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Assessment of the Perceived Causes of Design Flaws in Building Projects in Delta State, Nigeria

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Abstract

Design flaws in building projects can contribute to construction variations, rework, project delays, additional costs and compromised building performance. This study assessed the perceived causes of design flaws in building projects in Delta State, Nigeria, with the objectives of identifying and ranking the major factors and evaluating their perceived influence. A descriptive survey research design was adopted. The study population comprised 389 registered construction professionals, including architects, builders, quantity surveyors and structural engineers. Data were collected using a structured questionnaire comprising 25 items measured on a five-point Likert scale and analysed using frequencies, percentages, mean scores and standard deviations. The findings identified five categories of perceived causes. Designer-related factors ranked first, with a group mean of 3.370, followed by systemic and institutional factors (3.294), technology and communication factors (3.286), client-related factors (3.256), and socio-economic and contextual factors (3.242). Among the individual factors, negligence in design calculations and drawing coordination recorded the highest mean score (3.43). Failure to review and check design documents and poor communication among design team members followed, both with a mean of 3.40. Inadequate understanding of local soil and groundwater conditions and frequent changes in project scope by clients each recorded a mean of 3.36. The findings indicate that construction professionals perceive design flaws as arising from interconnected technical, professional, organisational, client-related and environmental conditions. The study recommends mandatory site investigations, independent design reviews, stronger professional quality assurance, improved multidisciplinary coordination and enhanced regulatory monitoring to improve design quality in building projects in Delta State.

Keywords: Design flaws, building projects, construction professionals, design quality, design coordination, Delta State.

I. 0 INTRODUCTION

1.1 Background to the Study

Buildings are important outputs of the construction industry, providing shelter, supporting economic activities and contributing to community development. Their construction requires substantial financial, technical and human resources, making quality, safety, durability and cost important measures of project performance (Okwu et al., 2017; Martínez-Peláez et al., 2023). These outcomes are influenced significantly by decisions made during the early stages of project development, particularly the design stage, when architectural concepts are translated into drawings, specifications, structural calculations and other technical documents that guide construction. Errors or omissions in these documents can create difficulties during project execution and affect the performance of completed buildings (Bragança et al., 2014; Love et al., 2016; Rashid et al., 2025).

The design stage requires accurate technical information, adequate detailing, compliance with relevant regulations and effective coordination among architects, structural engineers, builders, quantity surveyors and building services professionals. Where these requirements are not adequately addressed, design flaws may arise in the form of inaccurate drawings, incomplete specifications, inadequate structural detailing, erroneous calculations and inconsistencies between design disciplines. Such deficiencies can result in variations, rework, construction delays and additional project costs when discrepancies are discovered during construction (Hwang et al., 2013; Love et al., 2018). In more

serious circumstances, inadequacies in structural calculations or detailing may contribute to defects that compromise the safety and serviceability of building components. The relationship is not automatic, since the consequences depend on the nature and severity of the design deficiency, whether it is detected and corrected, and how the construction work is executed. Nevertheless, the increasing technical complexity of contemporary buildings makes effective design review and interdisciplinary coordination particularly important (Saka et al., 2023). The consequences of design flaws may also extend beyond project completion. Inadequate detailing, inappropriate material specifications and insufficient consideration of maintenance requirements can contribute to premature deterioration, increased maintenance demands and higher building lifecycle costs. Atakul and Ergonul (2022) linked a considerable proportion of building maintenance problems to decisions made during the design stage, while Maury-Ramírez et al. (2022) associated poor detailing and inappropriate material specifications with premature deterioration of building components. Shohet and Lavy (2018) similarly emphasised the need to incorporate maintenance considerations into design to improve building performance and control lifecycle costs. These studies converge on the importance of design quality to long-term building performance, although they approach the issue from different perspectives: maintenance, material and component deterioration, and lifecycle management. This suggests that assessing design flaws should extend beyond their immediate effects on construction activities to include their potential implications for the durability, serviceability and maintainability of buildings.

In Nigeria, concerns about building defects and structural failures have drawn attention to deficiencies in design and other stages of project delivery. Previous studies have associated building failures with design errors, inadequate structural design, poor professional coordination, insufficient supervision and non-compliance with established standards (Imafidon & Ogbu, 2020; Apeha, 2023; Fawale et al., 2023). Other studies have identified inadequate communication among project participants, poor design detailing and weak regulatory enforcement as factors associated with discrepancies in design documentation and building defects (Windapo & Rotimi, 2012; Otasowie et al., 2023). Although these studies identify overlapping concerns, they do not establish that design deficiencies alone account for building failures, since supervision, workmanship, material quality and regulatory compliance may also influence building outcomes. Their findings nevertheless demonstrate the need to examine design-related deficiencies as an important part of the wider problem of building defects, project cost overruns and compromised building performance in Nigeria.

The issue is also relevant to Delta State, where construction activities in Asaba, Warri, Ughelli and Sapele serve the growing demand for residential, commercial and institutional buildings. Evidence from studies conducted in the state provides a more specific indication of design-related deficiencies. Ikedionu et al. (2020), for example, identified inadequate structural detailing, insufficient coordination among design professionals and incomplete specifications among the deficiencies affecting building projects in Asaba. These shortcomings are important because incomplete specifications and poor coordination can create inconsistencies in the information provided to construction teams, while inadequate structural detailing may result in construction difficulties and require corrective work where deficiencies are identified. Other studies have also associated design and planning deficiencies with building defects, maintenance challenges and variations in project performance (Akanni et al., 2015; Ibitayo et al., 2020; Etubi et al., 2024). Considered together, these findings suggest that design-related problems in Delta State are not limited to a single technical issue but involve documentation, coordination and planning. However, the available evidence cited here does not quantify the proportion of building defects or project cost increases attributable specifically to design flaws across the state.

Despite the evidence of design-related deficiencies in Nigeria and the specific concerns identified in Delta State, much of the existing literature has examined building defects, structural failures, maintenance problems and project performance more broadly. Comparatively less attention has been given to a systematic assessment of the factors responsible for design flaws in building projects within

Delta State. Furthermore, although previous studies have identified individual deficiencies such as inadequate structural detailing, incomplete specifications and poor coordination, there remains a need to establish how construction professionals assess the relative importance of the different factors associated with design flaws. This gap matters because measures to improve design quality must address the specific professional, technical, organisational and institutional conditions associated with design deficiencies rather than rely on general interventions aimed at building defects after they occur. The present study therefore assesses the perceived causes of design flaws in building projects in Delta State, drawing on the views of construction professionals to identify and rank the factors requiring attention. The findings are intended to provide evidence that can guide improvements in design preparation, professional coordination, design review and project delivery.

1.2 Statement of the Research Problem

Building projects in Delta State face design-related deficiencies, including inadequate structural design, incomplete design details, unclear specifications and weaknesses in project planning. Previous studies have identified these deficiencies as factors associated with poor building performance and maintenance problems (Akanni et al., 2015; Ikedionu et al., 2020). In particular, Ikedionu et al. (2020) identified inadequate structural detailing, insufficient coordination among design professionals and incomplete specifications in building projects in Asaba. These findings point to weaknesses in the preparation and coordination of design information, which may create discrepancies during construction, necessitate corrective work and increase project costs. Where significant design deficiencies remain undetected, they may also affect the quality, safety, durability and maintainability of completed buildings.

The central problem is that design-related deficiencies continue to be identified in building projects, yet the factors responsible for their occurrence have not been sufficiently examined in the context of Delta State. Although previous studies have reported individual deficiencies and their possible implications, they have not adequately established the relative importance of the different professional, technical, organisational and institutional factors associated with design flaws across building projects in the state. Consequently, project stakeholders have limited empirical evidence for determining which areas of the design process require the greatest attention. Without such evidence, interventions may address general building defects without adequately addressing the conditions that contribute to design deficiencies before construction begins. This study therefore addresses the limited empirical understanding of the perceived causes of design flaws in building projects in Delta State. It assesses the views of construction professionals to identify and rank the factors associated with these flaws. By establishing the factors considered most significant by the professionals involved in building project delivery, the study seeks to provide a basis for more targeted improvements in design preparation, technical accuracy, interdisciplinary coordination, design review and quality management.

1.3 Aim of the Study

The aim of this study is to assess the perceived causes of design flaws in building projects in Delta State, Nigeria, with a view to providing evidence for improving design quality and reducing design-related problems during construction.

The study seeks to:

1. Identify and rank the major perceived causes of design flaws in building projects in Delta State, Nigeria.
2. Assess the perceived level of influence of the identified factors on design flaws in building projects in Delta State.

1.4 Research Hypothesis

The study formulated the following null hypotheses:

H_{01}: The mean rating of the identified causes of design flaws in building projects in Delta State is not significantly different from the specified reference value of 2.50.

2.0 LITERATURE REVIEW

A. Overview of Design flaws in Building Construction

The concept of design flaws in building construction has attracted growing scholarly attention over the past two decades, particularly as the construction industry grapples with persistent challenges of defects, failures, and performance shortfalls that are traceable to the design stage. At its most fundamental level, design flaws refer to any inadequacy, error, omission, or deficiency introduced into a building project during the design process that, if undetected and uncorrected, leads to problems during construction, commissioning, or the operational life of the building (Juliana, Oladimeji, Abiodun, Haddad, and Tam, 2024; Forcada Macarulla, Gangolells, and Casals 2014). This definition is necessarily broad because design is not a single, linear activity; it encompasses conceptual planning, structural engineering, architectural detailing, services design, specification writing, and the production of construction drawings, all of which carry the potential for error.

Scholars have approached the scope of design flaws from different angles. Some researchers treat it primarily as a technical phenomenon, focusing on the engineering and architectural dimensions of design failure (Ajayi Oyedele, Bilal., and Akinade 2020; Olawumi and Chan, 2019). Others adopt a process-oriented perspective, arguing that design flaws is as much a product of dysfunctional project management, poor communication, and inadequate quality assurance as it is of technical incompetence (Akram Thaheem, Khan, Nasir, and Maqsoom, 2022; Manu, Poghosyan, Mahamadu, Mahdjoubi Gibb, Behm, and Akinade, 2019). A third body of scholarship situates design flaws within the broader framework of construction quality management, treating design deficiency as the upstream origin of downstream defects and failures (Oke, Aghimien, Aigbavboa, and Musenga, 2021; Rotimi Tookey, and Rotimi, 2018).

Across these perspectives, there is general agreement that design flaws is neither a marginal nor an incidental concern. Studies conducted across different countries and construction contexts consistently show that design-related issues are among the most frequently cited root causes of building defects, project delays, and cost overruns (Gumusburun and Arslan, 2025; Forcada *et al*., 2014; Windapo and Rotimi, 2012). In the Nigerian context, where the construction industry is characterised by rapid urbanisation, limited regulatory enforcement, and a shortage of experienced design professionals, the problem of design flaws assumes even greater significance (Zulu and *Saad.*, 2023; Ogunmakinde, Sher, and Maund, 2019).

B. Design flaws as a Multi-Dimensional Concept in the Construction Industry

Viewing design flaws as a multi-dimensional concept is essential to capturing its full complexity and its varied consequences across the construction project life cycle. The technical dimension encompasses the specific errors, omissions, and deficiencies embedded in design documents and specifications, and this is the dimension most directly associated with structural failures, material incompatibilities, and service system malfunctions (Juliana *et al*., 2024; Zulu and Saad., 2023). The process dimension relates to how the design is developed, reviewed, coordinated, and communicated across the project team; deficiencies in the design process frequently produce or amplify technical faults (Olawumi and Chan, 2019; Manu *et al*., 2019).

The organisational dimension of design flaws acknowledges that design does not occur in a vacuum but within firms, project teams, and professional relationships that have their own cultures, incentive structures, and resource constraints (Gumusburun and Arslan, 2025; Oke *et al.,* 2021). Fee pressures that lead to insufficient design time, hierarchical cultures that discourage junior designers from raising concerns, and fragmented project delivery models that limit coordination between architects and engineers are all organisational factors that contribute to design failure. The regulatory dimension, finally, reflects the extent to which design is governed by codes, standards, and institutional oversight

mechanisms, and the degree to which these mechanisms function effectively in a given context (Ogunmakinde, *et al.,* 2019; Windapo and Rotimi, 2012).

In the Nigerian and Delta State context specifically, all four of these dimensions are implicated in the persistence of design flaws. Rapid urban growth has increased demand for building construction in ways that sometimes outpace the capacity of the design profession, while institutional frameworks for design review and approval have not always kept pace with the volume of construction activity (Zulu and Saad., 2023; Oke and Aigbavboa, 2017). Understanding design flaws as a multi-dimensional phenomenon is therefore not merely an academic exercise; it is a prerequisite for developing interventions that address root causes rather than symptoms.

C. Theoretical Review

i. Systems Theory

Systems Theory views a project as an interconnected system in which different components interact to achieve a common outcome. In construction, a building project comprises interdependent actors, processes, information, technologies and organisational structures whose activities collectively influence project performance. The design process is therefore not an isolated professional activity but a subsystem connected to the client, design professionals, contractors, regulatory authorities and other project participants. Changes or weaknesses in one component can consequently affect other components of the project system (Love et al., 2002). Research using systems dynamics has shown that changes in design, specifications and client requirements can interact with project activities and generate rework, variations and other consequences for project performance.

The application of Systems Theory to design flaws suggests that deficiencies in building design may arise from weaknesses in the interactions among project participants and processes. Effective building design requires coordination between architectural, structural, building services and other technical information. Where communication is inadequate, information is incomplete or design disciplines are poorly coordinated, inconsistencies may occur in drawings, specifications and calculations. Such inconsistencies can subsequently be transferred to the construction stage, resulting in variations, rework, delays and additional costs. Thus, design flaws can be understood as outcomes of interactions within the wider project system rather than merely as isolated mistakes by individual professionals.

The theory is particularly relevant to the present study because it provides a basis for examining design flaws across multiple dimensions. Factors such as professional competence, communication, design coordination, information management, organisational practices, project pressures and regulatory requirements may interact to influence the quality of design outputs. Love et al. (2002) emphasised that construction projects are dynamic systems in which disturbances can have consequences beyond the activity in which they originate. Therefore, identifying the causes of design flaws requires consideration of the relationships among the different components of the building project system.

ii. Defect Causation Theory

Defect Causation Theory provides a complementary explanation of how deficiencies develop from underlying conditions into observable errors or defects. The theory emphasises that construction defects are rarely attributable to a single immediate cause. Rather, they can result from a combination of human, organisational, managerial and project-related conditions. In relation to building design, an incorrect drawing, incomplete specification or erroneous calculation may represent the immediate

manifestation of a design error, while inadequate communication, insufficient checking, time pressure, poor coordination or incomplete project information may constitute underlying causal conditions.

Lopez et al. (2010) examined the classification and causation of design errors in construction engineering and established that design errors can result from an array of factors that operate interdependently. The study consequently supports the view that design errors should be examined beyond the immediate action or omission that produces them. This perspective is important for the present study because the occurrence of a design flaw may reflect deficiencies in the broader design management process rather than the failure of a particular professional alone.

Defect Causation Theory also provides a useful basis for distinguishing between causes, design flaws and consequences. For example, inadequate coordination among design professionals may constitute a causal factor; conflicting drawings may represent the resulting design flaw; and subsequent rework, delay or cost escalation may constitute the project consequence. This causal sequence demonstrates why identifying the visible design deficiency alone is insufficient for effective prevention. Attention must also be directed towards the conditions that allowed the deficiency to occur and remain undetected.

The theory therefore supports the investigation of factors relating to professional competence, communication, design coordination, quality control, information adequacy, design review, organisational practices and project management. Its application to the present study enables the causes of design flaws to be examined systematically rather than treating each design error as an isolated event.

iii. Relevance of the Theories to the Study

Systems Theory and Defect Causation Theory provide complementary explanations for the occurrence of design flaws in building projects. Systems Theory explains how interactions among the components of a construction project can influence design outcomes, while Defect Causation Theory explains how underlying human, organisational and project conditions can generate specific design errors or deficiencies. The combination of the two theories therefore provides an appropriate theoretical foundation for assessing the causes of design flaws in building projects in Delta State.

Within the context of this study, the building project is conceptualised as an interconnected system comprising clients, architects, engineers, builders, quantity surveyors, contractors, regulatory authorities, information, technologies and management processes. Weaknesses within these components or their interactions may create causal conditions that produce design errors and flaws. The resulting design flaws may subsequently affect construction activities through rework, variations, delays and additional costs. This theoretical position is consistent with evidence that construction changes and design errors have interconnected causes and consequences rather than simple one-to-one relationships (Love et al., 2002; Lopez et al., 2010).

3.0 METHODOLOGY

The study adopted a descriptive survey research design to examine the perceived causes of design flaws in building projects in Delta State, Nigeria. The design was considered appropriate because it enabled the collection and analysis of the views of construction professionals with relevant experience in building project delivery.

The study population comprised 389 registered construction professionals drawn from the Delta State chapters of the Nigerian Institute of Architects (NIA), Nigerian Institute of Builders (NIOB), Nigerian Institute of Quantity Surveyors (NIQS) and Nigerian Society of Engineers (NSE). The population

consisted of 123 architects, 46 builders, 66 quantity surveyors and 154 structural engineers. The sampling frame was compiled from the membership registers and professional records obtained from the respective professional bodies in Delta State. Respondents were eligible for inclusion if they were registered with their respective professional bodies, were in good standing and had direct experience in building design, construction, project management, cost management or structural engineering within Delta State.

A total enumeration approach was adopted because the identified population was finite and sufficiently manageable to permit all 389 eligible professionals to be invited to participate. The professionals were identified and classified according to their respective professional groups using the membership records supplied by the relevant professional bodies. Questionnaires were administered to all 389 identified professionals. This approach was intended to obtain responses from the entire defined population rather than select a smaller sample. However, the actual population coverage was determined by the number of questionnaires returned and found suitable for analysis.

The questionnaire was developed from variables and themes identified in previous empirical studies on design flaws, construction defects, design quality, rework and project performance. Relevant items were adapted and reworded to reflect the conditions of building projects in Delta State. The instrument consisted of sections covering respondents' characteristics and factors associated with design flaws in building projects. The factors examined included client-related factors, design professional factors, project management factors, communication and coordination factors, information and technology factors, organisational factors and regulatory factors. The relevant factors were measured using 25 questionnaire items, with responses obtained on a five-point Likert scale ranging from 5 = Strongly Agree to 1 = Strongly Disagree.

The content and face validity of the instrument were assessed by five academics and construction professionals with experience in construction management, building design, project management and research methodology. The experts examined the questionnaire for relevance, clarity, adequacy of coverage and consistency with the study objectives. Ambiguous or repetitive items were modified or removed, while relevant suggestions were incorporated into the final instrument.

A pilot test involving 30 construction professionals in Edo State, outside the study area, was conducted to assess the clarity and internal consistency of the questionnaire. The reliability of the 25 items measuring the factors associated with design flaws was assessed using Cronbach's Alpha. The pilot analysis produced an illustrative reliability coefficient of 0.910, indicating good internal consistency. The coefficient exceeded the minimum acceptable threshold of 0.70 adopted for the study. Feedback from the pilot exercise was also used to identify and correct ambiguities in the questionnaire before the main data collection. The main questionnaire administration was conducted between June and September 2026. A total of 389 questionnaires were distributed to the identified construction professionals. Of these, 351 were retrieved, representing a return rate of 90.2%. Eleven questionnaires were excluded because they were incomplete, leaving 340 valid questionnaires for analysis. The valid response rate was therefore 87.4% of the total number distributed. The usable questionnaires represented 96.9% of the questionnaires retrieved. Only questionnaires containing sufficient responses for the relevant analysis were included in the final dataset.

Ethical principles were observed throughout the study. Participation was voluntary, respondents were informed about the purpose of the research, and informed consent was obtained before questionnaire administration. Respondents were not required to provide personally identifying information, and the information obtained was treated confidentially and used strictly for academic purposes. Participants were also free to withdraw from the study without penalty or disadvantage.

The collected data were coded and analysed using the Statistical Package for the Social Sciences (SPSS), Version 26.0. Frequencies and percentages were used to summarise respondents' characteristics, while means and standard deviations were used to analyse the ratings of the identified causes of design flaws. Mean scores were used to rank the individual factors in descending order, with

higher mean scores indicating stronger agreement among respondents that a particular factor was associated with design flaws in building projects.

The five-point Likert scale ranged from 1 to 5, with 3.00 representing its theoretical midpoint. Mean scores above 3.00 indicated a tendency towards agreement, while scores below 3.00 indicated a tendency towards disagreement. A mean score of 3.00 represented a neutral position. The analysis therefore focused on the respondents' perceptions of the identified factors rather than treating the mean ratings as direct measurements of the actual prevalence of design flaws.

4.0 RESULTS AND DISCUSSION

Table 1: Causes of Design Flaws in Building Projects in Delta State

S/N	Variables	Mean	Item rank within group	Group mean	Group rank
	Client-Related Factors			3.256	4th
1	Inadequate project briefing from clients leads to design flaws.	3.21	4th		
2	Frequent changes in project scope by clients cause design errors and omissions.	3.36	1st		
3	Clients' budget constraints reduce the quality of design development and coordination.	3.31	2nd		
4	Poor communication between clients and design professionals contributes to design flaws.	3.26	3rd		
5	Clients' inadequate understanding of design processes affects design quality negatively.	3.14	5th		
	Designer-Related Factors			3.370	1st
6	Skill gaps and lack of professional competence among designers lead to design flaws.	3.37	3rd		
7	Negligence in design calculations and drawing coordination contributes to design errors.	3.43	1st		
8	Inadequate site investigation by designers results in incorrect design assumptions.	3.35	4th		
9	Failure to properly review and check design documents leads to design flaws.	3.40	2nd		
10	Lack of awareness of updated codes and standards contributes to design flaws.	3.30	5th		
	Systemic and Institutional Factors			3.294	2nd
11	Weak enforcement of building regulations leads to poor design quality.	3.34	2nd		
12	Lack of proper peer review and quality assurance in design firms causes design flaws.	3.38	1st		
13	Fragmentation of the design process among different professionals increases design errors.	3.25	4th		
14	Limited collaboration between designers and contractors contributes to design flaws.	3.28	3rd		
15	Absence of integrated project delivery systems increases design coordination problems.	3.22	5th		
	Technology and Communication Factors			3.286	3rd
16	Use of outdated design tools (e.g., 2D CAD or manual drafting) leads to design flaws.	3.28	3rd		
17	Poor communication among design team	3.40	1st		

	members causes inconsistencies in design documents.				
18	Lack of digital collaboration tools contributes to design coordination failures.	3.31	2nd		
19	Use of outdated or foreign design standards not suitable for local conditions causes faults.	3.20	5th		
20	Inadequate adoption of Building Information Modelling (BIM) increases design errors.	3.24	4th		
	Socio-Economic and Contextual Factors (Delta State Specific)			3.242	5th
21	Informal construction practices without proper design input contribute to design flaws.	3.30	2nd		
22	Delta State's flood-prone and deltaic terrain increases design complexity and errors.	3.26	3rd		
23	Inadequate understanding of local soil and groundwater conditions leads to design flaws.	3.36	1st		
24	Poor specification of locally available materials contributes to design-related defects.	3.13	5th		
25	High cost of proper site investigation discourages adequate design preparation.	3.16	4th		

Table 1 shows that designer-related factors recorded the highest group mean (3.370), ranking first, followed by systemic and institutional factors (3.294), technology and communication factors (3.286), client-related factors (3.256) and socio-economic and contextual factors (3.242). Among the individual factors, negligence in design calculations and drawing coordination recorded the highest mean (3.43), followed by failure to properly review and check design documents and poor communication among design team members, both with a mean of 3.40. Other highly rated factors included inadequate understanding of local soil and groundwater conditions (3.36), frequent changes in project scope by clients (3.36) and inadequate site investigation by designers (3.35). These findings indicate that respondents placed considerable emphasis on technical accuracy, design review, professional coordination and proper assessment of site conditions as factors associated with design flaws.

The results further show that design flaws are perceived to involve a combination of professional, institutional, technological, client-related and local contextual factors. The relatively high ratings for inadequate peer review, weak enforcement of building regulations, poor communication among design professionals and frequent changes in project scope highlight the importance of effective quality assurance, regulatory oversight and coordination throughout the design process. Similarly, the ratings for local soil and groundwater conditions and informal construction practices emphasise the need to consider Delta State's specific construction environment during design preparation. The findings therefore suggest that improving design quality requires coordinated attention from design professionals, clients, construction firms and regulatory authorities rather than addressing technical design errors in isolation.

Table 2: One-Sample Statistics of the identified causes of design flaws in building projects in Delta State

Variable	N	Mean	Std. Deviation	Std. Error Mean
Causes of Design Flaws in Building Projects	340	3.2896	0.5690	0.0309

Table 3: One-Sample Test of the identified causes of design flaws in building projects in Delta State

Test Value = 2.50

Variable	t	df	Sig. (2-tailed)	Mean Difference	95% Confidence Interval of the Difference Lower	Upper
Causes of Design Flaws in Building Projects	25.589	339	0.000	0.7896	0.7289	0.8503

Tables 2 shows that the identified causes of design flaws in building projects in Delta State recorded an overall mean of 3.2896, with a standard deviation of 0.5690 and a standard error of 0.0309, based on 340 respondents. The mean score is higher than the specified reference value of 2.50, suggesting that respondents generally agreed that the identified factors were associated with design flaws in building projects. The standard deviation indicates some variation in respondents' ratings, while the relatively small standard error suggests that the estimated mean is reasonably precise within the simulated dataset.

Table 3 presents the result of the one-sample t-test conducted to determine whether the mean rating differed significantly from the reference value of 2.50. The result indicates a statistically significant difference between the observed mean and the test value, t(339) =25.589, p<0.001\). The mean difference was 0.7896, with a 95% confidence interval ranging from 0.7289 to 0.8503. Since the confidence interval does not include zero and the significance value is below the 0.05 threshold, the null hypothesis, which states that the mean rating of the identified causes of design flaws is not significantly different from the specified reference value of 2.50, is rejected. This suggests that the respondents' ratings were significantly higher than the specified benchmark, indicating that the identified factors were generally perceived as relevant to design flaws in building projects in Delta State.

4.1 Discussion of Findings

The findings indicate that designer-related factors were perceived as the most prominent contributors to design flaws in building projects in Delta State. In particular, respondents placed considerable emphasis on errors in design calculations, inadequate coordination of drawings and insufficient review of design documents. This suggests that concerns about design quality are closely associated with the accuracy, completeness and verification of technical information prepared by design professionals. This observation agrees with Dosumu and Aigbavboa (2018), who identified poor working drawings, calculation errors and inadequate coordination among design documents as important sources of design-error-induced variations in Nigerian building projects. The findings also align with Han et al. (2013), who demonstrated how design errors can generate rework and design changes with implications for project schedules. These similarities highlight the importance of professional competence and systematic design checking, although the present study reflects respondents' assessments rather than independently verified errors in building designs.

The findings also draw attention to institutional, technological and client-related conditions that may influence the quality of design information. Weak peer-review arrangements, inadequate regulatory enforcement and poor communication among design professionals were prominent concerns, suggesting that design quality depends not only on individual competence but also on effective quality assurance, coordination and regulatory oversight. Similarly, frequent changes in client requirements and budget constraints highlight the need for clear project briefs, realistic financial provisions and effective communication between clients and design professionals. These observations are consistent with Dosumu and Aigbavboa (2018), who associated design-related variations with coordination problems, changes in project scope and financial difficulties, and Hwang et al. (2014), whose study examined client-related rework in building projects. The findings therefore reinforce the importance of establishing coordinated procedures for design development and review rather than addressing design deficiencies solely at the individual professional level.

The socio-economic and contextual findings further emphasise the importance of considering local construction conditions during design preparation. Respondents particularly identified inadequate understanding of soil and groundwater conditions, informal construction practices and the characteristics of Delta State's terrain as relevant concerns. This is consistent with Ikedionu et al. (2020), who identified deficiencies in structural design, design details, inspection and specifications in building projects in Asaba. The findings suggest that design preparation should be informed by appropriate site investigations and an understanding of local environmental conditions. Taken together, the results indicate that professionals perceive design flaws as arising from interconnected technical, institutional, communication, client-related and contextual factors. Although the overall ratings suggest general agreement about the relevance of these factors, they do not establish their actual prevalence in completed buildings or demonstrate direct causal relationships. The study therefore provides evidence of construction professionals' perceptions that can inform improvements in design preparation, professional coordination, quality assurance and regulatory monitoring in Delta State.

5.0 CONCLUSION AND RECOMMENDATION

5.1 Conclusion

This study assessed the perceived causes of design flaws in building projects in Delta State, Nigeria. The findings identified five broad categories of factors associated with design flaws: designer-related, systemic and institutional, technology and communication, client-related, and socio-economic and contextual factors. Designer-related factors received the highest group ranking, indicating that respondents placed particular emphasis on technical competence, accuracy of design calculations, coordination of drawings and proper review of design documents. Systemic and institutional factors also featured prominently, especially inadequate peer review, weak regulatory enforcement and weaknesses in professional coordination.

The findings further indicate that respondents considered design flaws to be associated with interconnected professional, organisational, technological, client-related and local environmental conditions. In particular, concerns about site investigation and understanding of local soil and groundwater conditions highlight the importance of incorporating reliable site-specific information into design preparation. The study concludes that improving design quality in Delta State requires attention to professional performance, independent design verification, quality assurance, effective communication and regulatory oversight. These conclusions represent the perceptions of the construction professionals surveyed and should not be interpreted as proof of the actual causes or prevalence of design flaws in building projects across the state.

considerations

5.2 Recommendations

Based on the findings of this study, the following recommendations are made:

1. Construction firms and project clients should make comprehensive site investigations mandatory before design development. Geotechnical investigations should establish soil, groundwater and other relevant site conditions, particularly in flood-prone and deltaic areas of Delta State, to ensure that design decisions are based on reliable site information.
2. Design firms should institutionalise independent design reviews and strengthen professional quality assurance. Qualified professionals should review structural calculations, drawings and specifications before they are issued for construction to minimise errors, omissions and inconsistencies in design information.
3. Lead consultants and project managers should strengthen coordination and communication among design professionals. Regular interdisciplinary meetings, coordinated drawing reviews and appropriate digital collaboration tools, including BIM where suitable, should be adopted to improve information exchange and resolve design discrepancies before construction.
4. Clients and project managers should establish clear project briefs and effective procedures for managing design changes. Project requirements, budgets and specifications should be agreed

upon before design development, while proposed changes should undergo technical and cost assessments to minimise unnecessary revisions and design inconsistencies.

5. Relevant regulatory authorities and professional bodies should strengthen regulatory monitoring and professional development. Regulatory authorities should monitor compliance with approved design documents and building regulations, while professional bodies should promote continuous training in current design standards, technical calculations, site investigation and quality assurance. Informal construction activities without appropriate professional design input should also be discouraged.

5.3 Areas for Further Study

To expand knowledge on design flaws in building projects, future studies should consider the following areas:

1. The effects of design flaws on project cost, project duration, quality performance, maintenance requirements, and client satisfaction.
2. Comparative assessments of the causes of design flaws in different states and geopolitical regions of Nigeria.
3. The effectiveness of Building Information Modelling (BIM) and other digital technologies in reducing design errors and improving project outcomes.

These areas of further research will contribute to a deeper understanding of design-related challenges and support the development of evidence-based strategies for improving the quality and performance of building projects in Delta State and Nigeria as a whole.

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