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ASSESSMENT OF AUTOMATED QUALITY CONTROL IN SPECIFICATION WITHIN THE NIGERIAN CONSTRUCTION INDUSTRY

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ABSTRACT :

In the Nigerian Construction Industry, maintaining specification compliance remains a critical component of delivering high-quality construction outcomes. Traditional quality control methods, which often rely on manual inspections, have proven time-consuming, error-prone, and inadequate in addressing the complexity of modern projects. This study investigates the role and effectiveness of automated quality control systems in improving specification compliance within the Nigerian Construction Industry. Using a quantitative approach, data were collected from 506 industry professionals through structured questionnaires. The data were analyzed using descriptive statistical methods, including frequency distributions, percentages, means, and relative index calculations. The results were presented in tabular form for clarity and ease of interpretation. The findings reveal a generally positive perception of automation tools and their potential to enhance drawing accuracy, reduce coordination errors, and improve compliance with legal and regulatory standards. However, the study also highlights the limited implementation of such technologies, mainly due to cost, inadequate training, and infrastructural constraints. It concludes that the integration of automation tools such as BIM, AI-driven checking systems, and cloud-based platforms can significantly improve the quality and consistency of working drawings. The study recommends increased investment in training, standardization of specification writing, and policy-driven encouragement for digital adoption in quality control practices across the Nigerian construction sector.

Keywords- Automated Quality Control, Compliance, Nigerian Construction Industry, Specifications, Working Drawings.

1.0 INTRODUCTION

The Nigerian Construction Industry (NCI) remains central to national development, characterized by rapid urbanization, infrastructure expansion, and evolving regulatory demands (Egwunatum, Anumudu, Eze, & Awodele., 2021; Adewumi, Onamade, Asaju, & Adegbile, 2023). Core to project success is adherence to clearly defined specifications within working drawings and construction documents, as these provide the technical foundation upon which

construction performance and compliance are based (Adewumi, Onamade, David-Mukoro, Bamiloye, Ogundele, Paul, & Olatunji, 2025; Adewumi, Onamade, David-Mukoro, Bamiloye, Otuonuyo, Chukwuka, & Oru, 2025;). Ensuring stringent quality control at this stage is paramount; errors in drawings directly lead to time delays, cost overruns, or structural failures (Idowu & Shakantu, 2018; Owolabi, Harry, Adewumi, Onamade, & Alagbe, 2024). Traditionally, quality control in Nigeria has been manual, relying heavily on physical inspections and expert reviews (Idowu & Shakantu, 2018; Alugbue, Otuonuyo, Adewumi, & Asaju, 2024). While effective to some extent, this method is often time-intensive, prone to human error, and limited in scope (Asaju, Adewumi, Onamade, & Alagbe, 2024; Adewumi, Onamade, Onyikeh, Otuonuyo, Alagbe, Adegbile, & Dayomi, 2025b). A 2022 report by The Guardian Nigeria highlighted systemic weaknesses, such as irregular code enforcement, unqualified personnel, and inspection manipulation, as contributing factors in construction failures, most notably the Ikoyi building collapse, which underscored the urgent need for more transparent and automated quality control systems. Recent advancements propose the use of smart frameworks incorporating artificial intelligence (AI), computer vision, and automation tools to enhance compliance and reduce inspection errors (Oyetunji, Erinjogunola, Ajirotutu, & Adeyemi, 2024; Emesiobi, Otuonuyo, Adewumi, Asaju, & Onamade, 2024).

Globally, the construction sector is embracing automation, including Building Information Modeling (BIM), computer vision, AI-powered inspections, and 3D point cloud analysis, all aimed at enhancing quality assurance and specification compliance (Taghaddos, Mashayekhi, & Sherafat, 2019; Adewumi, Asaju, Bello, Atulegwu, Ibhafidon, David-Mukoro, Otuonuyo, & Ogunyemi, 2025a). For instance, an AI-driven framework successfully automated compliance checks and visual defect detection on-site using drones and cameras, significantly reducing manual errors (Oyetunji et al, 2024).

Similarly, research on formwork systems utilizing 3D laser scanning demonstrated how measurement accuracy improved with reduced human- induced variability (Liang, Le, Ham, Mantha, Cheng, & Lin, 2023).

However, studies focusing on the integration of these automated methods within the Nigerian Construction Industry (NCI) context, especially in the realm of specification-driven quality control, are limited (Owolabi, et al., 2024; Hassan, Adewumi, & Olukunga, 2024). While frameworks for BIM adoption in Nigeria indicate strong potential for improving coordination and compliance, actual deployment remains sparse due to factors such as inadequate technical capacity, cost implications, and organizational resistance (Saka, Chan, & Ajayi, 2024; Oru, Adewumi, & Asaju, 2024).

This study aims to evaluate the effectiveness and integration of automated quality control systems in ensuring specification compliance within the Nigerian Construction Industry (NCI), with a focus on the demographic profile of professionals, quality of working drawings, and regulatory alignment. While the objectives of the study are to: analyze the demographic characteristics of professionals involved in quality control on specification within the Nigerian Construction Industry; assess the level of automation currently employed for quality control of specifications in the Nigerian Construction Industry; evaluate the compliance levels of working drawings with established specifications and regulatory standards; and examine the impact of working drawing quality on the effectiveness of automated quality control systems in construction.

2.0 LITERATURE REVIEW

Importance of Specifications in NCI Practice

Detailed specification documentation remains underutilized in Nigeria, especially in smaller construction projects where informal practices are prevalent. Adewale et al. (2018) identified significant legal, communication, and technical deficiencies that undermine the effectiveness of specifications in architectural practice. Their study emphasized that poorly written or inconsistently enforced specifications often lead to disputes and substandard outcomes. In support of this, Anunike and Anigbogu (2011) found that only 65–67% of engineers include detailed material specifications in their working drawings, highlighting major lapses in interprofessional coordination and a lack of standardization in specification writing across the industry.

Regulatory Compliance and Quality Assurance

Opawole et al. (2022) found that compliance of concreting materials with national standards in Lagos is hindered by weak enforcement mechanisms and limited technical capacity among construction stakeholders. Their study emphasized the need for stronger institutional oversight and regular inspections to ensure adherence to material specifications and safety codes. Additionally, inadequate adherence to Nigeria's Construction (Design and Management) [CDM] regulations and the National Building Code has been linked to poor interprofessional communication, insufficient information flow, and low levels of regulatory awareness among clients and practitioners (Ogunsemi, Aje, & Fadun, 2020; Alugbue, et al., 2024; Owolabi, et al., 2024).

Automation in Construction Quality Control

Internationally, automation is transforming construction quality practices through technologies such as Building Information Modeling (BIM), computer vision, drones, and artificial intelligence (AI). For example, Taghaddos et al. (2019) demonstrated the use of BIM-driven automation in material estimation, significantly reducing manual errors and improving efficiency. Similarly, a recent arXiv review by Taiwo et al. (2024) emphasized the potential of generative AI to streamline construction workflows, including quality control, compliance monitoring, and risk prediction.

However, these advancements remain largely theoretical in the Nigerian context. A recent study by Saka et al. (2024) reported limited adoption of machine learning and other advanced digital tools in Nigerian construction, attributing the slow uptake to infrastructural challenges, limited technical expertise, and cost-related constraints.

AI Frameworks for Compliance and Quality Assurance

Oyetunji et al. (2024) proposed an AI-based framework using computer vision and drones to compare as-built conditions against design specifications in real time, significantly reducing manual inspection errors. This framework also enhanced safety monitoring and compliance forecasting, demonstrating the potential of automation to improve construction quality assurance processes in the housing sector.

Gap in Existing Research

Although empirical studies, for instance, Alugbue et al. (2024), confirm the positive impact of clear and well-developed specifications on project management within the Lagos Megacity,

there is a pronounced lack of studies evaluating the actual deployment of automated quality control (QC) tools in Nigerian construction practice. Most existing literature focuses on manual compliance methods or general specification issues, without integrating technological perspectives (Adewumi, et al., 2024; Asaju, et al., 2024; Oru, et al., 2024). Furthermore, the intersection of demographic variables, specification quality, and automation effectiveness in the Nigerian Construction Industry (NCI) remains largely unexplored, highlighting a significant literature gap that this study aims to fill (Adewumi, et al., 2025a; Hassan, et al., 2024).

3.0 RESEARCH METHODOLOGY

This study adopted a quantitative research approach, using a structured questionnaire to gather data from professionals in the Nigerian Construction Industry (NCI). The research aimed to explore the extent of automated quality control practices and their influence on specification compliance, working drawing quality, and regulatory adherence within the industry.

The target population included a wide range of construction stakeholders such as architects, engineers, contractors, and quantity surveyors. A total of 506 valid responses were received and analyzed. The respondents represented a broad spectrum of demographic characteristics, including age, gender, educational background, years of experience with working drawings, and firm types. These professionals operated across various regions of Nigeria, with the majority based in Lagos State, which accounts for a significant portion of construction activity in the country.

The sampling strategy ensured diversity in terms of firm structure, ranging from sole proprietorships and partnerships to limited liability companies and public liability firms. Additionally, the analysis captured experience levels in handling working drawings, ranging from less than 5 years to over 20 years. This diversity provided a comprehensive perspective on the role of automation and quality control practices across professional and organizational contexts.

Data were analyzed using descriptive statistics, including frequency distribution, mean scores, and Relative Importance Index (RII). These tools were used to interpret trends and rank responses across several thematic categories such as cross-disciplinary coordination, specification compliance, legal and regulatory issues, and the impact of automation on quality assurance. The results provide an empirical foundation for evaluating how effectively automated tools are being adopted and their perceived impact on construction specification standards in the NCI.

4.0 FINDINGS AND REVIEWS

Demographics Characteristics of Respondents

The demographic profile of the 506 respondents shows a strong representation of early- to mid- career professionals. The majority (41.5%) were aged 21–30, followed by 31–40 years (31.6%), indicating a youthful workforce that is likely to be more open to technological innovation such as automation. In terms of gender, 71.3% were female, and 28.7% male—a unique demographic tilt in a typically male-dominated industry.

Table 1: Demographic characteristics of the respondents

Gender	**N=506**	**Percentage (%)**	**Cum %age**
Female	361	71.34387352	71.3438735
Male	145	28.65612648	100
Total	506		
Age	**Frequency (N=506)**	**Percentage (%)**	**Cum %age**
Less than 20 years	26	5.14	5.14
21 - 30 years	210	41.50	46.64
31 - 40 years	160	31.62	78.26
41 - 50 years	79	15.61	93.87
51 years & Above	31	6.13	100.00
Total	506		
Level of Education	**N=506**	**Percentage (%)**	**Cum%age**
Below First Degree	29	5.73	5.73
First Degree (HND/BSc.)	175	34.58	40.32
Master's Degree	260	51.38	91.70
Doctorate Degree	39	7.71	99.41
Others	3	0.59	100.00
Total	506		

Years	N=506	Percentage (%)	Cum%age
0 - 5 years	148	29.25	29.25
6 -10 years	200	39.53	68.77
11 -15 years	107	21.15	89.92
16-20 years	33	6.52	96.44
Above 20 years	18	3.56	100.00
Total	506		

Source: Authors' field work 2025

Educationally, over half (51.4%) held a master's degree, and an additional 34.6% held a first degree, demonstrating a relatively high level of academic qualification. Most respondents were architects (68.2%), with engineers (17%) and contractors (5.5%) also participating. Respondents were primarily drawn from Lagos State (75.7%), which is expected given Lagos' prominence in Nigerian construction. The distribution of experience also reflected a balanced
mix, with 68.8% having between 6 and 15 years of experience dealing with working drawings. These demographic trends reflect a workforce with sufficient exposure and potential for adopting automated practices.

Level of Automation Used in Quality Control

Data under the *"Automating Quality Control"* section shows that respondents strongly believe in the benefits of automation for enhancing specification compliance. The statement "Automation tools improve the quality control process for working drawings" recorded a high mean score of 3.854 and RI = 0.771, ranking 1st among other automation indicators. Respondents also agreed that automation reduces errors (mean = 3.767, RI = 0.753) and that automation tools provide accurate and efficient quality control (mean = 3.743, RI = 0.749).

Table 2: Automating Quality Control

AUTOMATING QUALITY CONTROL	**Level of Agreement using the Likert Scale**					**Total (Ef)**	**Efx**	**Mean Score (Efx/Ef)**	**Relative Index (RI)**	**Rank**
	1	**2**	**3**	**4**	**5**					
Automation tools improve the quality control process for working drawings.	**17**	**21**	**107**	**235**	**126**	**506**	**1950**	**3.854**	**0.771**	**1**
The use of automation in quality control reduces errors in working drawings.	**10**	**35**	**111**	**257**	**93**	**506**	**1906**	**3.767**	**0.753**	**2**
Automation tools provide accurate and efficient quality control for working drawings.	**16**	**27**	**131**	**229**	**103**	**506**	**1894**	**3.743**	**0.749**	**7**
I find automation software helpful in identifying issues in working drawings.	**17**	**22**	**116**	**244**	**107**	**506**	**1920**	**3.794**	**0.759**	**6**

The integration of automation tools enhances the overall quality of working drawings.	**13**	**25**	**109**	**233**	**126**	**506**	**1952**	**3.858**	**0.031**	**6**

Source: Authors' field work 2025

This finding reveals a generally positive perception toward automation, highlighting its value in minimizing human error and improving the consistency of technical documentation. Despite this favorable outlook, the moderate RI values also hint at a relatively low actual deployment of such tools in practice, suggesting that while professionals are aware of automation benefits, integration in the field may still be limited due to barriers like cost, training, or software availability.

Compliance Levels in Working Drawings

Under *"Compliance Levels in Working Drawings"*, the statement "Working drawings meet the legal and regulatory requirements for most projects" had the highest rating (mean = 3.735, RI
= 0.747). However, only moderate agreement was recorded for exceeding minimum standards or prompt addressing of compliance issues. For instance, "I find that working drawings often exceed minimum compliance standards" had a mean score of 3.626 and the lowest RI = 0.725 in this category.

Table 3: Compliance Levels in Working Drawings

COMPLIANCE LEVELS IN WORKING DRAWINGS	**Level of Agreement using the Likert Scale**					**Total (Ef)**	**Efx**	**Mean Score (Efx/Ef)**	**Relative Index (RI)**	**Rank**
	1	**2**	**3**	**4**	**5**					
Working drawings meet the legal and regulatory requirements for most projects.	**22**	**36**	**106**	**232**	**110**	**506**	**1890**	**3.735**	**0.747**	**1**
I find that working drawings often exceed minimum compliance standards.	**16**	**31**	**148**	**242**	**69**	**506**	**1835**	**3.626**	**0.725**	**2**
The levels of compliance with regulations in working drawings.	**16**	**27**	**126**	**256**	**81**	**506**	**1877**	**3.709**	**0.742**	**7**
Working drawings are reviewed for compliance with relevant legal standards.	**20**	**29**	**114**	**256**	**87**	**506**	**1879**	**3.713**	**0.743**	**6**
Compliance issues in working drawings are promptly addressed.	**14**	**45**	**106**	**246**	**95**	**506**	**1881**	**3.717**	**0.034**	**6**

Source: Authors' field work 2025

This indicates that while a basic level of compliance is being achieved in the NCI, there is room for improvement, especially in proactively integrating updated regulations and ensuring that drawings go beyond mere compliance to deliver quality. Automated tools could play a significant role here by flagging outdated codes, enforcing consistency in regulatory references, and maintaining updated drawing libraries.

Impact of Working Drawing Quality on Automated Quality Control

The section on *"Quality of Working Drawings"* shows a strong correlation between automation and drawing accuracy. The highest-rated statement, "The quality of working drawings has improved with the use of automated quality control," received a mean score of 3.806 (RI = 0.761). Respondents also agreed that automated quality control reduces errors (mean = 3.858, RI = 0.772) and improves consistency (mean = 3.905).

Table 4:Impact of Working Drawing Quality on Automated Quality Control

LEGAL AND REGULATORY COMPLIANCE	Level of Agreement using the Likert Scale					Total (Ef)	Efx	Mean Score (Efx/Ef)	Relative Index (RI)	Rank
	1	2	3	4	5					
Working drawings consistently comply with the latest building codes and regulations.	22	35	106	238	105	506	1887	**3.729**	0.746	**4**
I am confident that working drawings reflect current legal requirements.	20	24	130	243	89	506	1875	**3.706**	0.741	**7**
The integration of new codes and regulations into working drawings is effectively managed.	13	39	130	243	81	506	1858	**3.672**	0.734	**6**
Working drawings are regularly updated to meet changes in building codes.	18	33	115	245	95	506	1884	**3.723**	0.745	**6**
Compliance with building regulations is adequately addressed in the working drawing.	15	29	115	249	98	506	1904	**3.763**	0.753	**4**

Source: Authors' field work 2025

These results reinforce the assertion that automated tools significantly enhance the quality of working drawings, especially by ensuring adherence to design intent and reducing discrepancies across disciplines. This aligns with global findings where tools like BIM and automated checking algorithms are credited with reducing rework and boosting specification fidelity. However, actual implementation within Nigerian firms may still be limited to large- scale projects or multinational-led developments.

5.0 CONCLUSION AND RECOMMENDATION

Conclusion

This study investigated the impact of automated quality control on specification compliance within the Nigerian Construction Industry (NCI). Findings from the analysis of responses from
506 industry professionals revealed key insights into the role of demographics, current automation usage, compliance levels, and the quality of working drawings.
The demographic results showed that the industry is populated by well-educated and relatively young professionals, particularly architects, suggesting a readiness for technology adoption. The respondents overwhelmingly recognized the potential benefits of automation, including improved accuracy, reduced errors, and greater efficiency in quality control processes. However, the data also suggested that actual implementation of these tools remains limited,
likely due to systemic challenges such as high software costs, lack of training, and infrastructure limitations.
Although working drawings generally meet minimum legal and regulatory compliance, the tendency to exceed those standards or integrate new regulations remains modest. Importantly, the study confirmed that the quality of working drawings improves significantly when automated tools are applied, reinforcing the need for wider adoption of such technologies across firms in Nigeria.

Recommendations

Based on the findings, the following recommendations are made to enhance the adoption and effectiveness of automated quality control on specification in the NCI:

- **Promote Awareness and Training on Automation Tools**: Construction regulatory bodies and professional associations should organize workshops and continuous professional development programs to introduce stakeholders to available automation tools and their applications in specification quality control.
- **Integrate Automation into Regulatory Compliance Systems**: Government and private sector regulators should encourage the use of automated systems for compliance checks, particularly for updating building codes, zoning regulations, and standard specifications.

- **Encourage BIM and Specification Software Adoption**: Firms should be incentivized to adopt Building Information Modeling (BIM), automated specification checkers, and cloud-based collaboration tools through tax reliefs, grants, or partnership models, especially for SMEs and sole proprietors.
- **Standardize Specification Writing Across Disciplines**: There is a need to develop unified specification templates that can be digitally integrated and checked across architectural, structural, and MEP (Mechanical, Electrical, and Plumbing) disciplines to minimize coordination issues.
- **Strengthen Regulatory Enforcement Through Technology**: Automation should be incorporated in government oversight mechanisms such as development control approvals, public project audits, and site inspection reports to enhance transparency, speed, and quality assurance.

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