Risk Assessment of Safety for Building Construction Projects in Abuja, Nigeria

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***Abstract**:*

The construction industry is considered as one of the most hazardous industries, with very high rate of accidents and ill-health problems to workers, organisations, society and countries. Fatalities, injuries and unsafe work conditions reported on construction sites are owing to contractors neglecting the risk involved in the construction activities that have the potential to cause injuries the most on site due to cost saving attitude. The study's objective is to assess the safety risk level for each work item, in terms of severity and probability on building construction projects in Abuja, Nigeria. 50 copies of well-structured questionnaires were administered to seek the opinion of construction professionals who managed and supervised construction projects in Abuja and 34 were returned representing a response rate of 68%. The data were analysed using Mean value method and prioritization number. The result on probability risk of occurrence (PRO) reveals that roof work and steel structure, with PRO of 3.15 and 3.05 are the building activities with medium risk level. While the result on severity risk impact (SRI): Electrical works, Steel structure, Roof work and Lift installation with SRI of 3.30 and 3.10 are the building activities with medium risk level. Safety risk prioritization result revealed that Roof work, Steel structure and Electrical works had the greatest risk level with an average risk score of 9.77, 9.46 and 9.14 respectively. It was concluded that though findings showed that most building construction activities in Abuja are of medium risks, but workers are still prone to injury and accidents which are tolerable. It is recommended that proper risk identification and prioritization should be a precondition for effective risk control on construction sites. The study provided an avenue for construction managers to identify the risk level of major construction activities which will assist them allocate safety measures in a more efficient manner.

***Keywords**: Construction projects, Hazards, Risk Assessment, Risk matrix, Safety Risk*

INTRODUCTION

The construction industry has a great influence on both the economy and social policies in many developing countries (Yoon *et al.,* 2013; Bilir & Gurcanli, 2018). Despite its socio-economic importance, the construction industry is considered as one of the most hazardous industries, with very high rate of accidents and ill-health problems to workers, organisations, society and countries (Muiruri & Mulinge, 2014; Sanchez *et al.,* 2017). The industry has a significant impact on the health and safety of workers. Construction workers perform a great diversity of activities, each activity with a specific associated risk. A worker is directly exposed to risks associated with task undertaking and passively exposed to risks produced by co-workers (Pinto *et al.,* 2011).

Accidents and fatalities at the construction sites results in numerous injury and death of worker yearly. According to the International Labour Organisation (ILO) there are 270 million occupational accidents resulting in two million deaths annually (Tadesse & Israel, 2016). ILO (2012) acknowledged that construction industry contributes 25 - 40% of the world's occupational fatalities. The Bureau of Labour Statistics (2016) reported that the fatality rate of the construction industry was 10.1 fatalities per 100,000 workers, which was higher than that of other industries, such as forestry 0.91, transportation 0.75 and fishing 0.24 fatalities per 100,000 workers. In the United States, the construction industry accounted for 19% of the overall industrial deaths in the year 2016 and globally the construction industry was found to have higher fatality rate than in other industries (Chan *et al*., 2018). In the United Kingdom, the death rate of the construction industries was 1.37 fatalities per 100,000 workers, which was more than thrice higher than the average of all other industries (Health and Safety Executive, 2017). A study carried out by Hamalainen *et al.* (2009) puts the annual work-related death rate of Nigeria at about 24 fatalities per 100,000 employees. The situation in developing countries like Nigeria is worse than what prevails in developed countries, this is due to lack of statutory regulations on health and safety and lack of accurate records of accidents and injuries on site by contractors (Idoro, 2011).

Fatalities, injuries and unsafe work conditions reported on construction sites are due to contractors committing little resources to the maintenance of a healthy and safe construction work environment due to cost saving attitude, thus neglecting the risk involved in the construction activities that have the potential to cause injuries the most on site (Idoro, 2011; Windapo, 2014). Owing to this fact, it is of fundamental importance for construction companies to assess the risks at the work site and to take effective measures to minimize these risks. This can be achieved through a holistic approach by carrying out a study to assess safety risk level on building construction projects in Nigeria. The study's objective is to determine the level of risk for each work item, in terms of probability and severity on building construction projects in Abuja.

Risk Assessment

Baranda and Usmen (2006) defined risk as the measure of both the likelihood and the consequence of hazard associated with an activity or condition. Hallowell *et al.* (2017) described risk as a potential event that results in an outcome that is different from what is planned. In construction safety risks are defined as potential incidents. Risk assessment is described as a method used to decide on the priorities and to set objectives for eliminating hazards and reducing risks (Hughes & Ferret, 2016). Health and safety risk assessment on construction site is an important measure towards the reduction of hazards and injuries (Kozlovska & Strukova, 2012**).** Identification of potential hazards and evaluating the risk associated with the hazards is an important step toward safety risk assessment (Aminbaksh *et al.*, 2013). According to Carter and Smith (2006) determining the risk for construction hazards depends on the probability of an accident occurring and the severity of the impact. Probability or frequency defines the likelihood or rate of occurrence of an accident or hazards in a specific period of time. In terms of safety risk probability of an accident is expressed in the form of an incident rate such as the number of worker-hours per incident (Hallowell *et al.* (2011). Severity defines the magnitude of the outcome. Severity may be defined in terms of the degree of injury (such as fatality, lost work-time and medical-case) or numerically in terms of money impact to the organisation (Hallowell *et al.,* (2017).

Research on safety risk assessment have different dimensions resulting in a great variety of units ranging from high level studies that compared risk among trades (Brauer, 2005; Baraban & Usmen, 2006; Fung *et al.*, 2010). And to detailed studies which looked at specific work activities and the risk associated with specific trades/tasks (Everett, 1996; Jannadi & Almishari, 2003; Gangolells *et al.,* 2010; Zolfagharian *et al*., 2014; Gurcanli *et al.*, 2015 and Okoye, 2018). It was observed that most of the studies mainly focused on injury and fatality risks as individual issues and were based on either frequency or severity alone resulting in a less comprehensive result. This study is based on quantifying the potential safety risk level of construction work items in terms of severity and likelihood.

The process of risk assessment consists of three distinct phases: identification of risks, risk estimation and risk assessment (Tixier *et al*., 2002 and Pino & Garcia*,* 2017). Safety risk assessment can be computed using qualitative, quantitative and semi quantitative method (Purohit *et al.,* 2018). In risk assessment, the risk matrix method is a semi-quantitative method. The semi-quantitative analysis uses descriptive scales to produce a more structured way of ranking risks according to their probability and severity (Purohit *et al.,* 2018). This is attained through a predefined scoring system which allows one to map a perceived risk into a category, where there is a logical and hierarchy between categories. The risk matrix is a table that comprises several categories of probability (frequency or likelihood) for its rows or columns and several categories of severity (consequences or impact) for its columns or rows (Zolfagharian *et al*., 2014). Risk value is determined by estimating the probability (likelihood) of occurrence (P) and the potential severity of hazardous event (S).

Risk value is expressed as: $R = P \times S$ (1)

Where: P= Likelihood of occurrence and S = Potential severity of harm.

The 5x5 risk matrix defines 5 classes of likelihood and 5 classes of severity in cooperates these classifications both in descriptive and quantitative features (Ceyhen, 2012). Each descriptive class for likelihood and severity has a corresponding quantitative value from 1 to 5. There are five categories of likelihood of risk occurrence which are: Rare, Remote, Occasional, Frequent, Almost and they take value from 1 to 5, respectively. In the same way, Severity of consequence is also categorized into five: which are Negligible, Minor, Moderate, Major, Catastrophic and they take value from 1 to 5, respectively (Workplace Safety and Health Council (WHSC), 2011). Risk are evaluated by multiplying the values for likelihood and severity, and as the result, risk values from 1 to 25 are produced in the combination of different categories of probability and severity of consequence. According to this risk categorization, risk categories are developed as, high having risk level of (13 to 25), medium high having risk level of (12 to 5) and low high having risk level of (1 to 4). The second classification of risks are made on the bases of risk acceptance. There are three categories in this meaning: acceptable, tolerable and non-acceptable. The correspondence of categories and their risk value is summarized in the subsequent part with the help of tables.

METHODOLOGY

Quantitative research approach was adopted for the study. Questionnaire survey was used for data collection. A survey is a positivistic methodology that draws a sample from a larger population in order to draw conclusions about the population (Collins *et al.,* 2007). A well-structured questionnaire was developed and distributed to respondents to seek the opinion of construction professionals who managed and supervised construction projects in Abuja. The study assessed the perceptions of respondents in determining the probability of occurrence (likelihood) and severity of risk impact (consequence) on construction projects in Abuja. A non-probability sampling technique known as convenience sampling technique was used in sampling the study's respondents. Collins *et al.* (2007) described convenience sampling technique as a sampling method that involves choosing from a sample that is not only accessible but also the respondents are willing to participate in the study. The study was such that the respondents were asked questions based on the building construction projects they were found handling on site during the self-administration of the questionnaires. This explains why the data obtained were limited to 34 and invariably 34 construction projects were examined, due to the fact that only 34 of the respondents were willing to participate out of the 50 supposed construction projects sites with on-going projects. The unit of analysis was construction project handled by each respondent. The data collected were analyzed using the descriptive analysis.

Method of Data Collection

The questionnaire was developed to assess the safety risk level for each work item, in terms of severity and probability on building construction projects in Abuja, Nigeria**.** The questionnaire was divided into two parts. The first part captured information about the respondents' background which includes: Academic qualification and year of experience. The second part of the questionnaire concentrated on 17 selected common work activities for building construction projects, were chosen after literature review (Jannadi & Almishari, 2003; Brauer, 2005; Baraban & Usmen, 2006; Fung *et al.*, 2010; Gangolells *et al.,*2010; Zolfagharian *et al.*, 2014; Gurcanli *et al.*, 2015; Okoye, 2018). Respondents were required to express their view, based on their perception on the severity of risk impact (consequence) and probability of occurrence (likelihood) on the identified work activities on a 5-point likert scale where (1) = Rare, (2) =Remote, (3) =Occasional, (4) = Frequent, (5) = Almost, for Likelihood of risk occurrence (probability of occurrence) and

(1) = Negligible, (2) = Minor, (3) = Moderate, (4) = Major, (5) = Catastrophic, for Severity of risk (consequence of impact)

Method of Data Analysis

The data were analysed using descriptive statistics which involved the use of Mean value and prioritization number. A semi-quantitative risk analysis was carried out to assess the severity (impact) and probability (likelihood) for each work item in the building construction projects.

Assessment of Probability or Likelihood

The mean value method as shown in equation 2 will be used to calculate the probability (likelihood) of risk occurrence.

$$PRO = \frac{\sum_{j=1}^{5} j \times N_j}{\sum_{j=1}^{5} N_j} \qquad (2)$$

Where PRO= probability of risk occurrence; j= probability of occurrence rating scale (integer value between 1 and 5)*,* and Nj =number of the respondents selecting the probability of occurrence equal to j.

The 5x5 matrix as shown in Table 1 will be used to identify the probability that hazard may cause injury or ill-health and rated in the order of 1-5 score.

Table 1 Categories for Probability of Risk Impact (Likelihood Classification).

Level	**Probability (Likelihood)**	**Description**
1	Rare	Not expected to occur but still possible.
2	Remote	Not likely to occur under normal circumstances.
3	Occasional	Possible or known to occur.
4	Frequent	Common occurrence.
5	Almost	Certain continual or repeating experience.

Mamman et al: *A Review of Housing Potentials in Curbing Pandemic: A Post Covid-19 Analysis...*

Source: Workplace Safety and Health Council (2011)

Assessment for Severity or Consequence

The Mean Value Method as shown in equation 3 will be used to calculate the severity of risk impact as shown below.

$$SRI = \frac{\sum_{k=1}^{5} k \times N_k}{\sum_{k=1}^{5} N_k} \qquad (3)$$

Where SRI = Severity of risk impact; K= Impact rating scale (integer value between 1 and 5), and Nk =number of the respondents selecting an impact equal to k.

The 5x5 matrix as shown in Table 2 will be used to identify the most likely severity outcome of the possible injury or ill-health.

Table 2 Categories for Severity of Risk Impact (Consequence Classification).

Level	**Severity**	**Description**
5	Catastrophic	Fatality, fatal diseases or multiple major injuries.
4	Major	Serious injuries or life-threatening occupational disease (including amputations, multiple injuries, major fractures, acute poisoning, occupational cancer).
3	Moderate	Injury requiring medical treatment or ill-health leading to disability (including lacerations, burns, sprains, minor fractures, deafness, dermatitis, work-related upper limb disorders).
2	Minor	Injury or ill-health requiring first-aid only (including minor cuts and bruises, irritation, ill-health with temporary discomfort).
1	Negligible	Not likely to cause ill-health or injury.

Source: Workplace Safety and Health Council (2011)

Risk Categorization on the Basis of Risk Level

The degree of risk score is attained through risk prioritization number which invariably determines the level of risk, which are obtained by multiplying the probability and severity columns. This is computed using equation (4):

$$R = \frac{\sum PRO}{N} \times \frac{\sum SRI}{N} \qquad (4)$$

Where PRO = Probability (likelihood) of risk occurrence, SR= Severity of risk impact and N= Number of items.

Risk rating requires rating the risk as high, medium or low, depending on likelihood of an activity to cause harm and how serious the harm might be. The risk rating or degree or risk and associated description of risk level are summarized in Table 3.

Table 3 Risk Prioritization Number and Risk Level of an Activity

Risks score scale	**Risk level**	**Risk Acceptability**
$1 \leq X \leq 4$	Low	Acceptable
$4 < X \leq 12$	Medium	Tolerable
$12 < X \leq 25$	High	Not acceptable

Source: Workplace Safety and Health Council (2011)

Where x = the actual risk score for the considering variable (work item).

RESULT AND FINDINGS

Response Rate of Questionnaire

In this study 50 questionnaires were administered and 34 were returned representing a response rate of 68%.

Analysis of Respondents' Profile

The section unveils the profile of the respondent by determining their professional qualification and years of experience. Data collected in this regard is presented in Table 4.

Table 4. Profile of respondents

Academic Qualification of respondent	**Frequency**	**Percent**
HND	6	17.65
Bachelor Degree	14	41.18
Post graduate	2	5.88
Master degree holders	11	32.35
PhD.	1	2.94
Total	34	100
Year of experience of respondent		
5-10	10	29.41
11-14	8	23.53
15-20	4	11.77
21 years above	12	35.29
Total	34	100

Source: Researchers fieldwork 2021

Table 4 illustrates the academic qualification of respondents; the largest majority of respondents were 14 (41.18%) those who possessed Bachelor Degree. Next is Master Degree holders with 11(13.6%), following are respondents with Higher National diploma 6(17.65%) next are Post graduate with 2(5.88%) and the last in the list is PhD with 1(2.94). Based on their various levels of qualification attained, it can be assumed that the respondents were competent. The highest number of respondents were those with the working experience of 21yrs and above 35.29%. 29.41% of the respondents have 5yrs – 10yrs working experience, while 23.53% of respondents having above 11yrs – 14yrs working experience and 11.77% of respondents having above 15yrs – 20yrs working experience. The result can be concluded that their responses could be considered to be dependable as they should have adequate knowledge of activities associated with construction safety risk assessment.

Analysis of safety risk assessment

This section reveals the result of the analysis for probability of occurrence, severity of risk impact and safety risk prioritization. These results are presented in Tables 5-7

Table 5 shows the summary of risk analysis of probability of occurrence (PRO), result of the top five main work activities in building construction projects: roof work, steel structure, electrical works, Rebar & other metal works and lift installation with PRO of 3.15, 3.05, 2.77, 2.55 and 2.5 respectively.

Table 5 Analysis of the Probability of Common Activities in Building Construction Projects.

S/N	**Work item in building construction projects.**	**Probability (Likelihood)**	**Rank**
1	Roof work	3.15	1
2	Steel structure	3.05	2
3	Electrical works	2.77	3
4	Rebar & other metal works	2.55	4
5	Lift installation	2.50	5
6	Concrete work	2.41	6
7	Frameworks	2.23	7
8	Masonry	2.36	8
9	Cladding work	2.24	9
10	Excavation	2.23	10
11	Ceiling Finishing	2.14	11
12	General site works	2.14	11
13	Mechanical works	2.09	13
14	Plastering & painting	2.00	14
15	Floor works	1.91	15
16	Door& window	1.86	16
17	Landscaping work	1.71	17

Source: Researchers fieldwork 2021

Table 6 Analysis of the severity of common activities in building construction projects.

S/N	**Work item in building construction projects**	**Severity (consequence)**	**Rank**
1	Electrical works	3.30	1
2	Steel structure	3.10	2
3	Roof work	3.10	2
4	Lift installation	3.10	2
5	Rebar & other metal works	2.60	5
6	Masonry	2.50	6
7	Cladding work	2.50	6
8	Mechanical works	2.50	6
9	Excavation	2.50	6
10	Concrete work	2.40	10
11	Frameworks	2.30	11
12	Ceiling Finishing	2.30	11
13	General site works	2.20	13
14	Plastering & painting	2.10	14
15	Floor works	2.00	15
16	Door& window	1.80	16
17	Landscaping work	1.60	17

Source: Researchers fieldwork 2021

Table 6 shows the summary of risk analysis of severity of risk impact, result of the top five main work activities in building construction projects: Electrical works, Steel structure, Roof work, Lift installation and Rebar & other metal works with SRI of 3.3, 3.1 and 2.6 respectively.

Table 7 shows the result of safety risk prioritization of building construction activities, the result revealed that roof work had the greatest risk level with an average risk score of 9.77, this was followed by steel structure with an average risk score of 9.46 next in line was Electrical works with an average risk score of 9.14. While landscaping work are lowest with safety risk prioritization score of 2.74 having very low risk. The result shows that the greatest risk level of activities is of medium risk according to the risk rating value.

Table 7 Analysis of safety risk prioritization of building construction activities.

S/N	**Work item in building construction projects.**	**Severity**	**Probability**	**Average**	**Risk level**	**Rank**
1	Roof work	3.10	3.15	9.77	Medium	1
2	Steel structure	3.10	3.05	9.46	Medium	2
3	Electrical works	3.30	2.77	9.14	Medium	3
4	Lift installation	3.10	2.50	7.75	Medium	4
5	Rebar & other metal works	2.60	2.55	6.63	Medium	5
6	Masonry	2.50	2.36	5.90	Medium	6
7	Concrete work	2.40	2.41	5.78	Medium	7
8	Cladding work	2.50	2.24	5.60	Medium	8
9	Excavation	2.50	2.23	5.58	Medium	9
10	Mechanical works	2.50	2.09	5.23	Medium	10
11	Frameworks	2.30	2.23	5.13	Medium	11
12	Ceiling Finishing	2.30	2.14	4.92	Medium	12
13	General site works	2.20	2.14	4.71	Medium	13
14	Plastering & painting	2.10	2.00	4.20	Medium	14
15	Floor works	2.00	1.91	3.82	Low	15
16	Door& window	1.80	1.86	3.35	Low	16
17	Landscaping work	1.60	1.71	2.74	Low	17

Source: Researchers fieldwork 2021

Fourteen out of the seventeen building construction activities sampled were medium risk making 82.35%, while three of the building construction activities making 17.85% where of low risk.

DISCUSION OF FINDINGS

The result on risk analysis of probability of occurrence revealed that roof work has the highest risk level with PRO of 3.15. Steel structure was ranked second with PRO of 3.05 and Electrical works was third with PRO of 2.77. While result on severity risk impact revealed that Electrical works had the highest risk level with SRI of 3.30. Steel structure, Roof work and Lift installation were ranked second with SRI of 3.10 respectively. Safety risk prioritization result revealed that Roof work had the greatest risk level with an average risk score of 9.77, this is in line with Baraban and Usmen (2006); Fung *et al.* (2010) and Okoye (2018) who identified roof work as a trade with frequent risk occurrence in construction. Steel structure was second, with an average risk score of 9.46, this is in line with Ghousi *et al.* (2018) who revealed that installation of Steel structure is a high-risk activity in building construction projects. Electrical works was third with an average risk score of 9.14, this is in line with Baraban and Usmen (2006); Gurcanli *et al.* (2015); Ghousi *et al.* (2018) who revealed that electrical works is one of the high-risk work activities in building construction projects. While landscaping work are lowest with safety risk prioritization score of 2.74 having very low risk. It was observed that 14 out of the 17 common building construction activities sampled were medium risk making 82.35%.

CONCLUSION AND RECOMMENDATIONS

The study determined the level of safety risk for building construction work item, in terms of probability and severity. The result of the study illustrates that different building activities have different levels of risk associated with them. This might be attributed to the differences in the types of activities and the approach of operations involved in different building work activity. This further indicates that there are building work activities associated with high risks which are unacceptable, medium risk which are tolerable, so also those associated with low risks which can be acceptable. Findings from risk level assessment of building activities revealed that Roof work, Steel structure and Electrical works are the building activities with the highest medium risk activities in Abuja. It is suggested that different strategies should be applied in managing health and safety risks in construction across building activities.

It can be concluded that although findings revealed that most building construction activities in Abuja are medium risks, workers in building construction sites are still prone to injury and accidents which are tolerable. It is recommended that proper risk identification and prioritization should be a precondition for effective risk control and management, in addition adequate measures should be put in place to control and reduce the risk to an acceptable level.

Further study should be carried out in the identification of health and safety measures for mitigating the risk associated with each building construction activities. The study provided an avenue for construction managers to identify the risk level of major construction activities which will assistance them allocate safety precautions in a more efficient manner. The use of risk assessment techniques, which focuses on the prioritization of risk will provide necessary information for safety budgeting and planning for contractors as well as safety experts. It is anticipated that this study will improve construction safety by promoting stakeholder's awareness of safety hazards and associated risks during construction.

REFERENCES

Aminbakhsh, S. Gunduz, M. & Sonmez, R. (2013) Safety risk assessment using analytic hierarchy process (AHP) during planning and budgeting of construction projects, *Journal of Safety Research*, 46, 99–105.

Baradan, S. and Usmen, M.A. (2006) Comparative injury and fatality risk analysis of building trades. *Journal of Construction Engineering and Management*] 132(5). https://doi.org/10.1061/(ASCE)0733-9364(2006)132:5(533).

Bilir, S., & Gurcanli, G. E. (2018) A Method for Determination of Accident Probability in the Construction Industry. *Teknik Dergi,* 511, 8537-8561.

Brauer, R. (2005) Risk management and assessment in safety and health for engineers. 2nd ed. Hoboken, NJ: John Wiley & Sons, Inc. doi:10.1002/047175093X.ch35

Bureau of Labor Statistics. (2016) "Census of fatal occupational injuries charts, 2003–2015." Accessed December 11, 2019. https://www.bls.gov/iif/oshwc/cfoi/cfch0014.pdf.

Carter G., Smith S**.** (2006) Safety Hazard Identification on Construction Projects, *Journal of Construction Engineering and Management*. 132, 197-205.

Ceyhan, C. (2012) Occupational Health and Safety Hazard Identification, Risk Assessment, Determination controls: Case Study on Cut and Cover Underground Stations and Tunnel Construction. Master thesis, Civil Engineering Department, Middle East Technical University.

Chan, A.P.C., Yang, Y., Dark, O. (2018) Construction accidents in a large-scale public infrastructure project: Severity and prevention. *Journal of Construction. Engineering. Management.*

Collins, K. M. T., Onwuegbuzie, A. J. and Jiao, Q.G. (2007) A mixed methods investigation of mixed methods sampling designs in social and health science research. *Journal of Mixed Methods Research,* 1 (3), 267-294.

Everett, J.G. & Frank Jr., P.B. (1996) Costs of accidents and injuries to the construction industry. *Journal of Construction Engineering and Management. 122(2),* 158-164.

Fung, I.W.H., Tam, V.W.Y., Lo, T.Y. and Lu, L.L.H. (2010) Developing a risk assessment model for construction safety. *International Journal of Project Management*, 28(6), 593-600. https://doi.org/10.1016/j.ijproman.2009.09.006.

Gangolells, M., Casals M, Forcada N, Roca X, Fuertes A. (2010) Mitigating construction safety risks using prevention through design. *Journal Safety Research,* 41(2), 107-122

Ghousi, R., Khanzadi, M., & Mohammadi, A.K. (2018). A Flexible Method of Building Construction SafetyRisk Assessment and Investigating Financial Aspects of Safety Program. *International Journal of Optimization in Civil Engineering*, 8(3), 433-452.

Gurcanli, G.E., Bilir, S.M. & Sevim, M. (2015) Activity based risk assessment and safety cost estimation for residential building construction projects, *Safety Science,* 80, 1-12.

Hallowell, M. R. (2011). "Risk-Based Framework for Safety Investment in Construction Organizations." *Journal of Construction Engineering and Management*, 137(8), 592-599.

Hallowell, M.R., Alexander, D. & Gambatese, J.A. (2017) Energy-based safety risk assessment: does magnitude and intensity of energy predict injury severity? *Construction Management and Economics*,1-14. http://dx.doi.org/10.1080/01446193.2016.1274418.

Hämäläinen, P., Saarela, K. L. & Takala, J. (2009) Global trend according to estimated number of occupational accidents and fatal work-related diseases at region and country level. *Journal Safety Research*, 40(2), 125-139.

Health and Safety Executive. (2017) Health and safety statistics for the construction sector in Great Britain, 2017. Accessed December 11, 2018. http://www.hse.gov.uk/statistics/industry/construction/construction.pdf.

Hughes, P., & Ferrett, E. (2016) *Introduction to health and safety at work* (6th ed.). New York, NY: Routledge.

Idoro, G.I. (2008). Health and Safety Management efforts as Correlates of Performance in the Nigerian Construction Industry. *Journal of Civil Engineering and Management.*14 (4), 277–285

International Labour Organisation (2012). Estimating the economic costs of occupational injuries and illnesses in developing countries: essential information for decision-makers'. Accessed February, 2018.

Jannadi, O.A. & Almishari, S., (2003) Risk assessment in construction. *Journal of Construction Engineering and Management,* 12(9), 492.

Kozlovská, M. & Struková, Z. (2012) Overview of safety risk perception in construction. *Journal of Civil Engineering and Architecture,* 6(2), 211-18. https://doi.org/10.17265/1934-7359/2012.02.010

Muiruri, G. & Mulinge, C. (2014) Health and safety management on construction project sites in Kenya: a case study of construction projects in Nairobi County. In: *FIG Congress,* Kuala Lumpur, Malaysia, 16-21.

Okoye, P.U. (2018) Occupational Health and Safety Risk Levels Building Construction Trades in Nigeria. *Construction Economics and Building*, 18(2) 92-109. https://dx.doi.org/10.5130/AJCEB.v18i2.5882.

Pinos, A. J. C., & García, M. N. G. (2017) Critical analysis of risk assessment methods applied to construction works. Revista de la Construcción. *Journal of Construction*, *16*(1), 104-114.

Pinto A, Nunes I. L, & Ribeiro R (2011) Occupational risk assessment in construction industry – Overview and reflection. Safety Science 49, 614–624.

Purohit, D.P., Siddiqui, N.A., Nandan, A & Yadav, B.P. (2018) Hazard Identification and Risk Assessment in Construction Industry. *International Journal of Applied Engineering Research*, 13(10)7639-7667.

Sanchez, F. A. S., Pelaez, G.I.C. & Alis, J. C. (2017) Occupational Safety and Health in Construction: A Review of Applications and Trends. *Industrial Health*. 55, 210-218.

Tadesse, S. & Israel, D. (2016) Occupational injuries among building construction workers in Addis Ababa, Ethiopia. *Journal of Occupational Medicine and Toxicology,* 11(16). https://doi.org/10.1186/s12995-016-0107-8.

Tixier, A.J.P., Hallowell, M. R., Rajagopalan, B. & Bowman, D. (2016) Application of machine learning to construction injury prediction. *Automation in construction,* 69, 102–114.

Workplace Safety and Health Council. (2011) *Code of practice on workplace safety and health (WSH) risk management*. The Workplace Safety and Health Council in collaboration with the Ministry of Manpower. [Online] Available at: www.wshc.sg. [Accessed 1 July 2018].

Yoon, S.J., Lin, H.K., Chen, G., Yi, S., Choi, J., & Rui, Z. (2013) Effect of Occupational Health and Safety Management System on Work-Related Accident Rate and Differences of Occupational Health and Safety Management System Awareness between Managers in South Korea's Construction Industry. *Safety Health Work* 4 (20), 1 – 9.

Zolfaghariana, S., Irizarrya, J., Ressangb, A., Nourbakhsha, M., & Gheisaria, M. (2014). An automated safety planning approach for residential construction sites in Malaysia. International Journal of Construction Management, 14 (3), 134 -147.