Effect Of Construction Technology On Public Housing Sustainability: A Study Of South-East Nigeria

Chukwu Chinaechetam[1], Chukwunonso Obiefuna Umeora[2], Vitalis Maduabuchi Irouke[3]

[1]Department of Architecture, Godfrey Okoye University, Nigeria
[2]Department of Architecture, Faculty of Environmental Sciences, Chukwuemeka Odumegwu Ojukwu University ,ULI Campus
[3]Department of Architecture, Nnamdi Azikiwe University, Faculty of Environmental Sciences

Abstract
The study examines the effect of Construction Technology on Public Housing Sustainability: A Study of South-East Nigeria. The specific objectives were to investigate the extent of application of construction technology in public housing estate projects in the study area and examine the effect of construction technology deficiency on public housing estate projects in the study area. The study combined a cross-sectional descriptive survey and a correlational research design. A structured questionnaire designed with a five-point Likert scale was adopted for the study. The data collected were analyzed using the Pearson Product-Moment Correlation test. The result revealed that there is a significant relationship between the level of application of construction technology in design/construction' and 'quality' in the Performance of Public Housing Estate Projects in South-East, and there is no significant relationship between 'Effects of construction technology deficiency on the stakeholders and investors' and 'Budget/cost' in the Performance of Public Housing Estate Projects in South-East, Nigeria. The study concluded that construction technology adoption is a critical lever for improving quality in public housing estate projects, but cost performance may not respond in the same direct way to stakeholder- and investor-related technology deficiencies. The study recommended that policymakers and implementing agencies in South-East Nigeria should prioritize construction technology integration, especially at the design and execution stages, as a strategic pathway to improving quality.

Keywords: Construction, Housing, Public, Sustainability, Technology

Introduction

Construction technology is an instrument that should be considered in developing strategic plans for running housing construction projects. Oladapo and Olotuah (2007) maintained that the appropriate housing construction technology can be measured by the availability of locally made plant and equipment, skilled manpower resources, the extent of local material resources, and the degree of utilization of such local construction resources, as well as the use of ICT in the design, communication, and keeping and retrieving information. However, the housing construction industry in Nigeria is characterized by development projects that require advanced construction technologies and resources from developed countries. The lack of technological expertise and the shortage of managerial personnel are considered two of the major problems and constraints facing the industry. The situation as of the 1980s was described thus: ''lack of basic knowledge of production methods and design techniques for machinery constitutes a serious constraint to rapid industrialization of the country Oladapo and Olotuah (2007). The situation is aggravated by an acute shortage of managerial manpower. As of today, the country still remains a net importer of technical manpower, virtually all building materials and construction machinery spare parts are imported, and most investment in research and development is made abroad, except those sponsored by the government in public-owned institutions (World Economic Forum, 2014). Based on the developed countries, technology in construction management in the housing construction industry has led to increased demand for project management solutions throughout the world as

a fundamental force to complete projects within a defined scope, time, and within cost constraints Toor and Ogunlana, 2009). Most modern housing project systems deliver innovative solutions, and their management process has the latest tools, techniques, systems, and schemes in use. The indicators for housing construction technology are: Locally made plant and equipment (not imported), Use of computer aided design (CAD), Availability of skilled manpower, Use of electronic mails and communication and Building information modelling (BIM) and 3-Dimension models There has been massive growth in the Nigerian real estate sector with developers coming up with varied housing construction concepts to attract and accommodate the diverse needs of their clients. One concept that has been wholly embraced by various stakeholders in this industry is housing estates. (Landman, 2012) states that a housing estate is a type of estate that has strict entrances for its residents as well as their automobiles, and is often characterized by a massive perimeter wall around the estate. Housing estates offer different types of buildings, which include villas, bungalows, apartments, and mansionettes (Landman, 2012). For a housing construction project to be considered successful, it must meet certain performance measures such as timely completion, achieved quality, and within budget, as well as satisfy all the stakeholders' needs in the project (Chudley et al, 2006). The absence of reworks as well as 'fitness of purpose' for the occupiers has also been considered as a housing construction project success indicator (Landman, 2012).

1.1 Statement of the Problem

A review of the results of hundreds of World Bank projects by Joseph (2009) indicated that the success or failure of housing construction projects often depends on factors in the technology employed. The review pointed out that in the management of projects, the technology employed has an influence on the project performance and therefore should be given due attention to form a basis for analysis for overcoming or mitigating its effect on project performance. Many studies, though not conclusively, indicate that, among other factors, there exists a relationship between the technology employed to project performance. It is against this background that this study sought to examine the influence of technology on the performance of the housing construction industry, a case of housing estate projects in south-east, Nigeria. Based on the review of pass literatures on construction technology, it seems that less work has been done in addressing the influence of construction technology on the performance of housing at the design and construction phase.

Hence, in order to bridge the gap of this knowledge, there was a challenges therefore to carry out a study on influence of construction technology on performance of public Housing estates in five states of south-east Nigeria, directed on the owners' occupiers, facility managers, contractors and consultants in order to obtain feed-back information that is needed for future policy formation, program, project network planning, construction and design development of public housing construction in the study area. The problem this research tackle was therefore this lack of adequate feed-back information from public housing owners, consultants, facility managers and contractors on the influence of technology on the performance of these housing units during design and construction stages, that necessitates to the failure of these housing units. The information will then be used to generate criteria parameters or methods of conducting an evaluation of construction technology on the performance of public housing units. Unfortunately, no attempt has been made by any past research to develop a methodology for evaluating construction technology on the performance of public housing estates in the South-East in particular and Nigeria at large.

1.2 Objective of the Study

The main objective of this study is to examine the effect of Construction Technology on Public Housing Sustainability: A Study of South-East Nigeria. The specific objectives were to;

i. To investigate the extent of application of construction technology in public housing estate projects in the study area.
ii. To examine the effect of construction technology deficiency on public housing estate projects in the study area.

1.3 Hypotheses of the study

i. Ho2- There is no significant relationship between 'Potential Impact of locally made material resources' and 'Client satisfaction' in the Performance of Public Housing Estate Projects in South-East, Nigeria.
ii. Ho3- There is no significant relationship between 'level of application of construction technology in design/construction' and 'quality' in the Performance of Public Housing Estate Projects in South-East, Nigeria

Review of Related Literature

2.1 Conceptual Review

Construction Technology

The term "construction technology" refers to all methods, apparatus, and materials utilized in construction, from planning to dismantling (Sepasgozar, 2016; Tatum, 1988). Various construction technologies have been used in residential projects; however, the choice of technology depends on the project's specific requirements. Manufacturing services today are significantly affected by technological advancements, prompting industries to reconfigure production systems (OZTURK, 2018). Due to the tremendous efforts made over the past 70 years for the development and implementation of technological and organizational advances, the construction industry had to introduce innovative procedures and technologies, such as digital fabrication, to respond to architectural design requests for flexibility, complexity, high performance, detail, personalization of material, and technology (Carpo, 2012, Gramazio, & Yoon, 2018). Olsson et al. (2019) declared that the construction industry has changed from being a crafts-based sector to an industrialized and service-oriented enterprise. The term construction technologies has a broad definition that includes everything, from a drone to computer software, making it impossible to describe the state of the art in research accurately. Consequently, construction technologies are defined as computer software or applications that provide technological solutions for construction project management practices in residential and commercial projects, achieving a goal, carrying out a specific function, or addressing a problem (Skibniewski and Zavadskas, 2013; Hamza et al., 2022).

Application of Construction Technology

Construction technology (Contech) applications encompass digital tools, advanced materials, and automated machinery used to enhance efficiency, safety, and sustainability across the building lifecycle from planning and design to construction and maintenance (Li et al 2022). Key applications include Building Information Modeling (BIM) for 3D simulation, drones for surveying, robotic automation for site tasks, and AI for predictive scheduling. Emerging technologies provide new opportunities for construction management (Žujovi´c 2022). Through the introduction of building information modeling (BIM), Internet of Things (IoT), and other scientific and technological means, the digitization and intelligent construction management of the whole construction process

are realized. For example, the use of BIM technology to compare with the design drawings to find the quality problems existing in the construction process in time to ensure that the construction quality meets the design requirements (Li et al 2022). Using the capabilities of BIM's cloud platform, managers can conduct dynamic simulation exercises throughout the construction process and gain a clearer understanding of their own workflow and professional cross-cutting issues. This early risk identification and understanding of the key and difficult points of work not only improves the efficiency of communication and coordination in construction, but also enhances the overall management results (Žujovi´c 2022).

Construction Technology Deficiency

Construction technology deficiency is largely driven by a 75% lag in modern technology adoption among industry professionals, high initial investments, and a significant workforce skill gap. Key barriers include poor, outdated equipment in training, lack of knowledge-sharing platforms, and, in some regions, a reliance on unskilled labour. These issues result in project delays, budget overruns, and reduced structural quality (Li et al 2022). A recurring point in construction research is that "technology" should be treated as more than physical equipment. It includes process technologies (e.g., lean methods, prefabrication workflows), information technologies (BIM, project management platforms), and organizational technologies (standardization, quality systems, procurement innovations). Scholars in construction management argue that the sector's performance is shaped by how well it integrates these forms of technology into project delivery systems, not merely whether advanced tools exist in the market (Hamza et al., 2022).

Public Housing Estate in South-East, Nigeria

The housing estate process in South- Eastern Nigeria can be said to be little or no difference with the method adopted in many other states of Nigeria. The Nigeria Building Society, which was set up in 1959 with a capital of 2.25 million naira, was the first major attempt by the government to finance home ownership in the country. The Society was set up under an arrangement between the Colonial Development Corporation, the Central Government, and the Government of Eastern Nigeria. Unfortunately, the impact of this novel effort could not be felt by the majority of the populace; the NBS was only able to serve a very restricted section of the population due to its credit terms, commercial orientation, and lack of funds.

The introduction of the Regional Housing Corporation soon followed, with that of the Federal Territory of Lagos, known then as the Lagos Executive Board. The Board and the Regional Corporation were charged with the powers to acquire land, develop and manage housing estates, and make loans available to people who qualified for such loans to build their own houses. One of such Regional Corporations was Eastern Nigeria Housing Corporation. The impact of this Corporation was felt in Enugu and Port Harcourt, where it developed the Abakpa Nike Housing Estate, phase 1, and the Trans- Amadi Housing Estate (Rainbow Town) before the civil war in 1967.

After the civil war and the creation of three new states from the former Eastern Region, the East Central State Housing Development Authority was established in 1970 and by the time of bifurcation of the state in 1976, it had begun work in the Riverside Housing Estate Abakpa Nike and the Trans- Ekulu Housing Estate, both in Enugu, and Aladinma Housing Estate in Owerri. The activities of the Authority also included provision of per-contract consultancy services for Government and Government Agencies and the construction and refurbishing of some Government projects, for example, AlvanIkoku College of Education, Ohafia Army Barracks, Queen Elizabeth Housing Umuahia, etcetera.

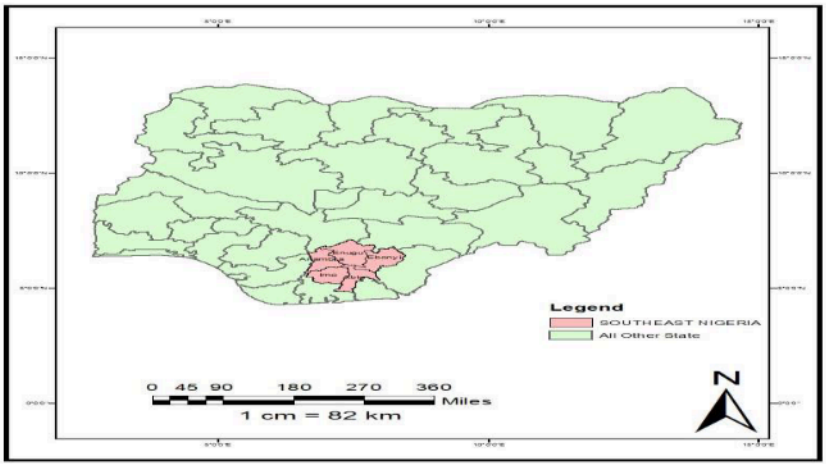
Construction TD Through the Lens of Diffusion and Adoption Theory

A large body of literature attributes technology gaps in construction to slow diffusion relative to manufacturing and ICT-heavy industries. Diffusion of innovation theory suggests adoption depends on perceived advantage, compatibility with existing practice, complexity, trialability, and observability (Ajzen, 1991). Construction projects are temporary coalitions of multiple firms, which makes consistent technology use harder to institutionalize (Hamza et al., 2022). Even when a contractor invests in technology, project-by-project fragmentation can prevent learning accumulation. The Technology Acceptance Model (TAM) and related behavioral frameworks add that user perceptions of usefulness, ease of use, and social influence shape whether digital tools (e.g., BIM, mobile field apps) are actually used (Dulaimi, et al 2002). In contexts where CTD is prevalent, studies frequently report that technology is "adopted on paper" (for compliance or bidding advantage) but not integrated into daily work routines. By Implication**,** Construction Technology Deficiency is partly a behavioral and organizational phenomenon, not only a resource problem (Ajzen, 1991).

Area of the Study

This study evaluates the influence of construction technology on the performance of public buildings in Nigerian Cities with a specific focus on residential buildings proposed and built by the state government under the public housing program. Notionally, the study area is the entire city in Nigeria, with a specific focus on the five states within the South-East geo-political zone of Nigeria. The cities include the following: Enugu in Enugu State, Owerri in Imo state and Aba and
Umuahiain, Abia State, Awka in Anambra State, Abakaliki, and Ikwo in Ebonyi State. The South-East geo-political zone (see figure 1) comprising Abia, Anambra, Ebonyi, Enugu, and Imo States is one of the most homogenous and cohesive geo-political zones in Nigeria.

Figure 1: Map of Nigeria showing the South East Geopolitical Zone with states



Source: Google Images @www.google.com

3. Methodology

This study combined a cross-sectional descriptive survey and a correlational research design. The use of the two designs was suitable because the study used both descriptive and inferential analysis of data. On one hand, cross sectional descriptive survey design is concerned with describing, recording, analyzing, and interpreting conditions that existed. The target population of the study comprised 24 public housing estate projects that were

active and running, initiated and completed between 2009 and 2020. The study employed a combination of census and stratified random sampling techniques. All the selected estates were included in the study using the appropriate technique, and this was the first stage. The average number of buildings in each estate is 80. A structured questionnaire designed with a five-point Likert scale was adopted for the study. The data collected were analyzed using the Pearson Product-Moment Correlation test.

4 Results

4.1 Aggregated Univariate Data Analysis

4.2.1 Aggregated data analysis of variables under socio-economic characteristics

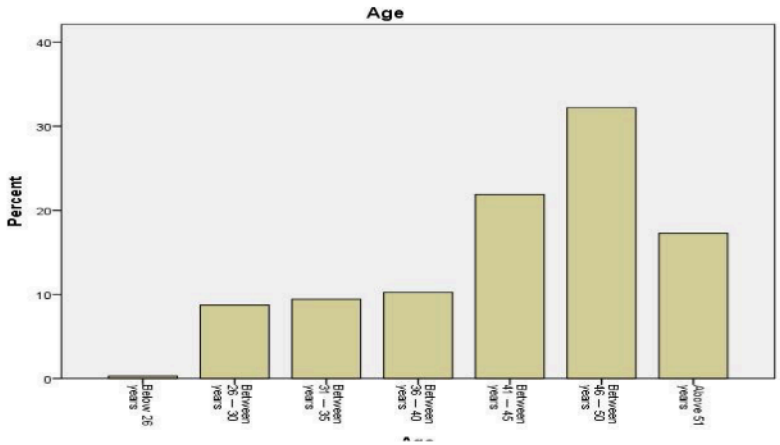
a) Aggregated data of the age of respondents (Variable 1)

On age, the findings indicated that 0.3% of the respondents were below 26 years, 8.7% were between 26-30 years, 9.4% were between 31-35 years, 10.2% were between 36-40 years, 21.9% were between 41-45 years, 32.2% were between 46-50years and 17.3% were 51years and above. These findings show that 81.6% of the professionals and project owners in the estates are above 36 years, hence were experienced and knowledgeable in their respective fields. This implies that the older generation dominates this industry and not only affects building design and structure, but also has a serious impact on the construction workforce. A great deal of knowledge and skills will be lost in the next few decades, with fewer professionals lined up to replenish the market. This is shown in Table 9 and Figure 6.

Table 9 Aggregated data on age of respondents (Variable 1)

Values	Frequency	Percent	Cumulative Percent
Below 26 years	3	0.3	0.3
Between 26 — 30 years	87	8.7	9.0
Between 31 — 35 years	94	9.4	18.5
Between 36 — 40 years	103	10.2	28.7
Between 41 — 45 years	220	21.9	50.6
Between 46 — 50 years	324	32.2	82.7
Above 51 years	174	17.3	100.0
Total	1005	100.0	

Figure 6: Analysis of aggregated Data of the age of respondents



b) Aggregated data on sex of respondents (Variable 2)
The research finding indicated that 78.2% of the respondents were male, while 21.8% of the respondents were female. These findings show the housing construction industry in Southeastern Nigeria is dominated by male professionals. Though not mandatory and not a requirement across all sectors, the constitution of Nigeria requires that there should be at least a third of either gender in all forums, especially in elective posts. This requirement is slowly creeping in and getting roots across all governmental and non-governmental institutions. This is shown in Table 10 and Figure 7.

Table 10 Aggregated data on sex of respondents (Variable 2)

Values	Frequency	Percent	Cumulative Percent
Male	786	78.2	78.2
Female	219	21.8	100.0
Total	1005	100.0	

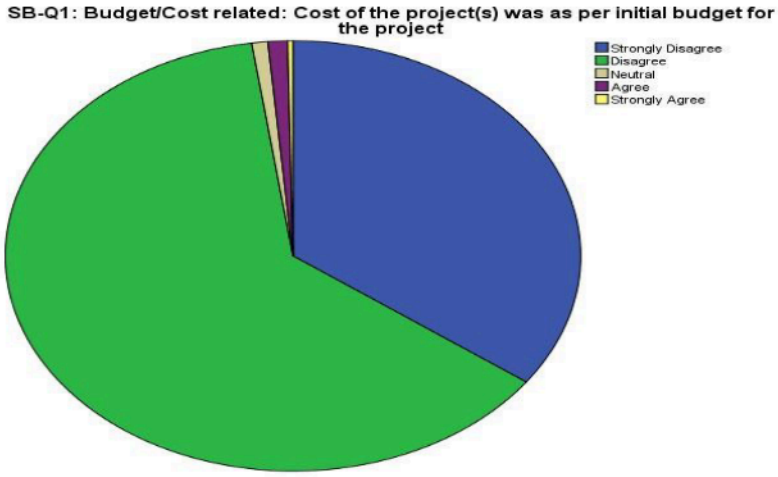
4.2.2 Aggregated data analysis of variables under 'Section 2: Analysis of project performance indicators in public housing estate projects in South-East, Nigeria?'

a) Aggregated data on 'cost of the project was as per the initial budget for the project' (Variable
13),
Analysis of the data shows that 35% of the respondents strongly disagreed that the cost of the project was as per the initial budget for the project, 62.7% disagreed that the cost of the project was as per the initial budget for the project, with only 1.1% agreeing that the cost of the project was as per the initial budget for the project. Also, 0.9% of the respondents had no opinion regarding the matter. The implication of the findings is that 97.7% of the respondents agreed that housing project cost overrun is a serious problem facing the industry in the study area. This is shown in Table 21 and Figure 18.

Table 21: Aggregated Data on 'Cost of the project(s) was as per initial budget for the project' - V13- (Budget/Cost related)

Value label	Frequency	Percent	Cumulative Percent
Strongly Disagree	352	35.0	35.0
Disagree	630	62.7	97.7
Neutral	9	.9	98.6
Agree	11	1.1	99.7
Strongly Agree	3	.3	100.0
Total	1005	100.0	

Figure 18: Appraisal on 'Cost of the project(s) was as per the initial budget for the project'

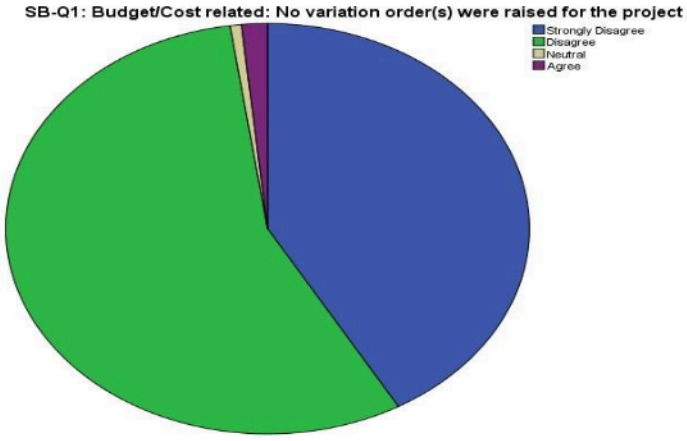


b) Aggregated data on, no variation order(s) were raised for the (Variable 14),
Analysis of the data shows that 41.7% of the respondents strongly disagreed that no variation orders were raised for the project, 56% of the respondents disagreed that no variation orders were raised for the project, and only 1.6% agreeing that variation orders were raised for the project. Also, 0.7% of the respondents had no opinion regarding the matter. The findings indicated that 97.7% of the respondents agreed on the variation order for the projects. This is shown in Table 22 and Figure 19.

Table 22: Aggregated Data on 'No variation order(s) were raised for the project' - V14- (Budget/Cost related)

Value label	Frequency	Percent	Cumulative Percent
Strongly Disagree	419	41.7	41.7
Disagree	563	56.0	97.7
Neutral	7	.7	98.4
Agree	16	1.6	100.0
Total	1005	100.0	

Figure 19: Appraisal on 'No variation order(s) were raised for the project'

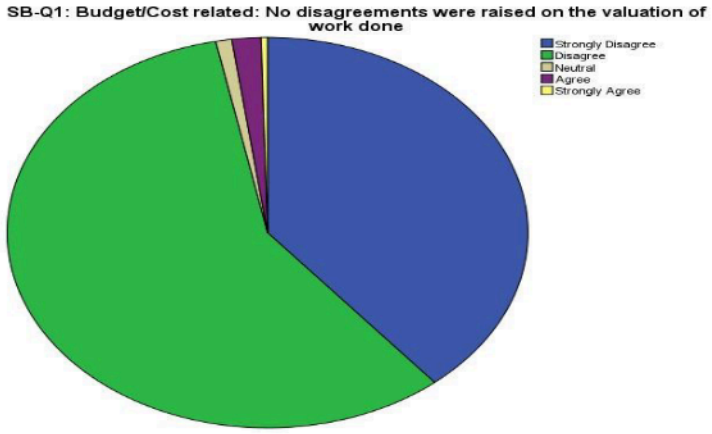


c) The Aggregated data on 'No disagreements were raised on the valuation of work done' - V15 (Budget/Cost related). Analysis of data shows that most of the respondents (96.8%) believed that a lot of disagreement were raised on the valuation of work done. Also, 1% were neutral, with 1.8% agreeing with the statement that no disagreement was raised on the valuation of work done. This is an indication that issues with the raising of valuation order is one of the most pressing problems the housing construction industry faces in the study area.

Table 23: Aggregated Data on 'No disagreements were raised on the valuation of work done' - V15 (Budget/Cost related)

Value label	Frequency	Percent	Cumulative Percent
Strongly Disagree	391	38.9	38.9
Disagree	582	57.9	96.8
Neutral	10	1.0	97.8
Agree	18	1.8	99.6
Strongly Agree	4	.4	100.0
Total	1005	100.0	

Figure 20: Appraisal on 'No variation order(s) were raised for the project'



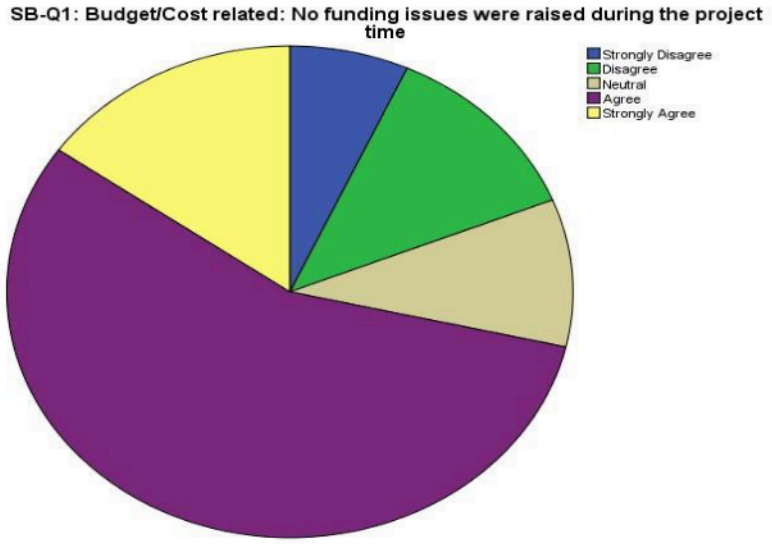
d) Aggregated Data on 'No funding issues were raised during the project time' - V16(Budget/Cost related). The findings are shown in Table 24 and Figure 21. They indicate that no funding issues were raised during the project time: The data shows that 56.2% of the respondents agreed that no funding issues were raised during the project time, 15.2% strongly agreed that no funding issues were raised during the project time with only 12.1% and 6.8% disagreeing and strongly disagreeing with the statement respectively. Also, 9.7% of the respondent had no opinion regarding the matter.

Table 24: Aggregated Data on 'No funding issues were raised during the project time' - V16 (Budget/Cost related)

Value label	Frequency	Percent	Cumulative Percent
Strongly Disagree	68	6.8	6.8
Disagree	122	12.1	18.9

Neutral	97	9.7	28.6
Agree	565	56.2	84.8
Strongly Agree	153	15.2	100.0
Total	1005	100.0	

Figure 21: Appraisal on 'No funding issues were raised during the project time'



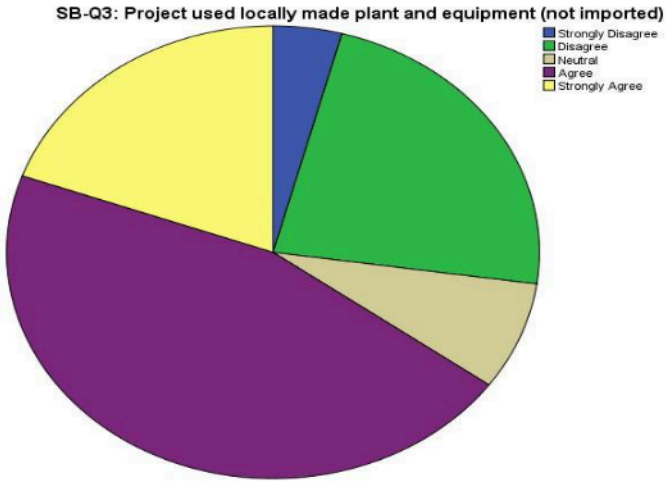
4.2.3 Aggregated data analysis of variables under 'Question 2: What is the level of application of construction technology at the design and construction of public housing estate projects development in the study?'

A) Aggregated data analysis of 'Project used locally made plant and equipment (not imported)'- Variable. The data gathered under the variable indicated that 45.5% (457) of the respondents agreed that their projects used locally made plant and equipment (not imported), 19.5% (196) strongly agreed with the statement, 23.2% (233) of the respondents disagreed with the statement that their projects used locally made plant and equipment (not imported), 4.2% (42) of the respondents strongly disagreed with the statement, with 7.6% (76) of the respondents been neutral on the opinion (see Table 81 and Figure 78). These findings show that above one-third of the respondents did not believe that their projects used locally made plant and equipment, thereby indicating that projects had problems with locally made plant and equipment issues.

Table 81: Aggregated data for 'Project used locally made plant and equipment (not imported)'- Variable 73

Value label	Frequency	Percent	Cumulative Percent
Strongly Disagree	42	4.2	4.2
Disagree	233	23.2	27.2
Neutral	77	7.7	35.0
Agree	457	45.5	80.5
Strongly Agree	196	19.5	100.0
Total	1005	100.0	

Figure 78: Aggregated data of data on 'Project used locally made plant and equipment (not imported)'



B) Aggregated data for 'Skills were available for operation of the plant and equipment'- Variable 74

The research findings show that 64.7% (650) of the respondents agreed that skills were available for the operation of the plant and equipment, 20% (201) of the respondents indicated that they were strongly agreed with the statement, only 3.4% (34) and 0.3% (3) of the respondents were in disagreement and strongly in disagreement with the statement, with 11.6% (117) of the respondents been neutral on the statement. These show that more than two-thirds of the respondents were in agreement with the statement (see Table 82 and Figure 79).

4.2.5 Aggregated data analysis of variables under 'Question 3: What are the effects of *construction technology deficiency on the stakeholders and investors in public housing estate projects in the study area?'*

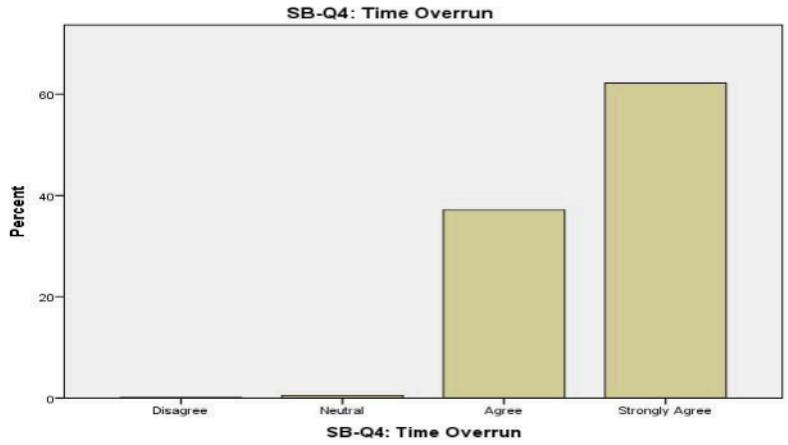
a) Aggregated data analysis on Time Overrun (Variable 80)

The results of the data analysis indicated that 62% of the respondents strongly agreed that one of the effects of construction technology on their housing projects was time overrun of the projects, 37.7% of the respondents agreed with the statement, 0.5% of the respondents been neutral to the statement, with only 0.1% of the respondent disagreeing with the statement (see Table 88 and Figure 85).

Table 88: Aggregated data on 'Time Overrun'- Variable 80

Value label	Frequency	Percent	Cumulative Percent
Disagree	1	.1	.1
Neutral	5	.5	.6
Agree	374	37.2	37.8
Strongly Agree	625	62.2	100.0
Total	1005	100.0	

Figure 85: Appraisal of time overrun as an effect of construction technology



b) Tying down of client's capital due to non- completion of the project (Variable 81)
Analysis of data obtained showed that 63.3% of the respondents strongly agreed that tying down of client capital due to non-completion of the project is one of the effects of construction technology deficiency, 36.4% of the respondents agreed with the statement, 0.2% of the respondents were neutral concerning the mater, with only 0.1% of the respondents disagreeing with the statement. These findings show that 99.7% of the respondents believed construction technology deficiency is a major problem to project stakeholders (see Table 89 and Figure 86).

4.3 Test of Research Hypotheses

At the beginning of the research six null hypotheses were put forward to establish the relationships between several research variables. These are:
Ho1- There is no significant relationship between 'Potential Impact of Computer Aided Drafting' and 'Time-related issues' in the Performance of Public Housing Estate Projects in South-East, Nigeria.
Ho2- There is no significant relationship between 'Potential Impact of locally made material resources' and 'Client satisfaction' in the Performance of Public Housing Estate Projects in South-East, Nigeria.

Ho1 -The relationship between potential impact of computer aided drafting and time related issues.

Here, the objective of interest is Study Objective 1 which is 'to investigate the impact of construction technology on project performance in public housing estate projects in the study area'. The variables - 'potential impact of computer aided drafting' and 'time related issues' were chosen because they involved the application of construction technology and attainment of project scheduled time. They were composite variables created by computing mean scores of related variables under the relevant sections. The two variables in focus were interval variables, hence Pearson Product Moment Correlation Analysis tool was used to test the nature of the relationship. The result of the analysis showed a Pearson correlation coefficient value of 0.123 with a significance value point of 0.000. This implies a weak but positive relationship exists. The significance value of 0.000 shows it is highly significant. It means therefore that the relationship though weak, but very significant. The null hypothesis is therefore rejected and alternate hypothesis accepted. This is that 'there is a significant relationship between 'Potential Impact of

Computer Aided Drafting used and the Indicator-Time' in the Performance of Public Housing Estate Projects in South-East, Nigeria'. The results are shown in Table 98.

Ho1 -The relationship between 'level of application of construction technology in design / construction' and 'quality' in the performance of public housing estate projects in South-East, Nigeria

Here, the objective of interest is Study Objective 1 which is 'to determine the extent of application of construction technology on public housing estate projects in the study area. The two variables in focus were interval variables, hence Pearson's product moment correlation analysis tool was used to examine the nature of relationship. The variables were composite variables created by computing mean scores of related variables under the relevant sections.

The result of the analysis showed a Pearson's correlation coefficient value of 0.110 with a significance value point of 0.000. This implies a weak, positive relationship exists between the two variables. The significance value of 0.000 shows it is significant at 5% (95% compliance). It means therefore that the relationship is weak and that it is very significant. The null hypothesis is therefore rejected and an alternate hypothesis accepted. This states that 'There is significant relationship between level of application of construction technology in design / construction' and 'quality' in the Performance of Public Housing Estate Projects in South East, Nigeria. The results are shown in Table 100.

Table 100: Pearson moment correlation analysis of relationship between level of application of construction technology in design / construction' and 'project quality'

Correlations			
		Level of application of construction technology in design / construction	**Performance Indicator-Quality**
Level of application of construction technology in design / construction	Pearson Correlation	1	.110**
	Sig. (2-tailed)		.000
	N	996	994
Performance Indicator-Quality	Pearson Correlation	.110**	1
	Sig. (2-tailed)	.000	
	N	994	1001

**. Correlation is significant at the 0.01 level (2-tailed).

4.3.4 Ho2 -The relationship between 'Effects of construction technology deficiency on The stakeholders and investors and 'Budget/cost' in the Performance of Public Housing Estate Projects in South-East, Nigeria

Here, the objective of interest is Study Objective 2, which is 'to examine the effect of construction technology deficiency on the stakeholders and investors of public housing estate projects in the study area. The variables in focus were interval variables, hence the Pearson product-moment correlation analysis tool was used to test the nature of the relationship. The variables were composite variables created by computing mean scores of related variables under the relevant sections. The result of the analysis showed a

Pearson's correlation coefficient value of -0.012 with a significance value of 0.706. This implies that a weak, negative relationship exists between the two variables. The significance value of 0.706 is above the accepted significance value (<0.05). It is therefore not significant. It means, therefore, that the relationship is weak and not significant. The null hypothesis is therefore accepted. This states that 'There is no significant relationship between 'Effects of construction technology deficiency on the stakeholders and investors' and 'Budget/cost' in the Performance of Public Housing Estate Projects in South-East, Nigeria. The results are shown in Table 101.

Table 101: Pearson moment correlation analysis of the relationship between 'Effects of construction technology deficiency on the stakeholders and investors' and project 'Budget/cost'

Correlations			
		Effects of construction technology deficiency on the stakeholders and investors	Performance Indicator-Budget/cost
Effects of construction technology deficiency on the stakeholders and investors	Pearson Correlation	1	-.012
	Sig. (2-tailed)		.706
	N	990	989
Performance Indicator-Budget/cost	Pearson Correlation	-.012	1
	Sig. (2-tailed)	.706	
	N	989	1003

There is significant relationship between level of application of construction technology in design / construction' and 'quality' in the Performance of Public Housing Estate Projects in South-East, Nigeria. There is no significant relationship between 'Effects of construction technology deficiency on the stakeholders and investors' and 'Budget/cost' in the Performance of Public Housing Estate Projects in South-East, Nigeria.

5 Conclusion

In conclusion, this study underscores the pivotal role construction technology plays in shaping the performance of public housing estate projects in South-East Nigeria, particularly in the area of quality. The findings clearly indicate a significant relationship between the level of application of construction technology in design and construction processes and the quality of completed housing estates. This suggests that when project teams adopt appropriate technologies such as improved design tools, modern construction methods, and better material/quality control systems, public housing projects are more likely to achieve higher standards of durability, finishing, functionality, and overall occupant satisfaction. In practical terms, greater technology uptake translates to fewer defects, improved workmanship, and stronger compliance with required specifications, thereby reinforcing quality as a key performance outcome directly influenced by technological application.

Conversely, the study reveals no significant relationship between the effects of construction technology deficiency on stakeholders and investors and the budget/cost

performance of these projects. This implies that, within the context of the South-East, the cost outcomes of public housing estate projects are not necessarily determined by the perceived or experienced deficiencies in construction technology among stakeholders and investors. Budget performance may instead be more strongly driven by other factors such as inflationary pressures, procurement procedures, funding delays, contract administration practices, material price volatility, governance issues, and broader macroeconomic conditions. As a result, even where technology gaps exist and stakeholders feel their effects (e.g., through inefficiencies, delays, or reduced confidence), these deficiencies do not automatically translate into measurable differences in cost performance. Overall, the results point to a nuanced conclusion: construction technology adoption is a critical lever for improving quality in public housing estate projects, but cost performance may not respond in the same direct way to stakeholder- and investor-related technology deficiencies.

Recommendation

Policymakers and implementing agencies in South-East Nigeria should prioritize construction technology integration, especially at the design and execution stages, as a strategic pathway to improving quality. At the same time, cost control efforts should be approached more holistically, targeting the broader financial and administrative drivers of budget overruns rather than assuming that technology deficiencies alone will determine cost performance. The following recommendation is as follows:

i. Public building designers and construction implementers should integrate an efficient construction technology information system, which maintains a continuous flow of feedback and feedforward information among all those concerned with the project, is crucial.
ii. Public building designers and construction managers should research more into the construction technology deficiencies from the perspectives of consultants, owners, occupiers, and contractors of public buildings in the South East, Nigeria.

References

1. Ajzen, I. (1991). The theory of planned behavior. Organizational Behavior and Human Decision Processes, 50(2), 179–211.
2. Carpo, M. (2012). The Digital Turn in Architecture 1992–2012; John Wiley & Sons: Hoboken, NJ, USA, 2012.
3. Dulaimi, M. F., Ling, F. Y. Y., Ofori, G., & De Silva, N. (2002). Enhancing integration and innovation in construction. Building Research & Information, 30(4), 237–247.
4. Gramazio, F.; Yoon, J.M. (2018). Digital materiality in architecture. In Proceedings of the William Cooper Mack Thesis Fellowship Lecture, NewYork, NY, USA, 27 November 2018.
5. Hamza, M.; Shahid, S.; Bin Hainin, M.R.; Nashwan, M.S. (2022). Construction labour productivity: Review of factors identified. Int. J. Constr. Manag. 22, 413–425.
6. Landman, K. (2002, September 18). Planning in the African Context: Reconsidering Current Approaches to Gated Communities in South Africa, Pretoria. Retrieved from unidep.org: https://invenio.unidep.org/invenio//record/20097/files/landmank.pdf
7. Li, L.; Wang, L.; Zhang, X. (2022) Technology Innovation for Sustainability in the Building Construction Industry: An Analysis of Patents from the Yangtze River Delta, China. Buildings 2022, 12, 2205.
8. Oladapo, R. A., & Olotuah, A. O. (2007). Appropriate Real Estate Laws and Policies for Sustainable Development in Nigeria. Structural Survey (Special Issue), 25(3/4), 330338.

9. Olsson, N.O.; Shafqat, A.; Arica, E.; Økland, A. (2019) 3D-printing technology in construction: Results from a survey. In Proceedings of the 10th Nordic Conference on Construction Economics and Organization, Tallinn, Estonia, 7–8 May.
10. OZTURK, G. B. (2018). The future of 3D printing technology in the construction industry: A systematic literature review. Eurasian J. Civ. Eng. Archit. 2018, 2, 10–24. 20.
11. Sepasgozar, S.M.; Loosemore, M.; Davis, S.R. (2016) Conceptualising information and equipment technology adoption in construction: Acritical review of existing research. Eng. Constr. Archit. Manag. 23, 158–176.
12. Skibniewski, M.J.; and Zavadskas, E.K. (2013). Technology development in construction: A continuum from the distant past into the future. J. Civ. Eng. Manag. 2013, 19, 136–147.
13. Tatum, C. (1988). Technology and competitive advantage in civil engineering. J. Prof. Issues Eng. 114, 256–264.
14. Toor, S., & Ogunlana, S. (2009). Construction professionals' perception of critical success factors for large-scale construction projects. Construction Innovation: Information, Process, Management, 9(2), 149 - 167.
15. Žujovi´c, M.; Obradovi´c, R.; Rakonjac, I.; Miloševi´c, J. (2022), 3D Printing Technologies in Architectural Design and Construction: A Systematic Literature Review. Buildings 12, 1319