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Effects of Construction Planning Techniques on Maintenance Efficiency of SUBEB Projects in Kaduna State, Nigeria

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Abstract

Construction projects within Nigeria's public sector are frequently criticised for poor maintenance outcomes resulting from inadequate planning frameworks. Persistent use of traditional planning techniques has contributed to cost overruns, delays, and reduced building lifespan, particularly in State Universal Basic Education Board (SUBEB) projects in Kaduna State. This study, therefore, aimed to examine the effect of construction planning techniques on maintenance efficiency in SUBEB building projects. Quantitative approach was adopted using a questionnaire survey. A total of 180 questionnaires were distributed to professionals through purposive sampling technique, with 175 successfully retrieved, achieving a response rate of approximately 97%. Data collected were analysed using descriptive statistics such as mean, SD and Inferential statistics such as regression analysis. Descriptive statistics (mean = 3.41–3.69; SD ≈ 1.3) revealed moderate usage of conventional scheduling methods such as Bar Chart and Critical Path Method, while advanced tools like Earned Value Management were rarely applied. Regression analysis ($R = 0.799$; $R^2 = 0.638$; $p = 0.003$) showed that construction planning techniques significantly predict maintenance efficiency, explaining 63.8% of its variance. The study concludes that systematic application of planning tools enhances cost control, durability, and timely maintenance of public infrastructure. It recommends capacity building in advanced planning methods such as CPM, PERT, and 4D simulation. The study contributes empirical evidence linking planning efficiency with sustainable maintenance performance, offering a practical framework for improving public educational infrastructure management in Nigeria.

Keywords; Maintenance, planning techniques, SUBEB Projects, Efficiency, & Kaduna.

Introduction

Construction projects continue to attract considerable scrutiny for contractors' reliance on techniques that often result in suboptimal performance with respect to time, cost, quality, and client satisfaction (Ingle & Mahesh, 2022; Ayeno, 2023). Over time, it has become increasingly evident that the overall efficiency and outcomes of construction projects are shaped by multiple interrelated factors such as planning techniques, design strategies, and the quality of materials employed (Yazdani et al., 2021). Among these, construction planning failures have been consistently identified as one of the five most critical contributors to productivity loss in the construction sector (Ogunnusi et al., 2020). Indeed, Beiki Ashkezari et al. (2022) contend that construction planning techniques encompassing design, methods, and material choices are essential in transforming resources into completed infrastructure. Faulty selection of these techniques often precipitates project delays, cost escalation, and long-term inefficiencies. In contemporary practice, construction planning techniques vary widely, with each approach offering distinct advantages and limitations. For instance, while traditional construction methods are valued for their flexibility and adaptability, they tend to be expensive and time-consuming. Conversely, prefabricated and modular construction systems offer faster completion times and potential cost reductions but may lack the contextual adaptability required for specific projects (Do et al., 2022; Subramanya et al., 2020).

Moreover, the choice of construction technique substantially affects maintenance effectiveness and long-term facility performance. Traditional construction methods often yield durable structures that are relatively easy to maintain, whereas prefabricated and modular systems—though efficient during assembly may present challenges in achieving long-term durability (Hořínková, 2021; Ishirugi, 2023). Accordingly, Ciulla and D'Amico (2019) as well as Hebebci et al. (2020) emphasise that the appropriate selection of construction techniques represents a critical determinant of maintenance efficiency and overall lifecycle performance. Selecting optimal planning techniques, however, remains a complex and iterative process requiring a delicate balance of cost, time, and quality considerations. As Erdogan et al. (2019) and Shou et al. (2021) argue, such decisions demand the collective expertise of project teams to identify methods that ensure both immediate and long-term efficiency. Environmental conditions, building typology, and project budgets are key contextual factors shaping these decisions. For example, hot and humid climates demand different construction planning approaches than those used in colder or arid regions. At the same time, residential structures typically require distinct construction strategies compared to large-scale commercial or institutional buildings. Furthermore, budget constraints frequently dictate method selection, as high-quality techniques with enhanced durability may involve greater initial costs but ultimately deliver superior maintenance performance and sustainability benefits.

Equally significant is the established relationship between construction techniques and subsequent maintenance practices.

Empirical evidence indicates that buildings incorporating prefabricated components typically require less maintenance due to the stringent quality control associated with off-site fabrication and the ease of component replacement (Shibani et al., 2021). Hence, selecting a method that aligns with specific project conditions can substantially enhance contractor performance, reducing both cost and completion time while improving overall outcomes (Safapour & Kermanshachi, 2019; Nnaji & Karakhan, 2020; Kim et al., 2020; Hamza et al., 2022). Within the Nigerian context, particularly in Kaduna State, the State Universal Basic Education Board (SUBEB) serves as a key agency responsible for the delivery of primary educational infrastructure. In recent years, the agency has embarked on extensive school construction programs aimed at expanding access to quality education. However, emerging concerns highlight inconsistencies in the construction planning techniques adopted, particularly the coexistence of traditional, modern, and hybrid systems, each exhibiting varying implications for maintenance effectiveness (Buba, Ahmed & Omeiza, 2022). Notably, many school buildings constructed using traditional methods have been found to require more frequent maintenance interventions than those developed through modern techniques. Additionally, the pervasive use of substandard materials and unskilled labour exacerbates maintenance difficulties, contributing to increased repair costs, reduced durability, and safety risks that compromise the learning environment (Bertram et al., 2019; Ogunode, 2022). Given these realities, it becomes imperative to approach the selection of construction techniques through a multidimensional lens that prioritises durability, cost efficiency, ease of maintenance, and the availability of a skilled workforce. A contextually informed selection process can significantly enhance the performance, sustainability, and maintainability of educational infrastructure. Therefore, this study seeks to assess the effects of building construction planning techniques on maintenance effectiveness in SUBEB projects within Kaduna State, Nigeria.

Problem Statement

Public buildings across Nigeria face persistent and widespread maintenance challenges, resulting in substantial deterioration, reduced functionality, and various structural defects (Daramola, Dare-Abel & Asaju, 2021; Osuizugbo & Olusanya, 2023). A critical factor underlying this condition is the continued dependence on traditional construction planning techniques, which, despite being outdated and error-prone, remain predominant in the country's construction industry. Consequently, these methods frequently produce substandard outcomes, inflated costs, and extended project timelines (Raouf & Al-Ghamdi, 2019). Usman (2020) underscores explicitly that many SUBEB projects in Kaduna State are typified by poor planning and weak execution, leading to delays, budget overruns, and compromised quality. Additionally, structural inefficiencies arising from corruption, limited oversight, and ineffective stakeholder communication have further compounded these challenges. Furthermore, maintenance effectiveness in SUBEB projects has been hindered by chronic underfunding and insufficient technical expertise (Amanda, 2021; Buba, Ahmed, & Omeiza, 2022). The resultant poor-quality infrastructure not only threatens the health and safety of

users but also diminishes the quality of education provided to students. Moreover, the financial strain associated with the recurring repair and reconstruction of deteriorated facilities places immense pressure on government resources (Fehintola & Fehintola, 2021). The cumulative effects of these conditions include increased maintenance costs, reduced building lifespans, disruptions in teaching and learning, underutilised school facilities, and escalating project expenses (Ghaffarianhoseini et al., 2017).

A critical review of the extant literature further reveals that most previous studies have addressed general building maintenance challenges (Femi, 2014; Alsheri, Motawa & Ogunlana, 2015; Abdul Rahman & Salim, 2013; Hauashdh, Jailani & Rahman, 2022; Ramadan, Khammas & Hameed, 2023). While these studies have contributed valuable insights, they primarily concentrate on residential buildings (Adeola, 2013; Alsheri, Motawa & Ogunlana, 2015) or specific factors such as design deficiencies (Aiyegbejeje & Lasisi, 2013) and material failures (Adeola, 2013). However, the maintenance issues affecting public educational projects—especially those under SUBEB in Kaduna State—remain insufficiently explored. As Hauashdh, Jailani, and Rahman (2022) observe, most research tends to emphasise typological maintenance classification while overlooking procedural, managerial, and planning-related aspects that are crucial to maintenance efficiency. Consequently, there exists a notable gap in the literature concerning the systematic assessment of construction planning techniques and their implications for the maintenance effectiveness of public educational buildings in Nigeria. Addressing this gap is vital for developing sustainable frameworks that can guide project planning and maintenance decisions in public sector construction. Therefore, this study seeks to investigate the extent to which construction planning techniques influence maintenance effectiveness in SUBEB school projects in Kaduna State, Nigeria.

Research Questions

i. What are the construction planning techniques used in SUBEB projects of Kaduna state Nigeria?
ii. How does the construction planning techniques impact the maintenance efficiency of SUBEB projects in Kaduna state, Nigeria?

Construction Planning Techniques and Maintenance Efficiency

Construction planning techniques form the strategic backbone of successful project execution, ensuring that resources, time, and activities are efficiently coordinated to achieve project goals. Fundamentally, construction planning defines what, how, who, and how much will be involved in various project tasks before scheduling begins (Akinradewo et al., 2022; Momanyi & Kamau, 2020). These techniques serve as analytical frameworks that guide contractors in structuring, sequencing, and managing complex construction activities. Among the most prominent planning tools are Bar Charts (Gantt Charts), Work Breakdown Structure (WBS), Critical Path Method (CPM), Programme Evaluation and Review Technique (PERT), Line of Balance (LOB), and Resource Planning (Harris & McCaffer, 2013; Akinradewo et al., 2023).

Each method offers distinct advantages for enhancing coordination and minimising inefficiencies. For instance, Bar Charts remain the most common due to their simplicity and visual clarity in tracking project progress (Handigund & Bhavikatti, 2019; Davila et al., 2020), while the WBS facilitates hierarchical decomposition of complex projects into smaller, manageable work packages (Agistin, Riantini & Latief, 2021). Network-based techniques such as CPM and PERT provide more analytical precision—CPM employs deterministic estimates to identify critical activities and optimise duration (Kendall-Langley et al., 2021), whereas PERT integrates probabilistic modelling to address uncertainty and forecast potential delays (Hasan, 2022; Jibril et al., 2022). Together with effective resource planning (Adeyemo et al., 2023), these methods enable contractors to anticipate constraints, optimise productivity, and enhance long-term project performance (Oba & George, 2022; Pan & Zhang, 2021).

Maintenance efficiency, in turn, represents the sustained capability of a structure to perform its intended functions optimally throughout its lifecycle. It embodies the extent to which maintenance activities are strategically planned, effectively implemented, and economically managed to minimise deterioration and operational costs (Fehintola & Fehintola, 2021; Ghaffarianhoseini et al., 2017). In developing contexts such as Nigeria, the absence of effective planning frameworks often results in poor maintenance outcomes, leading to premature structural failures and increased rehabilitation costs (Daramola, Dare-Abel & Asaju, 2021; Osuizugbo & Olusanya, 2023). As Amanda (2021) and Buba, Ahmed, and Omeiza (2022) observe, educational facilities under the State Universal Basic Education Board (SUBEB) are especially affected by underfunding and weak maintenance coordination. Furthermore, Raouf and Al-Ghamdi (2019) argue that the continued use of traditional, labour-intensive construction approaches exacerbates maintenance inefficiencies and escalates operational expenditures. In this regard, the adoption of modern, systematic construction planning techniques such as CPM, PERT, and WBS becomes indispensable for ensuring that project delivery decisions anticipate future maintenance demands. Efficient maintenance is, therefore, not an isolated technical concern but a reflection of planning quality, managerial foresight, and design integration (Ogunode, 2022; Usman, 2020). As Hauashdh, Jailani, and Rahman (2022) assert, achieving maintenance efficiency requires a proactive, process-oriented approach that links construction planning, resource allocation, and performance monitoring to ensure durability, safety, and cost-effectiveness throughout the building lifecycle.

METHODOLOGY

This study adopted a quantitative research approach to objectively examine the effect of construction planning techniques on maintenance effectiveness in public educational projects. A structured questionnaire survey was designed as the primary instrument for data collection, targeting construction professionals, including engineers, architects, builders, and quantity surveyors who have been directly involved in State Universal Basic Education Board (SUBEB) projects in Kaduna State. Using a purposive sampling technique, a total of 180 questionnaires were administered to ensure that only respondents with relevant professional

experience participated. Out of these, 175 questionnaires were duly completed and returned, representing an impressive response rate of approximately 97%, which enhances the reliability and validity of the findings. The collected data were systematically analysed using both descriptive and inferential statistical tools. Descriptive statistics such as mean and standard deviation were employed to summarise respondents' perceptions and patterns in the dataset, while regression analysis was conducted to determine the predictive relationship between construction planning techniques and maintenance effectiveness. This methodological design provided a robust empirical foundation for identifying significant associations and drawing evidence-based conclusions on how planning techniques influence maintenance performance in SUBEB projects in Kaduna State, Nigeria.

RESULTS AND DISCUSSIONS

The demographic Table 1 offers valuable insights into the characteristics of the respondents. A significant majority of the respondents are male, indicating a potential gender imbalance in the construction industry.

Table 1: Demographic information

S/N	Questions	Options	Frequency	Percent
1.	Gender	Male	97	57.1
		Female	73	42.9
2.	Age	Under 30 years	59	34.7
		30 to 60 years	101	59.4
		Above 60 years	10	5.9
3.	Professionals	Builder	59	34.7
		Architect	52	30.6
		Civil Engineer	37	21.8
		Quantity surveyor	22	12.9
4.	Educational Qualification	HND	49	28.8
		Degree	43	25.3
		Master degree	49	28.8
		PhD	29	17.1
5..	Years of experience	Less than 5years	25	14.7
		5-10 years	57	33.53
		Above 10years	88	51.76

Table 1 provides an overview of the respondents' demographic profile. The data reveals that males (57.1%) slightly outnumber females (42.9%), a trend that's quite typical in the construction industry. A majority of the participants (59.4%) fall within the age range of 30 to 60 years, indicating a workforce that is both mature and experienced. In terms of professional roles, builders (34.7%) and architects (30.6%) make up the most significant portions of the sample, followed by civil engineers (21.8%) and quantity surveyors (12.9%), which ensures a

diverse representation across different disciplines. Regarding educational qualifications, respondents are well-educated, with most holding HNDs (28.8%), Bachelor's degrees (25.3%), or Master's degrees (28.8%), while 17.1% have earned PhDs. Importantly, more than half (51.8%) of the participants bring over 10 years of experience to the table, highlighting that the insights gathered are from seasoned professionals well-equipped to discuss construction planning and maintenance practices.

Construction Planning Techniques Usage in SUBEB Projects

Table 2 presents the extent to which various construction planning techniques are utilised in SUBEB projects across Kaduna State.

Table 2: Construction Planning Techniques Usage In SUBEB Projects In Kaduna

Planning Techniques	Mean	Std. Deviation	Rank	Remark
Scheduling Techniques				
Bar Chart (Gantt Chart)	3.69	1.317	1	Moderate
Critical Path Method (CPM)	3.50	1.354	2	Moderate
Pert Chart	3.45	1.338	3	Moderate
Visualization Using 2D, 3D CAD, and 4D Simulation Clips.	3.41	1.303	4	Moderate
Resource Allocation Techniques				
Line Of Balance	3.32	1.407	5	Low
Gert chart	2.97	1.438	11	Low
Earned Value Management (EVM)	3.14	1.225	8	Low
Q Scheduling	3.11	1.122	9	Low
Risk Management Techniques				
Lean Construction Technique	3.08	1.172	10	Low
Lewis method	3.30	1.237	6	Low
Earned value analysis (EVA)	3.18	1.178	7	

The results reveal that scheduling techniques dominate planning practices, with the Bar Chart (Gantt Chart) recording the highest mean score (M = 3.69, SD = 1.317), indicating a moderate level of use. This is closely followed by the Critical Path Method (CPM) (M = 3.50, SD = 1.354) and PERT Chart (M = 3.45, SD = 1.338), both of which are also rated moderate, suggesting that project scheduling and activity sequencing are central to planning operations. Similarly, visualisation tools such as 2D, 3D CAD, and 4D simulation clips (M = 3.41, SD = 1.303) were moderately used, reflecting the gradual adoption of digital planning technologies. In contrast, resource allocation and risk management techniques showed relatively low usage levels, as indicated by lower mean values across methods such as Line of Balance (M = 3.32), Lewis Method (M = 3.30), Earned Value Analysis (M = 3.18), and Earned Value Management (M = 3.14). Notably, GERT Chart (M = 2.97) and Q-Scheduling (M = 3.11) recorded the fewest applications, signifying limited awareness or technical proficiency in advanced analytical tools. Overall, these findings suggest that SUBEB projects in Kaduna rely

predominantly on conventional and moderately sophisticated scheduling tools, while the use of integrated resource optimisation and risk management techniques remains relatively underdeveloped—highlighting a critical need for capacity building and the adoption of more data-driven planning systems to enhance project efficiency and maintenance outcomes.

Regression Analysis on the Effect of Construction Planning Techniques on Maintenance Efficiency

The regression analysis results presented in the model summary indicate a strong positive relationship between the usage of construction planning techniques and the maintenance efficiency of SUBEB projects in Kaduna State.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics		
					R Square Change	F Change	Sig. F Change
1	.799[a]	.638	.598	.05544	.638	15.864	.003

a. Predictors: (Constant), Construction Planning Techniques Usage in SUBEB Projects

The correlation coefficient (R = 0.799) demonstrates a high level of association between the two variables, suggesting that improvements in planning techniques correspond to significant enhancements in maintenance outcomes. The R^2 value of 0.638 reveals that approximately 63.8% of the variation in maintenance efficiency can be explained by the extent of construction planning techniques employed. At the same time, the adjusted R^2 of 0.598 confirms a substantial explanatory power even after adjusting for sample size effects. The F-statistic (F = 15.864, p = 0.003) further indicates that the regression model is statistically significant, meaning that construction planning techniques exert a meaningful predictive influence on maintenance efficiency.

Table 4: Regression Coefficients Results

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.721	.270		10.093	.000
	Construction Planning Techniques Usage in SUBEB Projects	.326	.082	.799	3.983	.003

a. Dependent Variable: Maintenance efficiency of SUBEB projects

The coefficient results show that the unstandardized beta value (B = 0.326) implies that for every one-unit increase in the use of planning techniques, maintenance efficiency improves by 0.326 units, holding other factors constant. Similarly, the standardised beta coefficient (β = 0.799, p = 0.003) signifies a substantial and statistically significant effect, confirming that effective utilisation of planning techniques contributes markedly to enhanced maintenance

performance in SUBEB projects. Overall, these results underscore that the systematic adoption of robust construction planning tools such as CPM, PERT, and resource planning plays a pivotal role in improving the durability, cost-effectiveness, and functional sustainability of public educational infrastructure in Kaduna State.

The regression findings conclusively demonstrate that the practical application of construction planning techniques significantly enhances the maintenance efficiency of SUBEB projects in Kaduna State. This empirical evidence aligns with the study's first objective, which sought to examine the relationship between planning techniques and maintenance performance, confirming a strong and statistically meaningful connection. The results corroborate prior research (Erdogan et al., 2019; Shou et al., 2021; Safapour & Kermanshachi, 2019) that emphasises the central role of planning methods such as scheduling, resource optimisation, and risk management in sustaining the functional performance of public infrastructure. Specifically, the high explanatory power ($R^2 = 0.638$) suggests that maintenance efficiency is primarily determined by how systematically construction projects are planned, monitored, and executed. Consequently, the findings imply that improving technical competence, institutional capacity, and the adoption of modern planning tools like CPM, PERT, and 4D simulation could significantly reduce maintenance costs, prolong building lifespan, and ensure higher service quality in public educational facilities. Therefore, policymakers and construction managers within SUBEB are encouraged to institutionalise advanced planning frameworks as a strategic mechanism for achieving sustainable, cost-effective, and resilient infrastructure development.

CONCLUSION

Based on the findings, the study concludes that the effective utilisation of construction planning techniques has a profound and statistically significant influence on the maintenance efficiency of SUBEB projects in Kaduna State. The results revealed that a higher level of planning competence particularly through scheduling tools such as the Bar Chart (Gantt Chart), Critical Path Method (CPM), and PERT correlates strongly with improved building performance, cost efficiency, and durability. However, the relatively low application of advanced techniques such as Earned Value Management, Line of Balance, and Lean Construction indicates persistent gaps in technical capacity and methodological integration. The regression results further confirmed that approximately 63.8% of variations in maintenance efficiency can be attributed to the degree of planning technique adoption, highlighting planning as a pivotal determinant of post-construction performance. This underscores that maintenance challenges prevalent in SUBEB projects are primarily systemic outcomes of inadequate planning frameworks, weak resource coordination, and limited use of modern analytical tools. Therefore, for sustainable educational infrastructure delivery, project stakeholders must adopt data-driven, technology-supported, and methodologically rigorous planning systems that emphasise efficiency, foresight, and accountability throughout the project lifecycle.

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