotiated contracts."	Yes	Yes, "We've had preconstruction conversations, which included roof tie-off points"	Yes
	If yes, what typically is the owner/contractor requesting, and what are their concerns?		Owner wants to review safety methods, "ex: asbestos removal sequence"	"We see interest in pre-construction conference", "Yes with roofs for maintenance, making safety then useful for the contractor"	"We did it on our own due diligence"
	If yes, how would you describe the experience in relation to your work – positive, negative, indifferent – and provide any related insights or lessons learned.		Consultation Services, "Will it OK with Structural Engineer?"		
21	Have you ever worked with or hired a construction safety and health consultant in the design phase of a project to address construction safety and health concerns?	No, "liability issues"	No	No	No
22	Have you heard of the United Kingdom's Construction (Design and Management) Regulations (a.k.a. "CDM Regulations"), passed into law in 1994?	No	No	No	No
CURRENT DESIGN PRACTICES					

2 3	Do you ever make design decisions in the design phase that improve construction worker safety and health? (This question does <u>not</u> refer to other design factors that may affect construction worker safety such as building codes, OSHA laws, etc.)	Sometimes	Never, "We design something and have a good idea it can be done."	Rarely, "mostly as a by product of owner's needs"	Never
2 4	Does your firm have a formal process to follow during design that allows for consideration of construction worker safety and health in project designs?	No		No	
2 5	What tools (checklists, design databases, use of safety consultants, etc.) do you use to address construction worker safety and health in the design phase?	None, "except for O&M"		Expertise of field agents "Contract Administrators"	
2 6	Are you aware of any other design tools that could be used to address construction worker safety and health in the design phase?	No		No, "structural engineers are in tune to deal with issues, we pass through to them."	
2 7	At what point in the design phase is construction worker safety and health addressed?	"Minimally in SD/DD, more in CDs"		"From DD on"	
2 8	What design modifications have you made in the design phase of a project that reduced safety and health risk to construction workers? Provide specific examples.	"Demolition, connections in wood frame construction, interior installation of windows."		"Maybe some structural issues"	
DESIGN FOR SAFETY IMPACTS/BARRIERS/LIMITATIONS					

29	What impact does designing for construction worker safety and health have on a project? (e.g., impacts to cost, quality, schedule, safety, productivity, etc.)		Maybe some, not sure	"Cost for constructability reasons is down", "Quality?", "Schedule is faster", "Productivity should go up"	Cost up, aesthetic down
30	What barriers or limitations do you see in addressing construction worker safety and health in project design?	"Liability insurance prohibits designer involvement in means and methods."	Liability, Contract structure	"More education and understanding", "We must not dictate to avoid means and methods", "Safety through design side and collaboration with out dictating worker safety"	"Lack of education tied to liability", "Aesthetics"
31	Do certain provisions of the building code affect construction worker safety and health?		No, they don't affect construction worker safety	No, they don't affect construction worker safety, "Improvements are due to OSHA"	"No, they don't affect construction worker safety", "only as a byproduct"
32	Do you believe that addressing construction worker safety and health in the design phase will increase your liability exposure?	Yes	Yes	No, "public safety"	Yes
33	Do you believe that not addressing construction worker safety and health in the design phase will increase your liability exposure?	No	No, "Should be clear division of responsibility", "State law says we can't be sued for means & methods unless we are negligent"	No, "None initially, but will probably will increase in the long run"	No
34	Do you believe that the traditional relationship between the designer and constructor precludes you in any way from formally addressing construction worker safety and health in the design phase?	Yes	No, "As long as we don't have to tell them how to do it"	No, "Design build often has less collaboration then CM/GC"	No, "We can still have collaboration, or should have"
35	What is your personal willingness to address construction worker safety and health in the design phase?	"Limited because that is not our area of expertise - that is the contractor's expertise"	Rare, but maybe subconsciously	Yes, "Better understanding, how to do that", Education needed	"Curious to learn more"

3 6	Prior to today, have you ever been asked your opinion about addressing construction worker safety and health during the design phase of a project?	No	No	No	No
3 7	Do you feel comfortable talking about construction worker safety and health issues in general? Why or why not?	No, "not our area of expertise and liability issues"	Yes, "Don't have knowledge of regulations, but we are seeing more protection now"	Yes, "I find it interesting"	Yes, "We had granite treads on a recent project that were very heavy to install and we solved safety challenges with the CM/GC"
3 8	What priority do you place on the following criteria when designing a project? Please rank the criteria with 1 being the highest priority, 2 the second highest priority, and so forth.				
	Quality of the work	1	1	3	4
	Project Cost	2	1	4	1
	Project Schedule	5	5	5	1
	Aesthetics	4	1	1	1
	Facility occupant safety and health	3	1	2	5
	Construction worker safety and health	6	6	6	6
	Program adherence	3			
	Best value per cost	2			
	Client			0	
	Sustainability	5			
	Please review the design for safety suggestions listed below and describe the prevalence and feasibility of implementing the designs on a project from the standpoints of cost, quality, productivity, scheduling, project administration, contractual, and ind				
EXAMPLE DESIGN SUGGESTIONS					
<u>Contract Drawings</u>					

39	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.	"We rely on the survey provided by the owner"	"Try to show everything on the locates"	"Note locations of existing utilities", "Mark a clear zone if code required", "Usually notes the source of information on drawings", "Would not note level of certainty"	"No clear zone", "Surveyor's survey is under his own stamp", "Yes on locates"
40	2. Review the condition and integrity of the existing structure and indicate any known hazards or deficiencies on the contract drawings.	"Already to this to a great extent"	"Yes, if structural integrity or hazardous materials (asbestos), but include disclaimer"	"Yes, would note, it is a judgment call especially if there is a major risk", Describe testing and major risks	"Yes in scope, due diligence", "part of design solution"
41	3. Provide or require the constructor to submit a construction sequence for complicated or unique designs.	"Already do this to some extent, but we do not want to have any responsibility for how they want to sequence the work.", "Tell contractor to hire their own engineer for shoring, bracing, sequencing, we don't request a submittal to keep responsibility clear"	"No, means & methods issues, assume it's OK if engineering effort", "Haven't verified submittals of licensed structural engineer."	Not usually, but "yes, if it is a historic building, or partial occupation was planned", "Would review them like show drawings"	"Information only, not stamped/submittal process"
Interview Results					
42	4. Maintain a minimum clearance between the project and existing overhead power lines.	Yes	"Willing to note line was there, not what clearance is"	"Just note overhead, not clearance"	"Show only lines, clearance not marked"
43	5. Provide electrical/instrumentation system enclosures which are adequate for the expected environmental/climate conditions.	Yes, "Code"	Yes	Yes	Yes, code requires it

4 4	6. Provide a clear, unobstructed, spacious work area around all permanent mechanical equipment.	Yes, "Code"	Yes, "accounted for, but not for construction safety."	Yes, "code requires this", "owner drives as much as 6' around mechanical equip."	No, "Means and methods", "However, always provided for O&M"
<u>Fall Protection</u>					
4 5	7. Design window sills to be 42 inches minimum above the floor level. Window sills at this height will act as guardrails during construction.	"Performs terribly for day lighting, so 6mo. Vs. 50yrs. We design for the end user."	No, "Just put in 2X4, will not limit owner"	No, "aesthetics"	"No, aesthetics take precedent"
4 6	8. Design columns with holes at 21 and 42 inches above the floor level to provide support locations for lifelines and guardrails.	"No, unless directed", "Figure design safety factor covers this item", "Contractor's responsibility to check"	"Sure, would work with contractor"	"Yes, if asked"	Yes
4 7	9. Design perimeter beams and beams above floor openings to support lifelines (minimum dead load of 5400 lbs. which is the design load for lifelines and lanyards as required by OSHA). Design connection points along the beams for the lifelines. Note	"Challenge for design team to do.", "Architect is not covered by insurance, so the owner is liable."	Yes, "We would be willing to work with the contractor but would need \$\$\$", "Not willing to note on plans, safety depends on how far structure is along (M&M)."	Yes, "with coordination with the structural engineer"	"Yes, as long as doesn't increase cost"
4 8	10. 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.		No	No, "aesthetics"	No
4 9	11. Provide a guardrail along the perimeter of a tank roof.	"Yes for OSHA, O&M, or owner request"	No, "Only for maintenance"	Not usually, "would depend on frequency of maintenance access"	No, "only for O&M"

50	12. Design special attachments or holes in members at elevated work areas to provide permanent, stable connections for supports, lifelines, guardrails, and scaffolding.	"Yes, if for maintenance", "We have a firm that specializes in this"	No, "Only for maintenance", "Depends on aesthetic"	Yes, "if benefits owner (saving costs and faster production)"	Yes
<u>Skylights</u>					
51	13. Provide permanent guardrails around skylights.	"Not required by code, unless owner requests."	"Depends on appearance, you can walk on them now", tempered glass is strong	"Not needed & skylights are obvious hazards"	No
52	14. Design domed, rather than flat, skylights with shatterproof glass or adds strengthening wires.	"No, codes require laminated glass, which is very strong and reinforced mullions, the code is worried about the glass falling out in a seismic event (public safety hazard)."	"All skylights are tempered glass"	No	No
<u>Ladders / Stairways</u>					
53	15. Use consistent tread and riser dimensions throughout a stairway run and the project.	"Should be done in all cases"	"No, just to meet code"	Yes, "right now we do this for design simplicity"	"Do anyway"
54	16. Provide access by means of a ladder or stairway when there is a change in elevation of greater than 19 inches.	Yes	"Yes in building, on roof we want a route for maintenance"	"Only if code required, or owner requested"	"Yes, especially for maintenance"
<u>Other Safety and Health Considerations</u>					

5 5	17. Before demolishing and renovating any structure, ensure that an engineering survey is performed by a competent person to determine the condition of the structure, evaluate the possibility of unplanned collapse, and plan for potential hazards.	Yes, "Structural engineer is involved, the existing condition needs to be understood or abated."	"Could see requiring stamped one, but not reviewing it (Not a submittal)"	"Yes, it is mandatory and depends on the scope of the project"	Yes
5 6	18. Provide permanent emergency showers and eyewash basins in areas where construction personnel might come in contact with highly toxic or poisonous materials.	No, "M&M"	"No, only for maintenance"	"No, only if code required, or owner requested."	No, "contractor's problem"
5 7	19. Provide adequate permanent illumination on projects to allow for construction work at night.	No, "M&M"	"No, only for work for a quality manner"	"Not normally"	No, "would add to lifetime cost"
5 8	20. 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.	No, "M&M" or "sequencing"	"No, contractor's sequencing issue"	"No, contractor's risk"	No, "contractor's sequencing issue"
5 9	21. Require concrete test results to be verified before removal of the forms and shoring.	"Special inspections by owner", "We only review"	"Interested in ultimate strength, not prior to stripping strength"	"Yes, we should be required to verify testing results, now we provide observation services; the 3rd party tester is relied upon."	No, "special inspector's responsibility", "We observe", "We recommend owner to require testing prior to removal."
6 0	22. Require regularly scheduled site housekeeping to ensure a neat, clean work area.	No, "M&M"	"No, but discussed with GC's rep."	Yes, "but only observational"	No, "keep quite, it is not your site", "no pictures"