

Analysis of Construction Site Safety by using ANN and Fuzzy Logic

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ABSTRACT

Construction industry is one of the most hazardous industries. Accidents may occur during construction which results in serious injuries and death to employees and also may cause severe damage to equipment. Hence it is important to prevent or minimize the accidents in the construction site. Safety during construction is very important for each employees. Safety means the condition of being protected from harm or other non – desirable outcomes. This project deals with construction site safety analysis in construction site by identifying the causes for accidents and implementing solutions for preventing the accident in the construction industry. Artificial neural network (ANN) and FUZZY logic may used to determine what kind of factor may affect the construction site safety mostly and also find how many companies follow proper rules and regulations. This paper will study the 15 case studies about safety management in construction site. And also will find the scope of safety management in construction site by using ANN and fuzzy logic.

KEYWORDS: Safety Behaviour, Multilayer Perception, Artificial Neural Network, Predictive Model, Safety Attitude, Fuzzy Logic, Safety Knowledge.

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I. INTRODUCTION

Construction industry is consider as one of the most hazardous industries. The development of construction industry has been plagued by the accidents or injuries that are frequently occurred . It is estimated that there are around 60,000 construction fatalities occurred worldwide each year, which equates to one accident happens every nine minutes. Human error is a main reason for upto 80% of all incidents and accidents in high risk industries.

According to the occupational safety and health administration (OSHA), the construction industry

is responsible for more than 20 % of all worker fatalities. Falls from elevation, struck by objects, electrocutions, and caught in between are among leading causes. Also, accidents related to scaffolding account for a large proportion of the causes of the safety hazards. It is desirable that all such potential safety hazards are identified in the early and planning stages and preventive actions are taken. Planning for safety typically consists of the identification of all potential hazards, as well as the decision on choosing corresponding safety measures.

A job site safety analysis is a technique that focuses on job tasks as a way to identify hazards

before they occur. It focuses on the relationship between the worker, the task and the working environment. The basic procedure for conducting job site safety analysis includes:

- (1) Identifying all the job steps of a given activity
- (2) Identifying potential hazards related to these different job steps and
- (3) Proposing action procedures to eliminate, reduce, or control each hazard

The complexity and uncertainty inherent in the nature of the construction industry require safety planners to adopt technologies as recent and innovative as available to make sure they are covering predictable surprises as much as possible.

The aim of the project is to present a decision making model for implementing safety in the construction site by finding out the factors and comparing them by implementing those factors in the software. This was used to avoid or minimise the adverse impacts on public health and safety of employees during the project life cycle from both routine and non – routine circumstances during the design, construction and design phase.

II. OBJECTIVES

The objective of this paper is to study the different literatures about safety management in construction industry

The scope of paper includes

- To study the safety management principles related to construction industry.
- To find out the risks and accidents in the construction projects.
- To develop solutions for eliminating accidents.
- To create a decision making model to evaluate safety in the site.

III. ENVIRONMENT SAFETY AND HEALTH MANAGEMENT

- Companies that likely to be eco –friendly agents invest in strong environmental, health and safety management otherwise known as EHS.
- From an environmental standpoint, it involves creating a efficient approach to managing waste, complying with environmental regulations, or reducing the effect of pollutions and also manage to safeguard labours from major and minor accident.
- EHS is nothing but a well – planned management system which is used to make the construction safely and eco-friendly.

IV. GENERAL HSE REQUIREMENTS

- Where work activities may conflict with or impacts upon other work activities take steps to discuss the matter with relevant parties and establish a consensus. Ensure that both parties and their team are fully aware of potential hazards together with appropriate precautions.
- All plant and equipment shall be inspected before work commences and at periodic intervals thereafter. All plant and equipment shall be safe before and during use.
- Only competent personnel are permitted to operate plant and equipment and such persons shall be tested by a competent person and issued with an Appointment Certificate authorizing them to operate specified plant and equipment.
- Method statements/risk assessments shall always examine the people, equipment, materials and the environmental aspects of the proposed work.
- Such method statements/risk assessments shall always be referred to subcontractor/contractor safety departments for review and comment.
- Ensure that an emergency/rescue plan to cater for any mishap is available, known to all people and capable of immediate activation.
- Maintain good housekeeping at all times. Provide and maintain adequate hygiene and welfare facilities such as toilets, hand washing measures, drinking water, and canteen shelter, food waste bins and defined smoking area.
- Hazardous area should be barricaded with the attachment of appropriate warning symbols.
- Work area should be always kept clean. Unwanted scrap or tools should not be left unattended that may be hazardous to others.

V. ARTIFICIAL NEURAL NETWORK

Artificial Neural Network (ANN) has been recognized as a strong tool for developing predictive models, particularly for such a complex context as human behavior modeling and prediction, in which the interrelationships among variables are of high complexity and somewhat unknown. The approach has been shown to be strong, flexible, and easy to apply, and is better than conventional statistical methods in several ways. Contrary to conventional statistical methods, such as regression, ANN is adaptive, which means they can learn and adapt themselves with new data and become more

intelligent in explaining and predicting the desired phenomenon. Another important advantage of ANN over conventional statistical methods is that ANN do not need an underlying distribution to be specified, while most of statistical tests are performed on the basis of an underlying probability distribution (in most cases Gaussian distribution) . The approach is able to model nonlinear relationships and its predictive performance is much better than that of conventional multiple regression approach.

Given the capabilities of ANN, it has been extensively used in the field of occupational safety and health for predicting various outcomes, e. g. safety climate and accident severity. Accordingly, the aim of the present study is to develop an ANN model for forecasting safe behavior at workplaces and determine the most important factors affecting such a behavior.

VI. FUZZY LOGIC

FST presents a natural way of modelling the intrinsic vagueness and imprecision of everyday concepts by providing a very precise approach for dealing with uncertainty which grows out of the complexity of human behaviour. It also allows the inclusion of human creativity and intuition, which is an essential ingredient for a successful OSRA .

VII. LITERATURE REVIEW

A literature review is a detailed report of information obtained from the literature that are related to our topic of study. The review describe, summarize, evaluate and clarify this literature. It gives a base for the research and helps in determining the nature of the study. This section represents the review of literature collected from various journals and articles that are most relevant to the study.

The report "Critical factors and paths influencing workers safety risk tolerances" was written by Jiayuan Wang , Patrick X. W. Zou and Penny P. Li (2016), it briefly summaries the mostly affecting safety factor and identify the critical factors and paths that influence workers safety risk tolerance and to explore how they contribute to accident casual model from a system thinking perspective. Data collected through interviews and questionnaire survey. In the first and second steps, factor identification, factor ranking and factor analysis were carried out, and the result show that workers safety risk tolerance can be influenced by

personal subjective perception, work knowledge and experiences, work characteristics and safety management. In the third step, hypothetical influencing path model was developed and tested using structural equation modelling. It is found that effects of external factors on risk tolerance are larger than that of internal factors. It also provides an in-depth knowledge of workers unsafe behaviours by depicting the contributing factors.

An another report "Factors influencing the implementation of safety management system for construction sites" was written by Zubaidah Ismail, Samad Doostdar and Zakaria Harun (2012), this paper discribe to determine the influential safety factors that governed the success of a safety management system for construction sites. The study involved a self -administration questionnaire among the workers and interviews with industry experts involved in brick laying, concreting and interrelated works. First part concerned personal particulars, the second part involved training and experience, and the third part was based on 28 industry accepted safety factor elements. From the followed closely by communication Suggestions and recommendations on equipment design and improved work practices and procedures to improve the efficiency and productivity of construction workers were proposed.

Brain H. W. Guo, Tak Wing Yiu, Vicente A. Gonzalez are the authors of the paper "Predicting safety behaviour in the construction industry : development and test of an integrative model" (2016), this paper proposed to developed and tested an integrative model of construction worker's safety behaviour with an attempt to better understand the mechanisms by which key safety climate factors and individual factors influence worker's safety behaviour. Data were collected using a questionnarie. Eight competing models were tested using structural equation modelling. The result showed that management safety commitment was significantly related to social support and production pressure Production pressure was identified as a critical factor that has direct and significant effect on safety motivation, safety knowledge .safety participation and safety compliance. The integrative model suggest a combination of a safe organization, safe group and safe workers strategies to reduce unsafe behaviour on sites.

The report "Attitudes in construction safety" (2005), written by Brenda McCabe, Dimitrios Karahalios and Catherine Loughlin, this paper

describe to conducted pilot study based on self-evaluated questionnaire to collect demographic information, attitudes and incidents. Attitudes were measured by asking participants to respond to a series of statements using Likert scale. Attitudes were compared by some of the demographic factors. ANOVA was also carried out. The results showed that safety and production significantly decreases with experience and time, and also safety interferes with work significantly decreases with age. One suggestion might be to ensure good age and experience mixes in the crews can provide better safety monitoring for improved attitudes and fewer incidents.

The report 'Artificial Neural network as a Technique in construction engineering and management :predicting hourly air pollutant of excavator in the earthworks' (2018) was written by Hassanean S. H.Jassim, it brief study the artificial neural networks as a general and principal concept application. And implementation in the construction engineering and management. However, a study concerning data relative with fuel consumption has been applied to the style of artificial neural networks to model fuel consumption per hour for different models of excavators. Five input parameters have been used and one output parameter where ANN model has been proven that the neural network is capable of modelling and forecasting with good accuracy moreover. ANN model has been shown the relative importance of the input parameters and their effects on output. Cycle time of excavator is demonstrated factor (66.76%) on fuel consumption per hour of earthworks. The prediction equation is a good practice to aided planners and practitioners in the construction management to estimate fuel consumption per hour of earthworks at early stage (i.e. at planning stage) of the construction projects. The report "A Neural Network Classifier Model for Forecasting Safety Behavior at Workplaces" (2017) was written by Fakhradin Ghasemi, Omid Kalatpour, Abbas Moghimbeigi and Iraj Mohammad fam, this paper describe to build a predictive model of unsafe behavior using the Artificial Neural Network approach. A brief literature review was conducted on factors affecting safe behavior at workplaces and nine factors were selected to be included in the study. Data were gathered using a validated questionnaire from several construction sites. Multilayer perception approach was utilized for constructing the desired neural network. Several models with various architectures were tested to find the best one.

Sensitivity analysis was conducted to find the most influential factors.

The report "A Framework for Evaluating the Safety Performance of Construction Contractors" (2012) was written by S. Thomas, Kam Pong Cheng, R. Martin Skitmore, this paper describe the importance of SPE factors is examined through a questionnaire survey conducted in Hong Kong. The results of the questionnaire survey are used to develop a SPE framework suitable for use in the construction industry and protocols for evaluating the safety performance at the organisational and project levels. Through this analytical framework, SPE scores can be computed which would facilitate the benchmarking process and various initiatives to improve the safety performance of construction contractors.

The report "A Bayesian Network Model for Reducing Accident Rates of Electrical and Mechanical (E&M) Work" (2018) was written by Albert P. C. Chan, Francis K. W. Wong, Carol K. H. Hon and Tracy N. Y. Choi, this paper describe the Bayesian Network (BN) model is proposed to establish a probabilistic relational network between the causal factors, including both safety climate factors and personal experience factors that have influences on the number of accidents related to E&M RMAA work. The data were collected using a survey questionnaire, involving a hundred and fifty-five E&M practitioners. The proposed BN provides the ability to find out the most effective strategy with the best utilization of resources, to reduce the chance of a high number of E&M accidents, by controlling a single factor or simultaneously controlling, both, the safety climate and personal factors, to improve safety performance.

The report "Prediction of Safety Climate through Neural Network" (2014) was written by D.A. Patel, describes to develop a model to predict the safety climate on a construction project using the artificial neural network (ANN). The constructs are used as inputs and safety climate of a project is used as output for the ANN algorithm. For the study, 200 responses have been collected through a questionnaire survey across the country. A three-layer feed forward back propagation neural network (10-18-1) has been found suitable for the analysis. It has been trained, validated, and tested during the model development. The developed model is found to be predicting the safe climate of a construction project reasonably well.

The report "The Game Theory Application in the Construction Safety

Management” (2016) was written by BuXiangyi, describes to study the influence of the participating parties in the construction process, the construction safety management analysis model based on the static and evolutionary game theory is put forward. The completely static game theory method of construction safety construction units, and supervision units were analyzed, obtained the relationship between the two sides of the basic game theory, the evolutionary game theory to establish the game model of the safety supervision units and construction units, has been on both sides of the balance relationship of strategy. Finally through the Vensim software established construction safety supervision game model of SD, and on safety supervision units and construction units on both sides of the implementation strategy of visual analysis, the safety rules of the construction unit execution probability curve, provide more valuable reference for the research of construction safety management.

The report “Implementation of Safety Management System for Improving Construction Safety Performance: A Structural Equation Modelling Approach”(2019) was written by Nicole S.N. Yiu, Daniel W.M. Chan, N.N. Sze, Ming Shan and Albert P.C. Chan, describes the motivation factors which characterize the quality and level of achievement should be identified. In this study, a structural model has been established to examine the relationship between the SMS implementation and operational & safety performance of the construction projects. Results of this study have unfolded the motivation factors in SMS implementation and their subsequent effects on project performance, throwing light on the need to enhance the safety management practice in order to reduce accidents and injuries in the construction industry in the long run.

The report “Organizational factors related to occupational accidents in construction industry” (2014) was written by J.M. Jackson Filhoa, E.D. Fonseca , F.P.A. Limab and F.J.C.M. Duarte, describes to understand the influence of organizational factors on occupational accident causation. A field study was undertaken and focused on the phase of concreting the floors of a residential block in a building project in Brazil. The methodological approach was based on the analysis of carpenter’s work practices and of the worker’s accounts of minor falls. Observations were noted on work practices over this stage. Furthermore, interviews were conducted with the workers hired by the subcontractors and with

professionals working for the main contractor. The results show that falls were related to the introduction of new building technology and its use by the workforce.

The report “Effects of Occupational Safety and Health Hazards’ Exposure on Work Environment in the Water Service Industry within Kisumu County – Kenya” (2014) was written by Oluoch, Paul Njogu and Jared O. H. Ndeda, describes to determine effects of exposure to occupational safety and health hazards on work environment in the Kenyan Kisumu County Water Service industry. The study utilized a descriptive research design. . Questionnaires were used to obtain primary data; that were analyzed using quantitative techniques. Standard deviation was adapted to measure disparity for the likert-scale questionnaires. The entire hypothesis was tested at 95% confidence level. Risk Severity rating was then done for Biological, Chemical, Ergonomics, Physical, Psychological and Safety risks. Results reveal that employees working in the water service industry in Kisumu County are exposed to hazards and risks. The report “Integral Diagnosis of Occupational Health and Safety Management in Colombian Construction Companies” (2017) was written by Fabian Alberto Suarez Sanchez, Gloria Isabel Carvajal Pelaez and Joaquín Catala Alís, describes to perform a comprehensive diagnosis of the implementation of the requirements of the Colombian Technical Standard (Norma Técnica Colombiana, NTC-OHSAS 18001) in Colombian construction companies through a SWOT analysis. A survey of 25 questions to industry professionals in 5 capital cities was used for data collection. The survey was conducted in two ways: virtually with the help of the Google Docs platform and directly through written forms. The findings show that a lack of commitment and a lack of knowledge about safety are the main weaknesses.

The report “Critical factors and paths influencing workers safety risk tolerances” (2016) was written by Jiayuan Wang , Patrick X. W. Zou, Penny P. Li, describes to identify the critical factors and paths that influence workers safety risk tolerance and to explore how they contribute to accident casual model from a system thinking perspective. Data collected through interviews and questionnaire survey. In the first and second steps, factor identification, factor ranking and factor analysis were carried out, and the result show that workers safety risk tolerance can be influenced by personal subjective perception, work knowledge and experiences, work characteristics and safety

management. In the third step, hypothetical influencing path model was developed and tested using structural equation modelling. It is found that effects of external factors on risk tolerance are larger than that of internal factors. It also provides an in-depth knowledge of workers unsafe behaviours by depicting the contributing factors.

VIII. CONCLUSION

This paper consider that wide literature and knowledge about safety management in construction site. Artificial Neural Network and FUZZY logic may used for predicting factors affecting safety in construction site. Several papers have been presented on safety management in construction site by using ANN. This research is carried out to show various technique for safety management in construction site. I have studied several journal papers about construction site safety by using ANN. Thus, it is concluded that ANN and fuzzy logic is used to predict the factors affecting safety and reduce it effectively.

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