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The Application of Smug Model in the Prioritization of Building Construction Hazards in Owerri Municipality of Imo State Nigeria

Obi Lawrence E. & Opara Hyginus E.

Department of Civil Engineering, Imo State University, P.M.B 2000, Owerri, Imo State, Nigeria

***Corresponding Author:** Obi Lawrence E, Department of Civil Engineering, Imo State University, P.M.B 2000, Owerri, Imo State, Nigeria.*

ABSTRACT

Hazards as sources of risks are very prevalent in the building construction industry. These hazards are hindrances to the construction process and lead to project delays, financial and human life losses, wastages of materials and collapse of buildings. This makes the research work very timely,needful and appropriate. The research work investigated the available and common hazards and prioritized them in terms of their prevalence and criticality. The SMUG model was applied as a method for this investigation and its hazard priority system was used in the prioritization process. The results of the research showed that falls from height, poor quality materials and unprotected workers are the most common hazards in the building construction activities within Owerri Municipality. It was discovered from the research that poor quality materials and poor design have the highest criticality index of 0.300 and 0.209 respectively.

Keywords: *Hazards, SMUG, risks, safety, prioritization.*

INTRODUCTION

The building construction industry is bedeviled with diverse construction hazards. The construction of building is subject and liable to lot of risks arising from these hazards. Construction companies had been subjected to extra-ordinary expenditure and this directly or indirectly affect the quality of the project on completion. Hazards are very prevalent in the building construction industry and this makes it necessary for hazards to be prioritized. Accidents that occur during any construction lead to project delay and loss of human lives. Due to the inevitability of accidents in the building construction, it becomes very imperative for available sources of accidents in a particular building construction to be identified and incorporated into the overall planning and management of the construction process. The necessity of incorporating these hazards at the planning stage makes the construction process to be free, safe and quality – biased.

Apart from the general inherent hazards which are common in the building construction industry, it is also necessary to consider the environmental implications of the locations where the buildings will be situated. Environmental implication affects hazards in such a manner that the hzards can be amplified or tempered in severity. The consideration of hazards at the planning stage will help to improve the provision of the necessary general and personal protective equipment at the site and for the workers.

In consideration of the enormity of human life loss, injuries, equipment destruction, delay, poor project execution, financial loss etc, suffered in Owerri Municipality, it becomes necessary for the identification of the hazards and its subsequent prioritization. This will help to add values in terms of safety and job quality in the building constructions going on in the municipality and also serve as a guide for risk/hazard reduction/control schemes in the study area.

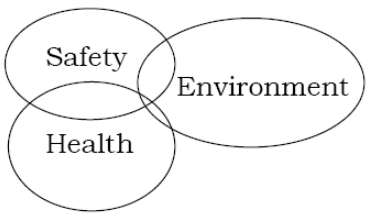
Safety in Building Construction

Present – day construction industry is becoming more and more complex due to the quest to meet the requirements of increased production rate, high efficiency and organization. There is no gain saying in the fact that in the construction of buildings huge investments are incurred. Any negligence at any stage from conception stage to design, erection, operation can result into

disaster, loss of human lives and huge production losses. Accordingly, safety aspects deserve serious attention. Today, safety is an integral part of the building construction. When a single worker neglects safety procedure, it can lead to serious problem for everybody. It is therefore essential that fool proof safety systems be designed and incorporated, people trained adequately, checks and counterchecks made to ensure the implementation of safety. As losses due to any accident can be avoidable, surmountable it is imperative that top management of building construction companies gets involved and exhibits full commitment towards the realization of safety.

As a matter of fact it is not only enough to take care of safety but two other interrelated issues namely health (i.e. welfare of workers) and environment are attached equal importance and consideration. All these three elements of safety, welfare of workers and environment are interrelated and affect each other. A typical example is what happens when the health status of a worker/equipment is not ascertained and taken care of – this is a situation that can cause accident at the construction site.

When the working environment is heavily polluted, it generates health nuisance and the scenario can adversely affect the workers' health and also their production capacity. The building construction industry has obligations towards keeping good environment and also towards the health of the people. Safety can only be said to thrive when health and environment are optimally in good working state. The interrelationship between safety, health and environment can be illustrated with the diagram below



In the building construction industry, safety is regarded as a complex mechanism and this demands necessary documentations check lists and the implementation/observation of all safety procedures and practices. It is necessary that the safety systems in the building construction industries should reviewed and updated in a routine manner. Building construction companies should have safety unit head who articulates and galvanizes all issues regarding to safety and report the same to the management with the safe objective of full compliance to safety standards.

Jobs in building construction are mostly carried out by human beings even when the construction processes are fully automated; the machines/equipment will be operated by humans. This emphasizes that the health of workers in any construction company will be held at the highest esteem. Any condition that is detrimental to the health of the workers should be eliminated. All workers should be subjected to routine medical check ups to ascertain their suitability capacity for any work assignment. Workers should be discouraged from poor health habits like smoking, snuffing, alcoholism, etc and be encouraged to undertake regular exercises and have adequate rest after work. The creation of health awareness will immensely benefit the building constructions industry due to the fact that it will make workers to be alert and contribute optimally and boost productivity and efficiency.

The erroneous notion created in developing countries which portrayed the thought that the monies invested in the health of workers and checking of pollution in the environment is regarded as waste, is counter-productive/ unacceptable and should be erased and corrected. Polluted working environment constitute great threat to the workers and this situation will eventually play out on the safety of the work- activity.

Role of Company Management in Health, Safety and Environment

The top management of building construction companies should give considerations to health, safety and environment not only as an integral part of their management functions but also the enforcement of all safety standards. Vision, establishing systems, setting the expectations, assessing performance, improving effectiveness, encouragement for safety practices among workers, prompt action for deficiencies, and allocating resources for responsible operations constitute the core responsibilities of top management of building construction companies. Safety culture should be enshrined in the company ordinances and should involve all workers, contractors, security personnel and all business associates of the company. For functional obedience to safety standards among workers, the commitment and involvement of

top management of construction companies to health, safety and environment is critical and inevitable.

Safety manuals should be prepared be for every department and unit and surprise safety checks, particularly at odd hours, should be carried out and findings documented. Punitive schemes should be put in place for the violation of safety procedures and non-compliance to personal protective equipment. Safety promotional activities like display of safety posts/precautions and safety records at strategic locations, publication of safety newsletter bulletins, safety talk to contractors/workers, safety competition etc should be canvassed and encouraged. Safety awareness survey should be carried out annually and input provided to enhance safety awareness.

Basic Issues on Construction Activity Safety

The construction industry is full of hazards and therefore this requires greater care and precautions on the partof workers in the industry with the aim of averting accidents thereby ensuring the safety of human live, machinery and plants. The antonym of safety is accident and accidents in the construction industry are too costly to bear. Compensations are ordinarily paid to injured workers in construction companies but it is always a financial loss and at times leads employer/employee dispute. Accidents in construction companies can lead to injury or death of a worker, damage to plant or equipment, disruption of work activity schedules, lowers morale of workers and prolonged absence of trained worker for medical attention including financial loss (compensation).

Accident can occur in the construction industry due to human error, mechanical failures, and acts of nature. Human error is precipitated by unsafe practice, non-adherence to safety rules, lack of foresight, over-confidence, and wrong attitude to work. Mechanical failure in the construction industry is caused by plant poor condition, poor machine/plant maintenance, equipment or machine failure, poor equipment maintability and poor operational skill. When accidents in the construction industry are caused naturally they are regarded as natural disasters and they include flooding, earthquake, landslide, cyclone and bad weather condition.

The basic personal protective equipment needed during building construction include hard hats, ear – masks, eye and face protection, ropes and belts, boots, overall clothes, etc. The hard hatsare worn to prevent head-injury due to falling objects, ear masks are used to protect the hearing system from loud sound, while belts or ropes help to prevent fall from heights during civil or building work. An accident can occur by any unplanned and uncontrolled event caused by human, situational or environmental factors any combination of these factors which interrupt the work process and which has the potential to result in minor or major injury, illness, damage or undesired event.

Hazards in Building Construction

Hazards generally can be defined as a source of risk or any physical condition, an object or any physical effect that has the potential to cause harm. In furtherance of its definition, hazards could be a workplace condition which exists or can be caused in combination with other variables, which have the potential or capacity to cause accidents, serious injuries, disease, and/or property destruction. Any hazard to an accident and thus safety programmes are hazard control programmes. An accident can occur by the unsafe act of a person or by the existence of a mechanical or physical hazard.

Accident prevention is difficult without an understanding of accident causation. Susceptibility to accidents depends on unsafe acts and unsafe conditions. Hazards recognition is aimed at understanding the accident process and attempts to discover the accident symptoms. Unsafe acts are on account of violation of rules, misjudgment, careless ness, abuse/neglect of safety devices, inadequate written procedures, and not imparting proper training to workers. An unsafe condition (harm) is any physical condition, which if left uncorrected, is likely to lead to an accident. Safety can be improved if such conditions in the building construction industry are detected before hand.

Hazard Identification

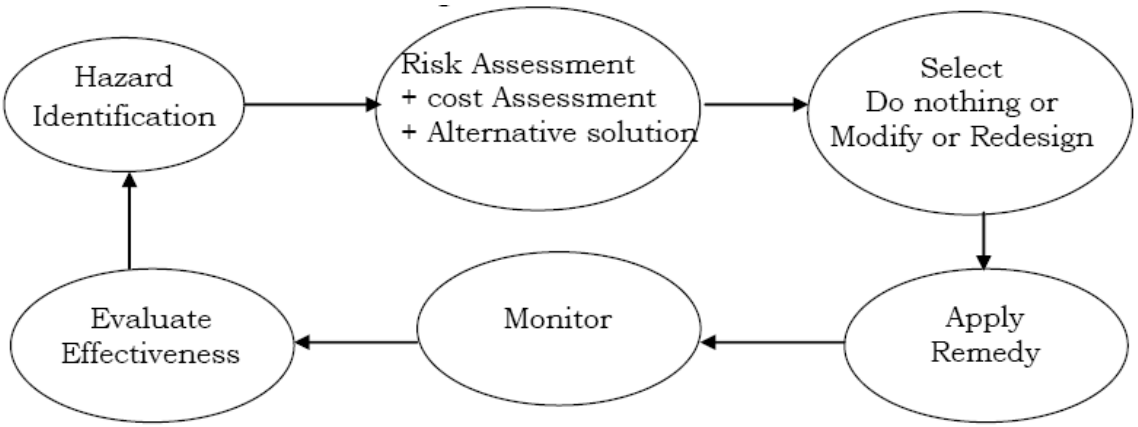
When hazards are identified, chances of occurrence of accident can be minimized. With hazard identification, the safety programmes and records can be improved. The scrutiny of accidents and injuries records help to direct the way efforts should be channeled to prevent or control accidents.

Hazard identification analysis, is a very careful study of all the components of a work system in order to detect problems, to understand the relationship between the system and the

problem in order to eliminate the problem and its potential consequences. There are about four methods of hazards identification and they include preliminary hazard analysis, failure mode and effects analysis, hazard and operability review (HAZOP) and fault tree analyses.

The preliminary hazard analysis is used as a guide for more in-depth analyses as more information becomes available. It focuses on what is already known about the product process or change to be made. It consists of formulating a list of hazards and subjecting them to series of questions. Failure mode and effects analysis is adopted for safety analysis from reliability analysis of complex systems. The system is broken down into all its components and systematic evaluation of how the components can fail and what the effects of these failures might be. This analysis requires a criticality rating for each failure mode depending on the degree of hazard posed by the failure. This method has demerit of not examining the linkage of components and its potential on human errors. Hazard and operability review (HAZAB) is popularly applied in chemical plants to identify operation problems, and it also uses brainstorming techniques, encouraging involvement and innovation thereby generating ideas for solutions. The fault tree analysis uses deductive reasoning technique which assumes an undesirable event and proceeds in a logical manner to examine events or combination of events which must precede the occurrence of the top event. It provides a graphic model that displays the various combinations of equipment faults and/or failures that can cause the top event. Such analysis is possible with complete and comprehensive understanding of the system operation and every equipment failure modes.

The elements involved in an effective hazard control system are shown in a schematic diagram below.



The potential hazards in building construction include falling from a height, trench collapse, scaffold collapse, electric shock or arc flash or arc blast, failure to put on personal protective equipment and repetitive motion. For safety of human beings in the construction industry, adequate protection of human body is essential. The nature of protection depends on the kind of hazard and type of operation/process involved in the construction activity. The use of personal protective equipment (PPE) by the employees during work process/operations is a statutory requirement. Some common personal protective equipment include cotton uniform, rubber apron, safety helmet, eye protectors, safety goggles, face shield, welding shield, electric shock proof gloves, chrome leather gloves, safety boots, gum boots, rubber sole shoes, canister mask, dust mask, ear plugs, and safety harness belt.

Risks in Building Construction

Risk is defined as the effect of an accidental occurrence and which normally has hazard as its source. Risk is often analyzed and this is a process which helps investigators to take right decisions that have the potential to produce the greatest improvements in safety, health and environment. It helps decision makers to have a scientific framework for choices between solving or mitigating safety, health and environment problems. Risk analysis can be used right from planning, construction, operation to the maintenance of a project.

Risk analysis presents rigorous and quantitative results in a simple format to help investigators make the appropriate personnel, economic, ethical and political decisions. It includes comparative costs and benefits, the basis for

setting priorities that maximize benefits and minimize costs. In the evaluation of risks all scientific information needs to be considered carefully and utilized correctly.

While a hazard refers to the source of risk, risk is the effect or the activation of hazard. A heap of toxic chemical may be a hazard to human health but is not a risk till someone is exposed to it. Risks in construction range from injuries, plant/equipment damage, death, human disability, job delay, financial loss, building collapse, etc.

Smug Model

This is a model framed from the abbreviations of seriousness, Manageability, Urgency, and Growth. This model utilizes a direct comparison by employing such ratings as high (H), medium (M), or low (L) against the four separate factors of seriousness, manageability, urgency and growth which are common to all the hazards in the building construction process.

The hazards are compared by using one factor at a time and recording the results on the table as shown;

Table1. *SMUG Hazard Priority System*

Hazard	Seriousness	Manageability	Urgency	Growth
	H M L	H M L	H M L	H M L
	H M L	H M L	H M L	H M L
	H M L	H M L	H M L	H M L
	H M L	H M L	H M L	H M L

The assigned ratings of H, M and L are ticked accordingly and a brief explanation is attached to justify the ratings. The terms that make up the SMUG model are described as follows;

Seriousness

This refers to the relative impact of hazards on financial expenditure/loss and/or people. A hazard is given a high rating when it represents a threat to the largest number of people and/or involves the highest financial cost. If the rating is a team work accept the one with 'high' to be on the safe side.

Manageability

This tries to investigate whether anything can be done about the hazard. If the impact of the hazard can be reduced through a management approach, then the rating for management will be high. If it were manageable only after it had occurred, then the rating will be low.

Urgency

The rating for urgency is high when something needs to be done about the hazard now. The rating is medium when something has to be done about the hazard in the near future. Low rating comes when there is no urgency and it would be appropriate to plan for action in the far future.

Growth

Refers to a condition that if no action is taken about the hazard whether it will grow worse, or remain as it is currently. If the hazards will increase quickly, it would be rated "high", if it would grow gradually, then rate "medium". But if it would remain as it is, rate "low".

SMUG model helps in decision making. Having allocated a relative rating to all identified hazards on each of the factors, then review the list. Those with the most highly rated factors are those that warrant a high priority for attention.

From the concept of numerical analysis, risk can be seen as the probability of exposure of individuals, populations, or ecosystems to sources of harm. Risks can be lowered by reducing the components of risks namely – probability that hazardous conditions exist, probability of exposure of people to hazardous condition and reducing the severity of consequences.

METHODOLOGY

The survey research design was used in this work. This design is suitable because it facilitated the retrieval of information from professionals in the building construction industry within the study area. Questionnaires and interviews were used to collect the primary data. The questions were stratified into hazard identification and hazard prioritization.

Data Analysis

The data collected were analysed using the SMUG model and other statistical tools. The hazard index was developed by recognizing the hazard and predicting its criticality in terms of degree of effects such as injury, number of workers/public likely to be involved and

damage to be done to the environment if the hazard is activated.

Application of SMUG Model

The SMUG model can be used for the prioritization of hazards. The model goes by the nomenclature SMUG which is coined from the abbreviation of seriousness, manageability, Urgency, and Growth. The model allows a direct comparison of a number of possible hazards through ratings of high(H), Medium M, or low (L) against four separate factors which are common to all the hazards. The factors were contained in the SMUG model. Scores were awarded for the various ratings of high, medium and low in the magnitude of 5, 3 and 1 respectively.

RESULT PRESENTATION AND ANALYSIS

Presentation of Results

The questionnaire which was structured into hazard identification and hazard prioritization was used to gather information from engineers, builders, architects etc. From the information gathered, it was observed that the prevailing hazards in the building constructions in Owerri Municipality included fall from height, collapse of trench, poor design, unskilled workers, unprotected workers, deafening noise/vibrations, poor quality construction materials and contractual procedures.

Safety in construction management deserves utmost attention because construction is widely recognized as one of the accident prone activities. Most of the accidents are caused by inadequate planning, failure during the construction/maintenance process and/or because of design deficiencies. The reasons for accidents during construction and other activities are related to unique nature of the industry, human behavior, difficult work-site conditions, extended duty hours, lack of training and awareness and poor safety management. Unsafe working methods and improper maintenance of equipment leading to failure contribute to the occurrence of accidents.

Ensuring good quality of materials, integrated maintenance, upkeep of equipment, competent supervision, compliance of standard safe engineering practices along side with the use of appropriate personal protective equipment go a long way to bring safety into the system. Inclusion of certain guidelines on safety in the tendering stage itself will help in assuring safety standards during execution of the contract.

The results of the data gathered from the respondents at the stage of hazard identification is presented on table 1

Table1. *Identification of Hazards Common in Owerri Municipality*

S/N	Identified Hazards	Frequency	No. of Respondents
1.	Contractual Process	𝍸 𝍸 |||	13
2.	Deafening Noise/Vibration	𝍸 ||	7
3.	Fall from Height	𝍸 𝍸 𝍸 𝍸 |	21
4.	Poor Quality Materials	𝍸 𝍸 𝍸 ||	17
5.	Unprotected Workers	𝍸 𝍸 |||	14
6.	Poor Design	𝍸 𝍸 |||	13
7.	Unskilled Workers	𝍸 𝍸 ||	12
8.	Collapse of Trenches	𝍸 𝍸 |||	13
	Total		**110**

Following the response gathered from the professionals in the building construction within the study area during the prioritization phase the respondents through their answers to the structured questions prioritized the identified hazards using the proposed score chart of the SMUG model. The results of the data collected are shown on table 2.

Table2. *Prioritization of Building Construction Hazards in Owerri Municipality.*

S/N	Hazard	SMUG Model Factor Ratings				Rating Indices		
		Seriousness	Manageability	Urgency	Growth	Prioritization Factor	Prioritization Index	Criticality Index
1.	Contractual process	-	5L	3L	5L	13	0.200	0.040
2.	Deafening Noise/Vibration	-	2M	5L	L	9	0.257	0.080
3.	Fall from Height	10H	3M	4L	4L	67	0.638	0.092
4.	Poor Quality Materials	8H	3L	3M	3L	55	0.648	0.300
5.	Unprotected Workers	5H	M	3L	5L	37	0.529	0.082
6.	Poor Design	2M	H	8L	2M	29	0.446	0.209
7.	Unskilled Workers	8L	2L	M	L	15	0.250	0.043
8.	Collapse of Trenches	2H	8L	L	M	23	0.353	0.172

Analysis of Results

From table 1, it can be observed that out of one hundred and ten professionals that responded to the questionnaire, twenty one of them saw fall from height as the most prevalent hazard in the building constructions within the study area. It was observed that poor quality construction is the second source of harm in the buildings construction process. From table 1, the respondents attested that the least prevalent hazard is deafening noise and vibrations. It can be observed from the table that workers show great apathy and non-challance to their personal protective equipment. A reasonable number of the respondents raised their concerns over the neglect of personal protective equipment by workers in the construction industry within the municipality.

From table 2, where efforts were made to prioritize the identified hazards it was observed that poor quality of materials had the highest prioritization index which singles it out as the first on the prioritized list. Poor quality materials had a prioritization index of 0.648. This is to say that it should be given adequate attention in terms of seriousness, manageability, Urgency and Growth. Next to the poor quality materials, are the fall from height and unprotected workers with prioritization indices of 0.638 and 0.529 respectively. It was revealed in table 2, that the quality materials and poor design had the highest criticality indices of 0.300 and 0.209 respectively. This means that any risk from the two will have more devastating, fatal and catastrophic effects in terms financial, material and human lives losses.

The prioritization of these hazards can be represented in a bar chart thus;

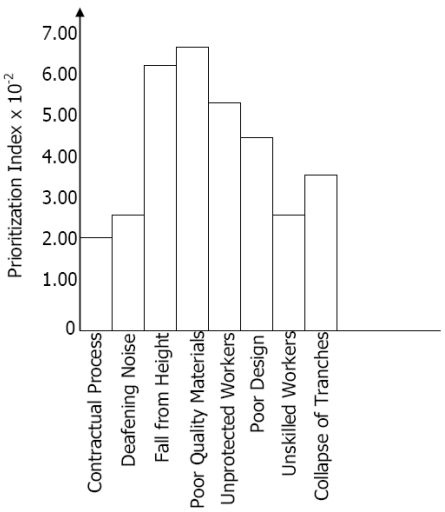


Fig3.1. *Prioritization of Hazards in Owerri Municipality.*

CONCLUSION OF RECOMMENDATIONS

Conclusion

It is obvious that this research will help guide the professionals in the building industry on areas of focus in terms of hazards to enable them minimize the risks that will affect their construction activities. When hazards are reduced or eliminated in a construction site, efficiency and safety are entrenched. Identification and prioritization of hazards in any construction process is tantamount to having accident- free and unhindered construction processes that are in tandem with earlier schedule of work planning. Adherence to safety standards, ensuring good quality of materials, competent supervision, well protected workers, and integrated maintenance of equipment are panacea towards the elimination of hazards at the construction sites.

Recommendations

The findings in the research work have prompted the following recommendations;

1. Attention should be given to the quality of materials used at the construction site to ensure that they meet the professional standards.
2. Workers should be compelled to put on their personal protective equipment before the commencement of any work especially those at a height.
3. All building construction sites should be under the supervision of a competent professional engineer as this will eliminate hazards and their associated risks.

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