Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2021, 8(8):110-125**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

Construction Project Sites Accident Evaluation versus Risk Analysis and Mitigation Measures

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Abstract This research work aimed at evaluating the current level of accidents in the Nigerian construction industries, with the objective to proffer current but sustainable accident risks and hazard mitigation measures. This research revelled the poor state of H&S in the Nigerian construction industries, for not being in compliance with current global sustainable practice. Research evaluation revels an overall accident incidence in7 selected construction companies in Nigeria for the period of 7 years to be, 814 of 77 deaths and 737 injury rates. Similarly, the trends of incidences are incremental, with risks rating from medium to very high risk severities for both deaths and injuries. The underlying factors to this menace ranges from; lack of sufficient and inappropriate strategically supporting mechanisms to aid designers, stakeholders and policy architects to evaluate probability of accidents risks, so as to design effective mitigation measures. Similarly, poor planning and designs as well as poor customs and practices in the construction industries has become order of the day, resulting from not having project managers or the use of ineffective managers that has little or no knowledge in Project management to plan, coordinate, and mitigate risks at different stages of project and construction activities. However, the negative implication is damage to structures and equipment, loss in company's confidence as well as its standard and reputations resulting to Insolvency.

Keywords Construction, Health and Safety, Accidents, Risk, Mitigation

1. Introduction

It's a general phenomenon that built environment is being transformed today by the construction industries and their numbers is increasingly becoming higher as a result of the increasing quest for urbanization and industrialization. However, majority of these construction industries had invested so much capitals, efforts and time in the quest to promoting general performance of both environmental as well as constructional health and safety (H&S) performances, but this positive drive is predominantly in the Europe (EU) and other developed nations of the globe, with some significant successes of industrial advancements recorded in the past, while it's not the same in the case of majority of the developing nations, Nigeria for instance (Authors R&D 2019 - 2021). According to Health and Safety Executive [1-2], that these industrial improvements had not being sustained in current years, but this day's construction industry are seen to be one of the promoters of unethical construction practices and are ranked one of the topmost dangerous industry in the current drive to environmental sustainability. According to Raymond [3], the safety records of the construction industries is continued to be rated as poor, with no much emphasis made for improvement. However, Davies and Tomasin [4], research result indicates that approximately 1500 individuals had lost their lives on construction sites in just a decade within Britain, while the seriously injured are around 25000 – 30000, and 300,000 – 400,000 are those suffering

various degree of injuries capable of keeping them away from normal construction site activities for more than three days.

Furthermore, according to DOH [5], that the major causes to preventable injuries, ill-health and deaths on construction sites is always an accident. According to Nutt et al., [6] reported a case of about 20% of accidents cases on construction sites are credited to poor sites logistics. It has been similarly reported by CIRIA, [7], that the case of severely injured person recoded per week is at list one or more person(s). However, according to DOH, [5], accident on construction sites is considered to be a major factor in the provision of health services. And effort to improving H&S on construction sites had been a major concern for industries that sees this as weekly major risk and uncertainty. Similarly, the occurring process of accidents are sometimes complex and are surrounded by many factors, which are interconnected to a matrix (Authors R&D 2019). Therefore, the understanding of this complex accident nature, requires a proactive prevention and mitigation measures (Authors R&D 2019 = 2021). Available result by HSE [1], shows an accidents sturdy within ten-years periods associated to civil engineering and the building industries titled "Blackspot construction" which came up with an evaluation of 700 people were involved in a fatal accident within this period, and 2357 people had major injuries as at 1985, and this accident figures never dropped for over ten years. Similarly, according to report by (HSE, 2018/19), that due to high numbers of accidents cases on sites, it's almost difficult and not possible to assess and progress accident investigation incidences on construction sites through to completions in twelve any (12) months, despite the HSE targets to sustain an improved reactive working timeliness, *table 1*.

Table 1: Percentage Fatality and Non-Fatality investigations compiled within seven (7) years [2]

Years	**2014/15**	**2015/16**	**2016/17**	**2017/18**	**2018/19**
Fatality rates investigation compiled in 12 months	61%	53%	72%	75%	65%
Non-Fatality rates compiled in 12 months	90%	90%	90%	89%	89%

H&SE research indicates 90% of this construction accident are technically preventable as analysed, while 70% of these figures could have had their lives saved by effective management actions. H&SE report concluded that majority of these accidents were preventable by the use of reasonable practical precautional measures. According to H&SE Self-Reported Work-Related Illness (SWI) 2002 / 2002 investigated to have 137,000 estimate persons whose present or most current placements within the construction industries in past 8 years had suffered a known illness that was believed was caused as a result of their job. However, research sturdy by Winkler [8], presented to Construction Productivity Network (CPN) reflects a 12-years' span (1990-2001), the H&SE statistical data indicates an improvement decrease concerning the numbers of fatalities in the construction industries with over 150 in the year 1990 against 100 in 2001. Similarly, The HSE noted that each year just fractions of non-fatal injury are conveyed /documented. With this obvious improvement, injuries in the construction industries remains way too very high, while timely completions of fatal accident investigation remain the HSE topmost priorities [2].

2. Research Aim

This Research aimed at investigating the current states of H&S in the construction industries as well as construction site activities in line with H&S principles

3. Research Objective

The major objective of this research is to analyse H&S on a considerable range of construction sites in Nigeria to:

1) Exploring current but sustainable state of the art technological accidents causation and mitigation measures on the construction sites in Nigerian;
2) Provide an enhanced understanding contributory factors influencing accident on construction sites in Nigeria; and
3) To identify potential hazards and to come up with effective strategic real time accident scenario and mitigation measures.

4. Research Materials

This research requires the application of V-R (Virtual Reality), 3-D (three dimensional) GIS (Geographical Information Systems) environment for H&S applications as well as accidents raw data from the construction industries or sites respectively.

5. Research Methodology

This research method is majorly analytical quantitative process, the procedural use of V-R, 3-D GIS environment, to spontaneously organise as well as to display comprehensive accidents figures with respect to individual related spatial-temporal (ST) elements H&SE compiled. With the view to analyse data technically and logically to provide effective facts about causation for accidents on construction processes and activities on sites, and to outline features where effective mitigation measures will be directed inline with developing risk analysis tool. However, raw data are not available from Nigerian H&SE. Hence, this research results are purely raw data from physical construction sites involving seven (7) different construction companies were considered, and company names are represented alphabetically A – G. Four (4) of these companies are 90% proficient in general civil engineering infrastructural constructions (i.e. high rise structure, highway and bridges, earth movements, dams and water retaining structure etc.) while three (3) of the remaining 7 companies are 80% inclined to oil and gas, onshore offshore construction related projects.

There were a total of eighty four (84) persons whom were considered for this research sturdy, forty two (42) of whom were administered with questioners, six (6) from each of the 7 construction companies, this involves the following professional personnel;

1) The Site engineers;
2) The Trades union heads; and
3) The Site foremen.

Similarly, forty two (42) other persons were taken through verbal interviews, six (6) from each of the 7 construction companies, while their resultant correspondence were subsequently filled into sane questioner in the aforementioned. The average (mean) respondence results are finally recorded against the company name. It's equally important to note that incidence reporting is throughout the years (twelve months) with the exception of festivity breaks, figures of fatalities and major injuries are considered for both company employed and sub-contractor employed.

6. Results and Discursions

Table 1a: Accident incidences on construction sites

Companies Designation	**A**							
Years	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Max.**
Numbers of Deaths	00	00	01	00	01	03	02	03
Numbers of Major Injuries	16	14	09	11	14	06	09	16
Total Numbers of incidence	16	14	10	11	15	09	11	16
Companies Designation	**B**							
Years	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Max.**
Numbers of Deaths	03	03	00	01	00	04	02	04
Numbers of Major Injuries	11	23	10	19	07	11	19	23
Total Numbers of incidence	14	26	10	20	07	15	21	26
Companies Designation	**C**							
Years	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Max.**
Numbers of Deaths	01	00	00	00	03	01	00	03
Numbers of Major Injuries	09	02	11	06	04	13	24	24
Total Numbers of incidence	10	02	11	06	07	14	24	24

Companies Designation	**D**							
Years	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Max.**
Numbers of Deaths	03	02	02	00	00	01	00	03
Numbers of Major Injuries	22	11	27	06	09	13	10	27
Total Numbers of incidence	25	13	29	06	09	14	10	29
Companies Designation	**E**							
Years	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Max.**
Numbers of Deaths	01	01	03	05	04	02	01	05
Numbers of Major Injuries	13	11	24	14	28	25	18	28
Total Numbers of incidence	14	12	27	19	32	27	19	32
Companies Designation	**F**							
Years	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Max.**
Numbers of Deaths	00	03	07	01	01	01	05	07
Numbers of Major Injuries	15	19	11	09	23	20	18	23
Total Numbers of incidence	15	22	18	10	24	21	23	24
Companies Designation	**G**							
Years	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**Max.**
Numbers of Deaths	00	00	03	05	02	04	00	05
Numbers of Major Injuries	29	13	21	18	12	27	16	29
Total Numbers of incidence	29	13	24	23	14	31	16	31
Legend								
	Construction sites with PM and without H&S Officer on sites							
	Construction site with PM and H&S Officer at main building							
	Construction sites without both PM and H&S Officer							

Project manager (PM), Health & Safety (H&S) **Source:** (Authors Industrial R&D Results, 2019 - 2021)

Table 1b: Hazard prompt list due to Accident incidences on construction sites above

ACCIDENT HAZARD (AH)	**PRESENT?**	
	YES	**NO**
OCCURRENCES DUE TO PHYSICAL SOURCE (AH1)		
Due to slippery surface or uneven surface/ground levels		✓
Working from height(s) without proper protection & scaffolding	✓	
Accident due to falling object(s) (tools. equipment or materials)	✓	
Tight/inadequate workspace(s)		✓
Entanglement, trapping, burns or other equipment(s) related case	✓	
Transport process (vehicular, machinery)		✓
Electron spark due to current electricity		✓
Noise and or vibrations		✓
Outbreaks of flammable fire and or explosions	✓	
Stored pressure system energy	✓	
Working in unsuitable and or unsafe thermal environment	✓	
Violence due to staff or local resident environment		✓

PERCENTAGE RATING (%)	**50**	**50**
OCCURRENCES DUE TO TECHNICAL SOURCE (AH2)		
Inadequate safety protocol provisions (kits, training, awareness)	✓	
Improper adherence to the use of safety processes	✓	
Lack of proper manual handling of equipment(s)/machineries	✓	
Lack of adequate safety provisions by self and or employer	✓	
Lack of adequate use of safety equipment/kits	✓	
PERCENTAGE RATING (%)	**100**	**00**
OCCURRENCES DUE TO CHEMICAL SOURCE (AH3)		
Attack due to physical contact with skin	✓	
Resulting from inhalation	✓	
Attack due to physical contact with eye		✓
Resulting from ingestion		✓
Resulting from Oxidising incidence	✓	
PERCENTAGE RATING (%)	**60**	**40**
OCCURRENCES DUE TO BIOLOGICALSOURCE (AH4)		
Resulting from inhalation	✓	
Possible contact with human body fluids	✓	
Resulting from ingestion of substance(s)		✓
PERCENTAGE RATING (%)	**66.7**	**33.3**
OCCURRENCES DUE TO PSYCHOLOGICALSOURCE (AH5)		
Resulting from excessive workloads		✓
Resulting from physical violence, kidnapping, or assault	✓	
Resulting from accident/post-traumatic stress incidence	✓	
PERCENTAGE RATING (%)	**66.7**	**33.3**

Source: (Authors Industrial R&D Results, 2019 - 2021)

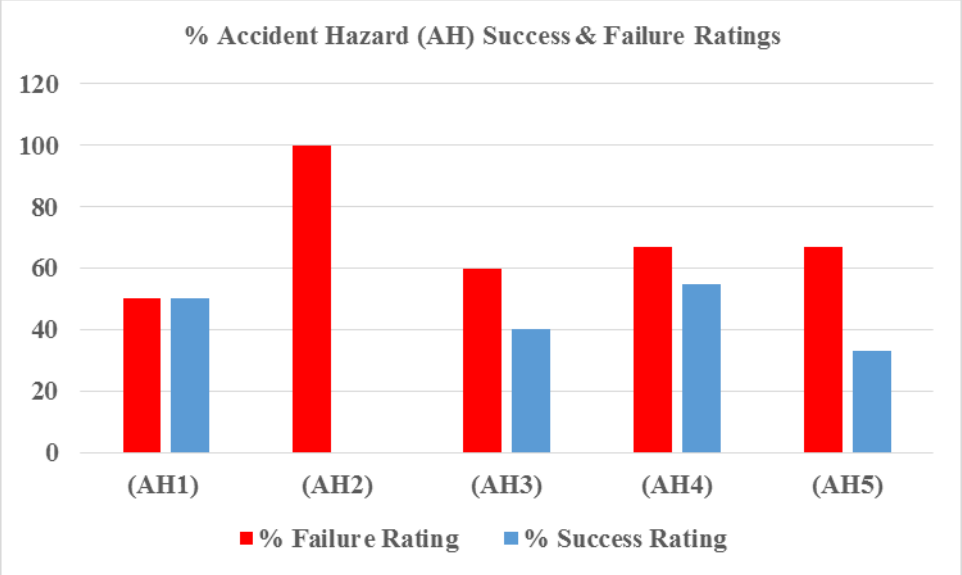


Figure 1: Accident evaluation, percentage success and failure rating

All the respondents in these companies had attributed the causes of the accidents within their respective companies to be due to poor management and general technical issues relating to ineffective safety protocols. However, it can be deduced from the plot above that there is little or no compliance to general health and safety the respective companies. Similarly, ineffective mitigation measures to the risks associated to accident occurrence herein is said to be much higher than the effective mitigation measures. Hence, this translates to severity of failure and success rating process *table 1a, 1b* and *figure 1* respectively.

Table 2: Risk and relative mitigation measure for deaths and injuries ratings

Risk Priorities	Deaths Risk Ratings	Injuries Risk Ratings	Risk Ranks	Risk Tolerance	Risk Description
	0	1- 3	Very low	acceptable	It requires no additional action plans, but rather to maintain initial effective control measures taken.
	1	4 – 5	Low	acceptable	It requires no additional action plans, unless otherwise the implementation process will cost just very minimal, in regards to both effort, time and capital requirements.
	2	6 – 8	Medium	Tolerable	Attention is to be centred towards the probability of ensuring the possibility of lowering the risks applicability, to the bearest tolerant level. However, effective measures should be taking into cognisance to minimising the cost implications associated to any unforeseen additional risks. Technically, implementing a define risk reductions measure will required a definite time frame to achieving efficiency.
	3	9 - 14	High	Tolerable	Substantial effort should be geared towards reducing or eliminating any possible risks. Risk reductionsprocesses requires urgent but prudent implementation strategy within a stipulated time frame. Hence, it may be required that limiting and or suspending certain activities, or to applying temporal risk controlling measure, until these scenarios are completed. Substantial resources may be required for allocation into added mitigation measures.
	4 and above	15 and above	Very high	Unacceptable	It's utmostly necessary and important to commence major effective risk control measures to improve on the possibility as well as the acceptable degree of risk occurrence severity.

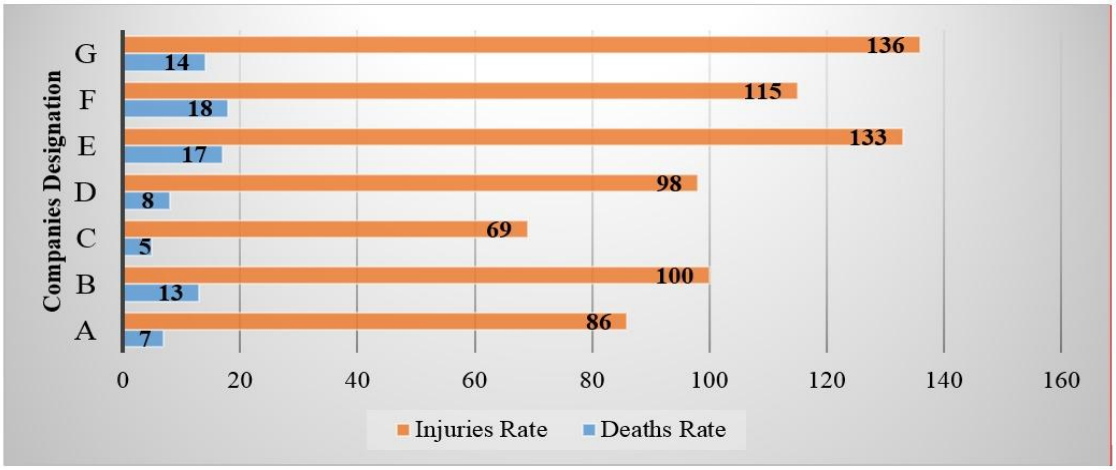


Figure 2:3D Severity of death and injuries rates on construction sites

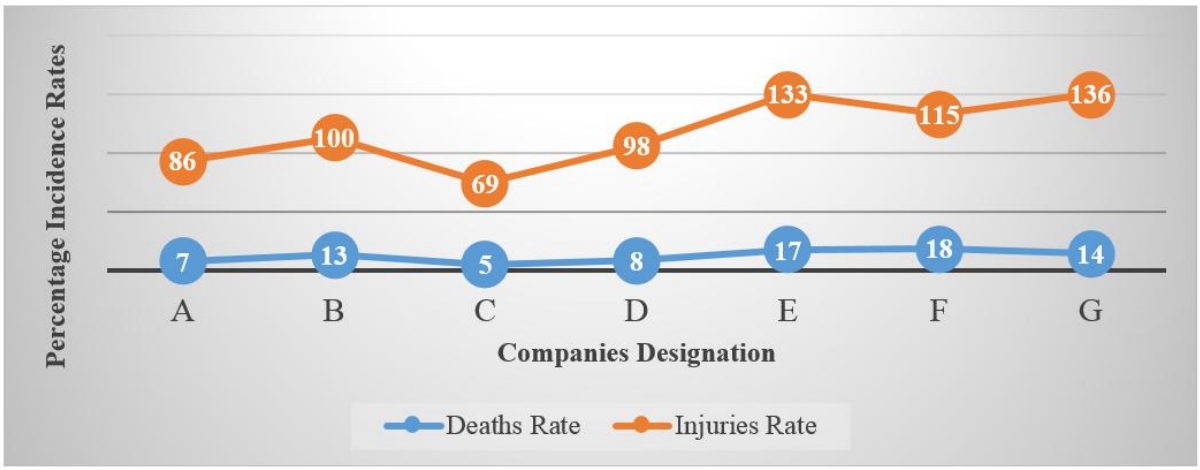


Figure 3: Numbers of accidents and injuries pattern in seven years

Source: *(Authors Industrial R&D Results, 2019 - 2021)*

From *table 1* above, it can be deduced that construction site (C) has the lowest numbers of incidences (death and injury rates) in seven (7) years totalling 5 deaths and 69 cases of injuries. Similarly, company (F) has the highest numbers of deaths rates over the period of 7 years, while company (G) had the highest numbers of injuries recoded within these periods. However, this figure may be more than what is presented here in this research work. Eminent reason is lack of proactive utilization of IT support H&S facilities in order to evaluate the individual construction sites H&S impacts records, on sites or at main office buildings, as well as neglect to show commitment by the Nigerian HSE to improving construction sites personal health and safety (PHS) through strict supervision

Furthermore, it can be interpreted from *figure 2* and 3 above that, the rates of deaths from the least to the highest on the construction sites is continuously on the rise, without declining and it's the same phenomenon for the rates of injuries on site. Hence, validating these scenarios into percentage deaths and injuries rates as in *table 3* and *figure 4* below, it is clear that company (A) and (D) has equal deaths and injuries rates for the same periods. While company (C) has the least percentage value of deaths rate in 7 years.

Table 3: Percentage Deaths and Injuries rates per months

Period	**Seven (7) Years**						
Companies Designation	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Percentage death rates	7.5%	11.5%	6.8%	7.5%	11.3%	13.5%	7%
Percentage injured rates	92.5%	88.5%	93.2%	92.5%	88.7%	86.5%	93%
Total Percentage	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**

Legend				
Risk Priorities	**Risk Ratings**	**Risk Ranks**	**Risk Tolerance**	**Risk Descriptions**
	1- 2	Very low	Acceptable	**Identify** the possible risks and maintain initial control measures taken within project lifecycle
	3 – 4	Low	Acceptable	**Analyse** frequencies and severity of risks, then improve with minimal, resources, effort & time
	5 – 7	Medium	Tolerable	**Respond** within definite time frame to lowering the risks applicabilityto the bearest tolerant level.
	8 - 14	High	Tolerable	**Transfer** by applying substantial resource & efforts to reducing any possible risks severity.
	15 above	Very high	Unacceptable	**Reduce/implement** with effective risk control measures to eliminate risk occurrence severity.

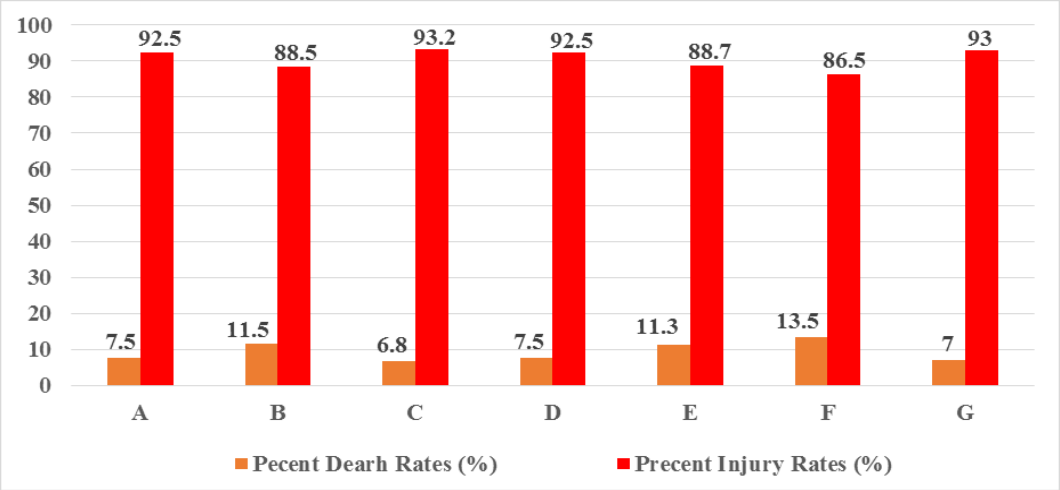


Figure 4: 3D Accidents and injuries rates in seven (7) years

Source: *(Authors Industrial R&D Results, 2019 - 2021)*

Therefore, translating this investigation results into risks severities, it reveals that all the seven (7) construction sites are operating at both medium and very high risks ratings for both death and injuries rates in the past seven (7) years periods. This implies urgent and drastic mitigation measures need to be taken by respective construction companies, with earnest stakeholder's involvements and participation.

7. The Nigerian Construction Industries Accidents Causation

Causes of accidents in any construction industry may generally termed to be a difficult task to easily analyse, this is as a result of compounding factors associated to the foundation that supports the accident on site. Understanding the interconnectivities between these factors as well as their negative impacts during accident, will however need proactive accident prevention strategies. Present accident data for this research work are inadequate to elucidate the bases and intricate causation process. It's a current practice in accordance with HSE guideline to have effective constructions accidents reporting system, indicating the forms and how these accidents occurred.

Even though some of these accidents causes are known to be falling from scaffolds and ladders, inappropriate use of equipment, wrong schedule of work etc. but the main factor that lead to these accidents are not often accounted for, that is being temporal and spatial-patterns.

Therefore, the designers should focus extensively on risks mitigation processes at the following construction project stages; planning, designing, construction as well as maintenance during the life span of the structure. However, the risks at all of these stages can be managed, minimized, sheared, transferred or accommodated, but it cannot be ignored, and when these risks are ignored, the consequential effects will result to compromise in the quality of work, client dissatisfaction, increased in project capital cost, profit reduction or loss, insolvency and reputation damage. Similarly, it should be taken seriously into account the designing stage, to incorporate health issues design, safety risks, and risks contingency for construction workers, contractors as well as the end users of the facilities. This means, drastic effort should be ensured to minimising both physical and emotional effects, and to include the unavoidable financial costs. However, from the above findings, it can be drawn that accident causation in Nigeria can be attributed to the following major factors.

a) **Sites manager's supervision is lacking:**

This research has identified that 65% of construction site have no skilled site managers in place, but the utilization of someone who lacks knowledge in H&S management, and it's strongly supported by majority of the unions in place if any. However, construction sites with even managers, its common practice that their functions are not practically implemented on sites, it only exists as a written document and the presences of these PMs are not felt on sites during construction works. Contributing factor to this is the employment for the services of subcontractors as well as the use of self-employed laborers which has been a major sources of

management problems and control. Nevertheless, these problems were promoted as a result of the porous form of contracting and supervision processes on ground.

b) **Customs and practices in the construction industries:**

Majority of the construction sites has little or no commitment to equipping their labour force with environmental health and safety (EHS) training, as such the workers cannot easily identify danger in the line of duty as well as taking a step towards mitigating or protecting themselves. Similarly, most of the industries do not motivate workers on sporting or preventing a danger from happening in the line of duty on construction site.

c) **Deficient coordination process:**

There are poor coordination processes among the respective construction professional team members at pre-construction phase, this has also grossly contributed to the factors influencing accidents during constructions on sites. However, accident preventions in cause of construction on sites, is a general obligation vested on everyone who is part of the construction processes, it's the duty of every team member to ensure effective mitigation of risk leading to an accident in a construction process that falls within his/her jurisdictions. Similarly, working collaboratively as a team with various players and stakeholders in construction site, will improve the general standard of the required H&S of the undertaking sites. However, when coordination at pre-construction stage is lacking among professional team members, this can change or contradict earlier positive decision taken by respective team members, and it will out rightly necessitate accidents during construction phases on site. Hence, it's equally important to employ accident supporting tool in the form of manpower training as an important accident prevention mechanism.

8. Cost of Accident Risks in Nigerians Construction Industries:

General Accidents data represented in this research work is not only representing the devastating human tragedies but likewise a considerable economic as well as psychological costs. Accident risks have affected the following activities and processes in the construction industries, namely:

a) Gross plants and equipment damage;
b) Damage and loss to previously completed construction work;
c) Damage to output productivities for clearing debris and for rebuilt of damaged work;
d) Legal contractual cost, delay in legal proceedings and the possibility of incurring fines;
e) Loss of company confidence as well as its standard and reputations;
f) Reduction on daily site work until staff morale and working rhythm are fully restored;
g) General delays and disruptions during ongoing investigation by company's safety unit; and
h) Conflict of interest by various stakeholders such as the insurers, HS&E inspectors, community or client etc.

9. Nigerian Construction Sites Accident Mitigation Measures

Owing to the fact that majority of these Nigerian construction companies lacks modern IT facilities in order to evaluate their construction sites H&S impacts as identified by this research. It's equally important to note that the advancement in computer age had provided over 500 products of H&S software available in the United Kingdom (UK) on sales. Hence, against these backgrounds its recommended that the construction companies should equip their sites with some of this numerous classified H&S IT Software (general purpose, specific and Wide-range) for the evaluation of proactive accident mitigation measures.

1) **H&S general purpose Software:** provides users to document detailed workplace hazards, working area, events and tasks, numbers of persons at risks, likelihood, severity, factors, assessment of workspace risks, control process, recommendation with application timeframes. Among other products in this class are; detailed history of employee health, medical investigations, as well as work-related hygiene sampling records.
2) **H&S specific Software:** this form of software generally addresses H&S issues like employee medical health e.g. coronary heart disease prevention as well as COSHH (Controlling Substances Hazardous to Health).

3) **H&S Wide-ranging software:** This form of software is capable of addressing virtually all aspects of organizational and managements safety structures, ranging from policies, risks management to auditing. Some related areas include allied specialty, environmental risks assessments and evaluations, computation of complete or partial risks, interprets levels in numerical or graphical forms, initiates effective criteria; outlines review dates as well as prompts for subsequent evaluation, and sets priority targets. While some will simultaneously export assessments to organizational controls, including issuance for permit-to-work structures.

Furthermore, other effective accident mitigation measures to be considered in the Nigerian construction sites will include:

a) The application of risks mitigation plans to proffer effective process to develop alternative options as well as action plans to enhance chances of H&S and to reduce possible threats in construction projects and its objectivity.

b) The application of risks mitigation implementations so as to execute the current risk mitigation action plans.

c) Also due applications of risk mitigations developmental monitoring plans to track known risks, identify newer evolving risks, and to evaluates the effectiveness of risk processes throughout lifecycle of an ongoing construction project.

Finally, accidents on the above construction sites can be mitigated through the bellow hazards prevention and control stairs measures, by combining both risk control hierarchy and risk rating strategy *figure 4* below.

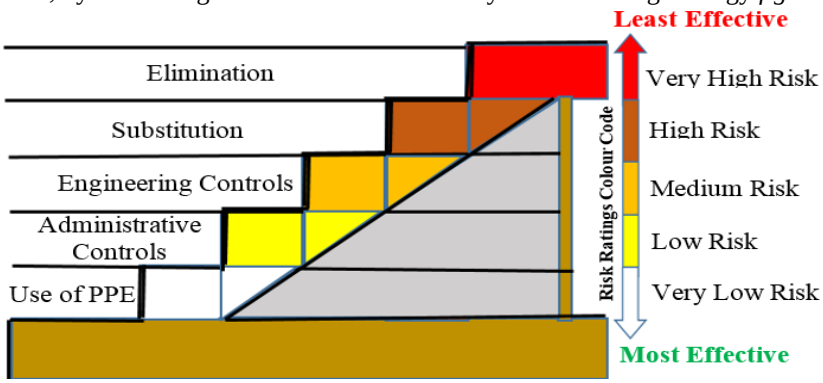
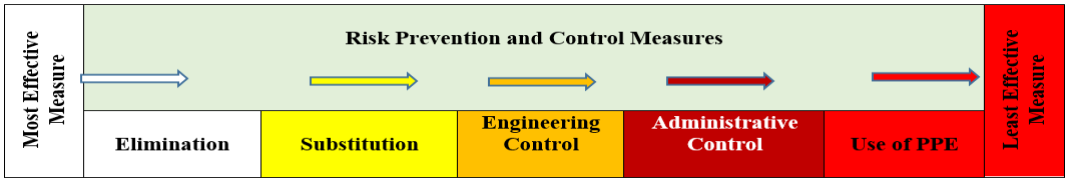


Figure 5: Construction Sites Hazard Prevention and Control Staircase

Source: *(Saleh Mamman Abdullahi, 2015/2016)*

The risk rating process depicts the severity and the likelihood of occurring risks at different levels within the phases of these projects (initiation, constructions, completion and handover), the least effective mitigation measure is known to be very high risk, while the most effective mitigation measure is known to be very low risk. Similarly, the hazard control measures are descending from top to bottom (very high risk →high risk→ medium risk→ low risk→and very low risk) respectively.



Legend	
Risk Priorities	Description
	Very Low risk
	Low Risk
	Medium Risk
	High Risk
	Very High Risk

Safety Hierarchy of prevention	
Safety Measures	Action Plans
Elimination	Physically remove the hazard
Substitution	Physically replace the hazard
Engineering Control	Isolate people from the hazard
Administrative Control	Change the way people work
Use of PPE	Protecting workers with PPE

Figure 6: Strategic Risk Prevention and Control Measures

Source: *(Authors Industrial R&D Results, 2020/2021)*

Similarly, the hazard preventive measures are ascending the staircase from the least effective control measure in line with effective application of personal protective equipment(PPE)safety gears to minimise risks) to most effective control measure (elimination risks) *figure 6*. Therefore, effective and strict implementation of this procedure, will however ensures sustainable construction risks and hazards preventions and control.

10. Major risks evaluated herein these construction projects

There are several risk types associated with the aforementioned companies, and which can be classified into the following namely:

1) Technical risks: The major form of risks in this class are basically inadequate site investigations with environmental impact assessment lacking (EIA), uncompleted design characterized by specification inadequacy, others in this class include unexpected changes in the project scope, faulty application of physical construction procedure which is also associated with inadequacy of resource allocation and or availability;
2) Construction process risks: Which involves poor productivity of labour and manpower requirements, complexity of site conditions with little or no adequate physical planning for project execution, others includes; the use of absolute and or faulty equipment, untechnical proven design changes and the quest to achieving higher quality standards which is characterized by slow technological application;
3) Physical occurring risks: improper use of equipment resulting to structural and equipment damages, resultant deaths and physical injuries to workforce on site, incessant kidnap as well as demand for ransomed payment of personals and theft of facilities/equipment/machineries on sites.
4) Organization structure risks: faulty contractual agreements, ineffective management communication, supervision and relationship with workforce, presence of inadequate experienced workforce, contractors and sub-contractors on some sites.

Following the outcome of the evaluation undertaking for this research work, it can be drawn that the fundamental contributory factors to the existence of these risks are as a result of the application of poor technical solutions within different project stages which is aided by gross errors as well as omissions, neglect in the use of EIA sturdy within the framework of the project, inclusively are also the presence of poor management principles, the safety of workforce and material handling are grossly ill-treated leading to major accidents on sites. Others includes; lack of effective insurance risks, major gaps in the employments of unexperienced workforce to could have handled or managed several technical project, flaws in supervision process resulting from misinterpretation of working drawings/variation design scope and or complexity of certain projects and in some cases appropriate constructions procedures are not chosen or followed. While variation in the scope of scheduled work contributes immensely to a higher degree impacts on both project tendering as well as procurements.

Similarly, others are legislative influences, bribery and corruption during tendering and contractual agreements. Among others includes; contractors defaults as well as contract breach by respective project partners, financially defaulting clients, neglect in the payments of compensation for the acquisition of lands, unrealistic market conditions and fluctuation in price characterised by insufficient cash flows, the need to make more profit/interest at whatever cost, price inflation characterised by poor economic regulation,

Furthermore, this research reviled that 50 – 65% of the workforce in these companies are cognisant to the importance and the application of safety as well as the adoption of risk management measures during project constructions. Nevertheless, the adopted measures by these workers are only at response levels instead of identifying and assessing the risks at all levels within the project lifespan. This phenomenon is hazardous, for its inability to prevent excessive cost and cannot deliver projects on time scheduled in most situations. It has been evaluated in the current ongoing project sites as well as initial ones can be attributed to higher probability of risks occurrence generally resulting from quackery, general design failures, flooding of the environments, ineffective managements of both project, human resource and time. Others also includes; complexity of certain projects and equipment failures, inadequate knowledge in advanced constructional technologies, lack of comprehensive site investigations as well as EIA, inappropriate and or defaults in general construction specifications, greater priority are given to only expatriates in terms of motivation and remuneration while

indigenous workers face serious neglect, unfavourable market condition supported by challenge in material supply chain among others.

Similarly, it was established during this research work that, 75 – 82% of the workforce realises the importance of having pass working experiences for successful project output. While 84 – 92% of these workforce has no knowledge in risk ranking preferences, prioritising risks, checklists and risk exploits, descriptive risk evaluation, probabilistic of risks, comparing risks sensitivity option analysis, risk control and sharing, risk enhancements, direct judgements of risks, brain storming process, risk transfer, acceptance and avoidance, contingency plans as well as effective risk mitigation process.

In view of the scenarios above, and the assessment/evaluation of the construction companies above, it can be deduced that the companies shears common and major risks types. Therefore, there is the urgent need for effective project management and risk mitigation at various stages of the project to preventing future costs as well as time overrun within the lifecycle of these companies and in subsequent projects executions. It's a principle that the beginning of all project has uncertain outcomes and its end has certain outcomes, in between the two phenomena are successive degrees of risk identification, to risk assessment and risk response, a continuous process which provides *figure 7* as sustainable risk management and prevention measures.

Figure 7: Sustainable Risk Management and Prevention Processes Source: (Authors own work, 2021)

Furthermore it's equally important to note that risk management in any project is a fundamental process which requires project engineers or project managers to identify, monitor as well as to manage the possible threats this risks may cause. With the aim of reducing drastically the detrimental negative effects this risks may affect any project in place. Similarly, such risks can generally be classified as manmade risks or naturally unforeseen risks, all can be effectively addressed through risk responses from the unknowns (project uncertainty) to known (project certainty) *figure 7* above.

11. Risks response

This response provides effective descriptions on the major types of actions to be undertaken in order to identify the immediate remote causes of the risk. Technically, the major response strategies to be taken will depend mainly on the risk nature. Vice versa having a competent supervisory personal to effectively monitor the progressive developmental response, and this will be in mutual agreements with the different stakeholders and or actors responsible at various stages of these risks management processes. When a risk is classified to having lower impacts, then it's much easier such risk are managed or handled. Effective applicable strategies of risk responses are basically; to avoid chances of the risks occurring, reduce the eminent risks, transfer the risk to the personnel responsible to take charge and retain most sustainable measure taken to achieving the success of this process.

12. Risk avoidances/preventions

Known risk to have consequential negative effects to the progress of a project lifecycle, it will be required technically to re-evaluates the aims of the ongoing project by either avoiding to modify the projects scope or by stopping the worst-case section of the project, to allow for collaborative brainstorming to arrive at sustainable solution(s), in line with this phenomena, it's important to undertake risk management at the initial project phase instead of having problem to deal with when risk of damage occurs.

However, in this perspective it will require seeking for and utilising alternative solution(s) within this phase of the project in order to eliminates several other risks. Whenever there are major requirements for modification within a project with the aim to avoiding possible risks, it will be effectively to develop sound as well as known approach rather than implementing newer ones. However, this applicability is only when the condition is efficient and is satisfied technically. It's equally important to note that risks can be avoided, and some of the processes and or events that can be followed to avoiding potential risks occurrence are generally among others:

a) The need for sustainable planning process;
b) The application of different approaches at the right time;
c) Provision for effective safety system and approaches;
d) Frequently check and review operational systems;
e) Frequently inspect regular inspectional activities;
f) Provide regular trainings to enhance skills and productivity development;
g) Adopt current sustainable change in procedures and
h) Ensure regular preventive maintenances

13. Reduce and or Mitigates

However, to reducing the level of risk severity, the entire project cycle should be assessed continuously, so as to holistically identify associated possible root cause leading to damage at various project stages. Hence by so doing, there is the likelihood of reducing the chances of potential risk occurrence. A long-term project benefit can be derived by singularly adding expenditures to reducing risks.

It's also a common practice to invest some project or certain project phase into insurances or to employ the services of a qualified expert(s) for the management of higher risk activities that can be envisaged, the essences is this experts may have effective measures to the problem on ground which the project/construction team may be limited of, or not considered.

Similarly, the prioritized risks which needed to be reduced should be sheared and or transferred to sub-contractor(s)/parties with essential background knowledge regarding the risk consequences as well as available resource to be employed. This will promote ones team to having accessibility to available resources on ground as well as benefits from the experiences of the other expertise. It's known to be one of the easiest process by which risk responsibility are shared in these and other project.

The risks mitigation processes that can be considered in this line of action will includes among other majors are:

1) Making adequate planning and provisions for contingency;
2) There should be proper consideration for quality control (QC) and quality assurance (QA) at all stages of the project;
3) There should be replacement for both the available resources as well as the expected activities within the project lifecycle;
4) There should also be a clear contract terms vice versa conditions; and
5) Bearing in mind environmental conditions and the nature of the project(s), there should be in place foreseen and unforeseen disaster recovering plans, vice versa crisis management control measures;

14. Risk transfer

Professionalism is key to project delivery, hence when risks are known to be effectively and actively handled by third party having greater capabilities and or capacities, and then the best options ever will be to transferring the risks to such parties who knows the risks much better and the process to managing it.

The various team players whom these risks may be transferred to base on the nature and the type of the risks are majorly; the project owner(s) i.e. clients, the project manager as well as those whom the contract is contracted to for execution i.e. the contractor(s) and or the sub-contractor(s) party, others includes the technical team (project designers, team of engineers, architects and surveyors), as well as to include the health and safety personnel etc. However, this risks transferring process might lead to increase in the project overall worth or supplementary work which are termed or referred to as premium risk. Vice versa these risks are only transferred to an expert in the field of risk management, while at times the risk isn't eliminated completely. Sometime risk management can be out of the project manager's control, in this case risk shifting as well its negative impacts are also considered as options, and it ought to be transferred via known insurance policy. Such risk type may be associated to striking workforce or politically motivated issues. Sometimes it's attributed to unpredictable definite environmental rare disasters/catastrophes.

15. Risk retentions

When there are no effective options for risk transfer and or avoidance, hence the only better option will be to retaining this risk at the time being. In such a scenario, such risks needed to be controlled to their bearest minimum occurring negative impacts within the project cycle. Similarly when there are no readily available suitable economical options, then retention becomes an alternative measure.

16. Monitoring

Monitoring risks is the concluding aspect in the processes of risk management, and it encompasses collecting as well as monitoring various available information regarding the nature of the risk being identified. It's obvious that other evolving new risks may surfaces during constant monitoring process and controlling associated to risk management cycle approach. Major benefit of monitoring in projects is keeping records on the past risks being identified and subsequently eliminates them from risks evaluations and within the projects. It's paramount to note that, assumption(s) made for monitoring the progress of these risks as well as controlling, are meant to oversee the risks ranking orders and to ensure corrective action in terms of need. Therefore, the effective techniques and mechanisms to be employed for monitoring as well as controlling risks are as follows:

1) Evaluating the entire project scope, to arriving at if there is any and or certain project phase which requires alterations that may negatively has detrimental effects and which may lead to the emergence of newer risks;
2) Continuous reassessing the project risks in order to identifying potentially newer evolving risks. However, this process should remain an utmost priority to observed throughout the lifecycle of these project and others alike;
3) Constant effective brainstorming to includes value engineering and value management sturdy to outline progresses, changes in the scope of work and the expected known and unknown risks as well as the risks owners; and
4) There is the need to continuously checking and improving the risk records (register) so as to ensure a proportionate safety are in place. Equally, safety is the topmost priority for a successful project execution, the higher a project safety the minimal risks severity is expected.

17. Conclusion

It can be concluded that the overall accident incidences in the 7 construction companies in 7 years have been computed to be 814, of 77 deaths and 737 injuries rates. Similarly, the trends of accident in the said industries is incremental, and the risks severities is medium to very high risk rating for deaths and injuries rates. An overall research assessment indicates lack of sufficient or appropriate supporting tools to aid designers, stakeholders as well as decision and or policy maker's to evaluate the probability of accident risks as well to design technical effectively mitigation processes. Therefore, in the current years it has become mandatory for the construction industries to devote the application of technological developments of 3D-GIS and (VR) virtual reality in analysing accidents pattern such as, accident type, site condition, accident date, day and time, type of injuries sustained and the person(s) involved etc. so as to squarely and effectively provide decisions and policy

supporting mechanisms dealing with H&S constraints during construction activities on sites. However, it's clear that most accidents on construction sites occurs due to poor planning and designs, resulting from not having project managers or the use of ineffective managers that has just little knowledge in planning, organising and mitigating risks at different stages of project execution and construction activities. Hence therefore, it's the responsibilities of all constructions related stakeholders to ensure maximum safety in designs, constructions and maintenance of the built environment, through hazard identification to supporting effective formulations of mitigating processes, which in return eliminates accident risks and injury during construction activities on sites.

17. Recommendations:

1) This research work has identified fundamental neglects in processes and information in the Nigerian construction industry and which are often the bases used for effective analyses of accident causation or contributing factors. Hence the construction sites and the Nigerian HSE should ensures these parameters are allays assessed and are properly as well as promptly documented for each and every construction sites.
    a) General individual population involved (ages, gender, and form of trainings);
    b) Types of injuries involved and their causes (falls, collusion, chemical spills);
    c) Time-based (daily, time of the day, seasonally);
    d) Location and section (trench tunnel, scaffold, roof); and
    e) Other associated features (organizational factors, safety, regulation, cost, or human factors) etc.
2) This research work is advocating the utilization of effective accidents and risks tools in the Nigerian construction industries for policymaking concerning prospective hazards on sites, in the likes of 3-D GIS, V-R, integrated Risks Modular, value and risks software among many;
3) Construction administrators and managers should focus more in developing IT tools to enabling accidents investigation and their effective preventions during civil engineering constructions. The recommended systems will allow employers to analyze factors capable of leading to accident even prior to the real accident factors occurs;
4) The construction teams should be provided with timely and routine Health Safety and Environment (HS&E) trainings and should always be specific to ongoing construction projects;
5) Value management (VM) and Value engineering (VE) evaluation should be conducted prior commencing and during all stages of the physical construction projects on sites;
6) Its highly recommended that, only professionally certified experienced personnel PM and PE should be allowed to head and handle major physical constructions projects through the initiation to completion and handing over stages; and
7) Respective stakeholders of the Nigerian construction industries should take proactive measures to ensure maximum promotion of H&S with strict adherences to principles of risks assessments as well as accident mitigation measures before, during and after construction projects.

Acknowledgement

Our sincere appreciation and acknowledgement goes to our noble Professor Stephen O. Ogunlana. School of Energy, Geoscience, Infrastructure and Society (Civil Engineering and Construction Management) Heriot-Watt University Edinburgh, Scotland the United Kingdom. For his utmost technical support to meeting this research objective, and for addressing the constraint during the periods for the preparation of this research work.

Data Availability Statement

Some or all data, models, or code that support the findings of this study are available from the corresponding author upon reasonable request.

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