FACTORS OF MACHINE FATALITY ROAD CONSTRUCTION SITE IN NIGER DELTA REGION, NIGERIA

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[1]Nkanta, Scholastica Daniel, [2]Akpanebu, Ime Jerome
[3]Jackson, Benjamin Udo & [4]Willie, Iniobong Solomon
[1-4]Department of Quantity Surveying Akwa Ibom State Polytechnic, Ikot Osurua
Email: scholastica.nkanta@akwaibompoly.edu.ng

ABSTRACT:

The study examines a comprehensive analysis of the frequency and impact of machine-related fatal accidents at road construction sites in the Niger Delta region of Nigeria, with the aim of understanding their repercussions for workers and the environment. Additionally, the research aims to identify effective strategies for preventing such accidents. The study utilizes a quantitative research design and employs a purposive sampling technique to distribute 300 well-structured questionnaires designed to gather detailed information on the causes and consequences of fatalities and accidents at road construction sites. The findings of the study demonstrate that various factors, such as workers' use of drugs and alcohol, prolonged work hours, use of faulty tools and machinery, as well as negligent and risky behaviour, significantly increase the susceptibility of workers to fatal accidents and loss of life. Consequently, this contributes to heightened stress, anxiety, and fear among workers, negatively impacting their productivity and overall performance. The study identifies several effective

preventive measures, including the implementation of traffic control protocols, regular inspection and maintenance of equipment, and stringent safety regulations within work zones, as well as the establishment of clear communication protocols. Furthermore, the research emphasizes the importance of close monitoring and providing counselling to machinery operators to instigate a change in their attitudes and behaviours, consequently averting accidents. In conclusion, the research strongly advocates for the reduction of the risk of machine fatalities at road construction sites by universally implementing and rigorously adhering to the highlighted measures by all stakeholders in the construction industry.

Keywords: *Environment, Fatality, Machine, Road Construction, Safety*

INTRODUCTION

Machine fatality accidents refer to happenings where someone is incurably injured because of a collision involving machinery (Abdul Hamid., 2008). These kinds of accidents typically occur in industrial settings, construction sites, agricultural operations, and other environments where heavy machinery and equipment are used.

For instance, being crushed by equipment, caught in moving parts, struck by falling objects, or involved in collisions with machinery are all cases of machine fatality accidents. These incidents can result from various factors, such as operator error, equipment malfunction, lack of safety protocols, or hazardous working conditions (Eguh & Adenaiya, 2020).

Therefore, machine fatality accidents remain a very significant concern for workplace health and safety and often require thorough investigation to determine the cause and prevent future occurrences.

Many cases were reported of negligence and non-compliance to health and safety (HS) in the workplace. In developing countries such as South Africa, Smallwood and Emuze (2016) reported that about 52.5% of construction sites

needed to be HS compliant, meaning no provision of HS measured in the contract documentation by clients nor such issues raised by the constructors. In advanced countries, van Heerden *et al*. (2018) reported about 4,693 machine fatalities in the road construction sector in the year 2016 in the US, attributing close to 21%, ranging from falls from height, being caught in-between, electric shock, and being struck by moving objects, reckless driving by machine operators and taxi drivers, bus drivers, and even car owners.

According to a report by the Construction Health & Safety Group of 2020, the United Kingdom has more cases of fatal work-related accidents compared to other sectors. These cases record lousy reputations and adverse effects on the construction site, which demands urgent attention.

Road construction sites are often characterized by the presence of various types of heavy machinery and equipment, such as excavators, graders, rollers, dump trucks, and bulldozers, which are the most frequent culprits. These machines are used for tasks such as excavation, grading, paving, and compacting. The construction industry, especially road construction sites across the world, recorded high injury and fatalities in accident cases as compared to other sectors. No wonder scholars described it as a highly volatile and life-threatening sector regarding health and safety due to harsh working conditions the use of heavy machinery and equipment attracting different kinds of calamities (Phoya, 2012; Eguh & Adenaiya, 2020; and Sampson, 2023).

Shuang and Zhang (2023) emphasize the importance of understanding the hierarchical relationship and critical combination of these causes, using machine learning techniques to predict accidents and recommend safety improvements, as behaviours of on-site workers remain questionable, full of arguments and disagreements, carelessness, and negligence.

Researchers and organizations have defined accident and safety. (Hamid *et al*., 2008), cited in Sampson (2023), explained accident as an unexpected, uncontrolled and undesirable occurrence incident that was not actually planned. In contrast,

Kadiri *et al*. (2014) define an accident as an unplanned and unexpected occurrence which upsets a planned sequence of work, resulting in loss of budgeted output, injury to workers, damage to plant and equipment, and eventually interrupting production flow. Thus, accident occurrences are inevitable**.** At the same time, safety refers to the quality of being anodyne or the freedom from risk and danger to protect people against wounds, failure, injuries, or any non-desirable occurrence (Sampson, 2023).

Meanwhile, the International Labour Organization (2011) observed that approximately 60,000 fatal accidents occur on construction sites globally on a yearly basis. Orji *et al*. (2016) reported from different developed countries the high rate of accident cases on construction sites when compared to other sectors. For instance, Britain recorded the high cost spent on accident treatment and compensation of victims on construction sites. The United States (US) and Italy recorded 20%-25% of accident cases on construction sites, respectively (Forst *et al*., 2013; and Ejiugwo, 2013). In Japan, Ireland, and Singapore, accident cases ranged from 40% to 50% and 59%, respectively, on construction sites.

In developing countries, Durdyev *et al.* (2017) stated that from 2011 to 2015, approximately 1,500 workers died of accidents on building construction sites in Cambodia. Adebiyi and Rasheed (2021) statistically reported that the accident rate on construction sites is very high compared to other sectors and listed some contributory factors such as a lack of project briefings, no safety manuals for communication and no operational policies to safeguard accident cases in building construction sites. Ebiri (2018) reported on the collapse of a seven-storey building as a source of accidents where many sustained injuries and some loss of life.

Kadiri (2014) identified the causes and effects of accidents on building construction sites in Abuja, the attitude of workers on site, irregular inspection of materials and machinery, loss of life, and property delay. Shah and Alqarni (2018) observed that most injuries transpired due to collisions with equipment and vehicle-related incidents. Dump trucks, tippers,

motor graders, and cars cause the frequently reported workplace injuries.

Recent studies have focused on the frequency and causes of accidents at building construction sites and the implementation of safety measures to reduce injuries and fatalities. However, little to no research has been conducted on machine-related fatalities at road construction sites in the Niger Delta region of Nigeria. This study aims to address this gap by identifying the occurrences of machine fatality accidents, examining their impact on workers and the environment, and proposing mitigative measures.

The findings of this study will provide valuable insights for stakeholders, helping to create a safe and harmonious working environment during and after construction activities, promoting peace and safeguarding the health and well-being of all involved.

LITERATURE REVIEW

The road construction industry is a medium through which a society achieves its goals of rural and urban development (Alhomidan, 2013; Choudhry *et al.*, 2008). Construction is one of the sectors that provide essential ingredients for the development of an economy, especially road infrastructures, as it enhances the investment movement of goods and services and equally harnesses economic potential (Ekanem *et al.*, 2020).

Road construction projects are complex processes and involve the activities of professionals and stakeholders for their execution at any given time. Olatunji and Bashorun (2006), cited in Sampson (2023) and Chen *et al.* (2020), observed that, despite the immense importance of rapid growth and development, road construction activities have been confirmed to contribute to a very high level of accidents, injuries, and fatality due to involvement with heavy-duty machinery majorly, exposing the workers to fatal accidents relative to other industries.

Ayodeji and Opeyemi (2021) opined that frequency of occurrence, cause of accidents, organizational status of victims, factors, and effects are vital contributors to the fatality in question. These contributors need to be assessed to demonstrate a viable approach to mitigate the

occurrence. Some of the causes identified are as follows: insufficient operation procedure, faulty machinery, and inadequate machine and tools training operation. To prescribe workable and sustainable solutions to rampant fatal accidents in the construction industry, adequate research, investigation, and analysis are ultimately required.

Vasconcelos and Junior (2015) listed significant basic safety and health requirements for accident-free activities in construction sites: efficient health and safety procedures, functional machines, equipment and spare design, technological advancement / management style, motivation, and friendly working environment.

Kamal et al. (2013) focus on the importance of addressing human factors such as unidentified ergonomic hazards and employer attitudes and motivation to reduce accidents at construction sites.

Ayodeji and Opeyemi (2021) noted that accidents on construction sites are significant products of complicated and interconnected causes of human factors, such as faulty machinery, wrong perceptions, defective technical designs, mode of operations, lack of understanding, and teamwork-related factors are responsible for fatal accidents in the construction site. Emmanuel *et al.* (2023) emphasized the importance of experience-based operations, recognizing the significance of accumulated knowledge and expertise in reducing risks and improving safety outcomes during work in progress.

Causes and Effect of Machine Fatality Accidents on Road Construction Sites. Fatalities on road construction sites account for damages and losses of life, life deformity and threaten project output. Investigating the causes and effects of fatal accidents on road construction sites in the Niger Delta region, Nigeria, becomes essential due to lots of intensive road construction projects ongoing, with some almost at the completion stage. A lot of incurable accidents occur nearly on a monthly basis because of heavy-duty machinery and equipment, making the environment hazardous (Udo *et al*., 2016).

Khosravi *et al*. (2014) observed that construction activities, mostly

road construction, are carried out in an open, noisy, dusty environment due to the operation of heavy machinery, equipment, and construction activities like drilling, cutting, and paving, exposing workers to unsafe and unhealthy atmosphere which could result of a decline of productivity. Eze *et al.* (2020) and Vasconcelos and Junior (2015) studied the causes and effects of fatal accidents in a construction environment.

The study revealed that errors due to crane operation, non-compliance with instructions of operation, faulty machinery, faulty construction site design, choice, and location of equipment are the most common causes of road construction accidents.

Smail *et al.* (2022). Highlighted: lack of training, lack of safety culture, lack of regular inspection for material and machinery, lack of measurement of site condition, lack of safety meeting or toolbox meeting, lack of personal protective equipment (PPE), lack of supervision, lack of communication network among workers and attitudes of the workers. Morais *et al.* (2018) revealed factors such as inadequate skills, lack of sufficient information, inadequate quality control, inadequate communication, inadequate working hours, design problems, and management issues as causes of human error. Such factors inflict injuries, wounds, loss of productivity, loss of life, stoppage of ongoing work, heavy payment of compensation on treatment and burial of victim cases.

Williams (2019) and Okoye (2018) observed that injuries and fatalities in the construction industry in Nigeria are at an alarming stage among unskilled labourers and older workers of 45 years and above, despite the level of technological advancement and level of professionalism in the construction industries in the 21st century.

Umeokafor *et al*. (2014) found that HS provisions and conventions are poorly implemented, and Idoro (2008) identified the non-existence of HS policy approval in the construction industry in Nigeria. These make health and safety left to the hands of contractors and their employees, who are constantly being under pressure to deliver at the expense of their safety in a hazard-laden environment and conditions.

However, with respect to the developmental growth this sector can bring, some unhealthy health and safety problems affect Nigerian construction workers, which can hamper the growth. Many contractors in the construction industry, according to

Oladiran *et al.* (2008), are much more concerned about cost, time, and quality of project delivery and less concerned about the health and safety of the employees (workers) who are the facilitators of the project delivery to cost, time, and quality.

Furthermore, the institutional and regulatory framework for construction health and safety is highly fragmented and poorly implemented (Okolie & Okoye, 2012). On a daily basis, people are killed, injured, and deformed, and many suffer from ill health due to construction activities. This is a significant problem in the Nigerian construction industry that needs investigation to find possible solutions to reduce some of these challenges.

METHODOLOGY

A quantitative research design was adopted for this study, and a purposive sampling technique was employed to obtain information for the study. The choice of the Niger Delta region was based on the volume of infrastructural development that is taking place in these cities. Copies of the questionnaire were distributed to the respondents. The construction respondents included civil engineers, quantity surveyors, land surveyors, safety managers, laboratory technologists, batching plant managers, and other technicians, including: (plant operators, iron fitters, truck drivers, and staff boys). The questionnaire was made up of three parts. The first part captured the respondent's background.

In contrast, the second and third parts comprised the objectives of the study, which focused on causes of machine fatalities accidents on road construction sites, effects on workers and the environment, and mitigative measures against fatality on road construction site accidents in the Niger Delta region.

The data used for the study were collected using a five-point Likert scale of 1 – 5 (Anyanwu, 2018), scale vis-à-vis 1= strongly disagree, 2 = disagree, 3 = moderately, 4 = agree, 5 = strongly

agree. Reliability for adequacy and degree to the items integrated was determined using Cronbach's Alpha, whose score ranges from 0.75- 0. 86, revealing that the instrument of data collection possesses a high degree of reliability and is suitable for the study (Pallant, 2020). Descriptive statistics, relative importance index (RII), and inter-rater agreement were used for the analysis.

Descriptive analysis was used to analyze the respondents' characteristics. In contrast, the relative importance index was used to assess the causes of machine fatality accidents as expressed in equation 1, where *W* is the mean weighted score given to each factor by the respondents, ranging from 1 to 5, *A* is the highest weight (i.e. 5 in the study), and *N* is the total number of samples (300 samples). The relative importance index (RII) was calculated using Equation (1).

Relative Importance Index,

$$RII = \frac{\sum W}{AN} \quad \text{..... Equation 1}$$

Inter-rater agreement (IRA)

To proffer mitigative measures to machine fatality accidents on road construction site, which is objective three, the inter-rater agreement (IRA) employed scoring as expressed in Equation 2. Estimates of IRA are used to justify whether aggregating provided by the respondent is interchangeable or equivalent in absolute terms; IRA represented by $\boldsymbol{RWG}$ (rating weighted agreement) was calculated using the Equations 2 and 3 as founded in LeBreton and Senter (2018).

$$RWG = 1 - \frac{S_x^2}{\sigma_E^2} \quad Equation\ 2$$

where: S_x^2 = the observed variance on the variable X;

σ_E^2 = the variance expected when there is a complete lack of agreement among the judges; and

$$\sigma_E^2 = \frac{A^2 - 1}{12} \quad Equation\ 3$$

where: A = number of response options in the scale.
S_x^2 = the observed variance

Interpretation according to LeBreton and Senter (2018) is as follows: 0.00 - 0.30-lack of agreement; 0.31 - 0.50-weak agreement; 0.51 - 0.70-moderate agreement; 0.71 - 0.90-strong agreement; and 0.91 - 1.00-very

strong agreement. The IRA is unique from other critical index parameter in exploring consensus using variance in respondents' judgment rather than mean score seen in others. Therefore, IRA is used for effective implementation and justification only the mitigating variables from many.

TARGET POPULATION

A total of 300 well-structured questionnaire were purposively distributed to achieve the objectives of the study. Only 133 copies were collected, giving a response rate of 44.27% This shows that the response rate was adequate suitable for the study as shown in Table 1. This is supported by pareto rule otherwise known as (80:20) states that, for many events, roughly 80% of the effects come from 20% of the events.

Table 1: Target Population

Respondents	Questionnaire Distributed	Questionnaire Retrieved	Response Rate (%)
Professionals		100%	
Civil Engineer	48	18	6.00
Quantity Surveyor	38	12	4.00
Land surveyor	34	8	2.60
Safety Managers	24	10	3.33
Batching Plant Managers	20	11	3.67
Laboratory Technologists	28	12	4.00
Technician			
Plant Operators	24	17	5.67
Iron Fitters	26	12	4.00
Staff Boys	22	15	5.00
Truck Drivers	36	18	6.00
Total	**300**	**133**	**44.27**

4.0 PRESENTATION AND DISCUSSION OF FINDINGS

4.1. Respondents' Characteristics

The respondents' characteristics reveal an educational qualification of 36.09% for HND and 43.61% for B.Sc., totalling 79.70%. This indicated that both categories have minimum qualifications. The respondents are core construction professionals and technicians with membership status ranging from

associate to fellow as the highest; this shows the level of proficiency in construction work. Good numbers of the respondents gained enough working experience, having between or more than 10 years of experience, and hence were conversant with what was happening in the industry, as shown in Table 1. These characteristics revealed that their responses were suitable for the analysis.

Table 1: Respondents' Characteristics

Attribute	Characteristics	Frequency		Valid Percent
		Professionals	Technicians	
Educational qualification	ND	-	29	21.81
	HND	18	30	36.09
	BSc	12	21	43.61
	MSc/PGD	7	10	
			-	15.79
	PhD	6		4.51
Professional designation	NIS	15	9	18.05
	NSE	38	20	43.61
	NIQS	20	8	28.57
	Others		13	9.77
Years of experience	6-10	23	20	32.33
	11-15	39	28	50.38
	16-20	11	12	17.29
Membership status	Technician	9	20	21.80
	Licentiate	6	3	6.77
	Associate	4	10	10.53
	Graduate	12	23	26.32
	Corporate	13	26	29.32
	Fellow	6	1	5.26

4.2. Causes of Machine Fatality Accidents on Road Construction Site

The discussion was based on the first six most significant and last three less significant causes of machine fatality accidents on road construction sites in the Niger Delta region as workers under the influence of drugs and alcohol (RII = 0.923), excessive overtime work (RII = 0.906), use of defective tools and machines (RII = 0.880), workers reckless action and behaviour (RII = 0.872), poor communication network among workers (RII = 0.851), weather condition (RII = 0.803).

The result portrays that fatality accidents occur due to workers working under the influence of alcohol and drugs in the study area, implying machine workers require close monitoring and counselling for a change of attitude and habit.

The second significant ranking was excessive overtime work. Workers become weak, tired and worn out after working 8 hours, but the client wants to compensate for the lost time, so insisting on overtime with little or no incentive could lead to incurable accidents. Defecting tools and machinery emerge third as a factor causing accidents because neglected maintenance can result in equipment malfunctions or failures while in operation, leading to fatality accidents. Lack of regular inspections, repairs, and replacements of worn-out parts can increase the risk of breakdowns. This result aligns with Kamal *et al.* (2013) and Eguh and Adenaiya (2020) studies that revealed unsafe use of machinery as the third and fifth significant cause of accidents in construction sites**.**

Workers' reckless actions and behaviour come forth; reckless or negligent behaviour by operators or other workers, such as speeding, improper use of equipment, or disregard for safety protocols, can lead to fatality accidents. This fourth-ranked significance is also likened to Kamal*et al.* (2013) study, which also identified human reckless behaviour as the first causation factor of accidents at construction sites.

The fifth most significant cause of fatality accidents emerges as poor communication among workers, operators, and supervisors, which can lead to misunderstandings and

errors in coordinating the movements of machinery. This result affirmed the findings of Morais *et al.* (2018). This can result in collisions between equipment or accidents involving workers on foot. The sixth factor with RII of 0.803 emerged as weather conditions, which the study area is known for.

Adverse weather conditions, such as heavy rain, fog, or high winds, can reduce visibility and affect the stability and control of machinery, increasing the risk of accidents. Therefore, these first six significant factors need constant and thorough supervision by the leaders on site. This is extremely important on road construction sites in preventing accidents and reducing the causes of site fatality accidents to the barest minimum. The last three insignificant factors in the study area include the lack of emergency measures, ranked with an RII of 0.673. lack of training rated RII of 0.684 remains another insignificant factor, and lack of personal protective equipment (PPE) with RII of 0.695.

Smail *et al.* (2022) ranked lack of training and personal protective equipment among the significant factors in their study area. These findings help to affirm that factors causing accidents on construction sites differ from site to site or location to location.

Table 2: Causes of Machine Fatality Accidents on Road Construction Site

Causative Factor of Machine Fatality Accidents	**RII**		**Rank**
	Professionals	**Technicians**	
Workers under influence of drugs and alcohol	0.923		1
Excessive overtime	0.906		2
Use of defective tools and machines	0.880		3
Workers reckless action and behaviors	0.873		4
Poor communication network among the workers	0.851		5
Weather condition	0.803		6
Lack of supervision by the supervisor in charge	0.782		7

Level of education and experience	0.782	7
Lack of accident records and official safety data	0.768	9
Non-effective adherence on safety regulation	0.763	10
Poor safety conscientiousness of managers	0.753	11
Attitudes of the workers	0.763	12
Non-perfect of safety and regulations	0.742	13
Poor maintenance system of tool and machines	0.737	14
Non-rigorous enforcement of safety regulations	0.737	14
Acts of God	0.729	16
Inadequate innovation and technology	0.715	17
Lack of safety meeting or toolbox meeting	0.704	18
Non-certified skill labour	0.701	19
Irregular inspection for materials and machineries	0.700	20
Unconducive working condition and environment	0.696	21
Lack of personal protective equipment (PPE)	0.695	22
Lack of training	0.684	23
Lack of emergency measure	0.673	24

4.3. Impact of Machine Fatality Accidents on Road Construction Sites

Relative important index (RII) was employed to identify the significant factors impacting machine fatality accidents on road construction sites. The analysis revealed five (5) most impacted factors on fatality accidents on road construction sites, as shown in Table 3. Loss of life with an RII of 0.742 emerged as the study area's first and most influential impact. This result affirmed McCann (2006), Pegula (2004), and Okolie & Okoye (2012) studies which revealed (63%) and 844 heavy equipment

operators and construction labourers deaths in 1992-2002. These accidents result in the tragic death of construction workers or bystanders, causing profound grief and trauma for their families, colleagues, and communities.

The second-ranked most influential impact in machine fatality accidents was worker morale and productivity, with an RII value of 0.739. Fatality accidents can significantly impact the morale of workers on the construction site.

Witnessing or experiencing such accidents leads to increased stress, anxiety, and fear among workers, which reduces productivity and effort on the job. The third impact emerges as an emotional toll on workers, worker turnover, and recruitment challenges, with an RII of 0.737. Fatality accidents pose difficulty for construction industries in retaining existing workers and attracting new talent.

Workers tend to withdraw and seek employment opportunities elsewhere due to safety concerns or disillusionment with the industry's commitment to worker well-being. Workers may develop long life or everlasting emotional trauma and grief, leading to abject poverty. Loss of reputation ranked fifth position with an RII of 0.724.

The loss of reputation stemming from a fatality accident on a road construction site can have far-reaching consequences, affecting trust, relationships, and opportunities within the construction industry and beyond for future engagement. Restoring the parties' reputation often requires proactive measures, which may be difficult sometimes.

Table 3: Impact of Machine Fatality Accidents on Road Construction Site

Impact of Fatality Accidents	Sum	RII	Ranked
Loss of life	293	0.742	1st
Worker morale and productivity	292	0.739	2nd
Worker turnover and recruitment challenges	286	0.737	3rd
Emotional toll on workers	286	0.737	3rd
Loss of reputation	285	0.724	5th
Community perception and trust	291	0.722	6th
Project abandoned	278	0.704	7th
Focus on productivity	275	0.696	8th
Safety reassessment	274	0.694	9th

Exposure to work health hazard (dust/fumes/gases/ radiation)	273	0.691	10th
Unemployment	270	0.684	11th
Regulatory scrutiny	268	0.678	12th
Technological advancement and management style	266	0.673	13th
Project delay	266	0.673	13th
Obstruction of movement	267	0.672	15th
Legal and financial ramification	264	0.668	16th
Focus on prevention.	258	0.653	17th
Improved Cultural belief/ tradition	257	0.651	18th

4.4. Mitigation Measures for Machine Fatality Accidents on Road Construction Site

Interrater agreement (IRA) was used to derive mitigation measures for machine fatality accidents on road construction sites, to minimize accident occurrence, and to create an enabling work environment. These measures were included in the questionnaire to obtain the opinions of the respondents based on their perceptions of mitigating machine fatality accidents on road construction sites, using a five-point Likert scale of 1-5.

The critical factors were spotted using IRA as expressed in Equation 2. The result is presented in Table 4. As discussed earlier, the interpretation is based on LeBreton and Senter's (2008) principles. The significant measures are those with a score $\geq$ moderate agreement of the respondents. The analysis revealed 11 significant measures based on the interpretation principle of $0.51 \leq x \leq 70$ = moderate agreement and $0.71 \leq x \leq 0.90$ strong agreement, as shown in Table 4.

Out of eleven (11) significant measures, Traffic control measures emerged first as the most strongly agreed measure mitigating machine fatality accidents on road construction sites in the study area. Traffic control measures ranked first with an RWG of 0.75. Shah and Alqarni's (2018) study, which was carried out in Liverpool, revealed similar results.

Implementing adequate traffic control measures such as signage, barricades, flaggers, and temporary traffic signals to guide motorists and other road users safely through construction zones remains the key to minimizing the risk of fatality

accidents in the study area. Regular equipment inspection and maintenance ranked second with an RWG of 0.73, meaning strongly agreed (SA). This measure reveals the importance of establishing a rigorous schedule for equipment inspections, maintenance, and repairs to ensure that machinery is in optimal working condition. Regular checks should include brakes, hydraulic systems, safety guards, and visibility aids.

This is in line with the studies of Abdul Rahim *et al.* (2008) in Malaysia and that of Emmanuel *et al.* (2023) in Nigeria. Clear communication protocols and work zone safety emerge in third position among the most significant measures, with an RWG of 0.71.

These measures are keys to minimizing fatality accidents on road construction sites by developing clear communication etiquettes and procedures for coordinating machinery movements, signaling between workers, and managing traffic flow in work zones. Practical communication helps prevent collisions and ensure the safety of workers, motorists, and pedestrians.

Table 4: Mitigation Measures for Machine Fatality Accidents on Road Construction Site

Mitigation Measures	Mean	Variance	RWG	Decision	Position
Traffic control measures	2.951	0.52	0.76	SA	1st
Regular equipment inspections and maintenance	2.921	0.57	0.73	SA	2nd
Clear communication protocols	2.832	0.54	0.71	SA	3rd
Works zone safety	2.895	0.49	0.71	SA	3rd
Continuous improvement	2.597	0.74	0.63	MA	5th
Safety culture and accountability	2.935	0.79	0.61	MA	6th
Regular safety audits and reviews	3.259	0.80	0.60	MA	7th
Comprehensive training program	3.259	0.85	0.57	MA	8th
Emergency response plans	3.134	0.92	0.57	MA	8th
Use of equipment and gears	3.039	0.95	0.52	MA	10th

Government policy enforcement on H/S compliance.	3.039	0.935	0.42	WA	11th
Encourage workers on casual leave	3.146	1.037	0.48	WA	12th
Regular health/safety practical workshops and seminars	3.177	1.072	0.46	WA	13th
Adequate welfare facilities	3.076	1.075	0.46	WA	13th
Severe punishment to defaulters	3.572	1.067	0.45	WA	15th

Strongly agreed (SA), Moderately agreed (MA), Week agreement (WA)

Other significant measures at moderately agreed (MA) include continuous improvement, safety culture and accountability, regular safety audits and reviews, emergency response plans, and comprehensive training programme with RWG of 0.63, 0.61, 0.60, 0.57, and 0.57, respectively.

Morais *et al.* (2018) revealed that workers are trained in equipment and safety culture roles similar to this work. The importance of implementing thorough training programs for equipment operators and construction workers can be overemphasized. Training should cover proper operation of machinery, safety protocols, hazard recognition, emergency procedures, and communication techniques. Equally, continuously seeking opportunities for improvement in safety practices, technology adoption, and risk mitigation strategies becomes necessary to stay updated on innovation, regulations, current best practices, and emerging technologies to enhance safety on road construction sites.

Nevertheless, Government policy enforcement on H/S compliance and encouraging workers on casual leave with RWG of 0. 46 and 0.48 were less significant measures in the study area. Therefore, by implementing the identified mitigation measures, construction industries can reduce the risk of machine fatality accidents and create safer and more conducive working environments for themselves, their employees, and

the surrounding community, as shown in Table 4.

CONCLUSION AND RECOMMENDATION

A range of factors contribute to machine fatality accidents on road construction sites. These include the type of machinery involved, with cranes, excavating machinery, and tractors being the most frequent culprits. Machine fatalities on construction sites are unplanned incidents in which no signal or notification is given. This incident may be avoided by taking adequate responsibility and adhering strictly to this study's findings and preventive measures to overcome the occurrence.

Workers under the influence of drugs and alcohol, excessive overtime, use of defective tools and machines, and workers reckless actions and behaviors were identified as some of the causative factors that exposed workers to fatal accidents leading to loss of life; workers experiencing such accidents led to an increased in stress, anxiety, and fear, hence reduces productivity and effort on the job. Therefore, constructors and companies should adopt the identified preventive measures of traffic control measure, regular equipment inspections and maintenance, work zone safety, and clear communication protocol. Implementing these mitigation measures by construction companies and stakeholders can minimize machine fatality accidents and create safer working environments for the employees, the environment, and the public. Further study is encouraged in other geographical regions within and outside countries to explore the research area globally.

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