

A Cross Sectional Study of the Perceptions of Large Contractors towards Prevention through Design

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With sustained fatalities and injuries of construction workers continuously over years, the construction industry within US requires a paradigm shift to occupational safety and health. The traditional practice of considering the workers' safety during construction phase needs to be changed. Instead, Architects and Engineers (A/E) should be involved with responsibility of identifying and addressing imminent safety and health hazards during design phase. As per the concept of Prevention through Design (PtD) initiated by National Institute of Occupational Safety and Health (NIOSH), the responsibilities of workers' safety should not rest completely with the contractors; A/E should play a critical role during design phase to improve workers' safety and reduce health hazards downstream. The research employed cross-sectional method to identify attitudes of large contractors towards adoption of PtD. Survey method was employed for the study, and large contractors listed by Engineering News Record was used as the sample. While a majority of respondents realized the importance of considering safety during design phase, not all of them were familiar with the concept of PtD. While respondents identified lack of financial incentive and regulatory requirements as critical challenges, alternative project delivery methods were identified as motivations for adoption of PtD.

Keywords: Occupational Safety, Prevention through Design (PtD), National Institute of Occupational Safety and Health, Safety Management, Project Delivery

Introduction

Construction industry in the United States has an unenviable safety record that is reflected in high fatality rate second only to Agriculture, Mining, and Transportation sectors (BLS 2013). The number of injuries and illness-related absences in the construction industry is also significantly higher (BLS 2012) in comparison to hospitals, nursing and residential care (AFL-CIO 2013). Further, construction is identified as one of the leading industry and occupation for injuries and illness related for men (AFL-CIO 2013). These figures (fatalities and non-fatalities) are disproportionately high as compared to other industry sectors, given that construction workers only account for approximately 7% of the total workforce (CPWR 2013). Apart from human cost of occupational accidents, economic impacts of an accident or an injury can have a sizeable impact on business performance. Accidents have an adverse effect on the cost related factors of a business, in the form of escalating workers' compensation insurance costs, high cost of medical treatment and rehabilitation programs. The economic losses also include indirect costs, such as administrative costs, productivity losses and low morale (Clough et al. 2005).

The implementation of the Occupational Safety and Health (OSH) Act in 1970, the subsequent emphasis on compliance with regulations listed in Title 29 of Code of Federal Regulation by construction workers have positive effects on the safety performance of construction projects. Based on published figures, safety appears to be improving somewhat in the construction industry. However, the numbers reveal that in the period from 2001 to 2011 11,620 construction workers lost their lives, an average of more than 1,000 workers per year. Thereby signifying that there is a need for continued effort to improve the current state of safety for construction workers. Researchers have indicated that state of safety within construction industry can be tied to the way industry views responsible party for safety. Typically, responsibility for safety of the construction workers rests entirely with the contractor. The OSHAct specifically mentions that employers (contractors) are responsible for providing a safe and healthy workplace for their employees (construction workers in this case). Within this setup, the capabilities of the architects

or designers to improve safety in construction projects are not being utilized. Recently, the National Institute of Occupational Safety and Health has started the initiative of 'prevention through design' (PtD) to address occupational safety and health needs in the design process to prevent/minimize the hazards downstream (Howard, 2008).

This paper presents the result of a national survey conducted among the contractors in the industry. The contractors in the study were listed in Engineering News Record (ENR) to develop a baseline understanding of their attitude towards PtD. In the following sections, the paper presents a brief comparison of different safety management approaches, the methods adopted for the research study, descriptive summary of the responses, analyses of the responses, and finally the conclusions.

Different approaches for safety management

A systematic review of the literature primarily from journal articles and conference proceedings identified several prevailing safety improvement approaches in the construction industry, such as personnel selection, technological intervention, behavior modification, poster campaign, quality circle, zero injury technique, and similar. A fundamental problem of the prevailing safety improvement approaches is the failure to recognize that safety of any operation is determined long before the people, procedures, and equipment come together at the work site. Construction operations are not different in this respect from any other operation. Until recently, most of the efforts expended to improve safety performance have been targeted towards implementing rules, regulations, and devising advanced equipment – in brief, transferring the burden on the contractors. Construction contracts and regulatory requirements from Occupational Safety and Health Administration (OSHA) place the burdens for worker safety solely on the contractor.

From a strategic point of view, the architects or engineers are the entities who have the most prolonged involvement in any construction project, other than the owners. As a corollary, they have the opportunity to influence the outcome of the project from the phase of inception. NIOSH is leading an initiative on PtD in US, to utilize the role of architects or engineers in safety improvement. American Society of Safety Engineers (ASSE) defined the concept of PtD as "addressing occupational safety and health needs in the design process to prevent or minimize hazards and risks associated with the construction, manufacture, use, maintenance, and demolition of a facility". PtD was first conceptualized in 1985 by the International Labor Office (ILO). It recognized that the architects and engineers could actually play a significant role in the safety of construction projects. ILO emphasized that architects and engineers should consider the safety of the construction workers who will be actually working in the construction site, during the design phase. Recommendations of ILO were supported by The European Foundation for the Improvement of Living and Working Conditions. Upon review of safety performance of the United Kingdom's construction industry, Jeffrey and Douglas (1994) concluded that safety considerations should be incorporated in the design process from the very beginning to increase the efficacy. According to Szymberski (1997), the ideal time to consider construction safety is during conceptual and preliminary design phases to be more effective. In contrary to the prevailing safety approaches, which are implemented during the actual construction phase, PtD is more effective as it is introduced earlier in the design phase.

Across the world, industry has started to recognize PtD as a cost-effective means to enhance occupational safety and health (Howard, 2008). Countries such as the United States, United Kingdom, Australia, France, and other European countries have adopted resolutions in this regard (Behm, 2005; Howard, 2008). According to Howard (2008), United Kingdom mandates construction companies, project owners, and architects to address safety and health during the design phase of projects since 1994 and companies there have responded with positive changes in management practices to embrace the move. Australia developed their Australian National OHS Strategy 2002–2012, which set "eliminating hazards at the design stages" as one of the priorities (Howard, 2008). With the worldwide acceptance of the concept of PtD, it might be beneficial for the US construction industry to adopt PtD in order to improve the current state of safety.

Research Goal and Objectives

The goal of the study was to identify the attitudes of US contractors towards the concept of PtD. The authors wanted to develop a baseline understanding about the knowledge of the contractors regarding PtD, and identify the perceived challenges and motivations for the implementation of PtD. The specific objectives were as follows:

1. To determine familiarity of contractors with concept of PtD
2. To identify challenges and motivations for adoption of PtD
3. To understand impact of PtD on cost and duration of construction projects

Research Methods

The authors decided that a questionnaire survey would be appropriate for achieving the objectives of this exploratory study, as they would be able to identify the beliefs and values of the sample with regard to adoption of PtD. The overall research process of the study involved the following steps: (1) selecting sample construction companies to participate in the survey; (2) developing the survey instruments; (3) distributing the survey questionnaire to selected samples; (4) collecting data to examine the attitude of the contractors; and (5) analyzing the collected data.

Selection of Samples

It was the intent of survey to gather information relating to PtD from a diverse sample of contractors located over a broad geographic area within US. For this purpose it was determined that the list of the 400 largest contractors published in the September 2011, issue of ENR be used as sample population. All 400 contractors were contacted through general e-mails and phone calls for the purpose of acquiring the contact information of the safety directors/supervisors. 112 email addresses and phone numbers of safety directors/supervisors from different companies were collected (28% of the sample of 400), and the survey questionnaire was sent to them. Descriptive statistics methods were used to analyze the data collected from the online survey responses.

Development of Survey Instrument

The author identified the survey items based on the study's key constructs of interest. Several construction professionals and academic experts in occupational safety were selected to "brainstorm" the issues that would reflect the attitudes of the contractors towards PtD. Based on the output of the brainstorming session, the initial draft of the questionnaire was developed. The instrument was further modified by the author through review of previous studies by CII (2002), Gambatese (2002), Hecker et al. (2005), and Behm (2005). The survey questionnaire was composed of three types of questions: (1) close-ended questions with ordered choices, (2) two point (yes/no) scale questions, and (3) five point Likert-type scale questions.

Distributing the Questionnaire and Collecting Data

The finalized survey questionnaire was made into printed copies, and encoded using a web survey tool (Qualtrics.com) to facilitate distribution and collection of data via Internet. After successfully developing the web survey questionnaire, the invitation email along with the survey questionnaire was sent to the study sample. The survey link was open for one month to limit the collection period. Two weeks after first invitation to participate in the survey, a reminder phone call was made to motivate the study sample for participating in the survey. 78 out of 112 (69.9%) safety directors/supervisors responded to the survey. However, there were in total 17 incomplete responses, which were not included in the analysis.

Analyzing the Data

As mentioned previously, the survey questionnaire was divided into four sub-sections. The first section was aimed to understand the profile of the responding contractors. The second section contained four items to determine the familiarity of the contractors with the concept of PtD. The third section contained 14 items to identify challenges and motivations for adoption of PtD. Finally, the fourth section contained four items to identify how adoption of PtD would influence project cost and duration.

In the third section, survey data responses were measured in a five point Likert scale and analyzed using Simple Relative Index (RI). An ordinal scale was used for the measurement of each of the 14 survey items, with each respondent being asked to assign a level of importance from 1 to 5, where 1 = least important and 5 = most important. From this, the magnitude of RI for each item was calculated. To evaluate the overall rank orders, the mean and standard deviation of each individual item was considered inconsequential, as they fail to demonstrate any relationship between the items. Thus, the numerical scores of each of the items on the questionnaire were transformed to relative indices to decide the rank orders. The RI was calculated using the following formula:

$$\frac{\sum w}{Wn}, (0 \leq RI \leq 1)$$

Where:
w = weight given to each item by the respondents ranging from minimum of 1 (denoting least important item) to a maximum of 5 (denoting most important item);
W= the maximum weighting (which was 5 in the study);
n = total number of respondents.

This was followed by rank ordering of the items based on the RI, where the highest RI = highest rank and vice versa. For items with equal RI, they were ranked in accordance with the percentage of respondents assigning 5 to the item. The ranked variables gave insight as to the perception of the contractors on various aspects of PtD.

Findings

Data from the study were analyzed using SPSS 17.0. Data analysis included descriptive statistics with a report of the appropriate frequencies to describe the responses to the questionnaire items as well as the profile of each of the responding contractor.

Profile of the Responding Contractors

Of the 78 responding contractors, a vast majority (75.6%) were involved in commercial projects. While half of the responding contractors were involved in healthcare projects, an equal share of the respondents delivered civil/infrastructure and educational projects. As evident from the distribution (in Table 1), all of the contractors were involved in more than one type of project. Thereby, the numbers exceeding 100%. In terms of involvement with publicly funded projects, responses indicated that for more than 60% of the contractors, the proportion of publicly funded projects each year was in excess of 40% of their total work volume. Out of which, for 18% of the responding contractors the proportion of publicly funded projects was in excess of 80%, as shown in Table 1.

The next question, which related to the profiles of the responding contractors, asked about their geographical area(s) of operation, and all the contractors had operations in more than one state of US. A low population (8.9%) of the contractors was involved in international projects. To realize the diversity of the responding contractors, the subsequent questions asked about the company size and annual revenue of the responding contractors. The majority of the contractors (78.2%) participating in this survey was in the category of having 251 to 1000 employees that classified them as large contractors. The majority of the contractors (96.2%) conducted business worth more than 50 million USD annually. Though the distribution was a little bit skewed, it appeared tailor made for this survey since the goal of the study was to understand the attitude of large contractors toward PtD.

Table 1 – Summary of the company profiles of the responding contractors

Items	Groups	n (%)
Primary types of project	Residential	3 (3.8)
	Commercial	59 (75.6)
	Civil/Infrastructure	17 (21.8)
	Health Care	39 (50.0)

Items	Groups	n (%)
	Educational	18 (23.1)
	Others	7 (8.9)
Annual share of public projects	None	0 (0.0)
	< 20%	23 (29.5)
	20% - 40%	7 (8.9)
	41% - 60%	19 (24.4)
	61% - 80%	20 (25.6)
	> 80%	9 (11.5)
Geographic location	Any one state of the US	0 (0.0)
	More than one state of the US	78 (100.0)
	Outside of the US	7 (8.9)
Approximate company size	Micro (<10 employees)	0 (0.0)
	Small (11-50 employees)	0 (0.0)
	Medium (51-250 employees)	8 (10.3)
	Large (251-1000 employees)	61 (78.2)
	Very large (>1000 employees)	9 (11.5)
Approximate company revenue	<1 million USD	0 (0.0)
	1-10 million USD	0 (0.0)
	10-50 million USD	0 (0.0)
	>50 million USD	75 (96.2)
	Do not want to disclose	3 (3.8)

N = 78 (total number of responding contractors). Percentages in the table might not add to exactly 100% for all the items due to overlapping responses from the participants.

Familiarity of the Contractors with PtD

To determine familiarity of respondents with the concept of PtD, four questions were included in the questionnaire. For clarification, the first question provided the definition of PtD as provided by the ASSE and also listed the names of some of the similar concepts such as 'Design for Safety', 'Safety in Design', and 'Construction Hazard Prevention through Design.' A little more than half (61.5%) of the participating contractors mentioned their familiarity with the concept of PtD. However, a vast majority (85.9%) of the respondents agreed that considering safety during the design phase can definitely improve occupational safety. The responses show that though a majority of the large contractors realized the importance of considering occupational safety during the design phase, they were not familiar with the formal approach to implement the idea. In spite of the awareness about the value of considering safety during design phase, less than one third of the respondents expressed their intentions to adopt PtD in the near future (see Table 2).

Table 2 – Summary of the responding contractors' familiarity with PtD

Items	Yes n (%)	No n (%)
Are you familiar with the concept of Prevention through Design (PtD)?	48 (61.5)	30 (38.5)
Do you believe considering safety during design can improve occupational safety and health?	67 (85.9)	11 (14.1)
Are you implementing PtD at present?	7 (8.9)	71 (91.1)
If you answered 'NO' to previous question, do you have plans of implementing PtD in future?	23 (29.5)	55 (70.5)

Challenges and Motivations for Adopting PtD

To develop a baseline understanding about challenges and motivations towards adoption of PtD as perceived by the contractors, respondents were asked to indicate their perception about importance of each of the 14 items identified

from literature (CII 2002, Gambatese 2002, Hecker et al. 2005, Behm 2005). To test internal consistency reliability of survey instrument, the Cronbach's alpha (α) was calculated. It was found that $\alpha = 0.81$ for the contractors' responses. Considering the threshold value of $\alpha = 0.70$ for acceptable reliability, the instrument was considered reliable for measuring the perception of the contractors.

From the list of challenges deduced from literature, the responding contractors identified the absence of any financial incentive for Architects/Engineers (A/E) as the biggest challenge for adoption of PtD (see Table 3). In present scheme, A/E were only contractually bound to deliver design without any consideration to occupational hazards downstream. In addition, lack of regulatory requirement was identified as second biggest challenge. In absence of any kind of regulatory requirement on the part of A/E, the contractors perceived it was very challenging to adopt PtD. Due to lack of requirement; no change was enforced in legal contracts as well. The A/E did not depict any proactive effort towards gaining training and knowledge about PtD, as perceived by the contractors. This showed the inertia of non-acceptance of the concept of PtD among the designers. A variety of reasons can be cited as probable causes for this inertia, the foremost among them could be the reluctance to absorb more liability and not add to their standard scope of work. However, the resistance of the owners to adopt PtD and their lack of knowledge were identified as lower level challenges by the contractors.

Table 3 – Rank order of the challenges for the adoption of PtD

Items	Relative Index (RI)	Rank
No immediate financial incentive for Architects/Engineers	0.89	1
Lack of regulatory requirement of Architects/Engineers	0.83	2
Lack of recognizable duty of Architects/Engineers	0.74	3
Reluctance to change the standard contracts to enable the adoption of PtD	0.71	4
Lack of knowledge and training about PtD among Architects/Engineers	0.68	5
Resistance from Architects/Engineers to adopt PtD	0.67	6*
Resistance from Owners to adopt PtD	0.67	7*
Lack of knowledge and training about PtD among Owners	0.64	8

* Equal RI; ranked in accordance with the percentage of respondents assigning 5 to the item

In addition to identifying challenges for adopting PtD, the contractors were asked to rank the motivations for adopting PtD. A strong underlying culture of safety in the organization was selected as the biggest motivation for adoption of PtD (see Table 4). In most cases, a strong safety culture is ingrained within an organization from the practice of effective risk management. As a consequence, 'effective risk management practices' was ranked as the second best motivation for the adoption of PtD by the respondents. According to the participating contractors, alternate project delivery methods such as Integrated Project Delivery (IPD) and Design-build approaches had positive impact on the adoption of PtD. Both the approaches adopt a collaborative approach to design and construction, bringing the designers and the contractors aboard from an early stage of the project. In addition the shared approach of risk and reward in the IPD method may be more conducive to addressing occupational safety and health needs earlier in the lifecycle of the project. However, "willingness of architects/engineers to adopt PtD" was identified as the least important motivation, which perhaps indicates that the designers were not willing to adopt PtD when there was no sharing of risk or reward (as in traditional delivery methods). It can be noted that in both the challenges and motivations, the owners play a passive role as per the responses of the contractors.

Table 4 – Rank order of the motivations for the adoption of PtD as perceived by large commercial contractors

Items	Relative Index	Rank
Strong project safety culture	0.94	1
Effective risk management practices	0.93	2
Project delivery methods: Integrated Project Delivery	0.89	3
Project delivery methods: Design-build	0.81	4
Willingness of Owners to adopt PtD	0.74	5
Willingness of Architects/Engineers to adopt PtD	0.69	6

Impact of PtD on the Construction Industry

In addition to identifying critical challenges and motivations for adoption of PtD, authors enquired responding contractors about their perceptions for PtD adoption on projects cost and duration. More than two third of responding contractors thought that PtD would not increase the project costs, and neither would it increase overall project durations (see Table 5). Though the survey questionnaire did not ask follow-up questions, investigators personally believe that adopting PtD may increase designers' fees, but the overall project costs will remain the same. There is higher probability that the contractor will be benefitted, due to better safety performance of projects. Similarly, better safety performance will help the contractors avoid delays caused by accidents or incidents on site. While more than 60% of the responding contractors perceived that adopting PtD would increase the liabilities of the designers, a significantly smaller number of respondents had the same thought about the owners.

Table 5- Responding contractors' perceptions of the impact of PtD on project costs and duration

Items	Yes n (%)	No n (%)
Do you think PtD will increase the total project cost?	23 (29.5)	55 (70.5)
Do you think PtD will increase the total project duration?	21(26.9)	57 (73.1)
Do you think PtD will increase the liability of the Architects/Engineers?	62 (79.5)	16 (20.5)
Do you think PtD will increase the liability of the Owners?	45 (57.7)	33 (42.3)

Conclusions

The goal of the cross-sectional study was to gauge the perceptions of the large contractors related to adoption of PtD. Specifically the investigators attempted to understand the familiarity of the contractors with the concept of PtD, which is fairly new to the construction industry in US. In doing so, the study tapped a representative pool of respondents among the sector of large contractors. The reasoning behind targeting this particular sector was their receptiveness to innovative techniques and methods. As adopting innovative techniques and methods always comes with an upfront investment of resources, smaller companies cannot always afford the burden of experimentation. From responses, it was evident that while majority of respondents agreed with the concept of addressing safety during design to be beneficial, not many were familiar with PtD or similar approaches. The respondents identified lack of financial incentive and absence of any regulatory requirement to be the two most critical challenges for the adoption of PtD in construction industry. At the same time, respondents expressed that any organization with a deeply engrained safety culture would make difference. Some of the project delivery methods, such as IPD, Design-build where the collaboration of the designer and the contractor are encouraged could be appropriate for the adoption of PtD. However, the respondents appeared to think that no directives came from the owners to either promote or reject the concept of PtD.

The results of the cross-sectional study showed that PtD was still a fairly new concept to large contractors. The contractors who were familiar with PtD could identify some critical challenges and motivations. The responses will be used as baseline data and future studies will look into dissecting individual barriers to formulate intervention strategies so that the concept of addressing safety and health needs in the design phase become an acceptable norm of the construction industry.

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