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Identification, determine and control of health, safety, and environmental hazards associated with the construction projects: State-Of-The-Art

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A B S T R A C T

The industry of construction is considered a strong economic factor and one of the most dangerous industries. This industry involves a wide range of activities that subject all employees from experts to non-skilled workers to intense undesired situations. Everybody is vulnerable to the hazards, risks, and dangers of this massive industry. Insufficient health and safety management, damage to construction, and constructed environments can also lead to increased accidents and injuries. Accidents not only have consequences of significant suffering and pain, but they are also marginalizing efficiency, time, productivity, negatively impact the environment and overall adding the construction costs. The results of the study will help to identify the essential factors that cause rising rates of risks in construction projects. By identifying these causes, emphasis on environmental, health and safety management will help in implementing awareness to all of those participating in the construction projects. This study demonstrates the criteria and guidelines for the identification, to determine the controlling environmental effects and health and safety hazards at construction project worksites. Furthermore, attempt to explain the techniques of decreasing hazards by the development of pre-construction planning and provide adequate controlling equipment for executing a safer, more profitable construction project from start to the end. Also, in the study suggestions are given for management that they must provide adequate health and safety training for the entire workforce, a supervised workplace by professional site safety managers and operators that will attempt to reduce health and safety hazards at sites.

1. INTRODUCTION

Construction project sites are a very significant sector since a vast number of employees are engaging activities in construction. Construction site employees can divide into three categories; "Technical and managerial", "Professional", and "Unskilled". All three types are at risk of accidents, death, or related hazards on the construction project sites. Construction project site workers typically face undesirable dangers of accidents at work (Almen et al., 2012). Compared to many industries, the construction sector is complex and unique. Such complexities cause the construction industry to become the most unsafe industry, which can lead to high accident rates (Pungvongsanuraks et al., 2010). Health and safety were also specified as one of the significant factors that influence project managers and corporations.

Efficient safety management designed to keep the protection of the environment, to make safety in the workplace activities and to make staff aware of their health. In previous decades, safety has been considered by many developing countries as one of the most valuable management subjects of construction executions (Chen et al., 2011).

Hazard identification on construction sites mainly depends on human observation (Reese & Eidson, 2006). Occasionally, safety management neglect to determine hazards because of their significant number, making it more challenging to review every area to determine hazards (Kim et al., 2015). Therefore, all projects require health and safety planning, which are designed and documented utilizing identification, the determining and controlling possible risks

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in the workplace are essential, especially in uncontrolled environmental hazards (Sawyer & Martin, 2000). The documented health and safety programs in projects must have to be updated regularly as new valuable information is discovered.

From a survey done by Pheng and Shiua (2000), they showed that more than 80% of the constituents either found it difficult to identify and assess hazards, also to execute the required control measurements. These survey results also corroborated with the empirical outcomes of a Solomone (2008) analysis. It presents the importance of such mechanisms to develop and indicates how environmental impacts and elements of health and safety can be accepted as part of the design, scheduling, and implementation in construction projects (Gangolells et al., 2011). Therefore, additional techniques and tools are also required to support architects and construction engineers with identifying hazards and optimizing designs (Gambatese, 2008). The primary aim of this study is to enhance the process of introducing environmental, health and safety programs in building construction implementation companies.

2. METHODOLOGY

Management of hazards is an essential aspect of all management programs, and it should establish the main characteristics of health, safety, and environmental hazards.

Table 1. Some approaches to identifying hazards in construction projects

Author	Description
Albert et al. (2014)	Workers training to better identifying hazards
Carter and Smith (2006)	Using a central database of health and safety that includes safety-related data and can be used to control the construction process, risks, and relationships
Ismail and Ghani (2012)	They explained how all three site monitors, the engineer, operations manager, and the health and safety officer, play an essential role in alerting all hazards that lead to accidents.
Kim et al. (2015)	By using the BIM programs, they introduce an automatic discovery program (on recent accident), which can search automatically for the same accident instances.
Matthew et al. (2013)	Identification and determine safety monitoring elements clearly, and resource demands have been demonstrated for assessment, supervising, and responding.
Ophir et al. (2010)	Evaluation of expected loss-of-control injuries for precise steps of commonly executed construction projects activities.

Besides that, hazard-management processes (hazard identification, hazards determination, and hazard control) are equivalent in either the environmental and health and safety areas. The concept of hazards refers similarly to risks on the lives, health of workers, the population around the sites and the environment.

As illustrated in some recent studies, the probability of an injury or accident established by controlling the necessary health and safety hazards and by using different strategies, they emphasize the employees' unsafe working conditions in the workplace. Table 1, summarizes some studies and their objectives. There are some gaps in knowledge about the relationship between specific activities of workers and the occurrence of hazards on some construction projects workplace.

3. OBJECTIVE

The purpose of this study is to identify possible hazards through the construction worksite, plus to determine and control all risks that can lead workers to have accidents in construction activities. By establishing and evaluating the disruptions in some worker's usual reaction, we want to identify necessary information regarding hazards since these disruptions may result in some effects on the environment. Even so, they can happen carelessly without the occurrence of risks, for instance, in a healthy environment, carelessness or neglect can create unsafe situations. Besides, some hazards cause workers to have difficulty responding and many workers do not react to the same health and safety hazards.

4. IDENTIFICATION OF POSSIBLE HAZARDS IN CONSTRUCTION SITES

Two considerable hazards that are common in all construction workplaces are being reported (Abdul et al., 2003). Physical harm hazards often occur by devices like power access devices, scaffolding, ladders and excavation machinery. These accidents can involve direct injuries to the workers and, if intense, could even lead to death. Various kinds of mechanical energies, like vibration, harsh noise, temperature and radiation, may also lead to physical injuries. Chemical injury hazards identified in construction work are like welding gases, asbestos, solvents and paints (Rwamamara, 2007).

Some hazards have chronic consequences, while others are acute on worker's health, as described in Table 2. For instance, if a worker unintentionally breathed a small quantity of asbestos fibre, he will not consider the impact of this, since no immediate symptoms (acute impacts) are present. However, if the worker breathes the small amount of asbestos fibre for an extended period, the risk for developing asbestos relevant diseases (like lung cancer)

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might increase. Furthermore, chronic hazards include contact with corrosive products, skin allergens, and sanitizers (Vitharana et al., 2015).

Table 2. Some identified health and safety hazards

Hazards' types	Examples
Chronic health and safety hazards	Corrosive resources (brick, concrete, and acid)
	Asbestos (ceiling tiles, isolation board, and lagging pipe)
	Physical hazards (heat, noise, humidity, nuclear power stations radiation, and also solar radiations)
	Irritants and Skin sanitizers (alkalis, bitumen, cement, and acids)
Acute health and safety hazards	Moving or carrying heavy equipment or products, Lifting
	Roofing works
	Trenches for deep excavations
	Dangerous chemicals
	Ladder
	Machinery and stations, usage device
	Falling workers from heights
	Emergencies like fire

Work-associated respiratory problems, back trouble, head and neck disorders are specific health troubles with workers. Most of the health injury hazards identified as acute impacts are falling workers from heights and electrical shocks (Ismail & Ghani, 2012).

5. JOB SAFETY ANALYSIS

The identification and determination of hazards is a critical step in managing health and safety. Job safety analysis (JSA) is a practical approach to identify and control risks in construction activities (Gopinath and Johansen, 2016). Due to Ophir et al. (2010) observation, the job safety analysis approaches involve three stages:

(1) Identification: Selecting a particular activity or job and analysing it into many steps and after that identifying any probable loss-in-control occurrences which that happen during the works.

(2) Determine: Analysing the relevant hazards level for the designated work incident.

(3) Control: Monitoring of the hazards by taking appropriate steps to minimize or remove the risks.

Many variables have a direct and indirect influence on the safety levels, which differ from one work site to another, which include the essence of training in worksite safety, environmental work conditions, weather, the use of protective facilities, and so more.

6. METHODS TO CONTROL HAZARDS IN CONSTRUCTION SITE

6.1. Causes of poor health and safety

The industry of construction suffers from poor health and safety planning, which involves a high amount of accidents and a high number of deaths. So, to improve these problems, hazard identification must become the primary safety managing process (Carter & Smith, 2006). Some poor performances in identifying hazards are mainly due to a lack of facilities to constantly identify all risks in a technical construction environment. The lack of expertise or mechanisms to detect hazards will be another significant impact, as each construction worksite is unique and mostly contains hazards that are not specified in previous knowledge (Mitropoulos et al., 2005).

Moreover, by human identification capability, many health and safety hazards are not merely recognized; for instance, the variability of surface-level friction may lead to slipping and falling. However, these hidden abnormal hazards may not represent direct risks to any construction site worker as these would pose potential hazards with or without more factors that contributed to such susceptible workers (Albert et al., 2014).

6.2. Health and safety training

Workplace accidents are the results of the integration of exposure to hazards and workers behaviour. Workers' inability to detect hazards and the proper response is the leading cause of injuries. Construction organizations should invest equipment in risk identification training and tendencies to communicate procedures for an adequate response (Matthew et al., 2013).

Training for taking data about health and safety is essential in all construction companies and requires familiarization, detection of hazards, responsibilities and requirements in any area. The health and safety mechanism should contain the first aid training for all employees, and the manager should hold the certification of essential life support. All employees must contribute in a session describing the health and safety program, the duties of individuals and teams, vehicles, emergency mechanisms, and fire-arms (Michael et al., 2006).

6.3. Safety system implementation and control

Successfully managing a construction project means not only implementing it within the specified period or with a determined budget, but with optimal health and safety (Belel & Muhmud, 2012). Also, it has become clear that implementing safety standards in construction projects is not an easy task, but it is possible.

Plenty of the reasons for poor construction site safety has been identified and grouped under health and safety

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equipment. They propose that corporate health management will enhance the organization's quality. Also, hazard identification is among the critical steps for health and safety management at construction project sites because the most uncontrollable risks come from undefined hazards (Zolfagharian et al., 2011)**.** It suggested that the contractors for construction worksites must develop site health, provide an internal safety strategy for appropriate safety management, have specific training for health and safety for their employees and conduct regular safety discussions. These advised holding weekly organized staff meetings at the operations level, to either ensure safety precautions at the workplace, to always protect their labours with personal protective equipment (PPE).

Table 3. Methods to control construction site hazards

Methods	Description
Equipment for safety protection	Continually supplying PPE for the workers.
Managing health and safety	Regular meetings for health and safety plan discussion.
	Planning for short term and long terms health and safety to ensure the required site safety performance.
	They are enforcing standards and strategies for health and safety.
	Documenting, assessing, and updating of activity conditions
	The suggestion of precautions.
	Determine and analysis of risks
Attitudes of workers on health and safety	Explain knowledge about risk impacts for workers would help increase efficiency and reduce the risk related to construction behaviours.
	Workers on the construction projects must understand and try to fix hazardous conditions and attitudes.
	Execute a health and safety inspection weekly.
	Incentive programs should develop.
	Carry out regular health and safety meetings and training.

To display safety warnings posters and signs at the workplace, to carry out weekly safety control, to reward workers for their positive behaviour and to motivate workers using safety devices (El-Mashaleh et al., 2010). Besides, using mandatory enforcement techniques like fines, the most effective strategies are used to increase safety output in construction projects (Table 3).

The most significant factor affecting safety program success at worksites is safety assessment (Chia-Kung Lee & Jaafar, 2012). It is most important to ensure that adequate training about health and safety inspection is awarded to the new worker at the construction projects.

It identified in many other studies that appropriate injuries control systems are dependent on exceptional attention to health and safety management, such as the profession of safety managers within the company, training of workers and daily communications between managers and workers. Geller (2001) explored a triad safety theory (see Fig. 1) should develop an extensive monitoring mechanism for three areas of "persons," "behaviour," and "environment."

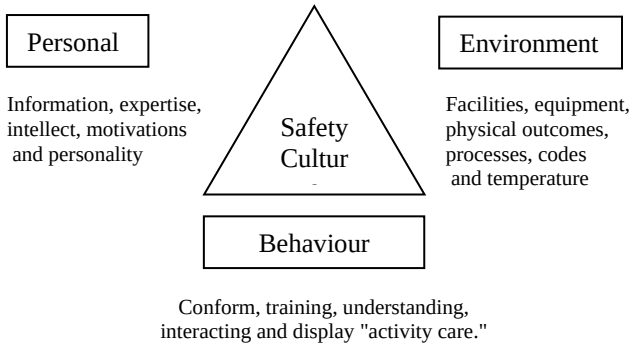

Fig. 1. Geller's safety triad

The "persons" express a worker's eligibility, while the "behaviour" shows worker's attitudes to perform the work safely in a "particular environment." These three dimensions are relational and dynamic, and ultimately, the change in each variable will affect the other.

7. CONCLUSIONS

Preparing a mechanism to enhance the implementation of the health, safety, and environmental management system, plus minimizing accidents in construction projects should be the main task of any company, not just preparing documents on paper. This study demonstrates the criteria and guidelines for identification, to determine the controlling environmental effects and health and safety hazards at the construction project worksites. Furthermore, attempt to explain the techniques of decreasing hazards by the development of pre-construction planning and provide adequate controlling equipment.

In building construction job sites, health risks can be divided into two types: acute risks and chronic risks. Many of the acute risks recorded in projects are shocks by electricity and workers falling from heights. While most of the chronic risks recorded are exposure to hazardous materials. The main requirements for producing a safer worksite in construction projects are increasing professional safety managers with modern safety management and the execution of awareness techniques that should enforce and develop construction project workers to improve safety behaviours. The contractors should provide proper training about operating the devices before using any tools by the

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workers in their duties, which will help the workers' in accident prevention.

It is suggested that project management staff should eliminate the expected hazards in the pre-construction designing and planning stage. Also, to ensure that all necessary equipment for health and safety and hazard protection is procured and available for use in the right locations. Furthermore, present and complete Health and Safety training for the entire workforce. Finally, the supervision of site safety by expert managers, who have better safety control at construction workplaces.

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