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Investigation of Design Errors and Their Impact on the Initial Cost of Building Construction Projects

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Abstract
Design errors remain a persistent challenge in building construction projects, often resulting in significant financial and operational consequences. This study investigates the causes of design errors and their impact on the initial cost of construction projects within Osun State, Nigeria. A quantitative research design was adopted, using questionnaires administered to 188 registered construction professionals, of which 101 responses were analyzed. Reliability tests confirmed strong consistency of the measurement variables (Cronbach's Alpha: 0.882 for causes; 0.812 for impacts). Findings revealed that inadequate coordination among disciplines, communication breakdowns, fragmented decision-making, and negligence were the leading causes of design errors. The impacts were most evident in schedule delays, increased material costs, financial penalties, and unnecessary waste, all contributing to cost overruns and disputes. The study concludes that design errors significantly affect project budgets, timelines, and reputational standing of firms. It recommends the adoption of Building Information Modelling (BIM), integrated project delivery systems, and sufficient time allocation during the design phase to mitigate errors and enhance project resilience.

Keywords: *Construction, design, errors, initial cost, project.*

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1.0 Introduction

Design errors in building construction projects have long been identified as a pervasive point that significantly impacts project outcomes. Understanding the background of this problem involves examining its historical context, the evolution of construction practices and the factors contributing to the persistence of design errors in the industry. The culture and practices prevalent within the construction industry also contribute to the occurrence of design errors. Compliance with regulatory requirements does not guarantee the absence of design errors, as interpretations and enforcement practices may vary. Moreover, the complexity and dynamic nature of the regulatory framework pose a challenge for designers and builders in ensuring compliance while balancing other constraints (Kostina et al., 2024).

The research problem statement serves as the foundation for any study, guiding the investigation and framing the research objectives. In the context of this research on design errors and

their impact on the initial cost of building construction projects, the statement of research problem articulates that design errors continue to pose significant challenges in the construction industry, leading to cost overrun (Kostina et al., 2024). Despite advancements in technology and project management practices, design errors continue to plague construction projects, impacting their initial cost and overall success (Smith, 2018). However, the objectives of this study are to identify causes of design errors in building construction projects and examine the impact of design errors on the initial cost of building construction projects. The scope of this research is basically the building sector in the construction industry within Osun State. The professionals in the building environment were the major target respondents. The research examines design errors and their impact on initial project cost. Design errors have significant financial implications for construction projects, leading to cost overrun, claims and disputes (Chinthaka et al., 2022). Furthermore, design errors pose risks to project schedules, budgets and quality standards, highlighting the importance of proactive risk management strategies. By identifying the root causes of design errors and their potential consequences, the research can inform the development of risk mitigation measures and enhance project resilience (Lim et al., 2024). Effective design error management is essential for ensuring the quality and integrity of constructed assets (Egbebi, 2024)

2.0 Literature Review

Design errors are a pervasive challenge in the construction industry, often leading to cost overruns, schedule delays and disputes (Sacks & Barak, 2019). Design errors encompass inaccuracies, deficiencies or misinterpretations in project documentation, including drawings, specifications and plans, which can arise due to various factors such as communication breakdowns, inadequate coordination among project stakeholders, and time pressures. However, common design errors commence from dimensional errors, which involve inaccuracies in measurements or dimensions specified in project drawings or specifications. This type of error can lead to inconsistencies in building components, resulting in clashes, misalignments or functional inadequacies during construction. Structural errors often occur when the design fails to adequately account for structural loads, forces, or stability requirements. Examples of structural errors include inadequate sizing of structural members, improper placement of reinforcements or insufficient bracing to withstand anticipated loads (Chinthaka et al., 2022). Furthermore, Lim et al. (2024) mentioned materials selection and coordination errors, respectively. The materials selection errors occurred when inappropriate materials were specified for construction purposes, which include selecting materials with inadequate strength and durability. Moreover, coordination errors arise when there are inconsistencies or conflicts between project components. Code compliance errors (Egbebi, 2024), detailing errors (Smith, 2018) and geometric errors (Lim et al., 2024) were mentioned as part of the errors. Code compliance errors occur when the design fails to meet regulatory requirements or building codes. This can include zoning regulations, fire safety codes, environmental regulations, etc. Similarly, Smith (2018) noted that detailing errors involves poorly detailed elements, which may lead to construction defects, materials wastage or compromised structural integrity during installation. Other errors noted by this research involve documentation errors, inadequate risk assessment (Sacks et al., 2019) and complexity of building systems (Zoubeir et al., 2024). These errors identified have major causes. Egbebi (2024) noted that one of the major causes of design errors in building projects is communication breakdowns among major stakeholders. This can lead to misunderstandings, misinterpretations or

omissions in project documentation. Furthermore, time pressures and resource constraints often contribute to design errors in construction projects. Under pressure to meet deadlines or budget constraints, designers may rush through the planning process, overlooking critical details or failing to conduct thorough reviews (Chinthaka et al., 2022). Furthermore, inadequate coordination among disciplines also forms part of errors in building construction projects. Failure of the professionals to align design documentation can result in clashes or conflicts during construction (Ibrahim, 2024). Misrepresentation of the requirements of the client can result in design errors that deviate from intended design objectives. Failure to accurately capture or communicate project needs can lead to discrepancies in design documentation, impacting project performance and quality (Smith, 2018). Negligent habits within project teams can also contribute to design errors. Inappropriate work, neglecting roles and responsibilities, or conflicting priorities may lead to critical design errors in building construction projects or fail to address potential risks (Egbebi, 2024). Limited accessibility to information and resources, such as project specifications, standards or historical data, can hinder the design process and contribute to errors. Designers may lack access to relevant information or resources necessary to make informed decisions, increasing the likelihood of errors in project documentation (Ibrahim, 2024). Additionally, these errors have an impact on the project as opined by Smith (2018), they both noted that design errors will bring change orders. Change orders are formal requests to alter the scope of work outlined in the original contract documents. These changes often result in extra expenses for contractors, subcontractors and project owners, including labour cost, materials cost and administrative cost associated with change orders. Lim et al. (2024) and Chinthaka et al. (2022) further noted that schedule delays and time–related costs are among the impacts of design errors. This will definitely affect the cost associated with the project duration. Delays in resolving design discrepancies or implementing corrective measures can prolong project timelines. Sacks and Barack (2019); Abdul-Rahman and Wang (2017) noted that design errors have an impact on project budget and contingency reserves. As long as design errors are noted, the mind always goes to contingencies to provide financial succour; however, this money may not be able to meet the expenses incurred from these errors. Loss of business opportunities and reputational damage is another impact of design error Chinthaka et al. (2022). Increased material costs, financial penalties, liquidated and ascertained damages, and unnecessary waste are parts of the impact of design errors (Smith, 2018; Lim et al., 2024).

3.0 Research Methodology

The research methodology outlines the systematic approach used to investigate design errors and their impact on the initial cost of building construction projects. This approach ensures that the study is conducted rigorously and that the findings are valid and reliable (Creswell & Creswell, 2018). Research design adopted is a quantitative approach to gather comprehensive data that captures both subjective experiences and objective measurements related to design errors and their impact on the initial cost of construction projects. Data was collected using a questionnaire. The questionnaire included items related to design errors, their impacts on the initial cost of building construction projects, and long-term implications of design errors. The research design outlines the framework and strategies used to investigate the impact of design errors on the initial costs of building construction projects. It serves as a blueprint for data collection, analysis, and interpretation. It ensures the study's objectives are met efficiently. The study population adopted for the study is construction registered professionals in Osun State. However,

the professionals in the Table1make up the sampling frame.

Table 1: Sampling Frame

S/N	Professionals	State	Numbers
1	Quantity Surveyors	Osun	95
2	Architects	Osun	55
3	Builders	Osun	90
4	Civil Engineers	Osun	115
	Total		**355**

Sources: NIQS, NIA, NIOB and NSE (Osun State Chapters, 2023)

The sample size refers to the number of individuals, elements, or observations included in a research study from a larger population under investigation. It is a critical aspect of research design and directly influences the precision and reliability of study findings (Creswell & Creswell, 2017).

$$n = \frac{N}{1+N(e)^2}$$

Where N =Population of study (355)
N=sample size
e=Level of significance at 5% (0.05%)
1=Constant
$N=355/1+355(0.05)^2$
n=188

Random Sampling Technique was adopted in the course of this research. The relative importance index (RII) was used in the analysis of the work. Random importance index is a basis for a mathematical function which is used to better understand the population. It is used for each of the indicators and ranked accordingly.

$RII=\sum W/A\ X\ N(0\leq RII\leq 1)$

Where
W=the weight given to each factor by the respondents and ranges from 1 to 5(where '1' is very low and '5' is very high.
A=Highest weight (i.e. 5 in the case) and
N=the total number of respondents.

Reliability and Validity Test

Prior to undertaking statistical analysis on variables, it is imperative to ascertain their validity by means of a reliability examination. The reliability of the variables was evaluated in this research by employing Cronbach's Alpha test. Sellar (2018) established that a value of 0.70 is acceptable. The result obtained is presented in Table 2. The variable "causes of design errors in building construction projects has an alpha value of 0.882, demonstrating excellent reliability, suggesting that the items related to causes of design errors are highly consistent. Similarly, impact of design errors on initial cost in building construction projects has an alpha of 0.812, which also indicates strong reliability. These results imply that the measurement items for each variable are consistently aligned, making the variables reliable for examining the research goal.

Table 2: Reliability of Research Variables

Variables	Cronbach's Alpha Value
Causes of design errors in building construction projects	0.882
Impact of design errors on initial cost in building construction projects	0.812

Table 3: Distribution of Questionnaire

Questionnaire	Frequency (F)	Percentage (%)
Questionnaire Administered	188	100
Questionnaire Retrieved	101	54

Source: *Authors' Survey, 2024*

One hundred and eighty-eight (188) questionnaires were administered as shown in Table 3, while one hundred and one (101) were

retrieved and used for analysis. This gives a response rate of 54%, which could be considered adequate following the submission of Mugenda and Mugenda (2008).

4.0 Results and Discussion

Table 4: Respondents educational qualifications

Qualifications	Frequency(F)	Percentage (%)
ND	5	5
HND	51	50
BSc	23	23
PGD	4	4
MSc	14	14
PhD	3	3
Total	**101**	**100**

Source: *Authors' Survey, 2024*

From Table 4, it is obvious that the majority of the respondents have a first degree and or its equivalent (73%). These show that the respondents are very knowledgeable to give adequate information in regards to this research.

Table 5: Years of experience of the respondents

Years of Experience	Frequency	Percentage (%)
1-5 years	36	35
6-10 years	26	26
11-15 years	5	5
16-20 years	6	6
Above 20 years	28	28
Total	101	100

Source: *Authors' Survey, 2024*

It is observed in Table 5 that 65% of the respondents have more than 6(Six) years' experience and above in the construction field, this is to say that the respondents have adequate experience to give answer to questionnaire

Table 6: Respondents' profession

Professionals	Frequency	Percentage (%)
Quantity Surveyors	62	61
Architects	12	12
Builders	17	17
Civil Engineers	10	10
Total	101	100

Source: *Authors' Survey, 2024*

Table 6 shows that 61% were quantity surveyors, 12% were architects, 17% were builders, while civil engineers were 10%. It shows that all professionals were represented.

Table 7: Causes of design errors in building construction projects

S/N	Causes	Total	RII	Rank
1	Inadequate coordination among disciplines	101	0.85	1
2	Communication breakdowns	101	0.83	2
3	Fragmented decision-making process	101	0.82	3
4	Negligence	101	0.82	4
5	Deficiencies in the design review process	101	0.79	5
6	Limited accessibility to information and resources	101	0.75	6
7	Misinterpretation of requirements	101	0.74	7
8	Time pressure and resource constraints	101	0.73	8
9	Human factors and cognitive biases	101	0.70	9
10	External influences and the market	101	0.69	10

Source: *Authors' Survey, 2024*

Referring to Table 7, it is obvious that among the causes of design errors, inadequate coordination

among disciplines was ranked highest among these factors, which confirms the position of Mustaffa (2024). When there is inadequate coordination among various professionals, their designs will be at variance with each other. Structural design could be different to architectural design, and definitely poor Bill of quantities will be produced. As long as there is inadequate coordination, there will be low or no communication among the professionals. Communication breakdown was ranked second among the causes of design errors. Smith (2018) critically confirmed this position that if the needs and basic information of a project are not communicated, there will be design errors which eventually lead to a problematic situation on the project. Negligence was examined and ranked among the causes of design errors. It is obvious that if there is carefree attitude from the side of the professionals, this will definitely affect the design if not checked. The respondents actually envisaged this and ranked Negligence as fourth among factors causing design errors.

Table 8: Impact of design errors on initial cost in building construction projects

S/N	Impacts	Total	RII	Rank
1	Schedule delay and time-related costs	101	0.94	1
2	Increased materials cost	101	0.90	2
3	Financial penalties and liquidated and ascertain damages	101	0.87	3
4	Unnecessary waste	101	0.85	4
5	Quality assurance and inspection costs	101	0.83	5
6	Change orders	101	0.82	6
7	Impact on project-on-project budgets and contingency reserves	101	0.80	7
8	Insurance Premiums	101	0.79	8
9	Loss of business opportunities and reputational damage	101	0.77	9
10	Dispute Resolution	101	0.75	10

Source: *Authors' survey, 2024*

In Table 8, it was stated that schedule delay and time-related cost ranked first among the impacts of design errors on building construction projects. There are many issues that are attached to this factor, among it is liquidated and ascertain damages. When design errors occur, there will be a delay at the point of correcting such errors, which will lead to extension of time, which may lead to liquidated and ascertain damages. Furthermore, increased materials cost was ranked second among the factors that were identified to have an impact on the cost of construction resulting from design error. Rework on the design must involve reconstructing that part or element of the building; this will definitely cause additional cost to the building. Other factors that have an impact on design errors are loss of business opportunities and reputational damage, and dispute resolution between the contracting firms and clients. Conclusively, BIM and Integrated Project Delivery can ameliorate the effects of design errors if properly adopted for project executions.

5. Conclusion and Recommendation

The research examined the impact of design errors on the initial costs of construction projects, highlighting their prevalence, causes and financial implications. The findings underscored the

significant role that design errors play in cost overruns, schedule delays and long-term project inefficiencies. The study also identified long-term consequences of design errors, including reputational damages for firms, increased cost of construction and liquidated and ascertained damages.

The research recommends that to mitigate design errors and their impact on the initial costs of construction projects, stakeholders should adopt integrated project delivery systems to align all parties toward project goals, utilise Building Information Modelling (BIM) for improved visualisation, coordination and error detection during the design phase. In addition, stakeholders should ensure sufficient time is allocated for the design phase to reduce the likelihood of rushed and incomplete designs

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