

Identifying Responsibilities of Interior Designers for Construction Workers' Safety

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Occupational hazards and accidents in construction job sites have been a reason for concern over the years. Accordingly, considerable amount of investigations have been directed at identifying the causes responsible for the hazards and the accidents. Recent investigations have identified associations between the decisions taken by the designers during the design phase to the occupational hazards and accidents occurring downstream. Based on these findings, an intervention that is gaining popularity is the concept of Design for Safety (DfS). So far, majority of the effort in the field of DfS has been targeted toward the designers in general. This paper focusses on the role of the interior design professionals on workers' safety and health needs. 60 accident reports extracted from OSHA's Integrated Management Information System database were analyzed to identify the root-causes of the accidents. From the list of identified root causes, the ones that could be addressed during the design phase were segregated. It was found that majority of the root causes that resulted to accidents could be controlled by the interior design professionals during the design phase.

Key Words: Occupational safety, Design for Safety, Interior design professionals, Root-cause, Root-cause analysis model

Introduction

The construction industry has historically been one of the most demanding and dangerous industries in the United States due to its complex and dynamic nature. This fact is reflected in the data published by United States Bureau of Labor Statistics which shows that construction industry sector recorded 738 fatal work injuries in 2011, which is almost 16% to all the work related fatalities (BLS, 2012). Each year, occupational injuries and fatalities in the construction industry temporarily or permanently disable many workers and accounts for the lives of others throughout the world. These alarming statistics continue to highlight the importance of health and safety in the industry. An intervention proposed by Korman (2001) that is gaining popularity in the construction industry is the concept of designing for safety (DfS) of the construction workers. The concept of DfS involves the designers to address occupational safety and health needs of the workers during the design phase to minimize hazards of the construction workers downstream.

It has been stated by the scholars that many safety hazards of the construction industry are "designed into" construction projects (Behm, 2005; Gambatese, Behm, & Hinze, 2005). Design determines the configuration and constructability of a facility and to a large extent determines how the facility will be constructed. The configuration of the facility can influence (both positively and negatively) the safety of the constructors. For example, providing a permanent guardrail around floor opening enhances safety. However, when an opening in the floor does not have permanently designed fall protection features (such as guardrails or anchorage points), safety of the workers is compromised. Therefore, designers (architects, interior designers, engineers) are in a position for addressing the safety needs of the workers during the design phase and influence construction safety. By addressing safety during the design process, hazards will be eliminated or reduced during construction, thus improving the safety performance. The fact that designers can influence construction workers' safety and the need to address safety early in the project lifecycle has already been recognized by the scholars and practitioners. Szymberski's (1997) time-safety influence graph succinctly illustrates how influence on workers' safety can be maximized by addressing it early in the project life cycle – that is during the design phase. OSHA's recommended hierarchy of control also highlights the influence the designers can have on the workers' safety. As shown in Fig 1 below, OSHA recommends elimination or substitution of the source of hazard as the most effective way of control. For example, a common way of eliminating hazard of onsite construction is to specify more offsite fabricated components in the design.

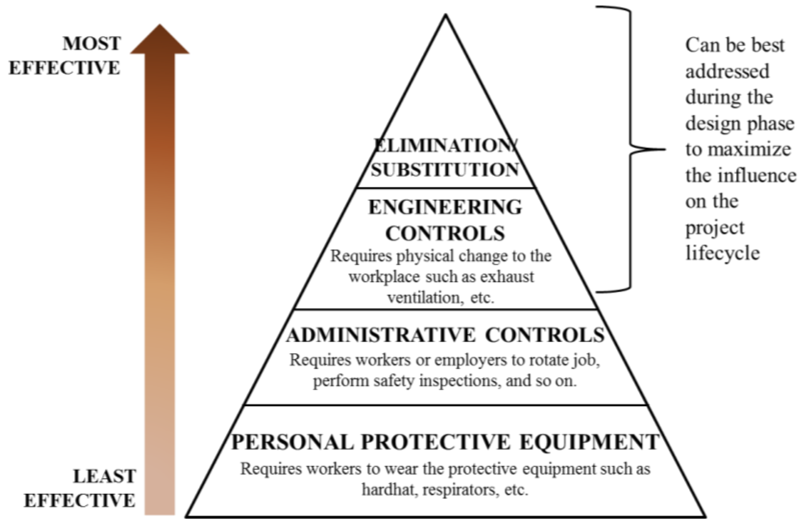

Figure 1: Hierarchy of control

Studies by Whittington et al. (1992) and Suraji et al. (2001) reveal that a significant number of construction accidents are results of decisions taken during planning and designing processes. In the study conducted by Behm (2005), the investigator examined more than two hundred fatality investigation reports and found links of 40% of the accidents to the decisions taken during the design phase. Though the impact of the design on construction safety is evident and the potential benefits of its implementation are apparent, there is a lack of widespread adoption of the concept of DfS among the design professionals in US (Gambatese, et al., 2005). The design professionals continue to reject this intervention as part of their standard practice. While the concept of DfS has been formalized and included in the standard practice of design professionals in countries such as United Kingdom and Australia, in the US there are no incentives for the design professionals to adopt this concept (Behm, 2005).

The paper draws on part of a study with larger scope undertaken to identify the root-causes of construction accidents, and determine the relationship of the causes to the concept of DfS. While all the existing studies have attempted to identify the responsibilities of the design professionals in general, the current paper focused on the interior design professionals. The intent was to specifically identify the root-causes that could be appropriately controlled by the interior design professionals to prevent the accidents from occurring.

Concept of Design for Safety (DfS)

Designers have the most prolonged involvement in any construction project, and thus have the most opportunities to influence the project. As early as 1985, the International Labor Office (ILO) recognized the need for designers to consider safety of construction workers 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. In US, the National Institute for Occupational Safety and Health (NIOSH) is leading an initiative on DfS to highlight the role of designers in improving safety of construction workers. American Society of Safety Engineers defined the concept of DfS 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”. Szymberski (1997) posited that the ideal time to consider construction safety is during conceptual and preliminary design phases, as a significant portion of the ability to influence is lost if it is left for consideration only during construction phase. With the current view of safety management in the US construction industry where the responsibilities for workers' safety are burdened on the contractors, the ability to effectively design for elimination or substitution of hazards are considerably reduced (Behm, 2005).

A growing number of industry leaders throughout the world have started recognizing DfS as an effective means to enhance safety of construction workers. The United Kingdom has made it mandatory for construction companies, project owners, and architects to address safety and health during the design phase of projects in 1994 and companies there have responded with positive changes in management practices to embrace the move. In Australia, the states of Queensland South Australia, Western Australia, and New South Wales place similar responsibilities on designers (Bluff, 2003). Following the same footsteps, France passed regulations, which mandate a holistic view of construction safety including the design and other European countries have since followed with similar regulations (Behm, 2005). Similarly, in South Africa, designers must ensure that their designs are safe and free of health risks (Republic of South Africa, 1993).

Previous Research

The concept of relating configurations and components of projects with safety performance is complex, and has been a topic of much interest among the researchers as well as practitioners lately. Researchers such as Hecker, Gambatese & Weinstein (2005), Weinstein, Gambatese & Hecker (2005), Behm (2005), Gambatese, Behm & Rajendran (2008) have attempted to identify and quantify the relationship between design decisions and construction workers' safety. While different methodologies were selected for the aforementioned studies, all of them could establish the link between design and safety performance in construction projects. Upon conducting a review of the safety performance of the of the construction industry of UK, Jeffrey and Douglas (1994) identified a link between design decisions and workers' safety in terms of accident causation. Hecker, Gibbon & Barsotti (2001) looked into intervention methods to prevent musculoskeletal injuries to construction workers, and identified decisions in the design and planning phases to be probable causes to risk of such injuries.

Smallwood (1996) conducted a survey among the general contractors in South Africa, and found that almost half of them identified design as an important factor affecting the workers' safety. Interestingly, a majority of the responding contractors suggested exposing the designers to construction site safety as part of their education. Other studies have attempted to attach a quantitative measure to the causal relationship between design decisions and accidents occurring in construction jobsites. An initial attempt to quantitatively determine the extent to which design decisions are linked to construction accidents was reported by the European Foundation for the Improvement of Living and Working Conditions (European Foundation, 1991). The study found that close to 60% of fatal accidents were due to decisions taken during the design phase. Since then several studies (Behm, 2005; Gibb, Haslam, Hide, & Gyi, 2004) have demonstrated possible contribution of design decisions to construction workers' safety with a quantitative measure.

The findings of the previous research clearly establish the merit of DfS and provide insight into the concept as applied to the construction industry. However, in recognition of the inherent difficulties associated with construction site safety research, Behm (2005) and Gibb et al. (2004) have recommended additional investigation to confirm the links between design decisions and construction workers' safety. Considering the recommendations of the researchers as point of departure, the current study was undertaken to further investigate and establish the relationship between design and workers' safety with a focus on the design decisions taken by the interior design professionals.

Research Method

In order to investigate how design decisions taken by interior design professionals is linked to accidents occurring in construction jobsites, a sufficiently large and representative database of this type was needed to be identified. Furthermore, the accident investigation reports must provide sufficient information in order to evaluate whether design decisions were the probable causes for the accidents. The source for this research study was OSHA's Integrated Management Information System (IMIS) database containing recordable accident reports. This paper focused on the reports filed for the years 2002 through 2012. As the study was focused on design decisions taken by interior design professionals, the data of the accidents that could be directly impacted by their decisions were only included in the analyses. Accordingly, the data pertaining to the workers performing painting and paper hanging (SIC 1721), plastering, drywall, acoustical, and insulation work (SIC 1742), and terrazzo, tile, marble, and mosaic work (SIC 1743) were used. However, this paper presents the results based on the data of SIC 1721 only as part of the study with larger scope. After the data was extracted, subsequent modification was done to refine the data. Some of the variable names were changed to make them more self-explanatory, such as "construction cause" was changed to "construction operation causing accident", "source of injury" was changed to "factor(s) prompting the accident." In addition, the variable name for "environmental factor" was changed to "non-human factor". The other factor was kept unchanged as "human factor". Within the non-human factor, it was found that "work surface/facility layout condition" was the most frequently occurring factor contributing to the accidents. As the term was ambiguous, the accidents having this as the causal factors were reviewed to assign more specific factors such as "malfunctioning of tools/equipment", "wrong selection of tools/equipment", "permanent feature of the project", and "temporary feature of the project" (for more discussion on the individual factors, please refer to the Accident Root-Cause Analysis Model (ARAM) discussed in the following section.

Accident Root-Cause Analysis Model

Accident analysis models attempt to understand the factors and processes involved in any accident. These models can be used to investigate any accident and develop strategies for preventing similar accidents from occurring in the future. The theoretical underpinnings of these models are based on accident causation models and human error theories. ARAM represents the further development and synthesis of many of the existing models. In developing ARAM the main intention was to provide the investigator with a tool to identify the root-causes of any accident. The main concept proposed in ARAM (Fig 2) is that an occupational accident will occur for one or more of the following root causes: unsafe acts by workers and/or co-workers (human factor); malfunctioning or wrong selection of tools /equipment (non-human factor); permanent and/or temporary feature of the project (non-human factor). These factors point to different root-causes that should be considered for corrective actions. ARAM has been designed to guide the investigation process of any accident through a series of possible answers to identify the root-cause(s) for why that particular accident occurred.

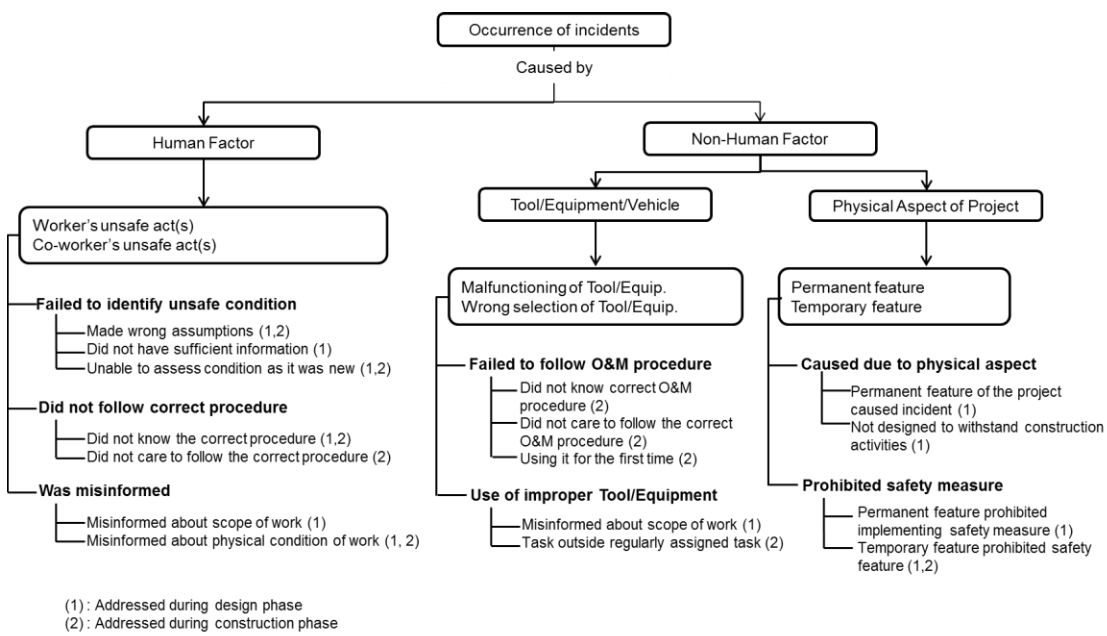

Figure 2: Framework of Accident Root-Cause Analysis Model (ARAM)

Data Analyses

The objective of this research study was to identify the relationship between the design decisions taken by the interior design professionals and workers' safety. In order to evaluate whether workers' safety is linked to design decisions, an objective model in the form of ARAM was used to analyze each of the accident reports extracted from OSHA's IMIS dataset. An initial screening of the dataset was performed to filter out the accidents that were not related to interior works and thus had no connection with the interior design professionals' decisions. Searching with SIC 1721 (workers performing painting and paper hanging) in the IMIS database (date range 2002 through 2012) returned a total of 446 accidents; 82 of them were selected after the initial search.

Each of the 82 accidents was analyzed using ARAM to identify the root-causes as also to link to the design decision. Each of the accidents was checked against all of the probable root-causes, and if any one of the root-causes identified had an accompanying number (1), that accident was linked to the design decision. If none of the causes related to any accident had an accompanying number (1), then that accident was not linked to the design decision.

Example of ARAM Utilization and Determination

This section presents an example of how the accident reports were analyzed to identify the root-causes using the ARAM. After identifying the root-causes, the following accident was affirmatively linked to design decision taken by an interior design professional. The accident involved an employee who was taping cardboard and rosin paper around the perimeter of a 10-foot by 5.5-foot floor hole. The cardboard strips extended over the edge of the floor hole by approximately 8 to 10 inches. The employee placed his hand on an unsupported section of the cardboard, lost his balance, and fell through the floor hole. He fell approximately 12 feet to the second level floor and fractured his shoulder for which he had to be hospitalized. Using ARAM as the model for investigating the root-cause(s) for the accident, it was evident that both human factors as well as non-human factors played their part in the accident. While the presence of the unguarded hole was the major root-cause of the accident in the first place, the worker involved clearly failed to identify the hazard, and made wrong assumption regarding the actual location of the hole. Based on the ARAM, both the root-causes are accompanied with number (1) that signifies that those can be linked to the design decisions taken by the interior design professional. The designer could have prevented the accident from happening by providing fall protection in the form of guard rails. In addition, the worker could have been informed more and not left to the mercy of his assumption if the designer had reviewed the condition of existing structure and indicate any hazards or deficiencies in the construction document.

Findings

22 out of the 82 accidents were not included in the analysis as the accident reports did not contain enough information. A summary of the accidents are presented below in Table 1. It is evident from the dataset that non-union workers were more frequently involved in accident than the union workers. Table 1 also shows that accidents were almost equally distributed between residential and commercial projects. The "other" category included projects such as school, army barrack, and similar. As seen in the table, accidents most frequently involved falling from ladder or scaffold followed by falling through opening in the floor. In reference to the degree of injury, it is observed that accidents involving the workers performing painting and paper hanging result in nonfatal injuries more frequently than fatalities.

Table 1

Summary of the accidents used for root-cause analysis

ITEMS	GROUPS	N (%)
Union Status of worker involved	Union	8 (13)
	Non-Union	52 (87)
End Use of the Project	Residential	26 (43)
	Commercial	30 (50)
	Other	4 (7)
Project Cost	<50,000 USD	27 (45)
	50,000 USD – 250,000 USD	8 (9)
	250,000 USD – 500,000 USD	5 (8)
	500,000 USD – 1,000,000 USD	3 (5)
	1,000,000 USD – 5,000,000 USD	10 (17)
	5,000,000 USD – 20,000,000 USD	5 (8)
	>20,000,000 USD	2 (3)
Type of Event	Fall from ladder	13 (22)
	Fall from scaffold	16 (27)
	Fall through opening	14 (23)
	Caught in between	2 (3)
	Shock	2 (3)
	Fire	5 (8)
	Mishandling of tool	2 (3)
	Inhalation	6 (10)
Degree of Injury	Hospitalized	40 (67)
	Non-Hospitalized	8 (13)
	Fatality	12 (20)

The root-causes identified for the 60 accidents following the analyses based on ARAM are presented in Table 2 below. The root-causes accompanied by number (1) could be addressed during the design phase. Results show that human factors and non-human factors were equally responsible for the causation of the accidents. Within the human factors, workers being unaware of correct procedure to perform tasks and not caring to follow correct procedures were the predominant root-causes identified. There is a fine line of distinction between the two items. The designers can incorporate relevant information related to particular scope of work in the construction documents and thus increase the awareness of the workers. However, if the workers care less to observe and abide by correct procedures to perform the tasks, the designers' notes will be of little or no value. The second most frequently occurring causes within the human factors were the ones related to failure of the workers in identifying unsafe conditions. The designers can certainly address this issue by providing information based on review of existing condition or anticipating condition that could lead to hazards.

Among the non-human factors causing the accidents, the most frequent was failure of the workers to follow the O&M procedures of the tools and equipment. It was found in the analyses that either the workers were not knowledgeable about the O&M procedures or did not care to follow the procedures recommended by the manufacturers. In either case, the interior design professionals could not influence their choice to not abide by the recommendations. However, the accidents that were caused due to physical aspect of the project could have been addressed by the interior design professionals during the design phase. The accidents caused due to permanent features of the projects occurred as the workers fell through any floor opening or fell of the end of the structure. These kinds of accidents could have been easily avoided if the designers had specified for permanent fall protection devices. Accidents related to workers stepping on structures not designed to carry load could have been avoided (or at least reduced) by increasing the awareness of the workers regarding the surroundings by incorporating note of warnings in the construction documents.

Table 2

Root-causes of the accidents identified utilizing ARAM

HUMAN FACTORS	**60 (100%)**
Failed to identify unsafe condition	**21 (35%)**
Made wrong assumptions (1,2)	14 (23%)
Did not have sufficient information (1)	4 (1%)
Unable to assess condition as it was new (1,2)	3 (1%)
Did not follow correct procedure	**37 (61%)**
Did not know the correct procedure (1,2)	20 (33%)
Did not care to follow the correct procedure (2)	17 (28%)
Was misinformed	**2 (1%)**
Misinformed about scope of work (1)	1 (1%)
Misinformed about physical condition of work (1,2)	1 (1%)
NON-HUMAN FACTORS	**52 (86%)**
Failed to follow O&M procedure of Tool/Equipment	**34 (56%)**
Did not know the correct O&M procedure (2)	24 (40%)
Did not care to follow the correct O&M procedure (2)	10 (16%)
Using it for the first time (2)	0
Use of improper Tool/Equipment	**0**
Misinformed about scope of work (1)	0
Task outside regularly assigned task (2)	0
Caused due to physical aspect of the project	**12 (20%)**
Permanent feature of the project caused accident (1)	9 (15%)
Not designed to withstand construction activities (1)	3 (5%)
Permanent/Temporary feature prohibited safety measure	**6 (10%)**
Permanent feature prohibited safety measure implementation (1)	2 (1%)
Temporary feature prohibited safety measure implementation (1,2)	4 (6%)

Note: Percentages in the table might not add to exactly 100% due to identification of multiple factors as root-causes for a single accident

Conclusion

The concept of DfS claims that the designers (architects, interior designers, engineers) are in a position for addressing the safety needs of the workers during the design phase and influence to improve construction safety. The paper, which presented a part of an ongoing study focused on the role of the interior design professionals in particular to address safety needs. OSHA's IMIS database containing recordable accident reports was selected to extract data. Accident reports related to workers performing painting and paper hanging were extracted for the period 2002 through 2012 from the database. After two screenings, 60 accidents were selected for analysis using the Accident Root-Cause Analysis Model (ARAM). ARAM is a tool to investigate and identify the root-causes of any accident. Based on the analysis, it was found that a good proportion of the root-causes identified could have been addressed during the design phase, and not left on to the contractors. There are design suggestions available in existing literature and the website of Prevention through Design (http://www.designforconstructionsafety.org) that could address safety needs of the workers during the design phase. Future phase of the study will look into developing more design suggestions that can address the workers' safety.

Future study will look into other trades such as plastering, drywall, acoustical, and insulation work (SIC 1742), and terrazzo, tile, marble, and mosaic work (SIC 1743), and follow similar methodology to identify the root-causes of the accidents and determine the connection with the design decisions of the interior design professionals.

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