



Review

Factors influencing safety performance on construction projects: A review

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ABSTRACT

Construction is one of the most dangerous industries due to its unique, dynamic, and temporary nature. This paper aims to review and extract the factors influencing safety performance on construction projects. In the presented work, methodologies, results, discussions and findings from a total of 90 previous papers are investigated to achieve the paper objectives. The reviewed papers are categorized based on their type, methods of data collection, analytical method, research objectives, key findings and contributions, limitations, year, and the country of origin. A qualitative content analysis procedure is used to extract variables and factors. Furthermore, a hierarchical framework is developed to illustrate how the extracted factors influence safety on construction projects. The proposed framework is validated by using interviews with experts. The hierarchical framework explicitly confirms that safety performance not only is determined by management activities within project levels, but also by the interactions among factors at different hierarchical levels.

1. Introduction

Construction is one of the most dangerous industries due to its unique, dynamic, and temporary nature (Al-Humaidi and Tan, 2010; Fang and Wu, 2013; Fang et al., 2015; Ikpe et al., 2012; Mohseni et al., 2015; Wanberg et al., 2013). More to this, due to its ever-growing importance and expansion, it can come to the point of reflecting grievously on the state of well-being throughout any given society since workplace accidents would incur various losses to the injured workers and their families, employers and society (Feng et al., 2015; Ikpe et al., 2012). In fact, the devastating impact of construction accidents stands far higher than that of the other fields of industry combined, and as far as the statistics are concerned, the construction industry accounts for 29% of the total number of industrial workers, but accounts for 40% of workplace accidents (Chua and Goh, 2004). By means of illustration, construction has approximately 6% of U.S. workers, but 20% of the fatalities, which is the largest number of fatalities reported for any industry sector (Hallowell and Gambatese, 2009). However, such catastrophic figures cannot be held as evidence against the indispensability of this industry and its ever-accelerating and rapidly growing pace since construction is vitally important to the economy of the nations and is righteously regarded as one of the pillars of the growth of public wealth, industrialization, development, and modernization and a firm solution to the problem of unemployment in many countries. For example, only in the United Kingdom, the industry represents nearly 10% of the gross domestic product (GDP) (Ferret and Hughes, 2007). So,

since construction industry is a key element of progress and development for countries, the success of construction companies should be given special attention. The strength and success of any construction company lies in the effective management of safety, productivity, quality, health and the environment, in addition to marketing and finance (Venkataraman, 2008); and this simply indicates that safety performance in a project is just as much a measure of the success of that project as are measures of time, quality and cost (Hasan and Jha, 2013). On one hand, delivery of construction project does not emphasize merely time, cost, quality as performance criteria, clients, should also broaden their concern to advocate site safety with regard to the importance of human being (Jitwasinkul and Hadikusumo, 2011). On the other hand, lack of adequate safety measures goes beyond health concerns, since the costs of construction injuries can have a substantial impact on the financial success of construction organizations and increase the overall costs of construction up to 15% (Hallowell, 2011). This brings us to the conclusion that both from economic and managerial aspects including those related to human resources, project and time management, plus the costs and expenditure in face of the outcome, in one side, and the humanitarian, social, and ethical concerns of the well-being and safety of the workers, in the other side, make it inevitable to regard the importance of the betterment of the safety measures and standards as an essential part of any construction-related conception.

Yet, it is by no means self-evident to the general atmosphere of construction project-holders since the facts and figures suggest

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otherwise and thus it is also important to mention that despite the wealth of construction safety literature, injuries and illnesses continue to occur at alarming rates (Wanberg et al., 2013), hence all the more the significance of the theoretical and practical reconsiderations in this area. Since, accident prevention, however, begins with having a clear understanding of those factors that play key roles in their causation (Hinze et al., 1998), this paper is mainly concerned with identifying key factors influencing safety on construction projects. The top-managers of the companies should identify and control the factors influencing safety performance of the construction projects to have better safety records, improve safety level on the construction sites, have an attractive reputation, and have the ability to compete with other companies in the world. Furthermore, this paper uses a framework to show how the identified key factors influence safety on construction projects. There is previous research on the key factors of accidents in the construction projects. For example, Jannadi (1996) studied factors affecting the safety of the construction industry and ranked these factors according to their importance and determination. He concluded that the six top factors are maintaining safe work conditions; establishing of safety training; educating workers and supervisors to have good safety habits; effective control by the main contractor of the subcontractors; maintaining a close supervision of the workers; and, lastly, assignment of responsibility to all levels of management and workers. Moreover, Sawacha et al. (1999) discussed factors influencing safety on construction sites. The results showed that the most important issues found to be associated with site safety are management talk on safety; provision of safety booklets; provision of safety equipment; providing safety environment; and appointing a trained safety representative. Additionally, Hinze and Gambatese (2003) conducted a study to identify a number of other factors that significantly influence the safety performance of specialty contractors. They reported some factors that positively affect safety performance included minimizing worker turnover; implementing employee drug testing; and training with the assistance of contractor associations. Also, Fang et al. (2004) identified factors that correlate closely with onsite safety management performance on construction sites in China. They prioritized five important factors as foreman related factor, worker-related factor, crew-related factor, manager related factor and safety training related factor, respectively. Tam et al. (2004) examined the status of safety management in the Chinese construction industry and, found out that the main factors affecting safety performance include poor safety awareness of top management, lack of training, poor safety awareness of project managers, reluctance to input resources to safety, and reckless operations. Moreover, Aksorn and Hadikusumo (2008) studied critical success factors influencing safety program performance in Thai construction projects, and concluded that the most influential factor is management support. Li and Li (2009) developed a model to evaluate the safety management performance of construction projects, and considered safety management organization, safety management measures, safety personnel, and equipment and material management as the main factors affecting safety management performance. Omran et al. (2010) identified the critical success factors that influencing safety program performance in Malaysian construction projects. The results of their study showed that good communication shall be treated as the most important factor, followed by clear and realistic goals, safety committee/safety officer, sufficient resource allocation and continuous participation of employee. Furthermore, in line with these studies, Jitwasinkul and Hadikusumo (2011) studied important organizational factors influencing safety work behaviors in construction projects and identified seven important factors of Thailand construction industry as a particular case-study, namely: communication; culture; management commitment; leadership; organization learning; empowerment; and reward system. Hasan and Jha (2013) collected data from 32 Indian construction projects and examined the effectiveness of safety incentive/penalty provisions. They found six determining factors to be important for improving safety performance, including incentive

distribution method; proper labor training; special attention to risky situations; the role of the safety committee and sub-contractors; specialized works and safety equipment; and, finally, the right form of incentive/penalty.

Considered as a whole, one can say that there were several literature reviews on construction safety in the past, but most of the previous reviews were focused on specific aspects of construction safety, rather than comprehensive and systematic ones (Zhou et al., 2015). For example, Pinto et al. (2011) studied traditional management methods related to occupational health and safety, and pointed out the limitations of these methods to deal with the occupational problems in the construction industry. Swuste et al. (2012) implemented a review to identify the possibility to influence safety in the building sector. Furthermore, the previous studies which focused on key factors of accidents on the construction projects mostly used questionnaire and interview to identify factors and variables. These limitations make it difficult to generalize the obtained results to new projects in other countries and continents. Hence, this review attempts to fill these gaps by developing a comprehensive framework to identify the factors that affect the safety of construction project. The objectives of this paper are (a) exploring the factors influencing safety performance on construction projects all over the world, (b) applying the content analysis of the previous papers to categorize these factors, and (c) developing a framework to illustrate the relationships between identified factors in the construction industry.

2. Method

2.1. Literature search

The literature review included papers that investigated safety domain in the construction industry. The literature search is accomplished in two steps. At the first step, the titles, abstracts and keywords are searched using a manual search in the databases of papers published between January 2010 and January 2016. These databases included American Society of Civil Engineers (ASCE) library (<http://ascelibrary.org/>), the Scopus database (<http://www.sciencedirect.com>), and Taylor & Francis Online (<http://www.tandfonline.com/>). To identify relevant previous papers, the research keywords were selected to be (“safety” OR “safety performance”) AND (construction). After completing the search in the databases, the total number of identified papers were 977.

Next, the titles and abstracts of the papers were reviewed and those identified as relevant to the review were selected to be retrieved and reviewed in full. The papers were chosen based on the following inclusion criteria: (a) the paper had implied the factors that influence safety on construction projects, (b) the paper was published between January 2010 and January 2016, (c) the paper was available online, (d) the paper was published in a refereed journal, and (e) the paper was written in English. In total, 55 papers were investigated in the first round of review to determine variables that influence safety on construction projects.

At the second step, the publication date of the papers is expanded (Fig. 1). The keywords, titles, and abstracts are searched using a manual search in the databases of papers published between January 2000 and January 2016. The databases included ASCE library, the Scopus database and Taylor & Francis Online. Like the first round, the titles and abstracts of the papers were reviewed and those identified as relevant to the review were selected. These papers were chosen based on the same inclusion criteria mentioned in the first round, as well as the papers not selected at the first round of literature search. In total, 166 papers were selected in the second round.

After reviewing the 40th paper of the first round, the list of the influencing factors was almost saturated and there was not any new factor to be registered. However, the reviewing process continued for the selected papers from the first round. Hence, it was decided to select 35 papers from the chosen papers of the second round based on the

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