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The Variety of Materials Specification Formats and its Impact on Sustainable and Smart Building Specification in Nigerian Construction Industry

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ABSTRACT

This study investigates the impact of varying material specification formats on the advancement of sustainable and smart building practices in the Nigerian Construction Industry (NCI). It focuses on how different specification types (prescriptive, performance-based, proprietary, and reference) affects the selection of materials, integration of smart technologies, and the overall project performance. A mixed-method approach was adopted, involving a quantitative survey of 605 built environment professionals and qualitative interviews with 15 leading architectural and construction firms in Lagos. The results show that prescriptive specifications remain dominant, often limiting innovation and adaptability. In contrast, performance-based and hybrid specifications were associated with better outcomes in terms of energy efficiency, material sustainability, and digital integration. Key challenges identified include inadequate technical expertise, poor stakeholder coordination, lack of standardized templates, and low adoption of digital tools like BIM. The study recommends developing standardized, digital-friendly specification frameworks, increasing professional training, and enhancing regulatory enforcement. Therefore, by modernizing specification practices, the NCI can support smarter, greener, and more resilient infrastructure delivery in line with global best practices.

Keywords: *Material specifications, Smart buildings, Sustainable construction, Nigerian Construction Industry, Performance-based specification*

1.0 INTRODUCTION

This chapter lays the foundation for the study by presenting the context, relevance, and central focus of the research. It investigates how the diversity in materials specification influences the implementation of sustainable and smart building practices within the Nigerian Construction Industry (NCI). With the rapid rate of urbanisation, the rising impact of climate change, and the growing demand for infrastructure across Nigeria (Adewumi, Onamade, Asaju & Adegbile, 2023) and Geroge, Adewumi, Otuonuyo, Oyewole, Oparinde & Yusuf, 2025) there is increasing pressure on the construction sector to transition towards methods that promote environmental sustainability, energy efficiency, and technological advancement (Eze, Ugulu, Onyeagam, & Adegboyega, 2021) ; (Asaju, Adewumi, Onamade, & Alagbe, 2024) and (Oru, Adewumi & Asaju, 2024). This pressure has prompted the need for an integrated specification framework that aligns with international climate goals and Nigeria's sustainable development targets. As such, this study highlights the urgency of optimising materials specification formats to drive sustainable construction outcomes and the integration of smart technologies.

Material specifications, defined as the technical documentation of material requirements and performance expectations, serve as a bridge between design concepts and practical execution (Owolabi, Harry, Adewumi, Onamade & Alagbe, 2024) ; (Emesiobi, Otuonuyo, Adewumi, Asaju & Onamade, 2024) . In contemporary sustainable and smart building projects, these specifications are not merely procedural tools but critical instruments that influence lifecycle performance, construction quality, environmental impact, and operational efficiency (Akwaowo, Edem, Akpan, Umoh, Osurua, & Ikot Ekpene, 2024). They guide construction professionals in selecting appropriate materials based on environmental standards, economic viability, safety regulations, and long-term resilience criteria. Yet, despite their importance, the variety and application of material specifications in Nigerian projects remain underdeveloped, inconsistently applied, and poorly monitored resulting in limited uptake of sustainable materials and smart building systems (Eze et al., 2021). There are different types of materials specification formats employed across projects namely, prescriptive, performance-based, proprietary, and reference-based specifications (Adewumi, Asaju, Bello, Atulegwu, Imafidon, David-Mukoro, Otuonuyo & Ogunyemi, 2025a). Prescriptive specifications dictate exact materials and installation procedures, ensuring uniformity but often limiting innovation. In contrast, performance specifications provide the freedom to select materials that meet desired performance benchmarks, enabling the inclusion of environmentally responsive and smart-enabled components (Akwaowo et al., 2024). However, the effective use of these advanced formats is frequently hindered by challenges such as inadequate

technical knowledge, cost prioritisation, low awareness, weak regulatory enforcement, and fragmentation among project stakeholders (Akwaowo et al., 2024; Eze et al., 2021).

Moreover, the specification process in Nigeria is often not data-driven, and many projects especially those executed by informal contractors or non-professionals lack robust specifications that address sustainability or smart-readiness (Adewumi, Onamade, Onyikeh, Otuonuyo, Alagbe, Adegbile & Dayomi, 2025b). This deficiency contributes to frequent project delays, increased lifecycle costs, substandard building performance, and poor environmental outcomes (Akwaowo et al., 2024). Recycled materials, low-carbon composites, smart insulation, or renewable-based systems such as bamboo, mycelium, cellulose, and fly ash are either poorly specified or entirely omitted, despite their proven benefits in achieving green construction goals (Eze et al., 2021). Additionally, the disconnect between architects, engineers, contractors, and policymakers has further complicated the institutionalisation of high-performance specifications (Adewumi, Onamade, David-Mukoro, Bamiloye, Otuonuyo, Chukwuka & Oru, 2025).

Against this backdrop, the Nigerian Construction Industry faces two interdependent challenges: the first is to improve sustainability through effective and responsible materials selection; the second is to integrate smart technologies that enhance functionality, efficiency, and monitoring of built assets (Alugbue, Otuonuyo, Adewumi, Onamade & Asaju, 2024). Although previous research has established that material specifications affect building performance and resilience, there is a scarcity of empirical studies evaluating how different specification types impact sustainable practices and smart building integration in the Nigerian context (Eze et al., 2021; Akwaowo et al., 2024). This research seeks to fill this critical knowledge gap.

The aim of this study is to assess how the variety of materials specification formats impacts sustainable and smart building practices in the Nigerian Construction Industry. The study seeks to determine the prevailing types of specifications used, evaluate their effect on project outcomes, and examine barriers hindering their effective implementation.

The Objectives are to:

- Assess the types and frequency of material specification formats used in sustainable and smart building projects in Nigeria;
- Examine the impact of material specification types on project quality, sustainability performance, and smart building integration; and
- Identify key challenges and limitations affecting the implementation of advanced material specifications in the Nigerian Construction Industry.

The significance of this research lies in its potential to inform national policy development, enhance industry practices, and support Nigeria's transition to a digitally adaptive and environmentally responsible construction sector. Therefore, demonstrating the pivotal role of specification diversity in improving building outcomes, the study provides actionable insights for architects, engineers, quantity surveyors, contractors, and regulatory institutions. Recommendations from this study will support the standardization of sustainable and smart specifications, encourage the adoption of performance-based frameworks, and promote the use of digital tools for specification authoring, assessment, and compliance tracking (Akwaowo et al., 2024; Eze et al., 2021). Ultimately, this research contributes to strengthening Nigeria's built environment through improved specification strategies that foster resilience, sustainability, and intelligent infrastructure delivery.

2.0 LITERATURE REVIEW

The Nigerian Construction Industry (NCI) is undergoing a gradual yet essential shift in its approach to material specification, sustainable design, and smart building practices (Adewumi et al., 2023 and Emesiobi et al., 2024). This evolution reflects the growing awareness that material specification serves as a foundational element in achieving project quality, resource efficiency, and environmental responsibility (Owolabi et al., 2024 and Adewumi et al., 2025a). As Eze, Ugulu, Onyeagam, and Adegboyega (2021) observed, material specifications significantly influence building performance by determining the sustainability, energy efficiency, and environmental footprint of selected construction inputs.Therefore, their study emphasized that the appropriate selection and use of sustainable materials guided by well-documented specifications can lead to a reduction in greenhouse gas emissions, enhanced indoor air quality, and long-term resilience (Asaju et al., 2024 and Geroge et al., 2025).

In the Nigerian context, traditional construction practices have been marked by inconsistent application of design specifications, often resulting in the use of substandard materials and construction failure (Adewumi et al., 2025b and Alugbue et al., 2024). Akwaowo, Edem, Akpan, Umoh, Osurua, and Ikot Ekpene (2024) highlighted that the low adoption of design specifications especially in projects executed by non-professionals contributes to building collapses and environmental degradation. They argued that integrating specification practices into the early design and procurement stages can significantly enhance project durability and sustainability. The classification of material specifications into prescriptive, performance, proprietary, and reference types enables professionals to tailor project needs according to functional demands and sustainability goals (Adewumi et al., 2025). Eze et al. (2021) emphasized that performance-based specifications, in particular, allow flexibility in material selection, thereby encouraging the use of recycled, low-carbon, and environmentally friendly materials such as recycled plastics, natural clay, lime, bamboo, cellulose, and fly ash. These materials, when properly specified, not only support green building development but also reduce lifecycle costs and maintenance burdens.

Moreover, material specification plays a critical role in the emergence of smart buildings (Adewumi et al., 2025). Smart construction relies on materials that integrate seamlessly with digital systems and intelligent technologies, such as sensors, IoT devices, and automated controls (Oru, et al., 2024). While this technological dimension is increasingly being emphasized globally, its implementation in Nigeria is still limited due to fragmented specification practices. Akwaowo et al. (2024) stressed the need for modernized specifications that support smart-ready materials, especially in areas like insulation, energy storage, and environmental monitoring. However, despite the evident benefits of robust material specifications, their effective implementation in Nigeria remains constrained (Adewumi et al., 2025a). Eze et al. (2021) revealed that although the level of awareness about sustainable materials is

relatively high among professionals, actual adoption is moderate due to technical skill shortages, poor specification documentation, and limited regulatory enforcement. Similarly, Akwaowo et al. (2024) noted that even when specifications exist, they are often vague or not strictly followed, particularly in projects led by informal contractors or community-based developers.

In addition to material selection, design specifications contribute to building resilience and public safety. As Akwaowo et al. (2024) explained, specifications aid in choosing appropriate structural assemblies, determining safe load-bearing capacities, and ensuring thermal comfort all of which reduce the likelihood of structural failures and support occupant well-being. They also serve economic and environmental functions by promoting resource-efficient material use and minimizing construction waste (Oru, et al., 2024 and George et al., 2025). Therefore, both studies underscore the importance of multi-stakeholder collaboration between architects, engineers, builders, and government agencies to ensure specification compliance and promote sustainable practices. The absence of standardized specification protocols, coupled with weak institutional enforcement, remains a major challenge to material specification effectiveness in Nigeria (Owolabi et al., 2024 and Alugbue at al., 2024) . Furthermore, fragmented procurement systems and cost-driven decisions often undermine the role of specifications in achieving sustainability targets (Adewumi et al., 2025a).

2.1 Conceptual Framework

Material specifications are foundational documents in the construction process, directly guiding material selection, construction methods, performance standards, and environmental responsibility (Owolabi et al., 2024). The variety of material specifications namely prescriptive, performance-based, proprietary, and reference standards offers varying degrees of flexibility, innovation, and technical alignment with sustainable and smart building objectives. According to Adewumi et al., (2025) and Emesiobi et al., (2024), these specification formats influence not only the type of materials used but also how well buildings adapt to lifecycle sustainability, technological integrations, and climate goals. For instance, performance-based specifications emphasize outcome-driven results, allowing professionals to explore eco-friendly, durable, and tech-ready options like energy-efficient glazing, sensor-integrated cladding, and carbon-neutral concrete. On the other hand, rigid prescriptive specifications can inhibit creativity, leading to over-reliance on traditional, high-carbon materials. The effective use of these specifications significantly impacts a building's overall sustainability metrics, including embodied carbon, energy use, indoor environmental quality, and long-term functionality (Owolabi et al., 2024).

However, the impact of specification diversity is not automatic as it is shaped by a set of moderating factors that either enhance or restrict its effect on smart and sustainable outcomes (Alugbue et al., 2024) . These include: technical capacity (the availability of skilled professionals to understand and implement advanced specifications), regulatory enforcement (the presence of clear, enforceable national codes and compliance mechanisms), and stakeholder collaboration (the level of coordination between architects, engineers, clients, and regulators). As identified by Akwaowo et al. (2024), poor documentation practices, limited digital literacy, cost-driven decisions, and non-professional execution frequently dilute the effectiveness of well-intended specifications in Nigeria. Moreover, without deliberate attention to digital integration such as compatibility with Building Information Modeling (BIM), Internet of Things (IoT), and smart infrastructure; projects risk failing to meet smart building expectations (Emesiobi et al., 2024). This framework thus presents specification variety as the independent variable, moderated by contextual factors, to influence two key dependent variables: Sustainable Building Performance and Smart Building Readiness. This relationship is iterative, as successful project outcomes feed back into improving specification practices, raising industry benchmarks, and informing future policy and capacity development (Ahmad et al., 2013; Eze et al., 2021).

Figure 1: Conceptual Development Framework

Source: Research Fieldwork (2025)

2.2 Theoretical Framework

The theoretical foundation for this study is grounded in the intersection of sustainable construction theory, systems theory, and the theory of material performance and specification. These theories collectively underscore the importance of integrating technical documentation such as material specifications into achieving high-performance, sustainable, and smart buildings.

Sustainable construction theory emphasizes that the built environment must be developed in a way that meets present needs without compromising the ability of future generations to meet theirs. This involves minimizing energy consumption, reducing waste, conserving natural resources, and improving occupant well-being (Akwaowo et al., 2024; Ahmad et al., 2013). Within this framework, material specification serves as a tool for embedding sustainability principles into each phase of a building's life cycle from planning and design to construction, maintenance, and eventual deconstruction. For example, performance-based and environmentally aligned specifications can promote the use of low-carbon, recyclable, and energy-efficient materials (Adewumi et al., 2025). These specifications directly influence resource efficiency, energy conservation, and environmental quality, thereby aligning with global sustainability agendas.

The theory of material performance and specification posits that clearly defined material documentation ensures that building components meet functional, safety, aesthetic, and performance expectations under defined conditions. According to Emesiobi, Otuonuyo, Adewumi, Asaju and Onamade (2024), specifications serve not only as procurement tools but as control mechanisms that guide quality assurance, sustainability targets, and technological compatibility. Within this theory, material performance is linked to attributes such as durability, environmental impact, smart responsiveness, and cost-efficiency. The type of specification whether prescriptive, performance-based, or reference determines how flexibly these attributes can be evaluated and implemented in real projects (Owolabi et al., 2024).

Moreover, systems theory provides an integrative lens through which the Nigerian Construction Industry (NCI) can be viewed as a complex, multi-stakeholder ecosystem where components (e.g., design, procurement, specification, compliance) interact to produce either successful or poor outcomes (Owolabi et al., 2024). According to Akwaowo (2024), the success of a sustainable or smart project is not solely dependent on material properties, but also on the system's capacity to coordinate various inputs through specifications. The failure to properly specify and communicate requirements across this system often leads to poor adoption of innovative or green materials, fragmented construction practices, and post-occupancy inefficiencies (Emesiobi et al., 2024).

Collectively, these theories support the central premise of this research: that the variety and quality of material specifications significantly impact the implementation of sustainable and smart buildings in Nigeria. As Adewumi et al. (2025) argue, specifications that align with environmental and technological goals are crucial for transforming Nigeria's construction sector into a resilient and future-ready industry. Thus, this theoretical framework guides the study's examination of how specification formats, stakeholder practices, and systemic constraints interact to shape project outcomes in terms of sustainability and smart infrastructure integration.

2.3 Empirical Review

The significance of material specifications in shaping the sustainability and smart-readiness of construction projects has gained growing empirical attention in Nigeria's construction sector. In a comprehensive study by Adewumi et al., (2025), it was established that the type and clarity of material specifications significantly influence project outcomes in public construction. The study analyzed a set of government building projects across Southwest Nigeria and found that over 60% of the projects relied on outdated or incomplete prescriptive specifications, which hindered the integration of modern, energy-efficient, and digital-ready materials. Projects utilizing performance-based specifications showed better adherence to sustainability indicators such as waste reduction, lifecycle cost control, and energy efficiency. The authors recommend increased adoption of hybrid specification models and regulatory frameworks that support innovation.

In a similar vein, Emesiobi et al., (2024) assessed over 40 construction sites across Rivers and Delta states, highlighting widespread lapses in specification compliance. Their findings indicate that poor enforcement, insufficient documentation, and lack of technical training contributed to poor maintenance outcomes and short building lifespans. Specifications were either too vague or inadequately implemented, leading to poor selection of sustainable materials and inconsistency with international standards. These weaknesses increased the frequency of post-occupancy defects and limited the functional capacity of buildings, especially in public health and education facilities. The authors argue that proactive specification audits and embedded lifecycle planning are essential to improving the durability and efficiency of Nigerian buildings.

Figure 2: Total Quality Management

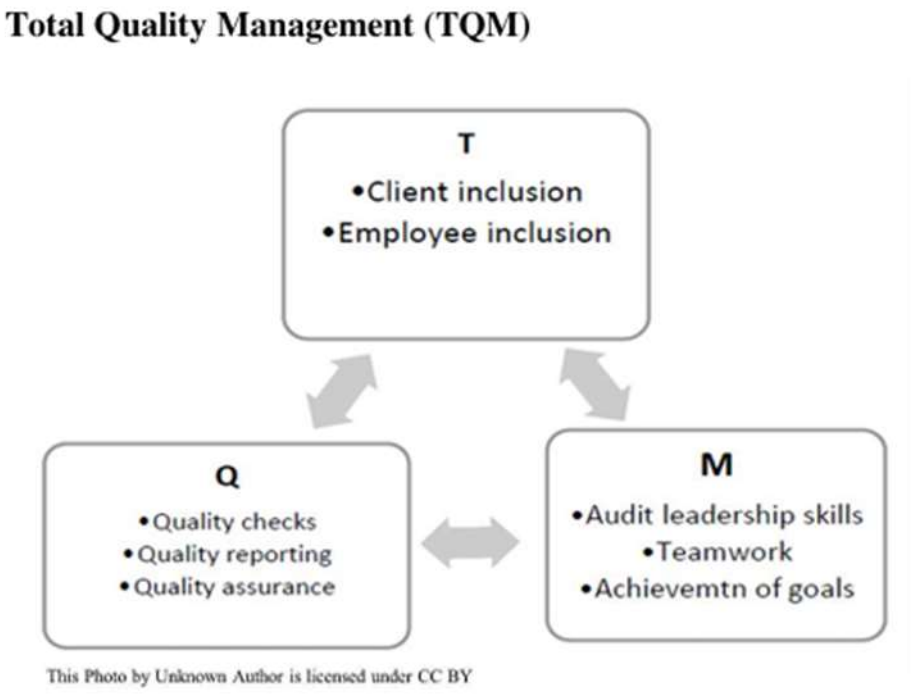

Fig.2: 2 showing Total Quality Management (TQM)

Source: Alugbue et al (2024)

Further empirical insights from Owolabi, Harry, Adewumi, Onamade, and Alagbe (2024) emphasized the role of standardization in specification writing for smart buildings. An evaluation of infrastructure projects in Lagos and Ogun states demonstrated that when Six Sigma, ISO 14001, and Lean Construction principles were integrated into material specification protocols, smart technology compatibility and quality assurance improved substantially. However, the study identified a knowledge gap among construction professionals, with less than 30% familiar with writing performance-driven specifications. This gap impairs the successful deployment of technologies such as Building Information Modelling (BIM), automated ventilation systems, and sensor-driven energy systems. The study recommends capacity building through professional training and specification toolkits.

From a regional perspective, Akwaowo, Edem, Akpan, Umoh, and Osurua (2024) conducted a field assessment of residential and institutional buildings in Akwa Ibom State, investigating the relationship between specification usage and sustainable performance. The study revealed that buildings executed with detailed design and material specifications had notably lower rates of material waste, higher structural integrity, and better alignment with environmental codes. However, less than 25% of construction activities in the region used professionally prepared specifications. The researchers attributed this to the dominance of informal builders and lack of regulatory enforcement. They suggest that empowering local councils and building control agencies to monitor specification compliance could reduce building collapse rates and improve environmental sustainability.

In another study, Ahmed, Fatai, and Musa (2023) investigated the impact of digital specification systems on smart building delivery in urban centers across Lagos State. The researchers found that the integration of digital platforms such as BIM, specification software, and IoT-enabled materials databases facilitated more accurate material documentation, performance forecasting, and automated procurement. Despite these benefits, adoption remains low due to infrastructural limitations, high software costs, and limited awareness. Their analysis recommends a national digital specification policy to support widespread adoption in both public and private sector construction.

Onamade et al., (2022) also examined material mismanagement in Nigerian construction, linking it to poor or absent specification protocols. Their empirical investigation into failed projects in Abuja and Ilorin showed that over 50% of structural failures stemmed from specification deviations, such as unauthorized substitutions, improper material mix ratios, and inconsistent testing procedures. The study emphasized the role of architects and quantity surveyors in enforcing specification integrity and recommended that specifications include mandatory third-party verification procedures and compliance checklists.

Lastly, Emesiobi et al., (2024) explored the role of specification diversity in supporting smart building functions, including climate-responsive facades, lighting automation, and digital water management systems. Through a survey of 85 professionals and 25 smart building projects in Nigeria, the study demonstrated that performance and functional specifications were strongly correlated with smart feature integration. However, barriers such as fragmented project coordination, limited stakeholder communication, and weak procurement standards prevented full utilization. The study calls for specification reform policies, stakeholder training, and improved interoperability between digital design and material selection systems.

Collectively, these empirical studies underscore that material specification when clearly articulated, enforced, and technologically aligned serves as a powerful tool for improving sustainability, innovation, and resilience in the Nigerian construction industry. However, persistent gaps in professional capacity, enforcement, and digital integration limit the transformative potential of specification diversity across the sector.

2.4 Gaps in Literature

This section identifies the existing research gaps in studying the influence of material specification diversity on sustainable and smart building outcomes in the Nigerian Construction Industry (NCI). Although there is growing literature on sustainable building practices and specification development, several critical issues remain unaddressed in the Nigerian context including the following:

- There is a Limited Empirical Evidence on Specification Variety in Nigeria: While studies such as Adewumi et al. (2025) and Emesiobi et al. (2024) have acknowledged the importance of specifications in project delivery and performance, few have examined how the different types of specifications such as prescriptive, performance-based, or functional affects the integration of sustainability and smart technologies in Nigerian buildings.
- There is an Underexplored Link Between Specification and Smart Technology Adoption: Research has not adequately explored how specific material specification practices contribute to or hinder smart building integration, including IoT systems, BIM compatibility, and automation tools. Although Ahmad et al. (2023) and Owolabi et al. (2024) emphasize smart infrastructure goals, there is a lack of detailed empirical analysis on the specification frameworks enabling these outcomes.
- There is a Lack of Focus on Informal Construction Practices and Specification Absence: Generally, Much of the literature focuses on formal sector projects, overlooking the informal sector that constitutes a large part of Nigeria's construction landscape. Akwaowo et al. (2024) note that specification usage in informal construction is minimal, yet its impact on building performance and environmental degradation remains poorly documented.
- There is an Inadequate Research on Specification Compliance and Monitoring Mechanisms: Studies such as Onamade et al. (2022) and Otuonuyo et al. (2024) mention specification enforcement challenges, but there is limited empirical data on how specification adherence is monitored, especially in public-sector projects, and the resulting impact on building lifespan and performance.
- This is a Low Exploration of Digital Tools in Specification Lifecycle Management: Although Ahmad et al. (2023) discuss the role of digital systems like BIM and smart databases, few studies investigate how these tools are currently integrated into the full specification lifecycle from design to maintenance and their measurable influence on sustainability goals in Nigerian projects. This study aims to fill these gaps by focusing on local dynamics, policy impacts, community participation, and compliance barriers.

3.0 METHODOLOGY

This study adopted a mixed-method to deeply investigate the influence of various types of material specifications on sustainable and smart building development in the Nigerian Construction Industry (NCI). The rationale behind this approach lies in the complexity of the subject matter, which involves both quantitative patterns in professional practice and qualitative insights into specification processes and implementation. The study was geographically anchored in Lagos Megacity, given its position as a national hub for construction innovation and architectural consultancy, and its higher concentration of professionals involved in specification production, smart technology integration, and green building advocacy (Adewumi et al., 2025).

The quantitative strand involved the distribution of a structured questionnaire to a sample of 605 construction professionals across multiple disciplines architects, civil engineers, quantity surveyors, contractors, and project managers. The majority of responses (over 90%) came from Lagos, aligning with its role as the country's commercial and construction epicenter. The questionnaire included both closed-ended and Likert-scale questions, designed to gather data on specification usage patterns, clarity, standardization, perceived effectiveness, compliance, and challenges faced during implementation. The demographic section captured data on respondents' age, gender, years of experience, area of specialization, and organizational affiliation. These details enabled a deeper contextual understanding of how professional background influenced specification practices. Descriptive statistics and inferential analyses including chi-square tests and one-way ANOVA were conducted using SPSS software to identify associations between experience level and awareness or effectiveness of sustainable and smart specifications.

In complement to the survey, the qualitative phase involved semi-structured interviews and document analysis with representatives of 15 architectural and construction firms, purposively selected based on their experience in handling specification documents and involvement in smart or sustainable projects. These included top-tier firms like James Cubitt Architects, FMA Architects, and Studio One. Interview questions focused on the clarity of specification documents, the integration of sustainability and smart-building requirements, use of digital tools like BIM, and real-life challenges encountered in enforcement and coordination. The use of triangulation helped ensure that survey findings were enriched and validated through professional narratives, consistent with recommendations by Emesiobi, Otuonuyo, & Onamade (2024) and Akwaowo et al. (2024).

4.0 RESULTS AND DISCUSSION

4.1 Demography of Respondents

The survey yielded 605 valid responses from built-environment professionals across seven Nigerian states, with Lagos contributing the largest share (90.9 %). Of the total respondents, 68.4 % were male and 31.6 % female, mirroring the gender distribution reported in earlier national studies (Adewumi et al., 2025). Most participants were between 20 and 30 years of age (57.2 %), reflecting the industry's youthful demographic, while 29.4 % fell within the 31–40-year bracket and 13.4 % were over 40. Educational attainment was notably high: 44 % held a B.Sc./HND, 37.3 % a master's degree, and 12 % a doctorate.

Professionally, architects comprised 54.0 % of the sample, followed by engineers (18.5 %), contractors (13.2 %), project managers (10.3 %), and other specialists (4.0 %). Work-experience data show 72 % with fewer than ten years in practice, suggesting that many respondents were trained during the rise of sustainability curricula and digital design tools—an exposure that likely shapes their attitudes toward advanced specification formats (Emesiobi, Otuonuyo, & Onamade, 2024).

Table 1: Geographical Distribution of Respondents

State	**Frequency**	**Percent**
Lagos	550	90.87%
Ogun	8	1.32%
Abuja	6	0.99%
Others	41	6.82%
Total	605	100%

Author's Fieldwork (2025)

Table 2: Demographic Characteristics of Respondents

Demographic Variable	**Category**	**Frequency**	**Percent**
Gender	Male	414	68.4%
	Female	191	31.6%
Age Group	20-30 years	346	57.2%
	31-40 years	178	29.4%
	41+ years	81	13.4%
Specialization	Architect	327	54.0
	Engineer	112	18.5
	Contractor	80	13.2
	Project Manager	62	10.3
	Others	24	4.0

Author's Fieldwork (2025)

4.2 Presentation of Results and Discussion by Objective

In examining the first objective to assess the types and frequency of material specification formats used in sustainable and smart building projects in Nigeria. The study revealed that prescriptive specifications are overwhelmingly dominant in current construction documentation, with 89% of respondents indicating their usage on recent projects. By contrast, performance-based specifications appeared in 46% of projects, while reference-standard and proprietary specifications were less common, occurring in 28% and 21% of cases respectively. This strong leaning toward prescriptive formats reflects a long-standing culture in Nigeria's construction documentation process, which often favors detailing fixed products or methods over flexible, outcome-based guidance. These results support Akwaowo et al. (2024), who observed that many Nigerian professionals default to prescriptive clauses due to familiarity and institutional inertia, despite the growing need for more adaptive strategies in response to environmental and technological challenges. When asked why performance specifications were underused, respondents pointed to limited client awareness (52%) and insufficient training on newer formats (48%), indicating both knowledge gaps and systemic barriers to adoption.

Table 3: Specification Application by Project Phase

Phase	**Frequency**	**Percent**
Construction	565	93.3%
Procurement	525	86.7%
Pre-Design/ Design	338	55.9%
Post-Construction	212	35.0%

Author's Fieldwork (2025)

Table 4: Effectiveness and Challenges in Specification Use

Parameter	**Agreement**
Specifications are highly effective	66.7
Ambiguities or scope changes are frequent	73.3
Compliance enforcement is adequate	40.0

Author's Fieldwork (2025)

In examining the second objective to examine the impact of material specification types on project quality, sustainability performance, and smart building integration. The perception of specification effectiveness was generally positive, with 66.7% of respondents rating them as effective tools for ensuring quality and compliance. However, a significant 73.3% reported frequent ambiguities and scope changes due to inconsistencies or poor coordination in documentation. Only 40% believed enforcement of specification compliance was sufficient, mirroring earlier findings by Onamade et al., (2022), who linked weak regulatory follow-through to quality shortfalls and structural failures in buildings. Cross-tabulation further showed that projects using both prescriptive and performance-based formats were 2.3 times more likely to include IoT-enabled systems and 40% more likely to specify low-embodied-carbon materials, highlighting the performance gains associated with hybrid specification approaches. One-way ANOVA tests ($F = 6.113$, $p = 0.003$) also indicated that professionals with 6–10 years of experience had the highest awareness of smart building features embedded in specifications, likely reflecting their dual exposure to traditional practices and emerging technologies. Qualitative interviewers reinforce these insights. For example, stakeholders from James Cubitt Architects and FMA Architects shared that on projects like the Lekki Smart Estate, hybrid specifications led to a 28% reduction in RFIs and better contractor alignment, confirming the positive impact of structured and flexible documentation on construction outcomes.

In examining the third objective to identify key challenges and limitations affecting the implementation of advanced material specifications in the Nigerian Construction Industry. The study identified several persistent challenges hindering the effective adoption of advanced specification practices. Chief among these was ambiguity in formatting (73.3%), followed by poor coordination among project stakeholders (68.0%), lack of standardized national templates (64.5%), and insufficient knowledge of smart or sustainable material options (59.2%). These constraints align with Emesiobi et al. (2024), who noted that specification practices in Nigeria are often fragmented and overly reliant on outdated templates, impeding their ability to accommodate innovative solutions. Furthermore, the widespread use of basic Word or PDF formats instead of structured digital tools exacerbates these limitations. Interview data revealed that even where smart features are specified such as energy-efficient HVAC systems or solar panels they are often described vaguely without measurable benchmarks, echoing concerns raised by Ahmed, Fatai, and Musa (2023) regarding the symbolic but non-functional inclusion of smart technologies in documentation.

To address these challenges, professionals surveyed strongly supported several innovation pathways. These included the development of standardized digital templates (88.5%), integration of BIM and AI-assisted specification tools (81.0%), and broader professional training and certification initiatives (76.2%). There was also considerable support (69.7%) for the inclusion of environmental performance metrics directly in specification documents to ensure enforceability and alignment with sustainability goals. These priorities closely follow the recommendations of Adewumi et al. (2025), who advocate for a digital transformation in Nigeria's construction sector, leveraging smart documentation tools to improve project delivery outcomes and sustainability performance.

In conclusion, the study confirms that while prescriptive specification formats still dominate in the Nigerian construction industry, there is growing recognition of the value of performance-based and hybrid models especially for smart and sustainable building projects. Yet, implementation is undermined by knowledge gaps, weak enforcement, and fragmented practices. Addressing these systemic issues through targeted innovation and capacity building will be essential for achieving smart, resilient, and environmentally responsible building practices in Nigeria.

Table 5: Experience Level vs Perceived Effectiveness

Years of Experience	**High Effectiveness (%)**	**Moderate/Low Effectiveness**
0-5	72.4	27.6%
6-10	68.5	31.5%
11 and above	59.3	40.7%

Author's Fieldwork (2025)

Table 6: ANOVA Summary Table

Source	**SS**	**df**	**MS**	**F**	**Sig (p)**
Between Groups	8.432	2	4.216	6.113	0.003
Within Groups	156.712	227	0.691		
Total	165.144	229			

Author's Fieldwork (2025)

Table 7: Specification Challenges Ranked by Prevalence

Challenge	**Ranking in Top 3**
Ambiguities in specification formatting	73.3
Poor coordination among stakeholders	68.0
Lack of standardized specification formats	64.5
Inadequate knowledge of smart specs	59.2

Author's Fieldwork (2025)

Table 8: Proposed Innovations

Variable	**Frequency**	**Percent**
Compliant	112	39.4%
Neutral	49	17.3%
Not Compliant	18	6.3%
Slightly Compliant	23	8.1%
Very Compliant	82	28.9%

Author's Fieldwork (2025)

Table 9: Proposed Innovations

Innovation Proposed	**Respondents (%)**
Standardised templates for specifications	88.5
Integration with BIM/AI	81.0
Enhanced professional training and certification	76.2
Environmental impact inclusion	69.7

Author's Fieldwork (2025)

5.0 CONCLUSION AND RECOMMENDATIONS

This study critically examined how the variety of materials specification formats impacts sustainable and smart building practices in the Nigerian Construction Industry (NCI). The findings revealed that although specifications are widely used and integrated into construction documents, their application remains heavily prescriptive, limiting innovation and the effective inclusion of smart technologies and sustainable materials. Performance-

based and hybrid specification formats, though less commonly adopted, demonstrated clear advantages in enhancing project quality, facilitating the integration of IoT systems, and improving coordination among construction professionals. However, challenges such as poor stakeholder collaboration, ambiguous specification templates, limited awareness of smart and sustainable features, and the absence of standardized digital tools persist. Furthermore, enforcement mechanisms are weak, and many practitioners particularly early-career professionals lack the technical training to fully implement advanced specification formats. To address these issues, several recommendations are proposed. First, the NCI should shift toward hybrid specification frameworks that combine both prescriptive and performance-based formats, enabling flexibility and fostering the adoption of smart technologies and eco-friendly materials. National bodies such as the Federal Ministry of Works and Housing, in collaboration with professional institutions like NIA, NIQS, and COREN, should develop and enforce standardized templates that incorporate sustainability, lifecycle performance, and digital-readiness benchmarks. The integration of Building Information Modelling (BIM), artificial intelligence, and cloud-based platforms into specification writing must be scaled up, as these tools enhance coordination, real-time editing, and compatibility with performance monitoring systems. Professional development programs are also essential targeted especially at mid-career and early-career professionals to equip them with up-to-date knowledge on smart and sustainable specification writing. Regulatory oversight needs strengthening; this includes implementing pre-construction peer reviews and stricter compliance enforcement by agencies such as LASBCA, NBRRI, and BPP.

Additionally, collaboration between academia and industry should be intensified to develop innovative tools, conduct pilot studies, and design context-specific training programs. Client education and awareness are also crucial: many clients, particularly in the private sector, lack the technical insight to demand smart or performance-driven specifications. Awareness campaigns, stakeholder workshops, and accessible policy briefs can help bridge this gap. Ultimately, transforming specification practices is not merely a technical endeavour but a strategic necessity for building smarter, greener, and more resilient environments in Nigeria's rapidly urbanizing cities. By adopting these recommendations, the NCI can significantly improve project outcomes, drive sustainable development, and align itself with global construction standards.

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