Expert Commentary

Construction Injury Prevention through Design

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Injury prevention usually falls in the safety arena. It becomes the responsibility of operational and safety personnel to try to identify risk, hazards, and exposures to the workforce. We know that the most effective way to deal with risk is to eliminate it. But in most cases, this is very difficult to achieve, so the best management can accomplish is to minimize its impact on the workforce while they are engaged in performing the tasks required of them.

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In a broader sense more people are exposed to risk when working in or using facilities. We have addressed workers working in facilities and worker building the facilities, but there is also the public that visits facilities and those who maintain these facilities. These folks also encounter risks and may get injured.

Building Codes

What are the means for protecting these four groups of people? Different codes and standards exist to ensure that people can enter, conduct business, work, and exit these facilities safely even in emergency situations. The building and life safety codes ensure that people in buildings are able to use and work in buildings that are healthful and are able to exit them in emergency situations. Design professionals are required to ensure that these standards are utilized in the design of structures, and the plans produced by these professionals are checked by building officials and fire marshals to ensure compliance. These same officials inspect the finished structure to ensure that it was built according to the approved plans and specifications.

The safety and health of workers working in facilities is governed by the OSHA General Industry (1910) Standards. These standards define minimum levels of safety that the employer is obligated to provide. These standards not only look at the physical conditions, but also at work practices, and obligate the employer to provide training and protective equipment so that workers may perform their tasks free from injury. This would apply to both the workers working in the facilities as well as those that maintain it. The safety of the construction workers is covered by another part of the

OSHA (1926) safety standards. These standards cover the protection of the construction workers from harm while they go about building the facility.

This article addresses the building process and the risks faced by construction workers engaged in building structures. The safety of the construction workers is viewed as the responsibility of the employer (the contactor). Research over the past quarter century has shown that a substantial number of worksite accidents have their root in decisions made before any construction work starts. These studies have, to some extent, focused on the design decisions made during the design process which create risks the contractors and construction workers have to deal with during the building process. Many of the solutions proposed by these researchers focused on what the design professional can or should do to mitigate these risks.

The complexity of the situation requires a holistic approach to identify and eliminate, where possible, the risk in the workplace. If elimination is not entirely possible, then the reduction of the impact of these risks should be addressed so that they are reduced to an acceptable level. To this end, we need to look at the process from inception (the decision by the owner that some sort of facility is needed) through the completion of the construction process. From this perspective, the key participants of the process are the facility owner (owner), the design team (architects and engineers—designers), and the constructor team (contractor, subcontractors, and construction managers, where applicable). To some extent, every decision made in this process ends up affecting the risks that the construction worker, in some way or another, has to deal with in the building process.

The Owner

The process starts with the owner, who has the greatest influence and control over it. So the decisions made at project inception should be carefully reviewed and analyzed for their potential influence on the design and construction process and the resultant risks they create. The owner decides what is needed and establishes a budget and time line for it based on financial and business considerations. The owner selects and procures the site. The owner selects the key participants (designers and contractors) in the process. And, to some extent, the role the owner plays during the development for the design ultimately has an impact on the cumulative project risk faced by the employees of the constructor team.

The initial decisions by the project owner can influence the quantity and quality of the risks eventually faced by the construction workers. Also, these decisions quite possibly create barriers to elimination strategies that may be considered downstream. The type of facility planned, its operational requirements, the physical attributes of the site acquired, where it is located, etc., all

have associated risks that flow downstream. There also are the financial and business considerations that may dictate certain project duration and completion requirements that will necessitate accelerated schedules of operational plans by the contractor creating its own body of risks.

The selection of the design team by the owner also influences the risk picture. The determination of the designer's expertise or experience in designing the project with sensitivity to construction risk in important. The scope of services, the negotiated fee, the establishment of the time available for design, and the owner's sophistication all impact the risk picture as well. The owner's involvement in the process and the extent to which the owner oversees the development of the design and the construction process also has an effect on the end results. The quality of the owner's staff involved in the process plays a role too.

The designers, contractors, and safety professionals selected by the owner can play a critical role at the inception of the project by providing the owner with input on the "safety" consequences of decisions. They may also assist in the selection of design solutions and materials, as well as address means and methods, which will either eliminate the resultant "system" risks or lower their impact to an acceptable level.

Fast-track construction is the norm rather than exception these days. In situations where accelerated schedules are a contract requirement and competitive bidding is the project delivery method, a greater quantity of risk is introduced into the system and more than likely increases the likelihood of incidents occurring. Given the required accelerated production schedule, the contractor may not be able to eliminate the imposed risks. And the aggressive pricing may limit resources available for instituting some of the mitigating interventions so as to diminish the impact of the identified risks which the construction worker will have to deal with.

The Design Team

From the purely architectural sense, prevention through design is a methodology applied to the various phases of the design process for the identification and mitigation of risks and hazards that will be encountered by construction workers during the building of the facility. This involves systematically incorporating hazard identification, analysis, and mitigation steps during the design phases of construction or renovation drawings and specifications. To accomplish this, one has to visualize the physical hazards and the exposure to the construction workers to conceptual design solutions.

Architects and engineers are used to referring to standard such as ASTM, NFPA, etc., in their specifications. So it would seem natural to refer to the OSHA 1926 standards when it comes to safety. Unfortunately, following the standards does not guarantee an injury-free worksite. Let us review some of the fall protection requirements in the standard.

Trade	Fall Exposure Requiring Protection	OSHA 1926 Standard
Most trades	6 feet	Subpart M
Scaffold erectors	10 feet	Subpart L
Metal deck welders	>15 feet	Subpart R, etc.
Steel connectors	>30 feet	Subpart R

So, following these standards, especially for steel erection, will result in considerable risk to workers on a construction site. To provide an injury-free work environment, the contractor should go beyond these minimum standards, and the designer cannot use them to that end.

Designer's Challenge

The designer's challenge at this conceptual phase of the design is to identify risks and potential physical hazards to construction operations from the design requirements. This may require contractor input as to the means and methods anticipated. Here, many researchers have suggested building parapet walls that are 42" high so as to eliminate the fall exposure for workers working on the roof of facilities. Assuming this does not have an adverse effect on other requirements or the design, it may be a good suggestion. But there are other situations where solutions are not as obvious or straightforward.

Let's consider the building's structural frame. It can either be steel or concrete, each having its own unique hazards and risks. There are some fundamental reasons for selecting one over the other where the fall exposure may not be a deciding factor. Given that one or the other frame will be selected, then the challenge is to come up with a design and construction operational solution that will reduce the hazard to the workers engaged in the erection of any structural frame selected.

The building envelope has its own challenges, as does the foundations, basements, materials, finishes—to name a few. There are other considerations that will make the job safer for construction workers. When placing equipment, it's preferable that it be installed while the worker is standing on the "ground" rather than in an elevated position. Allowing enough space/room so that workers can make the installation in a safe manner is another consideration, as is creating a design that will lend itself to prefabrication, modularization, or "make-ready" to minimize the exposure time. Creating

design solutions that are inherently safe to install is the goal. Reviewing the constructability of details, all of which will reduce the risks faced by construction workers, takes time, but making changes during construction tends to be more time consuming and expensive than addressing issues during design.

Understanding and appreciating the risks faced by contractors and their workers probably necessitates an exchange of information and ideas between the designers and the constructors. The design team will require some education in construction means and methods required to execute the design in the field. They will have to gain an understanding of how to use their design tools to identify risks and hazards (Building Information Modeling (BIM), etc.). Then, with the assistance of contractors and safety consultants, identify additional risks and hazards and come up with mitigating solutions that will meet the design requirements and intent as well as create a safer work environment for the construction worker. Designing for safety also encompasses communicating to the contractor the remaining risks and hazards that could not be eliminated during design so that the contractor may plan for appropriate controls to reduce their impact in the field.

There are a number of aspects to the implementation of the prevention though design concept. Architects and engineers, as well as other consultants, are reluctant to address construction worker safety as part of their standard practice. The design professionals' codes of ethics, such as the code established by the American Institute of Architects (AIA) dated 2004, as well as others set ethical priorities for ensuring final occupant safety and safety of the finished facility, but do not address the safety of the workers during construction. These professionals are also likely to avoid addressing worker safety out of fear that doing so will open them to legal action by injured construction workers. And there generally are no legal, contractual, or regulatory requirements to incorporate safety in design. Should a design professional want to engage in designing for safety, he or she will find it difficult to find insurance coverage. Risk transfer products are not readily available in the marketplace at the moment.

Conclusion

There is no question that safety can only be effective if the organization approaches it holistically. The creation of a safe work environment on a construction site requires a team effort in identifying, evaluating, and managing the risks that flow to the worksite. All the participants—owners, designers, contractors, and safety professionals—must cooperate and contribute to achieve this lofty goal. The owner plays a crucial role in orchestrating and managing the process, ensuring cooperation between the design team and the contractor team. Paying close attention to the risks associated with the owner's requirements and the design of the facility are critically important.

The second part of this article on the role of the construction and safety teams will be published next month.

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