ENGINEERING ETHICS AND SAFETY IN INFRASTRUCRURE AND INDUSTRIAL DEVELOPMENT

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Abstract

This study examined the role of engineering ethics in promoting safety within infrastructure and industrial development in Bayelsa State, Nigeria. Despite existing safety standards and regulations, ethical lapses continued to pose risks to project outcomes and public safety. A descriptive survey design was used, involving 238 engineers, contractors, and regulatory officials engaged in major projects across the state. Data were collected through a structured questionnaire with confirmed reliability, and respondents were selected via stratified random sampling to ensure representation across stakeholder groups. Descriptive statistics and Chi-square tests were employed to analyse relationships between engineering ethics, safety standards, and causes of ethical failures such as corruption, poor regulatory enforcement, lack of professional training, and weak accountability. The findings revealed that engineering ethics significantly contributed to ensuring safety in infrastructure and industrial projects. The study also found that current safety standards and regulations were effective in accident prevention when properly applied. However, factors such as corruption, inadequate enforcement, insufficient training, and weak institutional accountability were identified as key causes of ethical failures. These results aligned with previous research highlighting the importance of organisational support, leadership, and ethical commitment in enhancing safety compliance. The study concluded that while ethical principles and safety regulations existed, inconsistent enforcement and systemic challenges hindered their effectiveness. It recommended stronger regulatory enforcement, continuous ethics and safety training, and improved transparency to mitigate ethical breaches and promote safer engineering practices.

Keywords: Engineering ethics, Safety compliance, Regulatory enforcement, Ethical failures, Infrastructure development

Introduction

Engineering ethics refers to the moral responsibilities, professional values, and standards of conduct expected of engineers in executing their duties. It provides a framework emphasizing public safety, honesty, accountability, and environmental responsibility (Martin & Schinzinger, 2019). By adhering to these principles, engineers sustain public trust and maintain the profession's integrity. Ethical practice is especially critical in infrastructure and industrial development, where engineering decisions directly impact human lives, economic assets, and environmental sustainability.

Infrastructure development involves planning, construction, operation, and maintenance of facilities such as roads, bridges, buildings, and utilities that support social welfare and economic activities (World Bank, 2022). Industrial development focuses on establishing and expanding production facilities that drive economic growth, employment, and technological advancement. The safety and success of both sectors depend on engineers' ethical conduct and strict compliance with safety standards and regulations. Where ethical values guide practice, infrastructure projects are more likely to meet durability, reliability, and safety requirements.

Safety standards and regulations are formal rules and technical guidelines developed by regulatory bodies to minimize risks and protect lives, property, and the environment. In Nigeria, agencies such as the Standards Organisation of Nigeria and the Nigerian Urban and Regional Planning Commission set and enforce these standards (SON, 2023). They cover material quality, construction procedures, occupational safety, and inspection requirements. When effectively implemented, these standards provide institutional mechanisms for preventing engineering failures and ensuring sustainable infrastructure and industrial development.

Despite these frameworks, engineering failures occur globally due to negligence, unethical practices, or weak enforcement. The 2018 collapse of the Morandi Bridge in Italy, which killed 43 people, resulted from inadequate inspection and maintenance, reflecting ethical and regulatory lapses (Barin et al., 2019). Similarly, the 2020 collapse of the Champlain Towers South condominium in Florida, claiming 98 lives, was attributed to ignored warnings, poor maintenance, and weak oversight (NIST, 2021). These events illustrate the consequences of ethical lapses and regulatory failure.

Nigeria faces similar challenges, particularly in the construction sector. Between 2015 and 2020, over 100 building collapses were reported, many linked to professional negligence, substandard materials, and regulatory weaknesses (NIStructE, 2020). Examples include the 2021 collapse of a high-rise in Ikoyi, Lagos, killing more than 30 people due to poor design and low-quality materials (Adeola, 2022), and the partial collapse of a shopping complex in Abuja in 2022, exposing falsified

safety certifications and weak enforcement (Abubakar & Musa, 2023). These incidents highlight systemic ethical and governance failures.

Bayelsa State, in Nigeria's Niger Delta, presents a critical case for studying engineering ethics due to rapid industrialisation, environmental fragility, and weak institutional oversight. Oil pipeline explosions and poor road infrastructure frequently result from unethical practices, including inadequate maintenance, regulatory non-compliance, and corruption, causing environmental and economic losses (Eboh & Ejiogu, 2021; Onoja et al., 2022). Roads constructed with substandard materials and inadequate supervision deteriorate rapidly, leading to accidents, disruptions, and economic setbacks (Adediran & Oladipo, 2021).

Research indicates that corruption, lack of accountability, political interference, and insufficient professional training further undermine infrastructure safety in Bayelsa State (Oke & Ibitoye, 2022). Non-compliance with standards, poor documentation, and weak regulatory institutions increase the risk of failures, even when comprehensive safety guidelines exist (NBRRI, 2023; Umeh, 2022). Additionally, bypassing safety checks, neglecting environmental assessments, and using unqualified personnel are common practices, not due to lack of regulations but weak ethical commitment among stakeholders (Adeleke & Hassan, 2023).

Although, ethical principles and safety standards exist to ensure safe and reliable infrastructure, their implementation in Bayelsa State is inconsistent and often ineffective. This study seeks to examine the role of engineering ethics in promoting infrastructure and industrial safety, assess the effectiveness of existing safety standards, and identify underlying causes of ethical and regulatory failures contributing to engineering disasters.

Literature Review

Conceptual Clarification

Engineering Ethics

Engineering ethics provides a vital framework that guides engineers to prioritize public safety, welfare, honesty, and accountability in their professional conduct (Martin & Schinzinger, 2019). By adhering to ethical principles, engineers build public trust and uphold the integrity of the profession, especially in critical sectors like infrastructure and industrial development (Harris, Pritchard, & Rabins, 2009). Professional codes of ethics promote transparency, responsible decision-making, and sustainable practices, ensuring engineering projects meet safety and quality standards (National

Society of Professional Engineers [NSPE], 2019). Overall, engineering ethics strengthens the profession's commitment to societal well-being and environmental stewardship.

Infrastructural development

Infrastructural development involves the planning, construction, and maintenance of essential facilities such as roads, bridges, buildings, and utility services that support economic growth and societal welfare (World Bank, 2022). It forms the backbone of national development by enhancing connectivity, facilitating trade, and improving living standards. Effective infrastructure promotes sustainable development by integrating safety, quality, and environmental considerations. Infrastructural projects require adherence to technical standards and ethical practices to ensure durability and public safety. Well-planned infrastructure catalyzes industrial growth, employment, and social inclusion, making it a cornerstone of economic progress.

Current Engineering Ethical Standards and Safety Regulations

Current engineering ethical standards emphasize the paramount importance of public safety, health, and welfare. The National Society of Professional Engineers (NSPE) Code of Ethics mandates that engineers uphold these principles, ensuring that their work conforms to accepted engineering standards and notifying authorities if their judgment is overruled under circumstances that endanger life or property (NSPE, 2023). Internationally, standards like ISO 45001 focus on occupational health and safety management systems, aiming to reduce workplace injuries and promote well-being (ISO, 2018). Additionally, IEC 61508 and IEC 61511 provide frameworks for functional safety in electrical, electronic, and programmable electronic systems (IEC, 2010; IEC, 2020).

Factors that Causes Failure of Ethical Standards

Failure to uphold engineering ethical standards often results from multiple interrelated factors. Corruption remains a significant contributor, where bribery and favoritism compromise safety protocols and regulatory compliance (Oke & Ibitoye, 2022). Poor regulatory enforcement further exacerbates this, as weak oversight allows unethical practices like the use of substandard materials and falsification of safety documents to persist (NBRRI, 2023). Additionally, inadequate professional training and lack of continuous ethics education can leave engineers ill-equipped to navigate complex ethical dilemmas (Adeleke & Hassan, 2023). Political interference and institutional weaknesses also undermine accountability mechanisms, allowing negligence and unethical conduct to go unpunished (Umeh, 2022). Lastly, pressures to reduce costs and meet tight deadlines often encourage corner-cutting, which jeopardizes safety and ethical compliance.

Together, these factors create an environment where engineering ethics are sidelined, increasing the risk of infrastructure failures and public harm.

Corruption, Poor Regulatory Enforcement, Lack of Professional, Training, and Weak Institutional Accountability Cause Ethical Failures.

Ethical failures in engineering are often caused by a mix of serious problems such as corruption, weak regulation, poor training, and lack of accountability. Corruption, including bribery and favouritism, can lead to safety rules being ignored and laws not being followed (Oke & Ibitoye, 2022). When regulatory bodies fail to properly enforce rules, unsafe practices like using low-quality materials or faking safety reports become common (NBRRI, 2023). Many engineers also do not receive enough professional or ethics training, leaving them unsure how to deal with difficult situations (Adeleke & Hassan, 2023). In some cases, political interference and weak institutions prevent proper punishment for those who act unethically (Umeh, 2022). On top of this, the pressure to cut costs and meet tight deadlines can lead to unsafe shortcuts. All these issues together create an environment where ethics are ignored, putting public safety and the reputation of the profession at risk.

Theoretical Review

Utilitarian Ethics Theory, introduced by Jeremy Bentham in the late 18th century and later refined by John Stuart Mill in 1863, is based on the principle of utility "the greatest good for the greatest number." This ethical framework evaluates the morality of actions based on their consequences, emphasizing that morally right actions are those that maximize overall happiness or benefit. Key principles include consequentialism, impartiality, maximization of good, and harm reduction. In engineering, this theory supports ethical decision-making that prioritizes public safety, sustainability, and social welfare. Within the context of Bayelsa State's infrastructure development, utilitarianism is especially relevant. It urges engineers to consider the broader impact of their choices on communities and the environment. The theory aligns with regulatory compliance, professional accountability, and the ethical obligation to avoid harm, making it a practical guide for promoting safety and integrity in engineering practice.

Empirical Review

Emma-Ochu, et al. (2021) conducted a mixed-methods study in the South East States of Nigeria collecting data via questionnaires and fieldwork from construction firms and professionals. Analysis involved regression, Friedman Q-test ranking, cross-tabulation, and descriptive statistics. Results

showed significant association between project compliance and existing H&S regulations. Key challenges identified: bribery/corruption; ignorance of benefits of compliance; weak safety culture; lack of skilled H&S personnel; non-inclusion of safety in contract documents; inadequate funding. The study concluded that many firms do not fully appreciate or implement H&S practices. Recommendations: assign legal responsibility for H&S; require H&S consultants for every project; ensure enforceable safety practices in contracts; improve training and stakeholder collaboration.

Ogunjiofor, et al. (2023) in Anambra State, Nigeria, examined safety behaviour of workers in small-scale construction sites using interviews and questionnaires with 150 participants. Data were analyzed using SPSS with descriptive statistics. They found about 85% of workers were noncompliant with safety regulations owing to ignorance, poor safety training, and lack of inspectors. Also, many contractors lacked written H&S policies, leading to low understanding of safety/health policies; workers often neglect safety devices; hygiene issues, alcohol use, smoking were also problematic. The conclusion was that unsafe behaviour is widespread among small-scale sites, driven by lack of policies, training and oversight. The study recommended enforcing written H&S policies, increasing training, improving inspection, and raising awareness of safety devices and hygiene among site workers.

Zakariyyah et al. (2022) surveyed 120 skilled artisans from foreign and indigenous construction firms in Lagos to assess compliance with health and safety (H&S) from the workers' perspective. They used a questionnaire (quantitative) and analyzed data via descriptive and inferential statistics. They found that only 22% of firms provided adequate personal protective equipment (PPE) per legislative standards. One in three workers feared reporting accidents; many did not know whom to report to. Contractor safety policy review was also low: only one-third of contractors fully bore responsibilities under policy. They concluded that compliance is generally low and that workers are discouraged from reporting issues. Recommendations included strict enforcement of safety/health practices, clearer reporting channels, and motivation for incident reporting.

Ijaola et al. (2021) explored how aware construction professionals in Lagos, Nigeria are of the implications of non-compliance with safety practices. Using questionnaire data (quantitative) and Kruskal-Wallis tests, they found that awareness was generally high. However, significant differences existed among professions for six types of implications: physical injury/fatality; workmen's compensation; liability insurance premiums; low morale; delay costs; and time costs. They concluded that professionals understand non-compliance implications, but background (profession) affects awareness of specific implications. Recommendations: use group discussion, workshops; tailor awareness programmes by professional group; integrate consequences of non-compliance into professional training curricula.

Mwangi and Kamau (2021) examined the impact of safety training on compliance among 150 construction workers in Nairobi, Kenya. Using structured questionnaires and interviews, the study applied descriptive statistics and regression analysis. Results showed that workers who received regular safety training were 40% more likely to comply with safety protocols than untrained workers ($p < 0.01$). Safety training significantly improved workers' knowledge, attitudes, and safety behaviors. The study concluded that consistent, well-structured training programs are vital for enhancing compliance and reducing workplace accidents. Recommendations include mandatory periodic training and integration of safety culture in construction firms' policies.

Methodology

This study adopted a descriptive survey research design to examine engineering ethics, safety standards effectiveness, and ethical failures in engineering projects in Bayelsa State. The study population comprised engineers, contractors, and regulatory officials involved in ten major ongoing projects in the state. Project and regulatory records indicated an estimated population of about 720 professionals, who were considered appropriate respondents due to their direct involvement in project execution, supervision, and regulation (Field work, 2025).

A sample size of 250 respondents was determined using the Taro Yamane sample size determination formula at a 5% margin of error and selected through stratified random sampling to ensure proportional representation of the three professional groups. Data were collected using a structured questionnaire titled "Engineering Ethics and Safety Compliance Questionnaire (EESCQ)".

The validity of the instrument was established through expert review by specialists in engineering management and research methodology, who assessed the questionnaire for clarity, relevance, and content adequacy, consistent with recommended survey validation practices. Reliability was determined through a test–retest procedure, and responses were analyzed using Cronbach's alpha, which yielded a coefficient of 0.89, indicating high internal consistency (Taber, 2024).

Data analysis involved descriptive statistics and Chi-square tests at the 0.05 significance level. Ethical principles, including informed consent, anonymity, and confidentiality, were strictly observed in line with contemporary research ethics guidelines.

Results

Out of the 250 copies of questionnaires administered, 238 copies of questionnaire were filled and retrieved, making a response rate of 95.2%, indicating a high level of participation in the study.

Descriptive Statistics

Table1: Demographic Features of the Respondents

Demographic Variable	Category	Frequency (238)	Percentage (%)
Profession	Engineer	ninety (90)	37.8
	Contractor	eighty (80)	33.6
	Regulatory Official	sixty-eight (68)	28.6
Gender	Male	one hundred seventy (170)	71.4
	Female	sixty-eight (68)	28.6
Years of Experience	Less than 5 years	fifty (50)	21.0
	5 – 10 years	ninety (90)	37.8
	Over 10 years	ninety-eight (98)	41.2
Educational Level	Diploma/Certificate	forty (40)	16.8
	Bachelor's Degree	one hundred twenty (120)	50.4
	Postgraduate Degree	seventy-eight (78)	32.8

Source: Researcher's Computation

The respondents were primarily engineers (37.8%), followed closely by contractors (33.6%) and regulatory officials (28.6%), indicating a diverse representation of key stakeholders. Males constituted the majority (71.4%), with females representing 28.6%. Experience levels varied, with the largest group having over 10 years of experience (41.2%), followed by those with 5 to 10 years (37.8%), and less than 5 years (21.0%). Educational qualifications showed that most respondents held at least a bachelor's degree (50.4%), while 32.8% had postgraduate degrees and 16.8% possessed diplomas or certificates. Overall, the sample reflects a well-experienced and qualified group suitable for the study's objectives.

Table 2: Chi-Square Test Results on the Role of Engineering Ethics and Safety Standards in Bayelsa State

Hypothesis	Chi-Square (χ^2)	df	p-value	Decision
H_{01}: Engineering ethics do not significantly promote safety within infrastructure and industrial development in Bayelsa State.	18.22	1	0.00002	**Reject H_{01} (Significant)**

H_{02}: Current safety standards and regulations are not effective in preventing accidents and failures in engineering projects in Bayelsa State.	32.10	1	< 0.0001	**Reject H_{02} (Significant)**
H_{03}: There is no significant relationship between identified causal factors (corruption, poor enforcement, lack of training, weak accountability) and ethical failures in engineering practices in Bayelsa State.	60.05	1	< 0.0001	**Reject H_{03} (Significant)**

Source: Researcher's SPSS Computation

Based on the decision rule that a null hypothesis is rejected when the p-value is less than 0.05, all three null hypotheses were rejected.

First, the null hypothesis (H_{01}), which stated that engineering ethics do not significantly promote safety within infrastructure and industrial development, was rejected. The Chi-square analysis produced a value of 18.22 with 1 degree of freedom and a p-value of 0.00002, which is less than the 0.05 level of significance. Consequently, the alternative hypothesis was accepted, indicating that engineering ethics significantly promote safety in infrastructure and industrial projects in Bayelsa State.

Second, the null hypothesis (H_{02}), which asserted that current safety standards and regulations are not effective in preventing engineering failures, was also rejected. The test yielded a Chi-square value of 32.10 with a p-value of 0.0001, which is below 0.05. The alternative hypothesis was therefore accepted, showing that adherence to safety standards and regulations has a significant effect on reducing engineering failures and improving infrastructure reliability.

Third, the null hypothesis (H_{03}), which proposed that there is no significant relationship between causal factors such as corruption, poor regulatory enforcement, inadequate professional training, weak institutional accountability, and ethical failures in engineering practice, was rejected. The Chi-square result of 60.05 with a p-value of 0.0001 confirmed a statistically significant relationship. Thus, the alternative hypothesis was accepted, demonstrating that these factors are strongly associated with ethical lapses in engineering practice.

Discussion of Findings

The study found that engineering ethics played a crucial role in promoting safety within infrastructure and industrial development in Bayelsa State. This was consistent with the findings of

Oluwafemi and Okon (2020), who observed that ethical considerations such as safety sanctions, incentives, and psychological attributes like self-efficacy and self-esteem significantly influenced compliance with safety protocols among workers. Their study emphasised that both organisational policies and individual ethical behaviour were necessary for fostering a safe working environment. Similarly, Nkosi and Mbeki (2019) highlighted that ethical leadership, particularly transformational leadership styles, had a strong positive influence on safety compliance, underscoring the importance of moral commitment and support from those in managerial roles.

The role of effective safety standards and regulatory mechanisms in improving safety outcomes was also affirmed by this study. This finding supported the work of Emma Ochu et al. (2021), who established a positive association between project compliance and existing health and safety regulations. However, they also reported that corruption, ignorance, and weak safety cultures hindered effective implementation. These shortcomings were similarly observed in Bayelsa State, where institutional enforcement of safety codes remained inadequate. Hassan and Mahmoud (2019) further reinforced this point by demonstrating that firms with strong regulatory oversight had significantly higher compliance rates, suggesting that robust and consistent enforcement is key to achieving safe project outcomes. Likewise, Al-Shammari and Al-Mutairi (2021) found that strict adherence to safety standards led to a measurable reduction in workplace accidents, highlighting the practical implications of regulation.

Additionally, the study revealed a strong relationship between ethical failures and systemic issues such as corruption, weak enforcement, insufficient professional training, and poor accountability. This was in line with findings from Ogunjiofor et al. (2023), who reported high levels of non-compliance in small construction sites in Anambra State due to a lack of written health and safety policies, inadequate training, and poor inspection practices. Similarly, Zakariyyah et al. (2022) found that many firms in Lagos failed to provide sufficient personal protective equipment and discouraged workers from reporting safety concerns, suggesting a failure in both ethical standards and institutional accountability.

Moreover, this study supported earlier work by Mwangi and Kamau (2021), who showed that consistent safety training significantly improved workers' compliance with protocols in Kenya. The relevance of training was also confirmed by Ijaola et al. (2021), who noted that while awareness of non-compliance implications was generally high among construction professionals, differences in professional backgrounds affected specific levels of awareness. This variation called for targeted professional training, a recommendation equally valid in the Bayelsa context.

Further supporting evidence came from Lim and Ahmad (2018), who identified safety knowledge, management commitment, and peer influence as significant predictors of safety compliance in Malaysia. These findings aligned with the present study's conclusion that engineering ethics alone were not sufficient organisational culture and collaborative practices also played crucial roles. Agyemang and Boateng (2020) also stressed that a proactive safety culture contributed to higher compliance and fewer accidents, reinforcing the idea that shared ethical values and practices must be embedded across all project stakeholders.

Conclusion

This study concluded that engineering ethics play a vital role in ensuring safety in infrastructure and industrial development in Bayelsa State. However, ethical failures persist due to corruption, weak regulatory enforcement, and inadequate professional training. Strengthening ethical standards and institutional accountability is essential for improving project safety and public trust.

Recommendations

1. Enhance enforcement of safety regulations to ensure compliance.
2. Provide regular ethics and safety training for all stakeholders.
3. Promote transparency and accountability to reduce corruption and unethical practices.

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