

ROLE OF DESIGNERS IN CONSTRUCTION WORKER SAFETY

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ABSTRACT: In the development of a project, a significant role is played initially by the designer of the project and then by the constructor of the project. Construction worker safety has often been regarded the sole responsibility of the construction contractor. Despite the obvious reasons for placing the primary responsibility on the contractor, the safety performance on a project may well be dictated to a large extent by decisions made by the designer. To investigate this issue of whether designers were sensitive to the safety of construction workers, a survey of major U.S. design firms was conducted assessing the extent to which design decisions are made with specific consideration being given to the safety of construction workers. Of the respondents, only one-third stated that they made design decisions with the specific intent of improving safety conditions for construction workers. Specific illustrations of such design decisions are given in the paper. The fear of increased litigation is the biggest deterrent to addressing construction worker safety in design decisions. A rationale is developed in the paper for supporting the thesis that designers should consider worker safety in their designs. Suggestions are offered on how construction worker safety might be addressed by more designers.

INTRODUCTION

In simplified terms, the principal parties involved in the development of constructed projects are owners, designers, and constructors. Once an owner recognizes the need for a project and deems it economically feasible and practical, the services of a designer are obtained. The designer considers the owner's ultimate needs concerning the project and sets out to complete the design. The constructor is then required to bridge the gap between the finished design and the finished project, ready for the owner's use. Each of these parties plays an important and unique role in the process of project delivery.

One aspect of the construction phase that has been under persistent scrutiny for many years is the issue of construction worker safety. The Occupational Safety and Health Act (OSHA) of 1970 with its numerous regulations has had a profound impact on the construction industry. Although statistics may reveal declines in the number of construction worker injuries and fatalities, the numbers are still staggering. According to the latest figures published by the National Safety Council, over 2,000 construction workers die as a result of work-related injuries sustained each year, and over 200,000 construction workers receive disabling injuries each year (*Accident* 1991).

It has been postulated that the problem of construction worker safety may lie in the way the construction industry appears to view responsibility for safety. For the most part this responsibility has traditionally rested almost entirely with the constructor. The OSHA specifically states that the em-

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employers are responsible for providing their workers with a safe place in which to work. No mention is made of designers or owners. What is their role? Specifically, what is the role of designers on the issue of construction worker safety? Should, or can, designs be developed in such a way that the safety of the construction worker becomes one of the designer's objectives?

RESEARCH METHODOLOGY

A study was conducted to determine the extent to which designers recognize the need to address construction worker safety in their plans. Since the OSHA Act does not place any responsibility on designers, any efforts on their part to address construction worker safety are elective and voluntary. Since the design of a project may be altered after a constructability review, it was also of interest to determine the degree to which constructability reviews were conducted with the intent of improving the safety of the project during construction. Because designs and constructability reviews are generally performed by different parties, two different research instruments were developed. One questionnaire was directed to designers and the other to firms conducting constructability reviews.

The surveys that were developed were quite simple in format. The survey for designers included questions requesting information on the number of employees; the number, type, and size of projects undertaken; the total annual volume of work performed and so forth. Then a specific question was asked, "Does your firm make design decisions that impact construction worker safety?" If the response was in the affirmative, the respondent was asked to provide examples "where construction worker safety was specifically addressed by project design."

A similar questionnaire survey was developed for firms conducting constructability reviews. The background information elicited about the firm was similar to the questions asked of designers. They were then asked, "Do safety personnel participate in constructability reviews in any capacity?" If the response was affirmative, the respondent was asked to elaborate on this participation. Another question was, "Has your firm suggested safety constructability changes to a project design? and, if answered affirmatively, this was followed by "Were those suggestions incorporated into the final design? Examples of design changes that could make projects safer for the construction workers were then sought.

To conduct the study, designers and/or firms who perform constructability reviews had to be identified. This was done by selecting firms listed in the *Constructor*, *ENR*, and *The Military Engineer*. Design firms selected for this study were those with at least 35 employees. Constructors included in the survey were those engaged primarily in commercial and industrial building construction and employing at least 100 workers. Firms of any size and known to be specializing in constructability reviews were included in this study. Firms specializing in design/build services were also included in the study and received both types of surveys (design and constructability review). Designer questionnaires were sent to 82 design firms and 12 design/build firms. Constructability review questionnaires were sent to 86 construction firms and 12 design/build firms.

RESULTS

Of the 192 questionnaires mailed out, 35 were returned with responses. Questionnaires for designers were returned by 22 design firms and one

design/build firm; and questionnaires for constructors (constructability reviews) were returned by 10 constructors and two design/build firms. The cumulative annual dollar volumes, computed in terms of total project construction costs, were \$14.6 billion for the design firms and \$2.6 billion for the constructors. With the combined volume totaling \$17.2 billion, the respondents have a responsibility for a significant amount of the projects constructed in the United States.

RESPONSES OF DESIGN FIRMS

The design survey respondents employed a total of 16,380 workers and were responsible for 2660 projects valued at \$14.6 billion in one year. Approximately 40% of the projects were designed for public owners, including federal, state, and local governments. All types of projects were undertaken by the design respondents, including commercial, residential, industrial, engineering, and health care facilities. Of the 23 designer respondents, 20 conducted in-house constructability reviews. Respondents indicated that these constructability reviews were conducted primarily by design professionals, with some reviews being conducted solely by or with the assistance of construction management personnel and/or a field supervisor.

Three of the 20 firms conducting constructability reviews involved safety personnel in these reviews. These three were among the largest design firms that responded to the survey, with a combined annual volume exceeding \$7 billion. The role of the safety personnel in the constructability reviews was described as that of industrial hygienists reviewing health and safety plans for hazardous-waste construction projects and reviewing the design to allow or permit constructor compliance with the Occupational Safety and Health Administration safety regulations. One respondent stated that design problems relating to worker safety were corrected in the field, and this information was then communicated to the main officer to prevent repeat occurrences. Of the five largest design firms responding, two stated that they did not address construction worker safety in their designs and did not have safety personnel involved in the design review.

Of the 23 responding design firms, seven stated that they made design decisions specifically with the intent of improving construction worker safety. Some examples of these types of decisions are as follows.

- Design trenches at minimum feasible depths
- Detail methods to be used in trenches
- Avoid high fill and embankment heights
- Specify temporary decking to be installed as soon as possible to prevent injury from falling
- Substitute hazardous materials with less hazardous materials for chemical cleaning, paints, and castings
- Specify natural gas to be purged from manholes
- Detail the methods for polychlorinated biphenyl (PCB) removal
- Specify rigging procedures and crane placement for larger lifts
- Design trench requirements to match shoring systems
- Consider noise emissions from installed equipment
- Use three-dimensional computer-assisted design (CAD) programs to plan safe work sequencing and to identify and mediate hazards before construction begins
- Conduct a hazard assessment for construction during design

- Valve stems and motor operators on valves are examined during design to determine if they will protrude into walkway areas, and are rotated so as to provide safe passage on stairs and platforms
- Permanent stairways and walkways are designed to be constructed first, so that the use of temporary scaffolding is minimized
- Permanent stairs and walkways are designed as integral components of piping and structural steel assemblies
- Design permanent stairs to be constructed first, and verify that all component assemblies are modified suitably to accommodate the required access for installation with the stairs in place.

It is evident from respondents' comments that some design firms continue to assess the design with reference to worker safety even while a project is under construction. For example, according to one respondent the loading of a structure was monitored during construction to avoid any catastrophic occurrences. Another stated that suggestions regarding worker safety and health were continually received during construction and that this information was assimilated into future designs.

It should be noted that 16 design firms (70% of the respondents) did not address construction worker safety and health in their designs. One respondent maintained it was "an architectural firm [that] rarely gets involved in the design of safety issues" and as such did not address safety violations of the constructors. Another respondent, responsible for more than \$1 billion of construction per year, declared, "We do not make decisions that pertain to construction worker safety. We are a structural firm and as such are responsible only for the final product. The method and means of construction are the responsibility of the contractor. This may appear to be a hard and narrow perspective, but it is forced upon us by lawyers. Should we get involved with worker safety, then we would be liable and could fall victim to litigation every time a worker is hurt." Another large design firm acknowledged the inherent risks in its structures under construction but added that addressing these risks "is left to the contractor."

RESPONSES OF CONTRACTORS

Twelve firms provided "contractor" responses, including the two received from design/build firms. These 12 firms had over 16,000 employees, and annually had a cumulative responsibility for 350 projects, valued at \$2.5 billion. Forty percent of the projects were executed for public owners, and included diverse types of projects. Of the 12 respondents, nine conducted constructability reviews. In-house construction management personnel were used in these reviews. Five respondents stated that the services of in-house design personnel were used; and six respondents also used the services of field supervisors. One respondent stated that consultants were occasionally used for constructability reviews. Lastly, two respondents included the participation of safety personnel in the constructability review process. The primary role of safety personnel was to ensure compliance with the Occupational Safety and Health Administration regulations and to help in the design of the methods to be used during the construction process.

Eight of 12 respondents felt that design professionals never, or only rarely, consider construction worker safety in their designs. Five respondents had previously suggested safety constructability changes for projects resulting in all such suggestions being incorporated in the final design. Specific examples of such suggestions are as follows.

- A permanent stairway was designed and located in such a manner that it could be installed at the beginning of the construction process
- The release of metal decking was sequenced so that it could be used in lieu of temporary plywood decking
- Overhead power transmission lines were buried off-site to allow safe access and working areas for cranes
- Overhead power lines that could interfere with crane operations were relocated
- Underground facilities were relocated to allow sloping of excavations where possible
- Cut and cover was designed instead of a tunnel
- Satisfactory results of concrete cylinder tests were required prior to the removal of the forming and/or floor jacks
- Helped the designer select the appropriate locations, for safety purposes, of column connections to ensure that they were not at or below the floor line (best at chest height for accessibility)
- Designed all steel connections so that they could be easily reached by construction workers
- Tried to design the welding locations at easily accessed points

Respondents also gave examples of other possible design modifications that designers might consider for improving construction worker safety, as follows.

- Design higher parapet walls or an integrated guardrail system along all roof edges
- Design multistory buildings so the exterior wall covering (precast panels, etc.) can be installed as soon as the framework is in place and before most trades begin work on the floors
- Group the roof and floor penetrations so the number of openings is kept to a minimum
- Locate valves and fittings at safe and convenient locations where possible
- Lay out piping and mechanical systems so workers will have more than one exit, thus avoiding the need of passing through a hazardous area to escape
- Remove or relocate utilities to ensure a safe working area
- Enlarge the sizes of project sites to accommodate the required work in a shortened time frame or allow additional time to accomplish required work in congested sites
- Design a project so that it does not require sustained overtime
- Include permanent tabs for safety handrails on the structural drawings so that these items become an integral part of the shop fabrication process (saves on grinding steel, reduces welding in the field, and eliminates repainting)
- For modular construction assemblies built off-site, calculate the center of gravity and geometric center and design into the module the location of the lifting connections and rigging plan so that the modules are transported properly
- Avoid overhead power lines at the work site by relocating (under-

ground or rerouting) them, by altering the point of access to the work area, or by installing barrier cables

CONCLUSIONS

From the results, it was concluded that less than one- third of the design firms address construction worker safety in their designs, and less than one-half of the independent constructability reviews conducted address construction worker safety. Although the sample size of 35 obtained for this study may appear small, the respondents represent well over 5% of all the non-residential construction projects completed each year in the United States.

It is apparent that few design firms regard the safety of construction workers as being within their scope of responsibility. On the other hand, those few respondents who do regard this topic as being their responsibility provide some cause for optimism. Since some design firms address construction worker safety when designing projects, there is good reason to believe that more, if not all, design firms can or will eventually consider construction worker safety as part of the design process.

Designers must be responsive to their clients. To date, most designs have been undertaken with the end users of facilities in mind. With the trend in recent liability suits to include project owners in the litigation, owners may begin to insist that the designers consider not only the users of a facility after project completion, but to also consider the facility users as the project is being constructed, namely the construction workers. Evidence is clear that construction worker safety can be addressed during the design stage.

Partnering will naturally integrate safety and design. This is occurring on individual projects whose owners take the initiative to change the conventional adversarial roles of the contracting parties.

The past 20 years have shown that the safety of construction workers cannot be guaranteed by legislation alone. The commitment to worker safety has to extend beyond legislation and beyond the constructor. Designers can play a strong role in reducing the incidence of injuries and fatalities among construction workers; they should accept this responsibility with a heartfelt commitment to provide in each design a safer workplace for the construction workers. Many construction workers have been severely injured and killed on construction projects, a dear price to pay for the opportunity to work in the construction industry. For owners, these losses have ultimately resulted in higher costs of construction. Have some designers, in failing to address construction worker safety, contributed to these losses? Is this what the owners wanted? Clearly, this is not an added cost for which the owners want to pay. Thus, in serving their clients' fullest interest, designers should address construction worker safety in their designs.

RECOMMENDATIONS

An essential recommendation that is a direct outgrowth of the foregoing conclusion is to seek a means for sensitizing designers and those firms conducting constructability reviews to the need of providing for construction worker safety. Ideally, this should occur voluntarily, without legislative intervention. The safety and health of all human beings, be they the ultimate occupants of completed projects or the workers constructing the facility, should be of concern to design professionals and constructors alike. Safety is not an issue simply to be left to the constructor. Decisions of the designers have a direct impact on construction worker safety; therefore, it would be

naive to suggest that designers have no role in construction safety. The issue would be best solved if legislation and litigation were not key ingredients in this solution.

For safety of construction workers to be addressed by designers on a regular basis or as an integral design function on all projects, a dramatic change must occur in the mind-set of the design profession.

One of the means by which designers can become more responsive to the safety needs of construction workers is through education. Designers must be made aware of the various means by which their design decisions impact the job-site safety conditions for construction workers. Such an educational process could begin with a compilation of the various design approaches that have successfully addressed construction worker safety on past projects. Since few companies seem to regard matters of safety as being proprietary, there should be little reluctance among various designers and constructors to provide this type of information. The important step to this educational process is to have a central clearinghouse for this type of information. In addition, there must be a commitment of funds to maintain such a library of information and to disseminate the information to the design community.

Various existing groups or associations of firms have the ability to provide the necessary support to maintain a clearinghouse of information on safety constructability. The Construction Industry Institute (CII) would be a good resource for this type of effort since this group consists of both contractor and owner members. Although not a serious shortcoming, CII members tend to be large firms, and heavily oriented toward industrial construction. The National Constructors Association (NCA) is made up of several large construction firms and design/build firms who could contribute in a meaningful manner to collect information on safety constructability. The NCA is smaller in membership than the CII, but like the CII its members consist primarily of firms involved in industrial construction projects. Assistance may also be sought from the leaders of the building trades. Safety is in the best interest of the building trades and their support should be forthcoming with little difficulty.

While the forgoing suggestions have largely focused on how design/build firms can be linked through a common forum, the more difficult task will be to obtain the interest and commitment of architects and engineers (A/E)s. A/E)s are not conveniently linked to the construction industry. As a result, the design of many traditional projects takes place with little regard to the problems to be resolved during construction, much less those related to the safety of construction workers. As a result, this step of integrating A/E)s in safety constructability will require considerable effort.

Other groups may also prove to be valuable participants in an effort to synthesize a great deal of design information on construction worker safety. Such groups include the Associated Builders and Contractors, the Associated General Contractors, the American Subcontractors Association, the National Utility Contractors Association, the Construction Specifications Institute, the Specialty Contractors Association, the National Electrical Contractors Association, and a variety of other construction associations.

Because of the fragmentation that exists in the construction industry, some creativity may be required in the overall task of getting designers to be more sensitive to the safety needs of construction workers. First, information must be tapped from those already addressing construction worker safety in their designs. Second, the information must be disseminated to

those who currently do not consider this to be a legitimate concern or who do not know how to properly address construction safety in their designs.

The role of owners cannot be overemphasized. Owners must first be educated about the reality that designer decisions do impact construction worker safety. Owners are aware of the increased potential of their liability for construction worker injuries. Informed owners should generally come to the natural conclusion that designers should be sensitive to construction worker safety. If design firms are selected on the basis of their responsiveness to the needs of owners, owners need only communicate their requirements that construction worker safety be addressed by designers. This will result in fewer injuries sustained by construction workers and fewer lawsuits for owners.

APPENDIX. REFERENCES

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