

Adoption of Modern Construction Equipment: Implications on Quality Performance of Projects in Ebonyi State ¹

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Abstract

This study examined the adoption of modern construction equipment and its influence on the quality performance of construction projects in Ebonyi State, Nigeria. The objectives were to determine the level of equipment adoption, assess the availability and accessibility of modern equipment, identify factors influencing contractors' adoption decisions, evaluate challenges affecting equipment usage, and examine the effect of modern equipment on project quality performance. A descriptive survey design was adopted, and data were collected from construction professionals using structured questionnaires, with analysis conducted using descriptive statistics and correlation techniques. Data were analyzed using mean score, standard deviation, and Pearson correlation analysis. The findings revealed that the level of adoption of modern construction equipment in Ebonyi State is moderate, indicating partial integration of advanced technologies. Availability and accessibility of equipment were found to be uneven, with larger firms having better access than small- and medium-scale contractors. Importantly, the results established a strong positive relationship between the adoption of modern construction equipment and project quality performance ($r = 0.720$), indicating that increased adoption significantly improves construction accuracy, reduces defects, enhances durability, and ensures timely project delivery. However, negative relationships were found between adoption and influencing factors ($r = -0.650$) and between challenges and equipment usage ($r = -0.690$), showing that barriers significantly hinder effective utilization. The study concludes that improving access to finance, training, and policy support is essential to enhance adoption and project outcomes.

Keywords: *Modern construction, equipment adoption, quality performance, construction industry project delivery, technology adoption.*

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1. Introduction

The construction industry remains a critical driver of economic growth and infrastructure development across both developed and developing economies. It contributes significantly to gross domestic product (GDP), employment generation, and the provision of essential physical infrastructure such as roads, housing, bridges, and public utilities. In Nigeria, the construction sector plays a strategic role in the national development. It must not be overemphasized that Ebonyi State is a place where increasing urbanization and population growth continue to drive demand for infrastructure. However, Oke and Aigbavboa, (2023) claimed posit that the industry is often confronted with persistent challenges related to poor project quality, delays, cost overruns, and inefficiencies, many of which are linked to outdated construction methods and limited adoption of modern equipment.

Modern construction equipment are advanced machinery and technological tools designed to enhance efficiency, accuracy, safety, and productivity in construction operations (Aghimien, Aigbavboa & Thwala, 2022). These include equipment such as hydraulic excavators, automated concrete batching plants, tower cranes, graders, and digitalized surveying instruments. The integration of such equipment into construction processes has transformed the global construction industry by reducing dependence on manual labor, minimizing human error, and ensuring consistency in project delivery (Adeyemi, Ojo & Olawale, 2023). In developed countries, the adoption of modern construction equipment is widespread and has been linked to improved project performance, higher quality outputs, and reduced construction time (Zhang, Teizer & Lee, 2022). In contrast, many developing countries, including Nigeria, still rely heavily on traditional construction techniques and labor-intensive practices. This situation is more pronounced in less industrialized states such as Ebonyi State, where small- and medium-scale contractors dominate the construction sector. These contractors often lack the financial capacity, technical expertise, and institutional support required to acquire and utilize modern construction equipment effectively (Eze, Okeke & Nnaji, 2024). As a result, construction projects in such areas are frequently characterized by substandard quality, structural defects, and delays in completion.

The concept of quality performance in construction projects is multidimensional and encompasses compliance with design specifications, durability of structures, safety standards, and client satisfaction. Love, Matthews and Sing, (2023) assert that quality performance is a key indicator of project success and is influenced by several factors, including the materials used, the competence of the workforce, project management practices, and the level of technology employed during construction. Increasingly, studies have highlighted the critical role of modern construction equipment in enhancing these quality dimensions by enabling precision, consistency, and adherence to engineering standards. The adoption of modern construction equipment is influenced by several interrelated factors. One of the most significant is cost. The acquisition and

maintenance of modern machinery require substantial capital investment, which many local contractors find difficult to afford. Additionally, the cost of importing equipment, coupled with fluctuations in exchange rates, further limits accessibility (Aigbavboa & Thwala, 2022). Another important factor is the availability of skilled operators and technical personnel. Modern equipment often requires specialized knowledge for operation and maintenance, and the shortage of such skills in developing regions poses a major barrier to adoption (Oladipo, Adekunle & Salau, 2023).

Institutional and regulatory factors also play a role in shaping the adoption of construction technologies. Government policies, procurement practices, and regulatory frameworks can either encourage or hinder the use of modern equipment. For instance, policies that promote local content without supporting technological advancement may inadvertently discourage contractors from investing in advanced machinery. Conversely, incentives such as tax relief, subsidies, and access to credit facilities can significantly enhance adoption rates (Okoye & Ezeokonkwo, 2022). Despite these challenges, there is growing recognition of the benefits associated with the use of modern construction equipment. Empirical evidence suggests that projects executed with advanced machinery tend to exhibit higher levels of accuracy, reduced rework, improved safety, and better overall quality performance (Gamil & Rahman, 2023). Furthermore, modern equipment enhances productivity by reducing construction time and enabling the completion of complex tasks that would otherwise be difficult or impossible using manual methods. This is particularly important in a competitive construction environment where timely delivery and quality assurance are critical determinants of success.

In Ebonyi State, the construction sector is gradually evolving, with increased government investment in infrastructure and the entry of larger construction firms. However, the level of adoption of modern construction equipment remains uneven. While some large firms have embraced technological advancements, many local contractors continue to rely on conventional methods. This disparity creates variations in project outcomes and raises concerns about the overall quality of infrastructure within the state (Nwokoro, Ugwu & Ezeh., 2023).

Another critical issue is the challenge associated with the effective utilization of modern equipment. Even when such equipment is available, factors such as poor maintenance culture, inadequate training, and lack of technical support can limit its effectiveness. Equipment breakdowns, improper handling, and inefficient usage not only increase operational costs but also negatively affect project quality and timelines (Ibrahim & Musa, 2022). Therefore, adoption alone is not sufficient; effective utilization and management of modern construction equipment are equally important.

The influence of modern construction equipment on project quality performance cannot be overstated. Advanced machinery enables precise measurement, accurate material mixing, and

efficient execution of construction tasks, thereby reducing defects and ensuring compliance with standards. For example, automated concrete mixers ensure uniformity in material composition, which enhances the strength and durability of structures. Similarly, modern surveying equipment improves accuracy in site layout, reducing errors that could compromise structural integrity (Chen, Li & Zhang, 2022). Moreover, the use of modern equipment contributes to improved safety conditions on construction sites. By reducing manual handling and exposure to hazardous tasks, advanced machinery minimizes the risk of accidents and injuries. This not only protects workers but also enhances overall project performance by reducing disruptions and associated costs (Hwang, Shan & Supa'at, 2023). In this regard, the adoption of modern construction equipment aligns with global best practices in construction management and occupational safety. However, the extent to which these benefits are realized in Ebonyi State remains uncertain.

Nevertheless, in Ebonyi State, the issues of poor project quality, delays in completion, and cost overruns, despite the growing demand for infrastructure are more evident due to the dominance of small- and medium-scale contractors who rely heavily on traditional construction methods and outdated equipment. This limited adoption of modern construction equipment raises concerns about the industry's ability to deliver projects that meet required quality standards and client expectations (Aghimien, Aigbavboa, & Thwala, 2022; Oke & Aigbavboa, 2023).

Modern construction equipment plays a vital role in improving efficiency and enhancing project quality performance. Advanced machinery enables precision, consistency, and speed in construction processes, thereby reducing errors and minimizing rework (Chen, Li, & Zhang, 2022). However, in many developing regions, including southeastern Nigeria, the adoption of such equipment remains low. Financial constraints are a major barrier, as contractors often lack the capital required to acquire and maintain modern machinery. The high cost of operation further discourages investment (Aigbavboa & Thwala, 2022). Consequently, construction activities continue to depend largely on manual labor, increasing the likelihood of defects and compromising overall project quality.

Another significant issue is the shortage of skilled personnel needed to operate and maintain modern equipment. Effective utilization of advanced machinery requires technical expertise, yet there is a lack of adequately trained operators and technicians in the Nigerian construction sector (Oladipo, Adekunle, & Salau, 2023). This skill gap not only affects adoption rates but also limits the benefits derived from available equipment. As a result, even projects that use modern machinery may not achieve optimal quality performance.

Institutional and regulatory challenges further hinder adoption. Inconsistent government policies, limited access to credit, and inadequate support for technological innovation create an unfavorable

environment for contractors seeking modernization (Okoye & Ezeokonkwo, 2022). Additionally, weak enforcement of quality standards reduces the incentive to invest in modern technologies.

Poor maintenance culture also contributes to inefficiency, leading to frequent breakdowns, increased downtime, and reduced productivity (Ibrahim & Musa, 2022).

While there is general awareness of the advantages of modern construction equipment, empirical data on its adoption and impact on project quality performance is limited in Ebonyi State (Nwokoro, Ugwu, & Ezech, 2023). This gap in knowledge underscores the need for systematic investigation into the level of adoption, the factors influencing adoption decisions, the challenges faced by contractors, and the overall impact on project quality performance. Addressing this problem requires a comprehensive investigation into the level of adoption, the factors influencing contractors' decisions, the challenges faced in using modern equipment, and the extent to which such equipment affects project quality performance.

This study is therefore motivated by the need to provide empirical evidence on the adoption of modern construction equipment and its influence on the quality performance of construction projects in Ebonyi State. By examining these issues, the study aims to contribute to the improvement of construction practices and the delivery of high-quality infrastructure in the state. The findings will be useful to contractors, policymakers, and other stakeholders in developing strategies to enhance technological adoption and improve project outcomes.

The specific objectives are as follows:

- a.) Determine the level of relationship between adoption of modern construction equipment and project quality performance in Ebonyi State.
- b.) Identify the availability and accessibility of modern equipment in Ebonyi State.
- c.) Identify factors influencing contractors' decisions to adopt modern equipment on projects in Ebonyi State.
- d.) Evaluate the challenges facing the use of modern equipment on construction projects in Ebonyi State.
- e.) Assess how modern equipment affects overall project quality performance in Ebonyi State.

The following hypotheses were formulated to guide the study and were tested at a 0.05 level of significance:

H₀₁: There is no significant relationship between the adoption of modern construction equipment and project quality performance.

H₀₂: There is no significant relationship between the availability and accessibility of modern construction equipment and their utilization in construction projects in Ebonyi State.

H₀₃: Factors influencing adoption do not significantly affect contractors' use of modern equipment.

H₀₄: Challenges faced do not significantly hinder the use of modern construction equipment.

H₀₅: Modern construction equipment has no significant effect on the overall quality performance of construction projects in Ebonyi State.

2. Literature Review

The level of adoption of modern construction equipment represents the extent to which construction firms integrate advanced machinery, tools, and technological systems into their operational processes. It is a critical indicator of technological advancement within the construction industry and reflects the degree of transition from traditional, labor-intensive practices to mechanized and automated construction methods. In developing regions such as Ebonyi State, the level of adoption provides insight into the modernization of the construction sector and its capacity to deliver high-quality infrastructure efficiently.

Adoption, in this context, goes beyond mere ownership of equipment; it encompasses the frequency, intensity, and sophistication of equipment usage throughout the construction lifecycle. This includes planning, site preparation, material handling, execution, and finishing stages. Scholars have emphasized that adoption is a continuum rather than a binary condition, meaning that firms can exhibit varying degrees of integration ranging from minimal use of basic machinery to full-scale deployment of advanced automated systems (Zhang, Teizer & Lee, 2023; Gamil & Rahman, 2023). Consequently, understanding the level of adoption requires examining not only the presence of equipment but also how effectively it is utilized in achieving construction objectives.

Globally, the construction industry has witnessed significant technological transformation driven by the introduction of modern equipment such as hydraulic excavators, tower cranes, automated concrete batching plants, laser-guided grading systems, and digital surveying instruments. These innovations have redefined construction processes by improving precision, reducing manual effort, and enhancing productivity. In developed economies, the adoption level is generally high, with construction firms integrating advanced equipment as a standard practice. Studies indicate that high adoption levels are associated with improved project efficiency, reduced construction time, and enhanced quality outcomes (Chen et al., 2022; Hwang et al., 2023).

In contrast, the level of adoption in many developing countries remains relatively low to moderate. The construction industry in Nigeria, for instance, is characterized by a dual structure in which a small number of large firms utilize modern equipment extensively, while a majority of small- and medium-scale contractors rely heavily on traditional methods. This uneven distribution of technology creates disparities in project performance and limits the overall progress of the industry (Aghimien et al., 2022; Oke & Aigbavboa, 2023). In Ebonyi State, this pattern is evident in the coexistence of mechanized construction practices in major projects and manual operations in smaller, local projects.

The level of adoption can be assessed using several dimensions, including the type of equipment used, the frequency of usage, the diversity of equipment available, and the integration of equipment into project workflows. High adoption is typically characterized by the use of a wide range of advanced machinery across multiple stages of construction, supported by skilled operators and systematic maintenance practices. Moderate adoption involves partial integration, where some modern equipment is used alongside traditional methods. Low adoption, on the other hand, reflects minimal reliance on modern equipment, with construction activities predominantly carried out using manual labor and basic tools (Adeyemi et al., 2023).

One important aspect of adoption is the transition from mechanization to automation and digitalization. While mechanization involves the use of machines to perform physical tasks, automation incorporates control systems and information technologies to enhance efficiency and accuracy. Recent advancements in construction technology, such as Building Information Modeling (BIM), drones, and smart construction equipment, have further expanded the scope of adoption by enabling real-time monitoring, data analysis, and improved decision-making (Zhang et al., 2022). However, the extent to which these advanced technologies are adopted varies significantly across regions and organizations.

The level of adoption is also reflected in the operational practices of construction firms. Firms with higher adoption levels tend to exhibit structured workflows, standardized procedures, and a strong emphasis on efficiency and quality control. The use of modern equipment facilitates better coordination of activities, reduces delays, and enhances the overall performance of construction projects. Conversely, firms with low adoption levels often face challenges related to inefficiency, inconsistency, and increased risk of errors, which can negatively impact project outcomes (Gamil & Rahman, 2023).

Empirical studies have highlighted the relationship between the level of adoption and project performance indicators such as productivity, quality, and safety. For instance, Chen et al. (2022) found that projects utilizing advanced construction equipment demonstrated higher levels of accuracy and reduced incidence of defects compared to those relying on manual methods.

Similarly, Hwang et al. (2023) reported that the use of modern equipment contributed to improved safety performance by minimizing workers' exposure to hazardous tasks. These findings underscore the importance of adoption as a determinant of construction efficiency and effectiveness.

In the Nigerian context, research indicates that the level of adoption of modern construction equipment is gradually increasing, driven by factors such as urbanization, infrastructural development, and the entry of multinational construction firms. However, the rate of adoption remains uneven, with significant variations across regions and project types. In Ebonyi State, the adoption level is influenced by the scale of projects and the capacity of contractors. Large-scale projects, particularly those funded by the government or international organizations, are more likely to involve the use of modern equipment, while smaller projects often rely on traditional methods (Nwokoro et al., 2023).

Another dimension of adoption is the lifecycle usage of equipment. High adoption levels are characterized by the integration of modern equipment throughout the entire construction process, from site preparation to finishing. For example, excavators and bulldozers are used for land clearing and earthworks, cranes for lifting and positioning materials, and automated mixers for concrete production. The continuous use of such equipment ensures consistency and efficiency in project execution. In contrast, low adoption levels may involve the use of equipment at only specific stages, with manual methods dominating other aspects of the project.

The level of adoption is also influenced by the degree of technological innovation within the construction industry. As new technologies emerge, the definition of modern equipment continues to evolve. Innovations such as robotics, artificial intelligence, and Internet of Things (IoT)-enabled devices are increasingly being integrated into construction processes, further enhancing efficiency and accuracy. While these technologies are gaining traction in advanced economies, their adoption in developing regions remains limited, highlighting the gap between global trends and local practices (Hwang, et al., 2023).

Furthermore, the measurement of adoption levels often involves the use of quantitative indicators such as equipment-to-labor ratio, investment in machinery, and frequency of equipment usage. These metrics provide a basis for comparing adoption levels across firms and regions. Studies have shown that higher investment in modern equipment is associated with improved project outcomes, including reduced construction time and enhanced quality performance (Adeyemi et al., 2023). However, such investments require careful planning and management to ensure optimal utilization and return on investment.

The level of adoption also has implications for workforce dynamics within the construction industry. Increased use of modern equipment tends to shift the demand from unskilled labor to skilled operators and technicians. This transition reflects the changing nature of construction work and highlights the importance of capacity building and training in supporting technological adoption. As firms adopt more advanced equipment, there is a corresponding need for technical expertise to operate, maintain, and manage these systems effectively (Oladipo et al., 2023).

In Ebonyi State, the assessment of adoption levels reveals a gradual but uneven transition toward mechanization. While some construction firms have embraced modern equipment, others continue to rely on traditional practices due to various constraints. This variation in adoption levels has significant implications for the quality and consistency of construction outputs within the state. Projects executed with higher levels of equipment adoption tend to exhibit better quality performance, while those relying on manual methods are more prone to defects and delays.

Another important consideration is the sustainability dimension of equipment adoption. Modern construction equipment is often designed to be more energy-efficient and environmentally friendly compared to traditional methods. The use of such equipment can reduce material waste, lower emissions, and improve resource utilization, thereby contributing to sustainable construction practices (Aghimien et al., 2022). As sustainability becomes an increasingly important aspect of construction, the level of adoption of modern equipment is likely to play a crucial role in achieving environmental and economic objectives.

Availability and Accessibility of Modern Construction Equipment

The availability and accessibility of modern construction equipment are fundamental determinants of productivity, efficiency, and quality performance in the construction industry. In developing regions such as Ebonyi State, these factors are influenced by a combination of economic, institutional, technological, and human resource conditions. While global construction practices have advanced significantly through the integration of modern machinery and digital technologies, the extent to which these innovations are available and accessible at the local level remains uneven. Modern construction equipment plays a crucial role in transforming construction processes by improving speed, accuracy, and consistency in project execution. The integration of advanced machinery reduces dependence on manual labor, minimizes human error, and enhances overall project quality. However, in many parts of Nigeria, particularly in Ebonyi State, the construction sector is still transitioning from traditional methods to mechanized systems. This transition is often constrained by financial limitations, lack of technical expertise, and insufficient institutional support (Windapo & Moghayedi, 2020; Durdyev et al., 2022).

The types of modern construction equipment are diverse and correspond to various stages of construction activities. The types of modern construction equipment are: earthmoving equipment, material handling equipment, concrete equipment, road construction equipment, and specialized digital or automated systems. Each category performs specific functions that contribute to the overall efficiency and quality of construction projects.

- i. **Earthmoving equipment** forms the backbone of most construction operations, particularly during the initial stages of site preparation. This category includes excavators, bulldozers, loaders, and graders. Excavators are used for digging trenches, foundations, and other earthworks, while bulldozers are employed for clearing land and pushing large volumes of soil. Loaders facilitate the movement of materials within the site, and graders are used for leveling and finishing surfaces. The use of these machines significantly reduces manual effort and enhances operational efficiency (Kaming et al., 2020). In Ebonyi State, earthmoving equipment is relatively more available compared to other categories, especially on government-funded or large-scale construction projects. However, smaller construction firms often lack direct access to such machinery and may depend on hiring or manual labor, which affects productivity and project timelines.
- ii. **Material handling equipment** is another critical category of modern construction machinery. This includes cranes, forklifts, hoists, and conveyors used for lifting, transporting, and positioning materials. Tower cranes and mobile cranes are essential for high-rise building projects, as they enable the vertical movement of heavy materials such as steel and concrete. Forklifts are commonly used for moving materials within construction sites, improving efficiency and reducing physical strain on workers (Kassem et al., 2021). In Ebonyi State, the availability of material handling equipment is largely limited to large construction companies. Small- and medium-scale contractors often rely on manual methods or basic tools due to financial constraints, which reduces efficiency and increases the risk of workplace injuries.
- iii. **Concrete equipment** plays a vital role in ensuring the structural integrity and durability of construction projects. This category includes batching plants, concrete mixers, transit mixers, and concrete pumps. Automated batching plants ensure precise measurement and mixing of materials, resulting in consistent concrete quality. Concrete pumps facilitate the efficient placement of concrete in areas that are difficult to access manually, particularly in high-rise structures (Alaloul et al., 2021; Durdyev et al., 2022). In Ebonyi State, basic concrete mixers are commonly found on construction sites, but advanced equipment such as batching plants and pumps are less prevalent. Their use is generally limited to large projects handled by well-funded contractors, leaving smaller projects dependent on less efficient manual mixing methods.

- iv. **Road construction equipment** is specifically designed for the construction and maintenance of transportation infrastructure. This includes asphalt pavers, rollers, compactors, and milling machines. Asphalt pavers are used to lay road surfaces, while rollers and compactors ensure proper compaction, which is essential for durability and longevity. These machines contribute to improved road quality and reduced maintenance costs (Smallwood & Emuze, 2021). In Ebonyi State, such equipment is typically available only for government-funded road projects or projects executed by major construction firms. The limited availability of road construction machinery among smaller contractors restricts their participation in large-scale infrastructure development.
- v. **Specialized and digital equipment** represents the most recent advancement in construction technology. This category includes drones, laser scanning devices, and Building Information Modelling (BIM) systems. Drones are used for site surveying, monitoring, and inspection, providing real-time data that enhances decision-making. BIM technology facilitates better project planning, coordination, and visualization, reducing errors and improving efficiency (Saka & Chan, 2020; Ebekoziem et al., 2023). Despite their advantages, the availability of these technologies in Ebonyi State remains minimal due to high costs, limited awareness, and inadequate technological infrastructure.

The availability of modern construction equipment in Ebonyi State is influenced by several structural factors. One of the primary determinants is the financial capacity of construction firms. Large firms, particularly multinational companies, have the resources to invest in modern machinery and maintain them effectively. As a result, they dominate projects that require advanced equipment. In contrast, small and medium-sized enterprises (SMEs), which constitute the majority of contractors in the state, often lack the financial capability to acquire such equipment, leading to limited availability across the sector (Windapo & Moghayedi, 2020).

Another significant factor affecting availability is Nigeria's reliance on imported construction equipment. Most modern machinery used in the country is sourced from foreign manufacturers, making availability dependent on international supply chains. Fluctuations in exchange rates, import duties, and logistics challenges often lead to increased costs and reduced supply of equipment (Durdyev et al., 2022). These challenges are particularly pronounced in less industrialized regions such as Ebonyi State, where access to major distribution centers is limited. Equipment leasing and rental services have emerged as a potential solution to improve availability. Leasing allows contractors to access equipment without the need for large capital investment. However, in Ebonyi State, the leasing market is still underdeveloped compared to major urban centers. The limited presence of leasing companies and the high cost of rental services reduce the effectiveness of this option for many contractors.

Accessibility of modern construction equipment involves the practical ability of contractors to obtain and use machinery efficiently. Financial constraints remain one of the most significant barriers to accessibility. The high cost of purchasing equipment, coupled with maintenance and operational expenses, makes it difficult for many contractors to invest in modern technologies. Additionally, limited access to credit facilities and high interest rates further restrict the ability of contractors to finance equipment acquisition (Alaloul et al., 2021).

The level of technical knowledge and expertise among construction workers is another critical factor influencing accessibility. Modern construction equipment requires skilled operators and technicians for effective use and maintenance. In Ebonyi State, there is a shortage of adequately trained personnel, which discourages contractors from adopting advanced machinery. Even when equipment is available, inadequate training can lead to improper use, frequent breakdowns, and reduced efficiency (Saka & Chan, 2020; Ebekoziem et al., 2023).

Infrastructure and logistics also play a significant role in determining accessibility. Poor road networks and transportation systems make it difficult to move heavy machinery to construction sites, particularly in rural areas. This increases the cost and complexity of equipment deployment, limiting accessibility for many contractors. Additionally, inadequate maintenance facilities and limited availability of spare parts further hinder the effective use of equipment.

Government policies and institutional support systems are crucial in shaping accessibility. Policies that provide financial incentives, subsidies, or tax relief can encourage contractors to invest in modern equipment. Conversely, the absence of supportive policies and weak regulatory frameworks can hinder adoption and accessibility. In Ebonyi State, limited government intervention and support have contributed to the slow adoption of modern construction technologies.

In addition to these factors, the knowledge and skill level of construction workers significantly influence the effective utilization of modern equipment. Training and capacity building are essential for ensuring that workers can operate machinery safely and efficiently. However, many construction workers in Ebonyi State lack formal training in equipment operation, relying instead on informal or on-the-job learning. This limits their ability to fully utilize advanced technologies and reduces the potential benefits of modern equipment.

Literature Gap

A critical review of existing literature indicates that considerable attention has been given to the adoption of modern construction equipment and its impact on project performance across different countries (Aghimien et al. 2022; Zhang et al. 2022; Gamil & Rahman 2023; Oke & Aigbavboa

2023; Nwokoro et al. 2023). However, despite these contributions, several gaps remain. First, many of the existing studies focus on broader national or international contexts, with limited emphasis on specific states such as Ebonyi State. The construction environment in Ebonyi State is unique due to its dominance of small- and medium-scale contractors, limited access to finance, and infrastructural constraints. Therefore, findings from other regions may not fully reflect the realities within the Ebonyi State.

Secondly, most studies tend to examine either technology adoption or project performance independently, without providing a comprehensive analysis that links the level of adoption, influencing factors, challenges, and quality performance within a single framework. This creates a gap in understanding the combined effect of these variables on construction outcomes.

Thirdly, while previous studies identify general barriers such as cost and lack of skills, there is limited empirical evidence on how these factors specifically influence contractors' decisions and project quality performance at the local level.

Therefore, this study seeks to fill these gaps by providing a comprehensive, location-specific analysis of the adoption of modern construction equipment and its influence on quality performance in Ebonyi State, thereby contributing to both academic knowledge and practical improvement in construction practices.

3. Methodology

This study adopted a descriptive survey research design. The choice of this design is based on its suitability for collecting data from a large population in order to describe existing conditions, relationships, and patterns regarding the adoption of modern construction equipment and its influence on project quality performance. The design allows the researcher to obtain firsthand information from construction professionals such as Engineers, Architects, Builders, and Quantity Surveyors involved in project execution in Ebonyi State which formed the population of the study working in both public and private construction firms. Table 1 shows the population distribution of participants.

Table 1: Population of Construction Professionals

S/N	Category of Professionals	Estimated Population
1	Civil/Structural Engineers	120
2	Architects	80
3	Builders	70
4	Quantity Surveyors	60
	Total	330

Thus, the total population for the study is 330 respondents.

Based on the population size, judgmental sampling technique was used in determining the adequate sample size.

The sample size was determined using Taro Yamane's formula (1967):

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

Hence, the sample size is 181 respondents.

Data for this study were collected using a structured questionnaire designed using Likerts 5-point scale (Strongly Agree to Strongly Disagree). The questionnaire was administered directly to construction professionals across selected firms in Ebonyi State. Secondary data were obtained from journals, textbooks, conference papers, and official publications to support the theoretical and empirical framework of the study.

Data collected were analyzed using descriptive and inferential statistics such as mean score, standard deviation, and multiple regression analysis.

4. Results and Discussions

A total of 181 questionnaires were distributed to selected construction professionals based on the calculated sample size. Out of these, 170 were successfully returned, while 165 were properly completed and found suitable for analysis. This represent a response rate of approximately 91%. This high response rate enhances the reliability of the study findings.

Test of Hypotheses

Different analytical tools were deployed in testing the hypotheses formulated.

H₀₁: There is no significant relationship between the adoption of modern construction equipment and project quality performance.

Table 2: Correlation between Equipment Adoption and Quality Project Performance

		Equipment Adoption	Quality Project Performance
Equipment Adoption	Pearson Correlation	1	.720**
	Sig. (2-tailed)		.000
	N	165	165
Quality Project Performance	Pearson Correlation	.720**	1
	Sig. (2-tailed)	.000	
	N	165	165

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

Table 2 shows a strong positive correlation between equipment adoption and project quality performance ($r = 0.720$, $p = 0.000$). This indicates that increased use of modern construction equipment significantly improves construction accuracy, reduces defects, enhances durability, and promotes timely project completion in Ebonyi State. Since the p-value is less than 0.05, the null hypothesis is rejected. This implies that adoption of modern construction equipment plays a critical role in achieving high-quality project delivery.

H₀₂: There is no significant relationship between the availability and accessibility of modern construction equipment and their utilization in construction projects in Ebonyi State.

Table 3: Correlation between Availability/Accessibility and Equipment Utilization

		Availability & Accessibility	Equipment Utilization
Availability & Accessibility	Pearson Correlation	1	.702**
	Sig. (2-tailed)		.000
	N	165	165
Equipment Utilization	Pearson Correlation	.702**	1
	Sig. (2-tailed)	.000	
	N	165	165

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

Table 3 shows a strong positive correlation between availability/accessibility of modern construction equipment and its utilization ($r = 0.702$, $p = 0.000$). This indicates that as modern construction equipment becomes more available and accessible, its level of utilization in construction projects increases significantly. The positive correlation suggests that contractors are

more likely to use modern equipment when it is readily available and easily accessible through purchase, leasing, or hiring services. Conversely, limited availability and poor accessibility reduce the likelihood of utilization. Since the p-value (0.000) is less than the significance level of 0.05, the null hypothesis (H_{02}) is rejected. This implies that availability and accessibility have a significant influence on the utilization of modern construction equipment in Ebonyi State.

H_{03} : Factors influencing adoption do not significantly affect contractors’ use of modern equipment.

Table 4: Correlation between Influencing Factors and Equipment Adoption

		Influencing Factors	Equipment Adoption
Influencing Factors	Pearson Correlation	1	-.650**
	Sig. (2-tailed)		.000
	N	165	165
Equipment Adoption	Pearson Correlation	-.650**	1
	Sig. (2-tailed)	.000	
	N	165	165

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

Table 4 reveals a strong negative correlation between influencing factors and equipment adoption ($r = -0.650$, $p = 0.000$). This suggests that factors such as high cost, limited access to finance, lack of skilled personnel, and inadequate awareness significantly reduce contractors’ willingness and ability to adopt modern construction equipment. Since the p-value is less than 0.05, the null hypothesis is rejected. This indicates that these influencing factors play a major role in determining the level of equipment adoption in construction projects.

H_{04} : Challenges faced do not significantly hinder the use of modern construction equipment.

Table 5: Correlation between Challenges and Equipment Usage

		Challenges	Equipment Usage
Challenges	Pearson Correlation	1	-.690**
	Sig. (2-tailed)		.000
	N	165	165
Equipment Usage	Pearson Correlation	-.690**	1
	Sig. (2-tailed)	.000	
	N	165	165

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

Table 5 shows a strong negative correlation between challenges and equipment usage ($r = -0.690$, $p = 0.000$). This indicates that challenges such as high maintenance cost, poor infrastructure, inadequate power supply, and lack of technical support significantly hinder the effective use of modern construction equipment. Since the p-value is less than 0.05, the null hypothesis is rejected. This implies that these challenges have a substantial negative impact on equipment utilization and overall project performance.

H₀₅: Modern construction equipment has no significant effect on the overall quality performance of construction projects in Ebonyi State.

Table 6: Correlation between Modern Equipment Use and Project Quality Performance

		Modern Equipment Use	Quality Performance
Modern Equipment Use	Pearson Correlation	1	.781**
	Sig. (2-tailed)		.000
	N	165	165
Quality Performance	Pearson Correlation	.781**	1
	Sig. (2-tailed)	.000	
	N	165	165

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

Table 6 reveals a strong positive correlation between the use of modern construction equipment and project quality performance ($r = 0.781$, $p = 0.000$). This indicates that increased use of modern equipment significantly improves the quality performance of construction projects. The high correlation coefficient ($r = 0.781$) suggests that the relationship is not only positive but also strong, meaning that improvements in equipment usage are closely associated with better project outcomes. Since the p-value (0.000) is less than the significance level of 0.05, the null hypothesis (H_{05}) is rejected. This implies that modern construction equipment has a significant effect on the overall quality performance of construction projects in Ebonyi State.

4.2 Result Discussions

The findings revealed a moderate level of adoption of modern construction equipment, with a grand mean of 3.61. This indicates that while basic equipment such as excavators, concrete mixers, and heavy-duty machinery are fairly common on construction sites, advanced digital construction technologies and automated systems are still not widely adopted. This finding aligns with the study of Eze et al. (2024), and Oke and Aigbavboa (2023) noted that construction industries in developing countries often lag in full technological adoption due to financial and structural constraints.

The findings of this study reveal a strong and significant positive relationship between the availability and accessibility of modern construction equipment and its utilization in construction projects in Ebonyi State ($r = 0.702$, $p < 0.05$). This indicates that contractors are more likely to adopt and use modern equipment when it is readily available and easily accessible through purchase, leasing, or hiring channels. This result is consistent with the assertions of Ofori (2015), who emphasized that accessibility to construction resources is a critical determinant of technology adoption in developing countries.

The study identified cost of equipment, availability of skilled operators, and access to finance as the most significant factors influencing adoption. The highest-ranked factor was cost (mean = 4.21), indicating that financial constraints remain the strongest barrier to adoption. This finding is consistent with Aigbavboa and Thwala (2022), who reported that high acquisition and maintenance costs significantly limit the adoption of construction technologies in Africa.

The study also revealed that high maintenance cost, lack of skilled operators, difficulty in accessing spare parts, poor infrastructure, and unstable power supply are major challenges affecting the use of modern construction equipment. The grand mean of 4.03 indicates that respondents strongly agree that these challenges significantly hinder equipment utilization. This finding is consistent with Ibrahim and Musa (2022), who reported that poor maintenance culture leads to frequent breakdowns and reduced efficiency in construction projects.

The findings showed that modern construction equipment has a strong positive influence on project quality performance, with a grand mean of 4.11. Respondents agreed that equipment improves accuracy, reduces defects, enhances durability, accelerates project completion, and increases client satisfaction. This finding is strongly supported by Chen et al. (2022), who established that modern construction technologies significantly enhance quality performance by reducing human error and ensuring consistency in construction processes. Similarly, Zhang et al. (2022) found that automated construction systems improve precision and reduce rework in large-scale projects.

The correlation analysis revealed a strong positive relationship ($r = 0.720$) between equipment adoption and project quality performance. This indicates that increased adoption of modern construction equipment leads to significant improvements in construction quality. This finding is consistent with Adeyemi et al. (2023), who reported a strong relationship between construction technology adoption and improved project performance in Nigeria. Similarly, Oke and Aigbavboa (2023) found that firms using modern equipment achieve better quality outcomes and reduced project delays.

The study revealed a strong negative relationship ($r = -0.650$) between influencing factors and equipment adoption. This implies that as barriers such as cost, lack of finance, and inadequate skills increase, the level of adoption decreases. This finding is supported by Aigbavboa and Thwala (2022), who noted that financial constraints and lack of technical capacity significantly hinder adoption of construction technologies in Africa. Similarly, Okoye and Ezeokonkwo (2022) found that policy and financial barriers negatively affect technological advancement in Nigeria.

The study found a strong negative relationship ($r = -0.690$) between challenges and equipment usage. This indicates that increasing challenges significantly reduce the use of modern construction equipment. This finding is consistent with Ibrahim and Musa (2022), who reported that maintenance challenges reduce equipment efficiency. It also aligns with Nwokoro et al. (2023), who identified infrastructural deficiencies as major barriers to construction efficiency in southeastern Nigeria.

5. Conclusion

Based on the findings, the study concludes and recommendations as follows:

- a.) Construction firms in Ebonyi State should improve access to finance for contractors by collaborating with banks, cooperative societies, and government agencies to provide soft loans and flexible payment plans.
- b.) Construction firms in Ebonyi State should provide regular training and retraining programmes for skilled equipment operators and site workers.
- c.) Government and financial institutions should reduce the cost of acquiring modern construction equipment through tax reductions, import duty waivers, grants, and equipment leasing schemes.
- d.) Construction firms should strengthen maintenance practices by establishing routine inspection schedules, preventive maintenance systems, and proper servicing procedures for construction equipment.
- e.) Government should improve infrastructure and policy support for the construction sector by providing stable electricity supply, better road networks, and favourable construction policies.

Contributions to Knowledge

This study contributes to existing knowledge by providing empirical evidence on the relationship between modern construction equipment adoption and project quality performance within Ebonyi State. It extends previous studies by integrating key variables such as influencing factors and

operational challenges into a single analytical framework, thereby offering a more comprehensive understanding of equipment adoption in the construction industry.

Practically, the study offers actionable recommendations for policymakers, contractors, and stakeholders aimed at improving construction practices and project quality performance. It highlights the critical role of financial support, capacity development, and infrastructural improvement in enhancing the adoption and utilization of modern construction equipment.

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