Australian Journal of Basic and Applied Sciences, 9(22) Special 2015, Pages: 123-129

ISSN:1991-8178

Australian Journal of Basic and Applied Sciences

Journal home page: www.ajbasweb.com

Integration of Quality Management and Construction Accident Causation: Development of Accident Causation Theories

Noor Aisyah Asyikin Mahat, Faridah Ismail and Sharifah Nur Aina Syed Alwee

Universiti Teknologi MARA, School of Studies Quantity Surveying, Faculty of Architecture, Planning & Surveying, 40450, Shah Alam, MALAYSIA

ARTICLE INFO

Article history:
Received 12 March 2015
Accepted 28 April 2015
Available online 6 June 2015

Keywords:

ABSTRACT

Background: Managing safety in construction projects requires strategic management in preventing and controlling accident from occur. Many researchers have sought to understand why accidents happen and a lot of sophisticated systemic accident causation theories have been developed and proven successful in managing safety. Insuring safe and quality construction is an utmost concern of in construction industry. This paper represents the preliminary findings of fragmentary research carried out in Malaysian construction environment. The study focuses on the development of Accident Causation Theories that suit with Malaysian Construction environment, hence identifying the relationship of quality management in accident causation. **Objective:** The objective of this study is to identify the integration of quality management that influence to the development of Accident Causation Theories. **Results:** The findings highlight factors contributing to accident and the crucial attributes of quality management in ensuring safety in construction environment. The result can be used as a platform for the future research in developing Accident Causation Theories. **Conclusion.** The shift in emphasis on the role of the management, and considered the causes of accidents are provoked among others factors such environment, humans and job factors as well as work place conditions. The influence of management are demand to be addressed to reduce the causes of an accident. Although the safety improvement are implemented on the construction site (safety working environment, safety guidelines and safety program); the crucial area is to targets are the working organization, especially for the employees to understand and take the responsibility to ensure the presence of the hazard can tremendously evade on site.

To Cite This Article: Noor Aisyah Asyikin Mahat, Faridah Ismail and Sharifah Nur Aina Syed Alwee., Integration of Quality Management and Construction Accident Causation: Development of Accident Causation Theories. ***Aust. J. Basic & Appl. Sci.,*** *9(22): 123-129, 2015*

INTRODUCTION

The statistical reported by the Department of Occupational Safety and Health (DOSH), Social Security Organization (SOCSO) as well as the Construction Industry Development Board (CIDB), show an incrementing number of accident fatalities in recent years. A recent investigation related to occupational accidents by sectors, carried out by DOSH, it is that from 169 accident cases reported, there were 70 cases that involving death, 93 case associated with non-permanent disability, and the rest of cases reported were suffering permanent disability. With such a high figures reported, accidents in this industry have captured the attention and concern from both government and non-government organization.

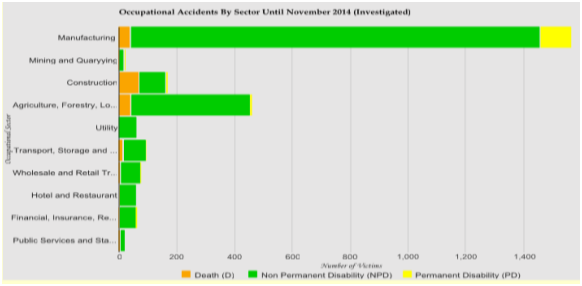
Accident that happened in the construction industry reputedly stemmed from construction failure is linked to the shortcoming or failure of safety implementation carried out at the construction site. Malaysia government, through the Human Resources Ministry, targets to reduce a workplace-related accident to three in 1,000 workers by year 2015, as compared to 3.31 in every 1,000 workers in year 2012. Managing safety in construction projects requires strategic management in preventing and controlling accident from occur. In order to minimise an accident rate from the construction industries, quality management has increasingly been adopted by construction companies as an initiative to solve quality problems and to meet the needs of the final customer (Kanji & Wong, 1998).

Safety And Accident Prevention Theories:

The nature of the construction industry's rapidly changing conditions, associated work hazards, and the characteristics of construction organizations further aggravate the situation. According to Chan *et al*. (2005) accidents happen due to a random

Corresponding Author: Noor Aisyah Asyikin Mahat, Universiti Teknologi MARA, School of Studies Quantity Surveying, Faculty of Architecture, Planning & Surveying, 40450, Shah Alam, MALAYSIA

combination of many contributing factors. Traditionally, they are categorized due to unsafe conditions and unsafe practices. Health and Safety Executives (HSE, 2002, p. 38) concluded that human behavior is a contributing factor in approximately 80% of the accidents. Many studies revealed that the majority of accidents and resulting injuries are attributed to unsafe work practices of the workers rather than unsafe working conditions (e.g. Garavan and O'brien, 2001). Some studies (e.g. Mullen, 2004) reveal that organizational and social factors are not to be overlooked because these factors influence safety behaviors.



Accident causation is a complex issue, as there are usually several contributing factors that are the root causes of accidents on sites. Accounting for the interrelationship between these factors and their effects on accidents, it is a critical for an effective accident prevention strategy. A review of the literature on construction safety reveals that much research effort has been heading for at probing accident records to categorize the most common types of accidents also the root cause on how these accidents happen. Table 1 summarizes limited numbers of literatures that highlighted the root cause of construction accidents.

Table 1: Root Cause Of Accidents.

Author	Root Cause of Accidents
Hinze and Parker (1978)	Job pressures and crew competition
McClay (1989)	Hazards, human actions, and functional limitations.
Raymond (1995)	Lack of supervision by the line managers:, Custom and practice in the industry, Lack of coordination
Kartam and Bouz (1998)	Worker turnover and false acts; inadequate safety performance; improper cleaning and unusable materials; destiny; low tool maintenance; supervisory fault; and misplacing objects.
Abdelhamid and Everett (2000)	Divided into two group . 1) Human factors: due failed to secure and warn; Failed to wear personal protective equipment (PPE); horseplay; operating equipment without authority; operating at unsafe speed; personal factor; remove safety device; serviced moving and energized equipment; took unsafe position or posture; used defective tool or equipment; and other unsafe action. 2) Physical factors : due to; unsafe act of another person(s); disregard know prescribed procedures; defects of accident source; dress or apparel hazard; environmental hazard; fire hazard; hazardous arrangement; hazardous method; housekeeping hazard; improper assignment of personnel; inadequately guarded; public hazard; and other unsafe conditions.
Suraji, A., A.R. Duff, and S.J. Peckitt (2001)	The nature of project , the method of construction , site restriction, project duration , procurement system , design complexity, level of construction and subcontracting contributing to accident causation
Toole (2002)	Lack of proper training, lack of safety equipment, deficient enforcement of safety, unsafe equipment, unsafe method, unsafe condition, poor safety attitude, and the isolated deviation from prescribed behaviour.
Tam *et al* (2004)	Poor safety awareness from top leaders; lack of training; poor safety awareness of project managers; reluctance to input resources for safety; reckless operation; lack of certified skill labor; poor equipment; lack of first aid measures; lack of rigorous enforcement of safety regulation; lack of organizational commitment; low education level of workers; poor safety conscientiousness of workers; lack of personal protective equipment (PPE); ineffective operation of safety regulation; lack of technical guidance; lack of strict operational procedures; lack of experienced project managers; shortfall of safety regulations; lack of protection in material transportation; lack of protection in material storage; lack of teamwork spirits; excessive overtime work for labor; shortage of safety management manual; lack of innovative technology; and poor information flow.
Abdul Rahim Abdul Hamid *et al* (2008)	Unsafe equipment, Job site condition, Unique nature of industry, Unsafe method, Human element and Management involvement.

2.1 Accident Prevention Theories:

Identifying the root causes of accidents by analyzing theories of accident causation is essential before proceeding to strategies manuals to implement it. There is a variety of theory of accident causation that can help to understand the occurrence of an accident, analyzing the causes and adapting the theories to reality. Accident investigation techniques can be done through the theories of accident causation also a human error. These theories provide explanations of why accidents happen. There are many available theories and models on the accident accusation. The various theories and models are based on perceptions of the accident process. Accident causation models differ in many fundamental ways. At one level, they may differ in their area of application, their purpose and focus. According to **Mark Letho (1991),** models and theories may also differ significantly in their general structure, their inputs, and outputs.

Accident causation models present factors and processes involved in accidents in order to develop strategies for accident prevention. Major theories of accident causation commonly used are Heinrich Domino Theory, Multiple Causation Theories, the Swiss 'Cheese' Model and Accident Root Cause Tracing Model (ARCTM) [4]. According to [9], the different models are based on the different perception of the accident process.

A. Domino Theory:

There are several domino theories of accident causation such as *Heinrich's Domino Theory* (1930's), *Bird and Loftus's Domino Theory* (1976) and *Marcum's Domino Theory* (1978). While each of the domino theory presents a different explanation for the cause of accidents, they all have one thing in common. Domino theories represent accidents as predictable chronological sequences of events or causal factors. Each causal factors builds on the affects the others. If allowed to exist without any form of intervention, these hazards will interact to produce the accident. H.W. Heinrich developed the original domino theory of accident causation in 1930's. Although written decades ago, his works in accident causation is still the basis for several contemporary theories. Heinrich had five dominoes in his model: ancestry and social environment, fault of a person, unsafe act and/or mechanical or physical hazard, accidents, and injury. Figure 2 shows the illustration of Heinrich Dominos Theory. This five-domino model suggested that through inherited or acquired undesirable traits, people may commit unsafe acts or cause the existence of mechanical or physical hazards, which in turn cause injurious accidents. The two key point in Heinrich's Domino Theory are that (1) injuries are by the action of preceding factors, and (2) removal of the events leading up to the incident, especial employee unsafe acts or hazardous workplaces conditions, prevent accidents and injuries. Heinrich believed that the unsafe act caused more accidents than unsafe conditions. Therefore, his philosophy of accident prevention focused on elimination unsafe acts and people-related factor that lead to injuries.

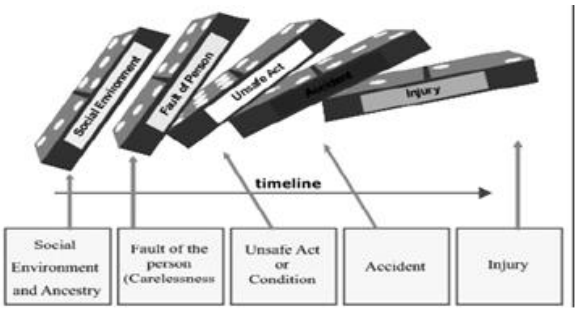


Fig. 2: Domino theory of accident causation.

Bird and Loftus (1976) rationalized the "Domino theory" in order to replicate the role of management system or management relationship in the sequence of the accident causes defined by Heinrich (Domino-based model) (See Fig. 3). The main point in this theory is that management is responsible for the safety and health of the employees. The theory also emphasizes the contact incidents can be if unsafe act and condition are prevented. The updated and modified sequence of events is:

1) Lack of control/management
2) Basic causes/origins (personal or job factors)
3) Immediate causes/Symptoms
4) Incident (contact with energy and substance)
5) Loss (property, people, process)

The update domino sequence can be used for accident prevention also in loss control management. Marcum's theory focuses on management responsibility for protecting employee safety as well as preventing the downgrading for an organization. The theory attempts to examine the management accidents response protocols to ensure that sustained losses and the subsequently incurred cost were minimized. Marcus theory focus on the human element of misact. The term of *misactsidents* in Marcus theory emphasizes the fundamental aspect of

his accident causation theory. Misactsidents is an identifiable sequence of misacts associated with *inadequate task preparation* which could lead to *substandard performance* and *miscompensated risks*. Marcum also includes the cost aspect of a loss. According to the revised model of Domino theory that signifies the role of management, the process of incidents begins by the lack of control by management. Planning, controlling, organizing, and leading by management are the factors that can prevent incidents to happen.

B. Multiple Causation Model:

Heinrich's theory is very much a theory of a single causation. However, very rarely an accident occur due to single causation. Multiple causation theory promotes the idea that accidents result from various hazards or factors interacting manner. Accident happens due to multiple and sometimes complex causal factors. Causal factor seldom contributes equally in their ability to trigger an event or contribute to accident severity. Vernon L. Gorse's multiple factor theory uses four M's (4M) to represent the factor causing an accident: machine, media, man, management.Table 2 explain the factor of an accident due to this theory also the characteristic for each feature.

Table 2: Gorse's Accident Causation Theory.

Factor	Description	Characteristic
Machine	Tools, equipment, or vehicles that may contribute to an accident	Design, shape, size, particular type of energy used to operate the equipment.
Media	Environmental conditions surrounding an accident ; weather, walking surface	Snow or water on a roadway, temperature (outdoor and indoor)
Man	People and human factors that could contribute to an accident	Gender, age, height, weight, condition, memory, recall, knowledge level
Management	Method used to select equipment, train personnel, or ensure relatively hazard free environment.	Safety rules, organization, structure, policy and procedures.

From the above mentioned theories, the adaptive accident prevention theories will be created to prevent an accident from occurs in the construction site Accident theories and models discussed have evolved from merely blaming workers, conditions, machineries into management roles and responsibilities. Nowadays, accident models are being used to better explain the causes of accident so that appropriate actions could be taken to make improvement.

Quality And Safety Management In Construction:

Quality in construction can be seen as a set of coordinated activities to direct and control the construction organisation in order to improve the effectiveness and efficiency of its performance. Low and Peh (1996) emphasise that, the quality implementation in the construction environment will lead to more efficient and effective of cost and resources. Any construction company will have a well-plan and organise management system that improve its quality of construction products and their organisation processes for continual improvement and consistently meet the client's requirements (Deming, 1993; SIRIM, 2007). Management practices are employed to reduce the occupational injuries and fatalities and improve efficiency and effectiveness of construction processes by eliminating waste and increase profit.

Loushine *et al*. (2006), in their review of the literature on quality and safety management in the construction industry, examined the definition of quality authors used. Researchers in construction quality gave the following definitions for quality performance: 'meeting expectations of the customer' (Chase, 1998; Kanji & Wong, 1998; McKim & Kiani, 1995; Torbica & Stroh, 1999), 'reduced rework or defects' (Atkinson, 1998; Love *et al*., 1999; McKim & Kiani, 1995; Pheng & Wee, 2001; Sypsomos, 1997), 'repeat business' (Sommerville, 1994; Sypsomos, 1997), 'conformance to ISO 9000 criteria' (Bubshait & Al-Atiq, 1999; Sun, 1999), and 'completion on-time and within budget' (Courtice & Herrero, 1991; Gransberg *et al*., 1999; Jaafari, 1996; Kiwus & Williams, 2001; Love *et al*., 1999; McKim & Kiani, 1995; Ripley, 1996; Sypsomos, 1997; Wong & Fung, 1999).

Most literature is unanimous in identifying management commitment as a pre-requisite for safety, the general reason being that management is responsible for establishing objectives, developing strategies, allocating resources, development and implementing systems and by virtue of its role setting an example (Levitt and Samelson,1993). The ways in which the management commitment's reflected, according to Faridah *et al*. (2011); participation, visibility, supportive, demonstrate leadership, positive attitude towards safety, in control of the activities, and the existence of values, belief and the acknowledged significant safety programmes. The integration of safety issues and quality provides a more comprehensive approach to the safety culture whilst at the same time achieving quality in construction (Husin *et al*., 2008). Krause (1994) and Cooper & Phillips (1995) argue that safety is parallel to quality in one way relationship whereas, safety management can be improved through quality management processes, not the other way around. Recent studies have proved that safety leads to quality, where working safe can enhance performance likewise quality can support safety by reducing losses of assets (Husin *et al* 2008; Stewart

& Townsend, 1999). The integration of safety and quality management will not only support each other but also they can be synergistic, thereby encouraging their mutual effectiveness.

4. The research:

Ensuring construction safety and the involvement of management are essential to manage hazard and improving the project success. With better understanding of the Accident Prevention Theories and a good quality management, productivity and safety and health can be increased, hence can minimized the cost overrun. The on-going research is carried-out to investigate the crucial factors influencing construction safety as well as the involvement of management quality performance, management attributes to accident prevention, and the integration of accident causation theories to the quality management in construction industry. With an aim to better understand the integration of quality management in accident causation theories, a research exercise was recently conducted to examine the quality of management that gives impacts to the construction accidents. The objective of this study is to identify the relationship of quality management that influence to the development of Accident Causation Theories.

An attempt was carried out by conducting preliminary pilot study using five Likert scales of questionnaires survey consisting of thirty (30) various grade of contractors listed under the Construction Industry Development Board (CIDB) directory, who undertake Building Works within the Klang Valley area. Convenience sampling involves collecting information from members of the population who were conveniently available to provide it (Sekaran, 2000). The questionnaire was administered to the respondents using face to face method to ensure validity of their responses. According to Farrell (2011), the use of qualitative method for data collection may be difficult to get an answer but the data captured are rich. Personal interviews were conducted with some respondents to clarify their answers. The study covered various aspects of the accident preventions, such as the root cause of accidents, the management quality performance, management attributes to accident prevention, and the integration of accident causation theories to the quality management in construction industry. Project supervision, employee involvement/ altitude, and expertise knowledge/ training were considered as the crucial quality factors influencing safety and quality management.

RESULT AND DISCUSSION

a. Analysis the Cause of Construction Accident:

:

Table 3: Cause Of Construction Accident.

Factors Of construction Accidents	Mean Deviation	Rank
1. Unsafe equipment	3.61	2nd
2. Job site condition	3.36	3rd
3. Unique nature of industry	2.41	6th
4. Unsafe method	3.23	4th
5. Human element	3.71	1st
6. Management involvement	2.82	5th

Table 3 signifies the overall mean scores of the cause of construction accident. The means scores indicate the degree of frequency of factors contribute to the cause of accidents. According to Table 3, human element was rated as the most frequent factors contribute to the construction accident. Human element is related to unsafe act conducted by construction personnel due to inappropriate operative actions such as inadequate is of PPE, improper handling object and material, etc. The contributing factors to the construction accident is also due to the engineering / machineries factors (equipment and method), as well as construction environment (job site conditions and nature of construction) and management factors (commitment and procedure). Therefore, the measurement and improvement of safety performance of this causal factors are essential to prevent accident on construction sites.

b. Management Involvement in Accident Prevention:

Figure 5 reveals the three most management involvement in Accident Prevention influencing safety management in construction projects are developing contractual safety arrangement, communication and safety dialogue, and implementing safety culture and behavior in organization. The results show that management commitment is essential for effective safety management. This is in line with study conducted by Gillen *et al*. (2004), which stipulates that company managers play a pivotal role in the definition and implementation of safety practices in the workplace and employees look up to them for guidance and modelling. Commitment by management and consistency in enforcement of safety rules are foundations for effective safety program. Selection of contractor is ranked fourth, this is generally accepted by the respondents that selection of project

participants can greatly influence the safety management in projects. The least important factor is address safety during design. Most respondents believed that a consideration of safety during design stage pay little or no significant influence in safety in construction.

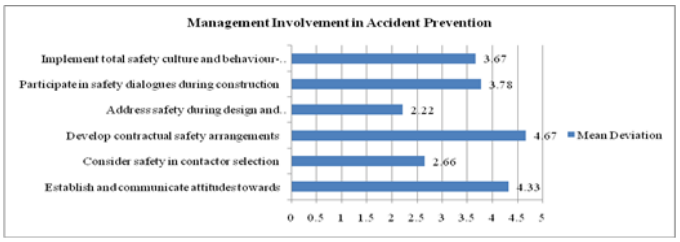


Fig. 5: Management Involvement in Accident Prevention.

c. Quality and Safety Management:

Fig. 6: Quality & Safety Management.

The requirements for a safety management system closely match the requirements for a quality management system, albeit with a different focus. Figure 6 shows the tools and processes used to manage quality also apply to safety (and environmental) management systems. From the result is shows the means score for each factors such as implementing and maintaining management resources (4.16), defining scope and policy (3.36), measurement, monitoring and evaluate hazard (3.12) as well as proper work planning (2.77). In a very practical way, safety is also important to quality. A safe work environment which allows a worker to concentrate on the job surely increases the probability that the job will be done correctly; this is the definition of quality.

d. Management Attributes in Preventing Accident:

Table 4 present the management attributes in preventing accidents. The table show the consistent enforcement of safety policy, regulations and procedures scored highest (3.67) mean, followed by management roles in ensuring workers to comply as well as continuously support and encourage safety officer in executing their job regarding safety aspect (3.37). Conducting toolbox meeting to the construction workers regularly marked as lowest attributes (2.67). The results indicate that the management attributes plays a crucial role in preventing accidents. More efforts should be give concern and maintaining a good relation with workers can certify safety at construction .

Table 4: Management Attributes In Preventing Accident.

No.	Management Attributes in Preventing Accidents	Mean Deviation
1	Management have to play roles in ensuring workers comply the regulation and safe working procedure	3.37
2	Management have the roles in raise awareness among the construction workers pertaining the safety and hazard at site	3.12
3	Management shall continuously support and encourage the Safety Officer in executing their job regarding on safety aspect	3.37
4	Management always give the priorities on the safety aspects without compromise	3.12
5	Conduct safety induction and orientation to the new workers	3.00
6	Conduct toolbox meeting to the construction workers regularly	2.67
7	Conduct external safety briefing for management staff	2.77
8	Provide more safety signs especially in foreign languages	3.00
9	Rewards and Recognition	3.33
10	Consistent enforcement of safety policy, regulations and procedures	3.67

f. Management Strategies in Reducing Accident in Construction:

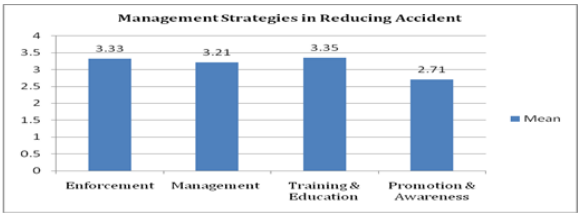


Fig. 7: Management Strategies in Reducing Accident.

Referring to Figure 7, the management strategies in reducing accident in construction can be opted in four (4) approaches. In order to prevent such hazard, most of the respondent agreed that training and education to workers can be the best approach in reducing accidents. Through training and education, it is believed can change significantly work culture at construction. Enforcement and management involved were also pointed out in solving hazard issues in construction. This means the management play vital roles in determining successful strategies. Other element, promotion and awareness also impart significant contribution to the strategy itself.

e. Level of Management Efforts in Developing Accident Prevention Theories:

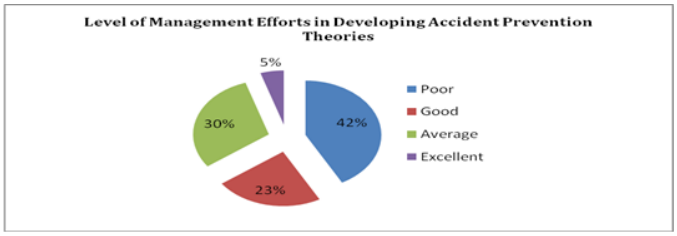


Fig. 8: Level of management Efforts in Developing Accident Prevention Theories.

Management commitments are essential in enhancing safety at construction at construction site. Although significant progress has been made in accident prevention, the management efforts in developing accident prevention theories is important to ensure the prevention can be more efficient and make better use of pooled information. Study shows that the management efforts in developing accident Prevention Theories are poor (42%) and only 5% of the respondent mentioned the management has shown an excellent efforts in developing accident prevention theories.

Conclusion:

Models and theories of construction accidents causation are on the basis of explaining how construction accidents occur. Several accident causation models have been presented in this paper. The theories focus on people variables, management aspects, and physical characteristic of hazard. The benefit of understanding accident causation is in recognizing how hazards in the workplace result in losses. Eliminating hazards before they result in losses is the proactive responsibility of everyone in the organization. Accident may still occur despite proactive safety program. It is at that point that an effective accident investigation program is of vital importance for a collection of critical data. The shift in emphasis on the role of the management, and considered the causes of accidents are provoked among others factors such environment, humans and job factors as well as work place conditions. The influence of management are demand to be addressed to reduce the causes of an accident. Although the safety improvement are implemented on the construction site (safety working environment, safety guidelines and safety program); the crucial area is to targets are the working organization, especially for the employees to understand and take the responsibility to ensure the presence of the hazard can tremendously evade on site.

ACKNOWLEDGEMENT

The financial support provided by the Ministry of Higher Learning Education (MOHE) and Research Management Institute (RMI) UiTM under research grant no. 600-RMI/RAGS 5/3 (172/2013) is acknowledged. The author would like to acknowledge the government agency, the consultants and the contractors for their kind responses and making available the data needed. This research would not be possible without the valuable advices, guidance and support of all the personal involved.

REFERENCES

Abdel Hamid, A.R., W.Z.W. Yusuf and B. Singh, 2003. "Hazards at construction sites." Proceedings of the 5th Asia-Pacific Structural Engineering and Construction Conference (APSEC), 26-28 Johor Bahru, Malaysia.

Abdel Hamid, T.S., J.G. Everett, 2000. "Identifying root causes of construction accidents", Journal of Construction Engineering and Management, 126(1): 52-60

Cheng, E.W.L., H. Li, D. P. Fang, F. Xie, 2004. Construction Safety Management: An Exploratory Study From China. *Construction Innovation*, 4: 229-241.

Seyyed, S.H., J.T. Zahra, 2012. "Major Theories of Construction Accident Models : Literature Review', International Journal of Advances in Engineering & Technology, ISSN: 2231-1963

Brauer, R.L., 1994. Safety and health for engineers, 2nd edition., New York, Van Nostrand Reinhold.

Reason, J.T., 2008. "The Human Contribution: Unsafe Acts, Accidents and Heroic Recoveries." Ashgate Publishing, Ltd.

Rausand, M., 2011. "Accident Models in Risk Assessment,' John Wiley & Sons, Inc., Hoboken, New Jersey.

Mark, A., Friend, James P. Khon, 2010. Fundamentals of Occupational safety and Health – 5th edition, Government Institute, The Scarecrow Press.

Mitropoulos, T.P., A.G. Howell, S.A. Tariq, 2012. "Accident Prevention Strategies," *J. of Constr. Engrg. & Mgt.*, 135(5): 407-415.

Powell, R., 2009. "The Measurement of Safety Performance," Government of Western Australia Department of Commerce.

Wang, W., J. Liu, S. Chou, 2006. "Simulation-based safety evaluation model integrated withnetwork schedule", Journal of Automation in Construction, 15(3): 341-354.

Jhamb. L.C. and S. Jhamb, 2003. "Safety and Services Management", Second Edition. NIR ALI PRAKASHAN.

Katsakiori, P., G. Sakellaropoulos and E. Manatakis, 2009. *Towards an evaluation of accident investigation methods in terms of their alignment with accident causation models.* Safety Science, 47(7): 1007-1015.

Kanki, B.G., R.L. Helmreich and J.M. Anca, 2010. "Crew Resource Management". Elsevier.

Suraji, A., A.R. Duff and S.J. Peckitt, 2001. *Development of causal model of construction accident causation.* Journal of construction engineering and management, 127(4): 337-344.

Sabet, P.G.P., 2013. Application of Domino Theory to Justify and Prevent Accident Occurance in ConstructionSite", *IOSR Journal of Mechanical and Civil Engineering*, 6(2): 72-76.