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QUALITY MANAGEMENT CHALLENGES IN CONSTRUCTION PROJECTS: INVESTIGATING FACTORS, MEASURES, AND THE ROLE OF MATERIAL QUALITY CONTROL

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Abstract

In spite of the considerable advancements and enhancements that quality assurance and control have undergone in the construction industry, quality of the products remain an issue. Notable prevalence of poor quality in final products and facilities such as premature defects, repairs and reworks, and overall product failures within construction projects continue to affect both end users and project stakeholders. This study delved into the intricacies of the role of material as a contributor to poor construction quality, specifically in the context of building projects. Results showed that the utilisation of non-compliant and poor-quality materials during construction primarily stemmed from lack of quality assurance/quality control (QA/QC) activities and lack clarity in QA/QC process as prominent factors for poor quality construction material. In addition, the inability of the project supervisory team to identify, rectify by removing or replacing these poor-quality materials at critical work junctures is also a substantial contributory factor. The results underscore the necessity for an enhanced QA/QC framework that possesses the capacity to comprehensively identify, address, rectify, and if required, replace materials that fall short of the stipulated standards and regulations. By resolving the issues of utilisation of poor materials, it is hopeful that substantial improvements to the overarching quality issues of construction projects can be achieved.

Keywords: Construction Material, Quality Management, Material Quality, Quality Control, Quality Assurance

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INTRODUCTION

Over the course of decades, the landscape of construction projects has undergone a profound transformation, becoming progressively more complex, multi components and technologically advanced. Nonetheless, the principal aim within the construction industry remains unwavering and that is to successfully complete projects within the confines of optimal quality, stipulated time frames, and minimal costs. In accordance to Mane and Patil (2015), it is evident that quality stands as a pivotal determinant in the successful execution of construction projects. It is also discerned by Saeed and Hassan (2012) that paramount consideration for construction quality concept is usually directed toward fostering customer's satisfaction, especially in meeting the requirements of the designer, constructor and regulatory agencies as well as the project's owner. In order to uphold and ensure the attainment of superior quality, it is imperative to exercise meticulous quality management (QM) practices through quality planning (QP), quality assurance (QA), and quality control (QC) (Janipha and Ismail, 2013).

Besides implementing an effective quality management system, it is imperative to acknowledge the various determinants that exert influence on construction quality. Pheng and Hong (2005) conducted an insightful study on the factors that significantly contribute to favourable quality outcomes within the construction industry in Singapore. The foremost priority lies in the unwavering commitment to quality, followed by strategic quality management, a customer-centric approach, the elimination of rework, collaborative teamwork, and comprehensive training initiatives. Moreover, the empowerment and respect afforded to individuals within the organisation also emerge as critical factors in fostering a culture of quality. Furthermore, Lam et al. (2008) delved into an examination of the dimensions of quality within large-sized public building contractors in Hong Kong. It was highlighted the paramount importance of focusing initially on strategic planning, effective human resources management, and dynamic leadership to lay the foundation for a culture of continuous improvement to further enhance the overall quality performance.

Despite a comprehensive understanding and knowledge of what measures can and should be implemented to guarantee favourable quality outcomes, the construction industry continues to confront its own set of challenges in relation to quality outcomes. Yaman et al. (2022) with reference to Malaysia Auditor-General Report spanning 2015 to 2018 underscores recurrent issues plaguing the quality of construction projects. In fact, consumers in the real estate sector have borne the brunt of subpar quality, as shown by the National House Buyers Association (HBA) in their record of a plethora of grievances from dissatisfied homeowners who have encountered myriad issues with their newly acquired residences. The terms defects, rework, poor quality, snagging, non-quality, deviation, and noncompliance have all been utilised interchangeably to

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refer to instances or conditions indicative of substandard quality (Olanrewaju and Lee, 2022). A recent study conducted in Malaysia by Yap et al. (2017) yielded a comparable finding, indicating that rework costs ranged between 3.1% and 6.0% of the overall project value. Yaman et al. (2022) highlighted that premature defect, failures and shortfall in the construction constantly plagued end user and owners of project alike. As highlighted above, it is obvious that despite many improvements, adoption and enhancement quality assurance and control has undergone over the decades, there remain many undesirable outcomes in end products in the construction industry.

The problem with poor quality construction work does stem from various causes. According to Olanrewaju and Lee (2022), the use of non-complying materials and poor-quality materials during construction as well as poor material choice during design are noted to be a major cause of poor-quality construction. Janipha and Ismail (2013) went on to emphasise that when organisational management prioritises supplier selection based on the lowest quotations, overall quality within the construction environment will be lowered, as the quality of materials directly influences the final product's quality. In addition, the inability or negligence in supervision to detect and remove this material at the opportune stage and allowing poor quality material to be produced through poor workmanship are also identified as a major contributing cause.

While on the surface, material quality, management and workmanship are deemed equally vital in determining the ultimate quality of the final product, it is not uncommon for the underlying issue to stem from specification error cause mismatch or incompatibility or substandard and nonconforming materials to enter the project (Janipha and Ismail, 2013). The inability to effectively identify and rectify these material discrepancies in the subsequent quality assurance/quality control (QA/QC) processes often leads to quality issues, culminating in escalated costs and budget overruns during the construction phase (Olanrewaju et al., 2021). This underscores the critical importance of rigorous material inspection and adherence to QA/QC protocols in preventing quality-related setbacks and financial overruns.

This study aimed to investigate the significant role played by construction materials in contributing to poor quality outcomes in construction projects. The research also seeks to delve into potential measures for mitigating these issues, with a particular emphasis on bolstering QA/QC processes. It is crucial to prioritise and scrutinise the quality of construction materials, as it forms the cornerstone of this research initiative dedicated to elevating the overall quality of building construction. This strategic focus is anticipated to yield substantial advancements in construction quality.

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LITERATURE REVIEW

Causes of Poor Quality in Construction

The following literature review will focus on the pivotal role that construction materials play in influencing the quality outcomes of projects. It will delve into the various factors that contribute to quality issues associated with materials, and subsequently, how the implementation of robust quality assurance/quality control (QA/QC) processes can effectively address and ameliorate these concerns within the construction industry. This review aimed to provide a comprehensive understanding of the interplay between materials, quality, and the critical role of QA/QC processes in ensuring superior construction outcomes.

Janipha and Ismail (2013) stated that many criticisms levied on the industry was due to poor workmanship and construction materials. The issues highlighted are poor workmanship, defects in facilities, non-complying work and low-quality material used in the construction. Daud and Ishak (2018) also stated that the defect or poor quality in works could be contributed by two segments, namely poor workmanship and poor quality of materials. Olanrewaju et al. (2021) pointed that poor quality occurs in >80% of building projects, whereby poor workmanship and poor quality of materials/ components were the dominant causes.

Ahzahar et al. (2011) also identified poor quality material used as a major contributor in poor quality of construction project, particularly seen in building defects and failures for building projects in the northern states of Malaysia Without due attention, the quality of construction materials used could derail the aspiration of the project team to achieve recognised quality in the construction project. Rumane (2018) mentioned that the products and materials used in construction projects, whether raw or processed, cheap and easily available, or expensive and complex will affect the final quality of the project. If they fall short of these standards, it can compromise the overall quality of the construction project, potentially leading to subpar outcomes.

Janipha and Ismail (2013) discovered the influence of construction materials on quality in the construction industry, revealing that a substantial 67% of the survey respondents identified material supply as the primary issue affecting construction quality. This underscores the critical importance of effectively managing and ensuring the quality of materials in construction projects to enhance overall quality outcomes. Yaman et al. (2022) pointed out that the selections of construction material need to be given due attention at the earlier stage of construction phases to avoid low quality. Its significance and impact to quality begin at the earlier stages of construction and right through the construction processes and activities, in comparison with workmanship.

The Chartered Institute of Building (CIOB) (2019) pinpointed eleven major drivers that exert influence over construction quality, one of which is the

procurement, storage, and handling of materials. This underscores the critical need for precise information regarding material requirements to ensure compliance with design specifications. The quality of materials and components constitutes a pivotal element within a comprehensive quality plan, ultimately culminating in the creation of a product that aligns with all specified quality parameters. The success of project delivery on site hinges on the proficiency and application of the workforce, often referred to as workmanship, as well as the calibre of materials employed (Howard, and Greenwood, 2018). Every facet of the construction process is intertwined with the utilisation of materials. Consequently, any lapses in the management of construction materials are bound to have a discernible impact on the project, regardless of its scale or complexity (Song et al., 2018). The quality of raw materials is unequivocally linked to the overall quality of construction projects and is rightly identified as the linchpin of engineering excellence (Yuan et al., 2018).

This collective body of literature unequivocally establishes that when the raw materials utilised in construction fall below the stipulated quality requirements, the final output of the construction project is inevitably compromised. Hence, it is of paramount importance to implement rigorous measures for managing and controlling the quality of raw materials from the outset, before they enter the supply chain that leads to the project site and the subsequent on-site works. The following section continues to explore specifically the definition of poor material quality.

Types of Poor-Quality Material

Non-Compliant Materials

As mentioned by Olanrewaju et al. (2021) non-compliant materials are items that do not meet established specific standards or requirements set by project designers and relevant authorities. Non-compliant materials are those that deviate from the stipulated requirements of the construction project, failing to meet the defined criteria. Akinyemi (2016) classified the causes of building collapses into three main categories: types and quality of materials used, operational issues, and personal problems. In cases where the collapse is attributed to concrete quality, the root cause is often linked to the use of inferior aggregates and lower-grade cement.

However, it is also worthy to note that when professionals on the design team responsible for specifying these materials are somehow lack comprehensive knowledge about the functionality and performance of the materials and components they recommend, it may be difficult to comply to the standard and specification stated (Adafin et al., 2011; Folorunso, and Ahmad, 2013). This implied that the established standard, against which the material is being assessed for compliance, may be flawed or inappropriate from the outset.

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Poor Quality Material

Poor quality materials are materials that fall below the recognised national, international, or industry standards (Olenwareju and Lee, 2022). These materials are generally of inferior quality on their own and the terms sub-standard or sub-par are often used. Poor quality material may be constructed from cheap raw materials, and/or may have never undergone testing or certification to validate their properties or performance and possess defects or flaws. Wai (2011) pointed out that low quality of material as the first factor causes poor quality of the building. The study uses the finding of an ongoing research project, presenting the important factors that have significant effect on material on the quality of building construction projects in Myanmar. The adaptation of a good material management system helps in improving the quality of the project. It is imperative to identify and rectify instances of poor material quality, as they can significantly impact the overall quality and longevity of a construction project.

Both non-compliant or poor-quality materials can lead to structural issues, safety hazards (Nik Him et al., 2023), and additional costs for repairs or replacements in the long run. Therefore, rigorous quality control measures, including adherence to established standards and thorough material testing, are crucial to ensuring the use of high-quality materials in construction projects.

Causes of Non-Compliant and Poor Materials Quality

Material Selection, Inappropriate Design

Talib et al (2015) stresses the critical importance of addressing material requirements during the design phase, emphasizing that the selection of materials at this stage significantly influences the potential for subpar material usage. This highlights the pivotal role of careful material selection in ensuring overall construction quality. Adewale et al. (2018) highlighted the need to provide clear and appropriate materials in specification for design, to address building defects or failure. Waziri (2015) found that one of the barriers to quality construction during construction defects is due to specifications indicating the use of new and untested materials, i.e. the design output of the projects. Olanrewaju and Lee (2022) emphasised on how materials can be specified or designed without adequate consideration for the surrounding environment, potentially leading to detrimental issues such as corrosion. This illustrates the necessity of comprehensive environmental assessments when specifying materials to prevent quality-related challenges in construction projects.

Stukhart (2021) noted the critical role of designers during the design stage prior to construction in ensuring quality of materials. Tan and Abdul-Rahman (2011) quoted Abdellatif and Othman (2006) that building construction materials which did not meet the expectations of customers and are not designed to suit the customer's requirements was one of the causes of poor quality of

residential building. Hence, the responsibilities to quality in the construction industry also should be shared by the designing architects and engineers as observed by Dwikojuliardi (2015) as it is noted that of the three contributing factors to the quality failures, 50% of the failures can be attributed to design faults.

Lack of QAQC

Various QAQC methods and approaches are adopted in the local construction scene. Amongst others are Project Quality Plan, Quality Assurance Plan, Inspection and Testing Plan, which are very much adaptation from Quality Management ISO 9001 concept (Pheng, and Hong, 2005). The quality control in the phase of project quality plan should be strengthened, and the emphasis on the inspection after completion should be transferred to the planning and process control of pre-construction. Razak et al. (2017) mentioned that project supervision is carried out by inspection, testing and monitoring of materials and workmanship on site. In their study, 67% of respondents also cited that the materials supply by the suppliers was the main issue influencing the quality in the construction environment. Nidal (2021) concluded that the failure to implement a quality control and assurance system is a root cause. Olanrewaju et al. (2021) similarly emphatically concluded that the various quality management systems should be updated to address poor quality in building construction. Therefore, there is a general consensus that there are shortfalls in current QAQC practices which need to be reviewed and revamped, particularly in view of the impact of quality of construction material.

Razak et al. (2017) mentioned that generally, in the construction industry in Malaysia, there is a quality control plan, which spells out the test on material required for a project. Besides, the plan may include also a material approval procedure, method statement approval procedure and a general approval form to proceed with works. The use of these documents depends on the nature of material or works. All these methods are essentially QC activity based, whereby the utilisation relies on the supervision team's experience in enforcing QC on the materials, as and when the contractor would seek for a green light to proceed with works.

Kandeil et al. (2010) mentioned that even though most of the construction companies are ISO certified and some of them have quality management systems and audits, there is still a room for improvement to achieve end customer satisfaction. Cao (2010) stressed that the quality problems in construction can be rooted back to the following aspects, namely, the construction procedures and regulations, for instance, undocumented design, construction without drawing or not according to drawing, delivery of material for use without final acceptance and undocumented construction quality control. Nidal (2021)

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concluded that the failure to implement a quality control and assurance system is a root cause of poor quality in construction.

It is undeniable that poor material quality is part of the impact on a construction project's outcomes (Howard, and Greenwood, 2018) and some may end up as a construction dispute in building projects if not properly managed (Muhammuddin et al., 2023). And poorly made products will eventually drop in strength, durability, lifespan and appearance. It is evident that poor quality remains a persistent concern within construction projects, resulting in end-products and facilities that fail to meet the expectations of stakeholders and end-users. This underscores the critical role played by materials in the overall quality of construction endeavours. The question remains how non-compliance and substandard materials infiltrate construction sites and find their way into end products or facilities. Following an extensive review of the existing body of literature, this study seeks to empirically investigate the practical issues of poor quality within the construction industry, with a specific focus on the pivotal role played by construction materials. The research methodology employed for this investigation is a quantitative survey, which is outlined as follows.

RESEARCH METHODOLOGY

The study employed an extensive survey method using questionnaires. Survey methods are effective and appropriate for collecting quantifiable data from a broad range of the general population. Survey method is particularly useful to obtain patterns and understand phenomena (behaviours and preferences), which in the case of this study is the occurrences of poor quality in construction works, its causes and the roles of material in contributing to poor quality occurrences. The study first uses random sampling to reach the large population, followed by snowball sampling techniques to obtain responses from any hidden population.

Respondents selected are construction related personnel who have at least 5 years' site experience and have completed projects in their records. A comprehensive set of 300 questionnaires were distributed through platforms like emails, phone calls, as well as social media channels, out of which 109 respondents actively participated, representing a 36.3% return rate. According to Gamil et al (2022), a response rate of 14.1% is deemed satisfactory.

The questionnaires survey was designed to have three (3) Section as follows:

Section A: Demographic and background of respondents
Section B: Causes of Poor Quality in Construction
Section C: Causes of Poor Material Quality Material

Section B and Section C aimed to extract perception and opinions from the respondents on the causes of poor quality in construction of building and the underlying causes of poor material quality being persistently used in projects. Deriving from the literature review, eight (8) causes of poor quality in construction are derived as follows:

i. Poor construction material quality
ii. Poor workmanship
iii. Inadequate design and specification
iv. Poor supervision
v. Time constraint; construction done in haste
vi. Unsuitable machineries used
vii. Restricted by budget; inferior material, workmanship used

In Section B, the respondents were asked to rank the causes from no 1-8 with 1 as the most prominent cause and 8 as the least likely cause. The analysis tool used to rank the causes is the Total Evaluation Score (TES) method as show in Equation 1.

$$TES = \frac{\sum W_i \times A_i}{10} \quad (1)$$

Where:
TES = total evaluation score
Wi = weight (importance) of rank i
Ai = Number of respondents selecting rank i

Each rank is provided with a weightage (Rank 1 as 7 to Rank 7 as 1).

The causes of poor construction materials in projects are as follows. These potential causes, sourced from the aforementioned extensive literature review, are instrumental in discerning the underlying factors contributing to the utilization of inferior quality materials in construction projects.

- Inadequate design and specification
- Lack of clarity of when and how frequently QC is needed
- Inadequate scope of responsibility of supervisory personnel
- Lack of clarity in QAQC process flow/steps
- Inadequate or insufficient QC activities
- Inadequate or ineffective use of material approval procedure
- Ineffective use of approval form/documents

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The questionnaire used a 5-point Likert scale for respondents to indicate how strongly they agree with the stated causes. The Likert scale has 1 – 'strongly disagree', 2- 'disagree', 3 – 'neutral', 4 – 'agree' and 5 – 'strongly agree'.

The selection of sample size for the survey was based on random sampling technique. The method to determine the sample size of an unlimited population is adopted from Enshassi and Al Swaity (2015) to calculate the sample size. Limited population (N) of 250,000 used is based on Construction Industry Development Board Annual Report 2021 on active personnel involved in site management including supervision.

Data collected from Section C were analysed using the Relative Importance Index (RII) based on the 5-point Likert scale on respondents' agreement to the statement. The relative importance index is based on a formula stated in Equation 3:

$$RII_1 = \frac{\sum \square x_c}{A\ X\ N} \qquad (3)$$

Where,
RII = Relative Importance Index
W = Weight given to each factor by the respondents (scale 1 to 5)
A = Highest weight (scale 5)
N = Total number of respondents

RESULTS AND ANALYSIS

Background of Respondents

This section presents the demographics of participants for the study. There are total 109 respondents to the questionnaire survey. Table 1 shows the demographic data of respondents based on their role in construction projects. Highest set respondents came from the on-site related personnel who are directly involved in the QA/QC aspects of construction projects.

Table 1. Background of Respondents

Background of Respondents	Frequency	Percentage (%)
Owners/End User	26	24
Project Engineer/Construction Site Personnel	50	46
Project Designer	33	30
Total	109	100

Findings

Table 2 presents the respondents' ranking of the causes of poor quality in construction.

Table 2. Rank of Causes of Poor Quality in Construction

Causes	Rank 1 Score (No)	Rank 2 Score (No)	Rank 3 Score (No)	Rank 4 Score (No)	Rank 5 Score (No)	Rank 6 Score (No)	Rank 7 Score (No)	TES	Cause Rank
Poor workmanship	168(24)	264(44)	80(16)	36(9)	27(9)	8(4)	3(3)	586	1
Poor construction material quality	210(30)	132(22)	80(16)	68(17)	24(8)	18(9)	7(7)	539	2
Poor supervision	98(14)	90(15)	155(31)	116(29)	33(11)	16(8)	1(1)	509	3
Restricted by budget; inferior material, workmanship used	168(24)	54(9)	45(9)	40(10)	39(13)	44(22)	22(22)	412	4
Inadequate design and specification	77(11)	36(6)	95(19)	76(19)	63(21)	26(13)	20(20)	393	5
Time constraint	21(3)	48(8)	60(12)	72(18)	108(36)	40(20)	12(12)	361	6
Unsuitable machineries used	28(4)	42(7)	30(6)	32(8)	36(12)	74(37)	35(35)	277	7

The findings of this study unequivocally point to poor workmanship as the primary driver of poor quality in construction, closely followed by subpar quality of construction materials and inadequate supervision. These results are in alignment with the assertions made in prominent literature, as evidenced by (Janipha, and Ismail, 2013; Daud, and Ishak, 2018; Rumane, 2018; Olanrewaju, et al., 2021; Ahzahar, et al., 2011).

With respect to the causes for poor material quality, the analysis of the results is put forward in Table 3.

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Table 3. Causes of Poor Material Quality in Construction

Reasons	1 = Strongly Disagree% (N)	2= Disagree% (N)	3= Neutral% (N)	4= Agree% (N)	5= Strongly Agree% (N)	RII	Rank
Inadequate or insufficient QC activities	3.7(4)	3.7(4)	13.7(15)	51.4(56)	27.5(30)	0.79	1
Lack of clarity in QAQC process flow/steps	1.8(2)	8.2(9)	19.2(21)	44.0(48)	26.8(29)	0.77	2
Lack of clarity as of when QC is needed	3.7(4)	7.3(8)	15.5(17)	57.8(63)	15.7(17)	0.75	3
Inadequate or ineffective use of Material Approval	1.8(2)	8.2(9)	25.7(28)	42.2(46)	22.1(24)	0.75	4
Inadequate scope of responsibility of supervisory personnel	4.6(5)	7.3(8)	23.8(26)	45.9(50)	18.4(20)	0.73	5
Inadequate design and specification.	3.7(4)	10.1(11)	27.5(30)	40.3(44)	18.4(20)	0.72	6
Ineffective use of approval forms/documents	2.8(3)	15.6(17)	30.3(33)	37.6(41)	13.7(15)	0.69	7

The ranking provided showed that inadequate or insufficient QC activities with RII of 0.79, followed by lack of clarity in QAQC process flow/steps (RII = 0.77) and lack of clarity as of when QC and lack of clarity as of when and how frequently QC is needed (both with RII = 0.75) are amongst the top contributors to why poor-quality materials are persistently included in construction projects. When quality control (QC) activities are not comprehensive or are lacking in rigor, it creates opportunities for substandard materials to go unnoticed and be incorporated into the construction process. With the lack of clear guidelines and steps in the (QAQC) process, confusion ensues and potential oversights occurs. Without a well-defined process, it becomes challenging to effectively identify and address issues related to material quality. Also, without clear guidelines on when to conduct quality checks, there is a higher likelihood of overlooking critical checkpoints in the construction process.

Other causes are of high importance as well as their RII are more than and close to 0.7. When there are shortcomings in the process of approving construction materials, it creates opportunity for inferior materials to be introduced. Furthermore, when supervisory personnel do not have clear delineation of responsibilities related to quality management, there may be gaps in oversight, allowing poor-quality materials to be used. Lastly, the use of

approval documentation may not be as significant as other factors on the list, it nevertheless serves as the gateway to capture the use of poor-quality materials.

CONCLUSION

From both an extensive literature review and the gathered survey data, it is evident that the predominant cause of poor quality in construction projects lies primarily in substandard workmanship, closely followed by inferior material quality and inadequate supervision. Remarkably, this pattern has persisted over the past decade, with previous studies substantiating this prevailing trend. The construction quality landscape seems to have seen little variations. Focusing on the issue of poor material quality, it becomes apparent that deficiencies and inadequacies in Quality Control (QC) activities are the foremost factors contributing to this problem. This underscores a shortfall in the planning of Quality Assurance and Quality Control (QAQC) measures to effectively address material QC on construction sites. Moreover, various underlying causes stem from the previously mentioned factors, resulting in inconsistent and incorrect application of QC activities.

It is evident that the construction industry continues to grapple with this issue, even in the face of the introduction and implementation of various QAQC philosophies and methodologies, such as Quality Assurance Plans (QAPs), Inspection Test Plans (ITPs), Approval Checklists, and the like. Despite the industry's increasing adoption of Total Quality Management and the ISO 9001 Quality Management System, the construction sector still contends with shortcomings and inefficiencies in QC activities as a primary cause of poor material quality. This suggests a notable gap in the understanding and application of construction material related QC activities, despite the widespread adoption of QAQC practices. The lack of clarity when executing QC procedures may lead to either the omission or improper implementation of crucial QC measures on materials. Deficiency in existing QA/QC documentation also plays a role in the persistence of poor material quality. This suggested that current QA/QC processes designed to oversee material quality in construction projects may be inadequate or non-comprehensive. Compounded by a lack of comprehension regarding QC processes and the appropriate timing for QC activities, both of which exert significant influence.

Therefore, it is imperative that study and effort be undertaken to address such significant weaknesses in the construction quality management processes over construction material. The QA/QC practices in the construction industry for material is in dire need of revamping and improvement with new measures, or methodology to unplug the worrying trend of poor material quality still being used in the construction industry. The QA/QC process on material needs to be

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further enhanced in order to elevate the quality in construction through adequate and compliant construction materials.

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