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Stakeholder perceptions of risk in construction

Dong Zhao [a,*], Andrew P. McCoy [b], Brian M. Kleiner [b], Thomas H. Mills [b], Helen Lingard [c]

[a] School of Planning, Design and Construction, Michigan State University, 552 W Circle Dr., East Lansing, MI 48824, USA
[b] Myers-Lawson School of Construction, Virginia Tech, 1345 Perry Street, Blacksburg, VA 24061, USA
[c] School of Property, Project, and Construction Management, RMIT University, GPO Box 2476, Melbourne, VIC 3001, Australia

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ABSTRACT

Safety management in construction is an integral effort and its success requires inputs from all stakeholders across design and construction phases. Effective risk mitigation relies on the concordance of all stakeholders' risk perceptions. Many researchers have noticed the discordance of risk perceptions among critical stakeholders in safe construction work, however few have provided quantifiable evidence describing them. In an effort to fill this perception gap, this research performs an experiment that investigates stakeholder perceptions of risk in construction. Data analysis confirms the existence of such discordance, and indicates a trend in risk likelihood estimation. With risk perceptions from low to high, the stakeholders are architects, contractors/safety professionals, and engineers. Including prior studies, results also suggest that designers have improved their knowledge in building construction safety, but compared to builders they present more difficultly in reaching a consensus of perception. Findings of this research are intended to be used by risk management and decision makers to reassess stakeholders' varying judgments when considering injury prevention and hazard assessment.

1. Introduction

Despite advances in technology and implementation of robust safety management and risk mitigation techniques, occupational safety and health (OSH) incidents continue to cause persistent suffering to the construction industry and its workers. In the United States, 769 construction workers died in the workplace due to OSH incidents in 2013 (U.S. Bureau of Labor Statistics [BLS], 2014). This is unacceptable. These incidents have been shown to arise from well-known hazards, which could be controlled with the implementation of known risk mitigation and injury interventions (Kleiner et al., 2008).

Risk mitigation is an integral effort in construction and its success requires inputs from all stakeholders including owners, designers, builders, and suppliers (Floyd and Liggett, 2010). Such effort is difficult due to a construction project's fragmented nature with a variety of stakeholders across phases from design to construction (McCoy et al., 2009). Stakeholders in the construction phase are often targeted as the sole administrators for safety measures and implementation (Toole, 2002). For example, in the U.S., design professionals are not responsible for specifying means and methods of construction while the contractors need to take full responsibility to substantial safety risks on the jobsites. Designers always avoid to expose themselves to liability by involving in a construction issue for which they are not responsible under the contract. Standard contracts provided by industry authorities also recognize this principle and the terms usually include exemptions of designers' liability that associates with the supervision of construction means and methods. However, many injury cases in the workplace bring claims against the design. Recent studies (Fleming et al., 2007; Gambatese et al., 2008) have revealed that stakeholders in the design phase have great influence on OSH as well. High levels of design related concerns can also impact injury and fatalities. The design-related OSH in construction can be to as high as 43.9% of fatal injuries in construction (Driscoll et al., 2008) and therefore a significant contributor. Godfrey and Lindgard (2007) argued that effective safety management requires the risks arising as a result of design to be eliminated wherever possible. As a result, productive communication and collaboration (Migliaccio and Martinez, 2010) between designers and builders during pre-construction stages becomes vital for effective risk mitigation.

Effective risk management rests upon the consensus and collaboration of all stakeholders, but such integration is difficult to attain. Godfrey and Lindgard (2007) recognized this difficulty and questioned the existence of a unity of purpose with regard to OSH in the Architecture, Engineering and Construction (AEC) industry. Toole (2002) conducted a survey that has shown the lack of uniform agreement on site safety responsibilities among design

* Corresponding author at: School of Planning, Design and Construction, Michigan State University, 552 W Circle Dr., East Lansing, MI 48824, USA.
E-mail address: dzhao@msu.edu (D. Zhao).

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engineers, general contractors, and subcontractors. Thekdi and Lambert (2014) demonstrated that consensus on risk mitigation is difficult to achieve among stakeholders within infrastructure projects due to discrepancies in perspective, expertise, and interests.

The authors posit one possible reason for this difficulty as an issue of risk perception from individuals or their corresponding roles. Most risk mitigation strategies assume that OSH risk is "objective" and can be impartially recognized and perceived (Arezes and Miguel, 2008), but this assumption can contain challenges. Flin et al. (1996) investigated the risk perceptions of offshore workers and found these perceptions are subjective and varied. Hallowell (2010) highlighted a significant difference in perceiving risk tolerance between construction workers and managers. Ouédraogo et al. (2011) observed that people react differently to the same consequences from different hazards and concluded that risk perception depends on fear, culture, education, society, and knowledge. However, little research has provided solid evidence to the discordance of stakeholder perceptions of risk in construction. The aim of this paper is to provide such evidence for AEC stakeholder perceptions.

Understanding risk perceptions in construction is critical, which necessitates research to investigate, compare, and contrast stakeholder judgment of risk. Risk perception is significantly related to risk behavior, providing an important insight to safety management (Rundmo, 1996). Risk analysis injects logic, reason, and scientific deliberation into risk management (Slovic and Peters, 2006), making it inappropriate to judge OSH from a simplistic and moralistic perspective (Toole and Gambatese, 2008). In the context of competing interests and goals, the determination of what OSH measure is acceptable, in terms of OSH outcomes, must involve an industry-wide conversation about risk and its acceptability from a range of diverse stakeholders (Saunders et al., 2012). As a result, every effort is needed to understand all stakeholders' OSH risk judgments and to develop strategies that encourage occupants of safety-critical roles.

This paper presents an experimental study that investigates AEC stakeholder perceptions of risk in construction. Specific objectives of the experiment are: (1) to verify whether safety-critical stakeholder groups have intragroup concordance in perceiving risk; (2) whether they have intergroup discordance in perceiving risk; and (3) to identify the discordance if it exists. Similar to other studies of risk perception (Slovic, 1987), this study examines the judgment made by construction stakeholders when they are asked to characterize hazardous conditions or technologies. Here, the writers define the risk as exposure to a hazardous condition which may cause work-related injuries, illnesses, and fatalities. The risk is measured in terms of the combination of (1) the likelihood of a hazardous event and (2) the severity of the hazard when it occurs (Chan et al., 2011; Fleming et al., 2007). Such setting is derived from the classic Risk formula: $Risk = P * D$, with P being the probability of threat (i.e., the likelihood) and D the expected damage (i.e., the severity), for quantitative risk assessment (Flammini et al., 2011). The experiment uses photographs to elicit responses in depicting hazards (Morgan, 2002) because it has been shown that the pictorial nature of a graphical risk display ignites stronger associations with risk outcomes (Chua et al., 2006).

2. Method

2.1. Participants

Table 1 provides a summary of participant groups and descriptions. A total of 60 ($N = 60$) industry practitioners from four safety-critical AEC stakeholder groups participated in the experiment. The four stakeholder groups are architects, engineers, construction contractors, and safety professionals. These groupings include all dominant professions who direct or are largely engaged in a construction project and are the substantial decision-makers in OSH risk. Within the four groups, the architects and engineers are primarily involved in activities during the design stage and thus more likely to represent designers. In contrast, contractors and safety professionals are primarily involved during the construction stage and more likely to represent builders. All participants had more than three years of professional experience and were working in the architecture, engineering, and construction (AEC) industry at the time of experiment. Their workplaces were geographically varied throughout the United States.

Table 1
Participant summary.

Code	Stakeholder group	Number	Description
Arch	Architects	15	Licensed architects, with at least five years of experience
Engr	Engineers	15	Structural engineers, mechanical engineers, electrical engineers, and other engineers, with at least three years of experience
Cont	Contractors	15	Principle contractors, trade contractors, project managers, site managers, and superintendents, with at least five years of experience
Safe	Safety professionals	15	OSHA safety experts, construction safety managers, safety officers, and safety consultants, with at least five years of experience

The researchers adopted a respondent-driven-sampling (RDS) approach (Heckathorn, 1997) to recruit participants. RDS lends statistical rigor to conventional snowball sampling through longer recruitment chains and recruitment limits (Salganik, 2006). Scholars have criticized the snowball sampling approach due to its inherent biases that persons of similar characteristics are often networked and likely to recruit each other. In contrast, RDS allows researchers to make asymptotically unbiased estimates. Moreover, to ascertain confidentiality, the researchers provided participants with a unique code (e.g., *Arch01*, *Arch02*, or *Engr01*) for profession identity at invitation and they did not necessarily disclose their names nor affiliations during the experiment. The Virginia Tech Institutional Review Board (IRB) approved the RDS approach and inspected the process under IRB protocol #09-701 to ensure the safety of human subjects participating in this research.

2.2. Procedure

The experiment was based on a validated procedure to manipulate risk perceptions on building systems (Zhang et al., 2013). As illustrated in Fig. 1, the researchers asked a participant to complete the experiment through four steps: (1) log in the online experiment system using the given code (e.g., *Arch01*, *Arch02*, or *Engr01*) and then go through instructions; (2) sort four sets of total 32 photos (i.e., eight photos each set) based on the perceived risk likelihood in an ordinal scale of five categories (i.e., 1 = Rare, 2 = Unlikely, 3 = Moderate, 4 = Likely, and 5 = Almost certain); (3) sort the same four sets of total 32 photos based on the perceived risk severity in another ordinal scale of five categories (i.e., 1 = Insignificant, 2 = Minor, 3 = Moderate, 4 = Major, and 5 = Catastrophic); and (4) answer follow-up open-ended questions to expand on judgments in the two rounds of photo sorting. During the experiment process, a research assistant was available online to answer any instruction-related questions. The entire experiment