International Journal of Scientific Research in Engineering and Management (IJSREM)
Volume: 06 Issue: 05 | May - 2022 Impact Factor: 7.185 ISSN: 2582-3930

# A REVIEW ON MATERIAL HANDLING SAFETY IN CONSTRUCTION SITES

**DEVLAL JATWAR[1]**

M.TECH SCHOLAR[1]

**JAYKANT GUPTA[1], ABHILASH TRIVEDI[2]**

ASSISTANT PROFESSOR [1,2]

DEPT. OF INDUSTRIAL SAFETY ENGINEERING, BHILAI INSTITUTE OF TECHNOLOGY, RAIPUR, CHHATTISGARH, INDIA

## ABSTRACT

Construction sites are one of many hazardous workplaces since they entail various harmful duties. Material handling equipment has been identified as a key source of accidents at these locations in several investigations. Despite the fact that safety precautions are consistently Despite the fact that safety rules are followed and monitored, accident rates remain high because either workers are uninformed of hazards or safety regulations are not strictly adhered to. This paper investigates the safety management systems at construction sites using employee questionnaire surveys, with a focus on material handling equipment safety. Construction sites were chosen for a security education programmed concentrating on worker safety connected to material handling equipment based on the findings of the questionnaire surveys. Before and after the training, workers' knowledge levels were examined, and the findings were subjected to a t-test analysis to determine the significance level of the completed safety education programmed.

## 1. INTRODUCTION

Material handling equipment (MHE) is a must on construction sites, and its poor functioning can lead to operator harm or even death. According to several research, the bulk of incidents occur during MHE material transfers. To prevent these tragedies, building sites should have proper safety management systems and procedures for MHE safety. Despite the general lower trend in recent years, India's MHE safety ratings are good, but the issue remains severe and concerns persist. Furthermore, human factors have a significant influence in MHE-related incidents. A safety management system allows you to detect hazards and manage risks in a methodical fashion. To handle safety concerns at building sites, Florio et al. [1] said that a systematic and complete method is required. According to Helander [2] and Neitzel et al. [3], "construction accidents account for around 6% of overall building expenses, while cranes and MHE are responsible for up to one-third of all deaths on construction and maintenance sites. Other types of accidents that occur in materials handling were researched in [4] using data from two separate sources, and the results indicated that all accidents recorded occurred during the materials transfer process, and these incidents accounted for around 36% of all absenteeism days". Workers must be taught to recognize and report dangerous circumstances and practices, according to Revelle [5]. "Another research conducted by Vinodkumar and Bhasi [6] examined employee views of self-reported safety knowledge, safety management practices, compliance, and engagement in safety activities among 1566 employees working in process industrial units. In addition to these investigations, numerous researchers" [7–11] "have looked into the safety of MHE. A safety study is conducted in this research among sixty construction sites situated in various areas of India using a questionnaire survey consisting of twelve safety factors. The data was then examined and used to develop a safety education programmed for two of the construction sites

that scored the lowest out of all of them. The goal of this initiative is to create a knowledge base interface for construction worker safety and health management". Three self-instructional modules have been produced for the safety programmed, each of which is utilized to train nineteen workers at site 1 and site 2. "A t-test significance analysis was utilized to examine the information obtained by workers using two surveys, one before and one after the training. Section 3 describes the survey and safety education programmed methodology, Section 4 examines the results, and Section 5 concludes".

## 2. LITERATURE REVIEW

J. S. Noble and C. M. Klein, A. Mid ha [1] "have examined several elements of the integrated cloth float system design hassle. However, as problem complexity has increased the ability to achieve answers to the extra integrated problem formulations has grown to be more difficult. They present a model which integrates material dealing with equipment choice and specification (such as interface equipment between exclusive kinds of gadget), and route/load-based unit load size and variable unit load size. The formula is solved using the meta-heuristic technique of tabu seek to discover" an "excellent" technique to a extra integrated formula. Ramazan YAMAN [2] "develop a know-how-based totally system for fabric dealing with equipment selection and pre-design of these 111equipments inside the facility format is mentioned. The look at accommodates sections. In first segment creator defined the selection of cloth coping with device for associated product necessities and in second phase choice making for equipment among departments". J. D. Tew, S. Manivannan, D. A. Sadowski, and A. F. Seila [4] "have been illustrate the simulation methodologies used within the layout of Automated Material Handling Systems (AMHS) at Intel wafer fabs for semiconductor manufacturing. The models used in AMHS layout has classified as AMHS fashions and manufacturing fashions. The AMHS fashions assist the layout of Interday and Intraday structures. The Inter bay systems handle the cloth glide between distinct bays (production centers)". Prasad Karande and Shankar Chakraborty[5] "have achieved the selection method for suitable MH system . They had proceeded with multicriteria decision-making (MCDM) hassle. As huge range of MH system is to be had today, for this complicated undertaking they carried out a multicriteria selection-making (MCDM) device to pick out the most appropriate MH system". "They enforce weighted software additive (WUTA) technique to remedy an MH device selection problem. A number of studies works and protection education programs had been carried out in several construction industries to inculcate safety in fabric managing. The construction industries in the EU-27 have furnished employment to about 11.5 % of the workforce in 2010 while producing an envisioned EUR 562 billion of added price" [12]. "And in 1998, the biggest wide variety of place of job fatalities has been suggested, as compared to another industry accounting for almost 20% of the full deaths [13–15]. A quantified hazard estimation technique was analyzed and applied on construction worksites via proposed solutions to degrade the likelihood of springing up deadly accidents from the final results of threat value [16]". Fung et al. [17] "explored 14 common forms of trades, injuries, and accident causes and investigated people's need involved in creation to take systematic and powerful chance tests for different trades through a evolved chance evaluation version. Zwetsloot et al. [18] 'analyzed the threat manipulate of 4 certification and testing regimes (CTRs) in the Netherlands to create an understanding of issues bobbing up in risk manage thru such regimes and identify critical approaches and factors that may affect the ones danger manage system'. Recent research show evidences that health and safety training have made a difference within the safety information of construction employees [19]". "A questionnaire was designed and implemented to 40 construction employees in southern Spain to examine the impact of health and safety investment on construction corporation prices [20] and the identical became discussed with slight alterations by El-Mashaleh et al. [21] for Jordanian construction enterprise". Park and Kim [22] "in their studies work proposed a framework and a prototype system for a singular safety management and visualization device (SMVS) consisting of four other construction technology, constructing statistics modeling (BIM), region monitoring, augmented reality (AR), and recreation technology". A digital fencing era become proposed by Williams et al. [23] "that triggers caution signals to prevent workers from status in unsafe positions.

In addition to research works related to MHE safety, articles have also been posted thinking about different factors affecting employee protection together with in [24] whose work undertakes a comparative look at of HR practices adopted for protection management on construction projects in the United States (US) and Singapore". "Another studies approach become proposed by Teoa and Ling [25] the use of a technique inclusive of 15 steps inclusive of a survey to develop and take a look at safety management machine audit gear being used to assess the effectiveness of construction web page's safety machine. Also, safety control device's implementation and improvement were discussed in [26–32]". Shepherd et al. [33] expected that the crane injuries are the motive for approximately 25–33% of casualties in creation sports". A tick list of important safety precautions being accompanied in Saudi Arabian creation websites turned into surveyed by way of Jannadi and Assaf [34]. "According to Hakkinen [35, 36], ¨ the character of lifting paintings relies upon on how the crane is being operated. One technique to prevent injuries is to mitigate the opportunities of disturbances with the aid of keeping the paintings environment appropriate to physiological and mental demands of human".

## 3. OBJECTIVE OF MATERIAL HANDLING SYSTEM: -

The fundamental goal of a material handling system is to lower production unit costs. The following are the other secondary goals:

Reduce the time it takes for a product to be manufactured, as well as delays and damage.

3. Enhance workplace safety and conditions

4. Maintain or increase the quality of the product

5. Enhance efficiency

i. Material should be transported in a straight path.

ii. Stuff should be moved as quickly as feasible;

ii. Stuff should be moved as quickly as feasible;

iii. Use gravity;

iv. Move more material at once;

v. Automate material handling

## 4. DESCRIPTION: MATERIAL HANDLING SAFETY

Analysis MHE's safety management is a challenging issue to implement and improve, and MHE's use on construction sites need continual and major research to improve the safety of its operation. Construction sites are divided into three categories: small, medium, and large. Each of these groups has its own safety management system that is tailored to the particular building site. The study's first phase concentrated on two types of construction sites: small and medium-sized projects. Small construction sites employ less than 50 individuals, whereas medium-sized construction sites employ between 50 and 100 people. Points earned by small-scale construction employees are listed in Table 1. Because they comply with all applicable safety criteria, the majority of large-scale facilities are not reviewed for this study .

### 4.1. Safety Components

The MHE safety management system of small and medium-sized sites were dismantled for this study and divided into twelve distinct components, which were then classified into two parts: administrative management and technical management. The security parameters were generated from construction site research and risk assessments. Each facet has its own questionnaire, which contains 10 questions for a maximum of 120 questions. General help build and maintain, cleanliness and wellness, safety gear, hazard and risk assessment, crane inspection, and worker behavioral safety are the first six parts of the safety management system. Construction cranes and monster cranes, commercial vehicles and dump trucks, passenger and builder hoist safety, warehousing and handling of materials safety, and earth moving equipment safety are all subject to inspection. and fire prevention and fire protection are the other six elements that fall under the technical management system. The questionnaire was issued to thirty small and medium size building sites across India, with twenty-eight small scale and twenty-nine medium scale sites

responding. Due to the irrelevance of the replies, one set of answers from the medium scale site was ignored. The questions were either "yes" or "no," and the number of "yes" responses was tallied and used in this study. The total points collected by small and medium scale sites are shown in Tables 1 and 4, respectively.

Table 1: Points obtained by small scale construction workers.

| Small scale construction sites | | | |
|---|---|---|---|
| Site | Total (max. = 120) | Mean | Correlation coefficient |
| 1 | 53 | 4.42 | −0.64 |
| 2 | 61 | 5.08 | 0.00 |
| 3 | 38 | 3.17 | −0.75 |
| 4 | 53 | 4.42 | 0.33 |
| 5 | 55 | 4.58 | −0.60 |
| 6 | 50 | 4.17 | 0.81 |
| 7 | 58 | 4.83 | −0.56 |
| 8 | 56 | 4.67 | −0.18 |
| 9 | 54 | 4.50 | −0.12 |
| 10 | 54 | 4.50 | −0.19 |
| 11 | 58 | 4.83 | −0.67 |
| 12 | 59 | 4.92 | −0.16 |
| 13 | 58 | 4.83 | −0.81 |
| 14 | 60 | 5.00 | −0.29 |
| 15 | 61 | 5.08 | −0.94 |
| 16 | 51 | 4.25 | −0.63 |
| 17 | 52 | 4.33 | −0.40 |
| 18 | 67 | 5.58 | −0.51 |
| 19 | 55 | 4.58 | 0.45 |
| 20 | 55 | 4.58 | −0.26 |
| 21 | 54 | 4.50 | −0.05 |
| 22 | 67 | 5.58 | −0.52 |
| 23 | 60 | 5.00 | −0.24 |
| 24 | 62 | 5.17 | 0.24 |
| 25 | 63 | 5.25 | 0.21 |
| 26 | 53 | 4.42 | 0.66 |
| 27 | 61 | 5.08 | −0.45 |
| 28 | 38 | 3.17 | 0.67 |

As illustrated in the following example, the mean and correlation coefficient values are calculated. Take a look at Site 1 in Table 1. Table 2 shows the breakdown of points earned in each of the twelve elements. The sum of all "yes" for each module is 53, while the mean of points in site 1 is (3 + 5 + 5 + 3 + 3 + 4 + 6 + 4 + 5 + 5 + 5 + 5 + 5 + 5 + 5)/12 = 53. (1) is used to determine the correlation coefficient "r," and the preliminary data is produced as indicated in Table 3. Table 3's summation values are used in the equation to determine "r" as shown in (2). Site 1's final "r" value is 0.64; similarly, site 2's final "r" value is 0.64 "$r$" is calculated for the rest of the sites:

$$r = \frac{n(\Sigma xy) - (\Sigma x)(\Sigma y)}{\sqrt{\left[n\Sigma x^2 - (\Sigma x)^2\right]\left[n\Sigma y^2 - (\Sigma y)^2\right]}}, \quad (1)$$

$$r = \frac{6(113) - (23)(30)}{\sqrt{\left[(6 * 93) - (23)^2\right]\left[(6 * 152) - (30)^2\right]}}. \quad (2)$$

### 4.2. Safety Education Program for MHE.

The workers were provided self-instructional modules comprising resources for the education programmed as part of the execution of the safety education programmed, which followed well-established safety protocols. According to our findings, workers have a lower degree of safety understanding than is necessary. The mean values and primarily negative correlation coefficients in Tables 1 and 4 demonstrate this. As a result, three modules that are regarded to be closely related for the successful development of worker safety were produced for the goal of teaching workers on safety via MHE. General worker safety, MHE inspection and operation, and MHE environment safety are the modules. These three safety modules were deemed useful for the educational programmed and typical for raising safety awareness among industrial personnel. Two of the lowest-scoring construction sites, one on a small size and the other on a medium one, were chosen for the education programmed, with around nineteen workers from each construction site. The goal of the education programmed is to teach personnel about safety when they are working with the MHE. 3.3. The Program's Effectiveness To assess the program's success, the workers were given a new set of questionnaires before and after the session. The questionnaire was divided into three sections: general worker safety, "MHE inspection and operation, and MHE environment safety, each having 40 questions totaling 120 questions, with each contributing 0.25 points. The points earned by each worker before and after the test were then compared to see if the workers' knowledge

level had improved. The significant value was determined using a two-tailed t-test analysis of the mean, standard deviation, and correlation coefficient of the findings of both the questionnaire sets before and after the programmed. Table 5 shows the results of the points acquired by the workers for the questionnaire before to the programmed. It displays the points earned by employees prior to training".

Table 2: Site 1 element-by-element pointers.

| | Safety modules | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site 1 | Administrative management system | | | | | | | Technical management system | | | | | Total |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | |
| Points | 3 | 5 | 5 | 3 | 3 | 4 | 6 | 4 | 5 | 5 | 5 | 5 | 53 |

Table 3: The correlation coefficient is calculated.

| Element | $X$ | $Y$ | $X * Y$ | $X^2$ | $Y^2$ |
|---|---|---|---|---|---|
| 1 | 3 | 6 | 18 | 9 | 36 |
| 2 | 5 | 4 | 20 | 25 | 16 |
| 3 | 5 | 5 | 25 | 25 | 25 |
| 4 | 3 | 5 | 15 | 9 | 25 |
| 5 | 3 | 5 | 15 | 9 | 25 |
| 6 | 4 | 5 | 20 | 16 | 25 |
| $\sum$ | 23 | 30 | 113 | 93 | 152 |

Table 4: Points acquired by the use of a medium-scale building method.

| | Medium scale construction sites | | |
|---|---|---|---|
| Site | Total (max. = 120) | Mean | Correlation coefficient |
| 1 | 58 | 4.83 | 0.56 |
| 2 | 48 | 4.00 | −0.22 |
| 3 | 50 | 4.17 | −0.14 |
| 4 | 47 | 3.92 | −0.59 |
| 5 | 51 | 4.25 | 0.33 |
| 6 | 52 | 4.33 | −0.06 |
| 7 | 53 | 4.42 | 0.03 |
| 8 | 41 | 3.42 | 0.69 |
| 9 | 43 | 3.58 | −0.09 |
| 10 | 51 | 4.25 | 0.00 |
| 11 | 53 | 4.42 | −0.39 |
| 12 | 50 | 4.17 | −0.33 |
| 13 | 51 | 4.25 | 0.05 |
| 14 | 53 | 4.42 | −0.60 |
| 15 | 60 | 5.00 | −0.24 |
| 16 | 55 | 4.58 | 0.18 |
| 17 | 49 | 4.08 | −0.74 |
| 18 | 47 | 3.92 | −0.47 |
| 19 | 51 | 4.25 | −0.13 |
| 20 | 50 | 4.17 | 0.19 |
| 21 | 68 | 5.67 | −0.06 |
| 22 | 54 | 4.50 | −0.35 |
| 23 | 54 | 4.50 | −0.45 |
| 24 | 52 | 4.33 | 0.56 |
| 25 | 54 | 4.50 | −0.37 |
| 26 | 59 | 4.92 | −0.26 |
| 27 | 51 | 4.25 | −0.19 |
| 28 | 57 | 4.75 | 0.42 |

Table 5: Points earned by employees prior to training

| Sl. number | General worker safety (max. = 10) | | Inspection and operation of MHE (max. = 10) | | Safety of MHE environment (max. = 10) | | Total of all areas of safety (max. = 30) | |
|---|---|---|---|---|---|---|---|---|
| | Site 1 | Site 2 | Site 1 | Site 2 | Site 1 | Site 2 | Site 1 | Site 2 |
| 1 | 4 | 4 | 3 | 2 | 4 | 4 | 11 | 10 |
| 2 | 2 | 3 | 4 | 3 | 3 | 5 | 9 | 11 |
| 3 | 1 | 5 | 5 | 1 | 5 | 3 | 11 | 9 |
| 4 | 3 | 3 | 3 | 2 | 2 | 4 | 8 | 9 |
| 5 | 4 | 4 | 2 | 4 | 4 | 5 | 10 | 13 |
| 6 | 3 | 3 | 4 | 3 | 6 | 3 | 13 | 9 |
| 7 | 5 | 7 | 5 | 5 | 4 | 4 | 14 | 16 |
| 8 | 7 | 6 | 3 | 4 | 3 | 5 | 13 | 15 |
| 9 | 3 | 5 | 1 | 6 | 5 | 4 | 9 | 15 |
| 10 | 2 | 5 | 2 | 4 | 2 | 6 | 6 | 15 |
| 11 | 3 | 7 | 5 | 3 | 1 | 4 | 9 | 14 |
| 12 | 1 | 4 | 2 | 1 | 2 | 7 | 5 | 12 |
| 13 | 5 | 6 | 3 | 4 | 3 | 2 | 11 | 12 |
| 14 | 3 | 5 | 1 | 3 | 2 | 3 | 6 | 11 |
| 15 | 6 | 6 | 0 | 6 | 4 | 5 | 10 | 17 |
| 16 | 4 | 5 | 3 | 5 | 2 | 3 | 9 | 13 |
| 17 | 2 | 3 | 2 | 4 | 3 | 5 | 7 | 12 |
| 18 | 5 | 6 | 4 | 5 | 1 | 5 | 10 | 16 |
| 19 | 2 | 7 | 4 | 3 | 2 | 6 | 8 | 16 |

## CONCLUSION

The key problem in developing the system was to handle rods of varying lengths and weights while maintaining a stable structure. After all of the components have been designed and selected, the system may be summarized as follows. The final system comprises of a chain conveyor with an extra support for when it is required. The position of the third support changes depending on the length of the rods. The device can transport 45 rods in one batch at a pace of 10 meters per minute. A functional attachment is developed and installed individually with chain to satisfy the functional needs. On the basis of finite element analysis, the attachment was determined to be safe. As a result, alternative components that were compatible with the system were chosen. The support structure was created for both the men's conveyor and the third support. Depending on the lengths of the rods being carried, the third support can be shifted to a different place. The system was built to the specifications and shipped to Sandvik. It is now operating effectively and adequately in that location .

## REFERENCES

[1] A. E. Florio, G. T. Stafford, and W. F. Alles, Safety Education, McGraw-Hill, Blacklick, Ohio, USA, 1979.

[2] M. G. Helander, “Safety hazards and motivation for safe work in the construction industry,” International Journal of Industrial Ergonomics, vol. 8, no. 3, pp. 205–223, 1991.

[3] R. L. Neitzel, N. S. Seixas, and K. K. Ren, “A review of crane safety in the construction industry,” Applied

Occupational and Environmental Hygiene, vol. 16, no. 12, pp. 1106–1117, 2001.

[4] P. Perttula, J. Merjama, M. Kiurula, and H. Laitinen, "Accidents in materials handling at construction sites," Construction Management and Economics, vol. 21, no. 7, pp. 729–736, 2003.

[5] J. B. Revelle, Safety Training Methods, John Wiley & Sons, New York, NY, USA, 1980.

[6] M. N. Vinodkumar and M. Bhasi, "Safety management practices and safety behaviour: assessing the mediating role of safety knowledge and motivation," Accident Analysis and Prevention, vol. 42, no. 6, pp. 2082–2093, 2010.

[7] S. M. Zin and F. Ismail, "Employers' behavioural safety compliance factors toward occupational, safety and health improvement in the construction industry," Procedia—Social and Behavioral Sciences, vol. 36, pp. 742–751, 2012.

[8] S. Alkass and F. Harris, "Expert system for earthmoving equipment selection in road construction," Journal of Construction Engineering and Management, vol. 114, no. 3, pp. 426–440, 1988.

[9] E. L. Fisher, J. B. Farber, and M. G. Kay, "Mathes: an expert system for material handling equipment selection," Engineering Costs and Production Economics, vol. 14, no. 4, pp. 297–310, 1988.

[10] S. Chittratanawat, "An integrated approach for facility layout, P/D location and material handling system design," International Journal of Production Research, vol. 37, no. 3, pp. 683–706, 1999.

[11] F. T. S. Chan, R. W. L. Ip, and H. Lau, "Integration of expert system with analytic hierarchy process for the design of material handling equipment selection system," Journal of Materials Processing Technology, vol. 116, no. 2-3, pp. 137–145, 2001.

[12] J. P. Reyes, J. T. San-Jose, J. Cuadrado, and R. Sancibrian, ´ "Health & Safety criteria for determining the sustainable value of construction projects," Safety Science, vol. 62, pp. 221–232, 2014.

[13] M. Gillen, D. Baltz, M. Gassel, L. Kirsch, and D. Vaccaro, "Perceived safety climate, job demands, and coworker support among union and nonunion injured construction workers," Journal of Safety Research, vol. 33, no. 1, pp. 33–51, 2002.

[14] J. M. Woodruff, "Consequence and likelihood in risk estimation: a matter of balance in UK health and safety risk assessment practice," Safety Science, vol. 43, no. 5-6, pp. 345–353, 2005.

[15] G. L. L. Reniers, W. Dullaert, B. J. M. Ale, and K. Soudan, "Developing an external domino accident prevention framework: Hazwim," Journal of Loss Prevention in the Process Industries, vol. 18, no. 3, pp. 127–138, 2005.

[16] P. K. Marhavilas, "Risk estimation in the Greek constructions' worksites by using a quantitative assessment technique and statistical information of occupational accidents," Journal of Engineering Science and Technology Review, vol. 2, no. 1, pp. 51– 55, 2009.

[17] I.W. H. Fung, V.W. Y. Tam, T. Y. Lo, and L. L. H. Lu, "Developing a risk assessment model for construction safety," International Journal of Project Management, vol. 28, no. 6, pp. 593–600, 2010.

[18] G. I. J. M. Zwetsloot, A. Hale, and S. Zwanikken, "Regulatory risk control through mandatory occupational safety and health (OSH) certification and testing regimes (CTRs)," Safety Science, vol. 49, no. 7, pp. 995–1006, 2011.

[19] A. Carbonari, A. Giretti, and B. Naticchia, "A proactive system for real-time safety management in construction sites,"Automation in Construction, vol. 20, no. 6, pp. 686–698, 2011.

[20] D. N. C. Lai, M. Liu, and F. Y. Y. Ling, "A comparative study on adopting human resource practices for safety management on construction projects in the United States and Singapore," International Journal of Project Management, vol. 29, no. 8, pp. 1018–1032, 2011.

[21] M. S. El-Mashaleh, B. M. Al-Smadi, K. H. Hyari, and S. H. Rababeh, "Safety management in the Jordanian

construction industry," Jordan Journal of Civil Engineering, vol. 4, no. 1, 2010.

[22] C.-S. Park and H.-J. Kim, "A framework for construction safety management and visualization system," Automation in Construction, vol. 33, pp. 95–103, 2013.

[23] Q. Williams Jr., M. Ochsner, E. Marshall, L. Kimmel, and C. Martino, "The impact of a peer-led participatory health and safety training program for Latino day laborers in construction," Journal of Safety Research, vol. 41, no. 3, pp. 253–261, 2010.

[24] M. Lopez-Alonso, M. P. Ibarrondo-D ´ avila, M. C. Rubio-G ´ amez, ´ and T. G. Munoz, "The impact of health and safety investment on construction company costs," Safety Science, vol. 60, pp. 151– 159, 2013.

[25] E. A. L. Teo and F. Y. Y. Ling, "Developing a model to measure the effectiveness of safety management systems of construction sites," Building and Environment, vol. 41, no. 11, pp. 1584–1592, 2006.

[26] A. M. Makin and C. Winder, "A new conceptual framework to improve the application of occupational health and safety management systems," Safety Science, vol. 46, no. 6, pp. 935– 948, 2008.

[27] B. Fernandez-Muniz, J. M. Montes-Peon, and C. J. VazquezOrdas, "Safety management system: development and validation of a multidimensional scale," Journal of Loss Prevention in the Process Industries, vol. 20, pp. 52–68, 2007.

[28] N. Mitchison and G. A. Papadakis, "Safety management systems under Seveso II: implementation and assessment," Journal of Loss Prevention in the Process Industries, vol. 12, no. 1, pp. 43– 51, 1999.

[29] C. M. Tam, T. K. L. Tong, G. C. W. Chiu, and I. W. H. Fung, "Non-structural fuzzy decision support system for evaluation of construction safety management system," International Journal of Project Management, vol. 20, no. 4, pp. 303–313, 2002.

[30] L. J. Bellamy, T. A. W. Geyer, and J. Wilkinson, "Development of a functional model which integrates human factors, safety management systems and wider organisational issues," Safety Science, vol. 46, no. 3, pp. 461–492, 2008.