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Review

Risk-based management of occupational safety and health in the construction industry – Part 1: Background knowledge

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ABSTRACT

During the last decades, there has been a growing awareness about occupational safety and health risks by the various interested parties in the construction industry. However, despite the substantial improvements achieved, the rate of accidents is still significantly higher than in most of the other industries. Two major reasons have been used to explain this high rate of accidents in the construction industry: (i) the intrinsic riskiness due to the nature of the activities and the particular characteristics of constructions projects and organizations and (ii) the financial and economic issues regarding the implementation of additional safety measures in a growing competitive market.

This companion paper is presented in two parts. The present document refers to Part 1 and reviews the major lines of research and main contributions in the field of occupational safety and health in the construction industry. The review covers occupational safety and health research, organized in accident understanding studies, accident analysis studies and accident modeling studies, and occupational safety and health risk management, in particular risk criteria and limits. The review reveals the need for a methodology to quantify occupational safety and health risk in construction projects following the guidelines set by the international standard ISO 31000:2009. Part 2 proposes and details the Occupational Safety and Health Potential Risk Model (OSH-PRM) that was designed to allow estimating the statistical cost of occupational safety and health risk.

Contents

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1. Introduction

Occupational safety and health has been and still is a topic of intense research and practical developments. Globally, there has been a substantial improvement on occupational safety and health in the construction industry, at large motivated by the publication and ongoing implementation of the two most relevant standards in the field, the ILO-OSH 2001 and the BS OHSAS 18001, and increasingly stringent regulations. Nevertheless, accidents still occur in the construction industry at a substantial higher rate than in most of the other industries and with severe consequences, both for the workers and the public. According to the *European Agency for Safety and Health at Work* (EASHW, 2003), the construction is the most dangerous industry in terms of occupational safety and health. At a worldwide level, the construction workers are three times more likely to die and two times more likely to suffer injuries at work than the average of the workers in all other activities. Additionally, construction workers are more exposed to biological agents, chemical substances, ergonomic deficiencies, as well as noise, vibration and temperature. Thus, in addition to accidents (fatal and non-fatal), construction workers have also higher incidence rates of several health problems (Drever, 1995). Musculoskeletal disorders (Schneider, 2001; Welch et al., 2009; EASHW, 2010), asbestoses, mesotheliomas and other health problems ensuing from exposure to asbestos (EASHW, 2004a; Engholm and Englund, 2005), dermatitis, in particular by reaction to cement (EASHW, 2008b), hand arm vibration syndrome (EASHW, 2008a) and hearing loss (EASHW, 2004b) are identified as some of the main occupational diseases in the construction industry (NAO, 2004). The consequences resulting from the exposure to other potentially harmful substances have also been reported (e.g., silica – Linch, 2002; Flanagan et al., 2003, 2006; Beaudry et al., 2013; manganese – Meeker et al., 2007; various – Woskie et al., 2002) as well as whole-body vibration (Cann et al., 2003), among other health related issues in construction (e.g., Hartmann and Fleischer, 2005; Burström et al., 2010).

This scenario of occupational safety and health in the construction industry is motivated by several interrelated and complex factors that can be related to the industry in general and to the construction projects in particular. There are several characteristics inherent to the construction industry contributing to this scenario. Although the relationship is not supported by empirical evidence, their identification is based on solid theories and several years of observations (Hallowell, 2008). Some of the inherent characteristics are (Fredericks et al., 2005): (i) industry fragmentation; (ii) dynamic work environments (multiple teams performing multiple tasks simultaneously and in proximity); and (iii) industry culture. Probably, one of the most particular aspects of the construction industry is the fragmentation of the involved parties throughout the various phases of construction projects. Considering the traditional design-bid-build contractual arrangement, the design phase is carried out by architects, engineers and other professionals, followed by the request of proposals and the execution by the winning contractors. The operation stage is, in many cases, the responsibility of another party, which may be the promoter of the project or an end-user client. Normally, this is a linear process, with each step properly compartmentalized and performed by separate entities, loosely tied and with different, sometimes conflicting, objectives (Tatum and Korman, 2000). Gambatese (2006) reports that integrated contracting methods, such as design-build, are associated with lower accident rates. Unlike what happens in other industries, the work environment in construction projects is often unique, transient and dynamic. Construction sites are workplaces in constant change, exposed to stochastic elements (e.g., weather conditions; soil characteristics; road accidents) and may be significantly different from previous projects. Additionally, it is common the coexistence of work teams with different tasks working in common areas of the construction sites. Also, the work teams are in constant rotation throughout the project and their members may also change along the way. All these factors contribute to increase the possibility of accidents occurring and distract workers from completing their tasks safely, even if they are familiar with and the tasks are simple (e.g., see Hinze, 1997; Hinze and Wilson, 2000; Carter and Smith, 2006; Yi and Langford, 2006). Finally, the culture of many of the workers contributes to explain the high incidence rates in the construction industry. Factors such as machismo, substance abuse, language barriers and low level of education are some of the most relevant worker culture related aspects (Hallowell, 2008). According to Hinze (1997), the attitude of construction workers increase the risk tolerance and, therefore, the frequency and severity of accidents. For instance, the consumption of alcoholic beverages or drugs by construction workers in the U.S. is roughly twice the average recorded across all industries, which is a serious aggravating factor when associated with the type of tasks performed (Gerber and Yacoubian, 2001). The low level of education and the coexistence of workers of different nationalities originate communication barriers, not only among workers, but also between the management and the workers. Cultural differences and communication deficiencies hinder the prevention of accidents and may contribute for their occurrence.

The remaining of the first part of this companion paper reviews some of the most important occupational safety and health risk research (Section 2) and occupational safety and health risk management practices (Section 3), setting the background knowledge supporting and motivating the Occupational Safety and Health Potential Risk Model (OSH-PRM) presented in Part 2.

2. Occupational safety and health research

Peláez (2008) organizes occupational safety and health research into three main groups: (i) accident analysis studies; (ii) accident prevention studies; and (iii) risk evaluation studies. The accident analysis studies are rooted in the works of Heinrich (1930a), Leplat (1978) and Kjellen and Larsson (1981), including accident causation models (e.g., DeJoy, 1990; Abdelhamid and Everett, 2000; Suraji et al., 2001), statistical analysis of accidents (Hinze, 1996; Huang and Hinze, 2003) and studies on the economic cost of accidents (e.g., Leopold and Leonard, 1987; Everett and Frank, 1996; Waehrer et al., 2007). The accident prevention studies, rooted also in the works of Heinrich (1930b) and Helander (1980), are divided according to the level or stage of focus. Jaselskis et al. (1996) researched the prevention of occupational accidents at an organizational/institutional level, with Baxendale and Jones (2000) studying the application of laws and standards and Teo et al. (2005a) investigating the importance of occupational safety and health policies and manuals. Hinze and Francis (1992) and Gambatese and Hinze (1999) analyzed the relevance of occupational safety and health prevention in the design stage. The construction stage has been the focus of several prevention related studies, including: (i) the measurement of the efficiency of prevention (e.g., Laufer and Ledbetter, 1986); (ii) the influence of human behavior (e.g., Hinze, 1981); (iii) the contribution of safety and health plans (e.g., Burkart, 2002); (iv) the influence of financial incentives (e.g., Hinze, 2002); and (v) the responsibility of involved parties (e.g., Toole and Gambatese, 2002).

In the present paper, a different organization is adopted, considering only two major categories: (i) accident causation models and (ii) accident assessment studies. The accident causations models are mostly generic organizational constructs representing the underlying causes of accidents, providing a means of understand-