Strategic Education Initiatives to Implement Prevention through Design (PtD) in Construction

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Persistent high rates of injuries, illnesses, and fatalities for construction workers, though unacceptable, are frequently attributed to the hazardous nature of work in this sector. While factors such as training, safety culture, and safe work practices and equipment can impact the safety of construction sites, their focus is often on improving hazard awareness and minimizing risk of harm. A strategy for eliminating hazards involves advanced planning, utilizing design considerations and engineering solutions for prevention. The concept of designing for safety is not new, and within the construction industry there is potential to expand its application using existing solutions and promoting the development of new ones. To accomplish this, proponents of designing for construction safety, and the broader concept of Prevention through Design (PtD) seek to improve awareness of opportunities to implement design solutions and increase the dialog about safety and health issues among all parties involved with construction projects. A significant component of the PtD National initiative, developed by the National Institute for Occupational Safety and Health and promoted through the National Occupational Research Agenda, involves educating the broad construction audience about PtD. Examples of implementation are described, along with efforts to expand education about PtD and increase partnership involvement.

Key Words: Construction, Design, Education, Hazards, Prevention through Design (PtD)

Introduction

While the concept of designing for construction safety is not new, recent developments have prompted growing interest and increased efforts to explore the potential impact of this strategy for promoting occupational safety and health in the construction industry. Among the pioneers in this effort, the National Safety Council Institute for Safety Through Design established in 1995 sought to advance workplace safety and health in its core mission: To reduce the risk of injury, illness, and environmental damage by integrating decisions affecting safety and health, and the environment in all stages of the design process (Christenson and Manuele, 1999). Within that mission statement are elements of issues that remain relevant and timely – sustainability, occupational safety and health, and the influence of design. Another noteworthy development in efforts to explore and promote discussion about this topic occurred in September 2003, with the convening of a symposium entitled *Designing for Safety and Health in Construction.* That event represented a "broad collaboration involving scholars and practitioners; the multiple disciplines involved in construction, design, and workplace safety and health; and different countries and continents (Hecker, Gambatese, Weinstein, 2004)."

By way of this introduction, the intent is not to provide a history of all significant events which lead to the current emphasis on designing for construction safety. Rather, it is to acknowledge that the interest in and knowledge of the role of design for workplace safety and health predate efforts and activities today. This paper will focus on discussion of current activities, in particular education initiatives aimed at promoting the elimination of hazards at the planning and design stages. Two specific initiatives will be described here: the Prevention through Design (PtD)

National initiative, developed by the National Institute for Occupational Safety and Health and promoted through the National Occupational Research Agenda (NORA); and the NORA Construction Hazards Prevention through Design (CHPtD) objectives. Although these efforts are harmonized, the former has a scope which encompasses all industry sectors and work practices, while the latter is more focused on unique characteristics of the construction industry.

It should also be noted that many of the concepts and objectives related to PtD and CHPtD are not exclusive to these programs; rather they may include elements which have evolved either as a continuation of earlier efforts or objectives being pursued in concert with other groups based on a common recognition of their importance.

Description of the Problem

The construction industry employs approximately seven percent of the workforce, yet accounts for 22.6% of all work related fatalities in the United States (Bureau of Labor Statistics, 2004; NIOSH, 2004). Similar statistics have existed for years with minor variance. Due to this persistence of adverse outcomes and the challenge of hazards in the construction industry, the broadening search for solutions has led to the involvement of design engineers and architects to consider safety during the design process (Korman, 2001). These solutions have received growing research interest, and are generally referred to as construction hazards prevention through design (CHPtD) or designing for construction safety (DfCS). At the center of this effort is the belief that the ability to influence construction safety and health is greatest at the earliest phases of the project, as shown in Figure 1 (Szymberski, 1997).

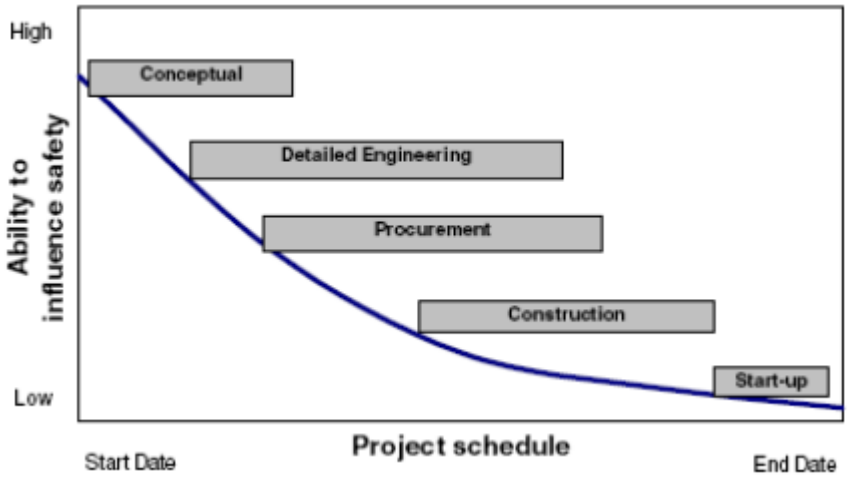

Figure 1. Time/safety influence curve (Szymberski, 1997).

The action or inactions made by engineering design and architects in the design phase of a project can affect construction worker safety and health in a negative or positive manner (Gambatese et al., 2005; Trethewy and Atkinson, 2003). Various studies have demonstrated injury surveillance (Hinze and Wiegand, 1992; Jeffrey and Douglas, 1996) and prioritized safety through design as a method to improve construction safety and health. Further studies identified the lack of including designing for safety as a causal influence in construction fatalities and injuries (Behm, 2005; Gibb et al., 2004). Behm (2005) found that 42% of construction fatalities were causally linked to the design process. Gibb et al. (2004) found that the causes in 50% of construction accidents were associated with decisions made in the design process.

The cause of an accident is complex and normally contains many contributing factors. In the construction industry, falls from elevation is one of the leading causes of worker fatalities. Attempts to reduce falls from elevation at construction sites have usually concentrated on personal fall protection systems with emphasis on their training and use, and changing work practices. All of these efforts from many construction organizations concentrated their efforts at on-site activities that relied on the ability of the construction organization to provide anchor points during

construction to attach their fall protection systems. These anchor points had to be determined by the construction company or designed or engineered during construction. Applying the concept of designing for safety would enable the project to have anchor points designed into the project at convenient locations. These anchor points would enable workers to attach their fall protection systems easily and safely during construction.

Previous research in Europe in the area of designing for safety has led many European countries to adopt legislation requiring architects and design engineers to implement design for construction safety (ILO, 1985; European Foundation for the Improvement of Living and Working Conditions, 1991). In the United States construction worker safety is solely the responsibility of construction firms and is reinforced by the Occupational Safety and Health Administration (OSHA) standards and contracts specifications.

A key component to reducing construction accidents through design and planning is the involvement of construction users and project owners. There are owners who recognize this possibility as an effective method to reduce accidents and accident producing situations, as evidenced when consideration is given to the life cycle system of a construction project from the conceptual phase to completion. Who influences the safety of construction workers? There is no single influence, as the safety of the worker is influenced by other workers, supervisors, contractors, subcontractors, owners, and designers. Recognizing this string of influences is essential for impacting construction safety, and includes involvement of designers and engineers. As a further incentive for considering the owner's role in construction safety, the Construction Industry Institute (CII 2003) examined the OSHA recordable injury rate (RIR) in a comparison of Design –Build and General Contract (Design – Bid – Build) projects. The results, presented in Figure 2, show that the RIR for General Contract Projects is nearly 2.5 times higher than the Design – Build projects where the owner's take a more active role in safety and health program planning and management.

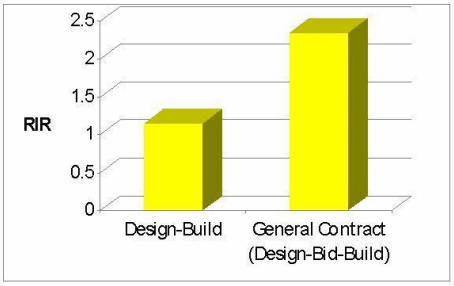

Figure 2. OSHA recordable injury rate (per 200,000 worker hours) for Design – Build and General Contract (Design – Bid – Build) projects (CII 2003).

Traditionally, safety was widely viewed as the responsibility of the contractor. Yet, the goal of zero injuries is not compatible with this view. Rather, the inclusion of owners, designers, and all parties involved in construction projects from planning to completion, is required to ensure that hazards are eliminated and workers are protected. As further justification, the time safety curve (Figure 1) indicates that integration of safety and health considerations during conceptual planning and detailed engineering can favorably influence safety in the design phase of a project. The objective at this stage of the project is to eliminate construction hazards by designing the project so that the construction hazard does not exist. One example of planning to avoid hazards involves structural design layout that affects erection and hoisting such that the sequence of erection could reduce exposure to falls when connections are made. Increased communication between designers, engineers, project owners, and construction project managers is essential for performing a safety constructability review during preliminary project phases.

Additional barriers associated with the acceptance and integration of safety by design concepts exist. Some of these are identified and discussed in the NORA CHPtD goals. To overcome these barriers, education can have a broad impact for informing designers, owners, and engineers about construction worker safety and how to develop and promote safe design solutions.

National Prevention through Design (PtD) Initiative

To catalyze and harmonize efforts to explore and promote the role of design in the broad field of occupational safety and health, NIOSH and its partners convened the first PtD Workshop in Washington, DC in July 2007. The intent was to launch a National Initiative aimed at eliminating occupational hazards and controlling risks to workers "at the source" or as early as possible in the life cycle of items or workplaces. PtD includes the design of work premises, structures, tools, plants, equipment, machinery, substances, work methods, and systems of work. The workshop attracted approximately 225 participants from diverse industry sectors and disciplines. Viewed as a collaborative endeavor, initial partners included the American Industrial Hygiene Association, the American Society of Safety Engineers, the Center to Protect Workers' Rights, Kaiser Permanente, Liberty Mutual, the National Safety Council, the Occupational Safety and Health Administration, ORC Worldwide, and the Regenstrief Center for Healthcare Engineering. Others have joined and continue to do so since.

The central tenet of this initiative is as follows:

> *Addressing occupational safety and health needs in the design process to prevent or minimize the work-related hazards and risks associated with the construction, manufacture, use, maintenance, and disposal of facilities, materials, and equipment* (NORA, 2008).

The approach to develop and implement the PtD National Initiatives framed by industry sector and within four functional areas: *Research, Education, Practice, and Policy*. Goals for each of these areas, and an additional focus area of small businesses, were established at a subsequent meeting of the NORA PtD Council in September 2008. The education goal for the National PtD Initiative is:

> *For designers, engineers, health and safety professionals, and business leaders to understand principles of PtD and apply knowledge in the design and re-design of facilities, processes, equipment, tools and organization of work (with 5 sub goals).*

A comprehensive description of the PtD initiative is documented in an issue of the *Journal of Safety Research* (Volume 39, Number 2, 2008) dedicated to proceedings of the 2007 PtD National Workshop.

NORA Construction Hazards Prevention Through Design Goals

The NORA Construction Sector Council was formed in 2006, and is comprised of invited stakeholders and subject matter experts from government, academia, industry groups, organized labor, and private consulting. During its initial face-to-face meetings, the Construction Sector Council identified priority topic areas through a series of discussions and multi-voting processes. Among the resulting topic areas identified, safety by design, later renamed Construction Hazards Prevention through Design (CHPtD) for harmonization and consistency with the broader PtD initiative, was determined to be a priority area for assessing research needs as well as the translation and dissemination of best practices for preventing hazards in construction through design and engineering solutions. A core CHPtD workgroup was formed from volunteers on the Sector Council with interest and experience in this topic area. Additional corresponding members were recruited through the Sector Council in February 2008.

To apply the concept of designing for safety to the construction industry the NORA Construction CHPtD workgroup was given the task of providing leadership to develop goals and priorities. The main idea was to utilize engineering strategies in the design phase of projects to reduce accident producing situations. This is to be accomplished by the formation of partnerships, coordination of efforts, and facilitating networking between the construction industry and associated groups of design organizations.

These activities were performed through a series of facilitated discussions, face-to-face meetings, and multiple teleconferences throughout a three-year period (2006-2008).

An overall strategic goal (Goal 13) was established for the CHPtD topic:

Strategic Goal 13 – Increase the use of "prevention through design (PtD)" approaches to prevent or reduce safety and health hazards in construction.
Performance Measure – Increase the use of CHPtD by 33% over the next 10 years.

The intermediate goals (IGs) and associated performance measures were established to support the strategic goal and describe specific research or research-to-practice (r2p) activities identified as priority activities for this topic area. The draft goals, first disseminated in February 2008, were later revised in July 2008 as they appear below.

IG 13.1 – Characterize the current use of CHPtD and coordinate efforts to promote its use. (5 subgoals)

Performance Measures: Provide a baseline report within 2 years describing key measures of current national use of CHPtD within construction, along with a repository of currently available materials, current construction organization activities and contacts, and current training. Use findings to inform and begin at least three promotion activities. Collect data from at least eight (8) design/construction firms and other organizations actively involved in this process. Compile cost comparison assessments and business case models to characterize costs of CHPtD approaches. Develop a repository for large and medium size AE firms which deal with electrical, mechanical, civil, and commercial projects. For target audiences (i.e., engineers, architects, construction managers, and safety and health professionals), develop the following training programs to disseminate the principles and benefits of CHPtD:

- Full semester undergraduate course
- One week modules which can be incorporated into existing college courses 8-hour continuing education course.

IG 13.2 – Confirm the most prevalent obstacles to acceptance and implementation of CHPtD: *(3 sub goals)*

- fear of liability;
- lack of expertise in safety and in designing for safety; and,
- increased costs associated with CHPtD.

Performance Measures: Conduct a survey or other quantitative research method of owners, AEs and professional liability insurance carriers to empirically confirm the factors hindering their adoption of PtD processes.

IG 13.3 – Develop tangible products and methods to address identified CHPtD obstacles and challenges. (*11 sub goals)*

Performance Measures: Develop tools, policies, sources of information, training courses and other formal mechanisms as described in the following goals to circumvent barriers to the acceptance and implementation of CHPtD.

IG 13.4 - Expand the use and evaluation of CHPtD practices. *(5 sub goals)*

IG 13.5 - Develop incentives for architects and engineers to include the following in facility design plans and specifications:

- Methods for safer project erection
- Methods for safe operation
- Methods for safe service and maintenance
- Methods for safety of the public

Within each of these intermediate goals there are multiple research and r2p subgoals providing further detail activities for meeting the broader objectives. The CHPtD goals are found within the NORA Construction Sector Agenda, which can be accessed at http://www.cdc.gov/niosh/nora/comment/public/ConstDraftDec2007/ .

Conclusions

Establishing these goals will help to guide efforts for understanding and enhancing the role of design for preventing or minimizing hazards in construction. These goals are not static and will need to be revised periodically as performance measures indicate the level of success with which the objectives are met. In addition, design is viewed as one of multiple factors impacting safety and health in construction; as such, the CHPtD topic fits into a suite of topics (both outcomes and contributing factors) the NORA Construction Sector Council has determined to be priority areas for research and implementation of research findings (i.e., research–to–practice).

The impact of addressing challenges related to design, and conducting additional research and evaluation, will ultimately be judged against measures that translate into fewer injuries and fatalities by eliminating or mitigating hazards. A reduction in the occurrence of accidents and injuries will not only save lives and improve the quality of life for workers, it can also result in lower workers' compensation claims and other financial expenditures for contractors and owners of construction projects.

Disclaimer

The findings and conclusions in this paper have not been formally disseminated by the National Institute for Occupational Safety and Health and should not be construed to represent any agency determination or policy.

Acknowledgments

The authors wish to acknowledge the members of the NORA PtD National Initiative and the NORA CHPtD councils for their participation in the development of the framework and priority topic goals. The authors also wish to acknowledge the other groups and individuals who have been and continue to be key proponents of PtD research and innovation.

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