IMPROVING SITE QUALITY MANAGEMENT PRACTICES OF LOCAL BULK CONSTRUCTION MATERIALS AT CONSTRUCTION SITES IN UGANDA

BY

MUGAGGA DAVID

(B.Eng. CBE - Kyu)

18/U/GMET/22130/PD

A DISSERTATION SUBMITTED TO THE DIRECTORATE OF RESEARCH AND GRADUATE TRAINING IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF THE DEGREE OF MASTER OF SCIENCE IN CONSTRUCTION TECHNOLOGY AND MANAGEMENT ENGINEERING OF KYAMBOGO UNIVERSITY

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DECLARATION

I, Mugagga David, affirm that this thesis is my original work and has never been presented for a degree in any other University and to the best of my knowledge, contains no material previously published or written by another person for any other degree or award from any university or higher learning institution.

Signed………………………………………

Date………………………………….

Mugagga David

18/U/GMET/22130/PD

CERTIFICATION

We, as University supervisors confirm that this dissertation/thesis has been written by the candidate under our supervision.

Assoc. Prof. Muhwezi Lawrence (Supervisor)

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Date: ------------------------------

Eng. Dr. Bulolo Sam (Supervisor)

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Date: ------------------------------

DEDICATION

This dissertation is dedicated to my family, my wife Nankabirwa Mary Grace, and my children.

ACKNOWLEDGEMENT

First and foremost, I extend my deepest gratitude to God Almighty, the creator of heaven and earth, for his grace and the wonders he manifests. I am profoundly grateful for His blessings throughout my life.

I am sincerely grateful to my supervisors, Assoc. Prof. Muhwezi Lawrence, and Eng. Dr. Bulolo Sam, for their invaluable guidance and constructive criticism, which greatly contributed to the successful completion of this work. Their mentorship has been instrumental.

I also thank my beloved wife, children, parents, and siblings for their unwavering support and devotion. I am truly blessed to have you, and may God richly bless you.

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ABSTRACT

This study aimed at enhancing building quality by improving site quality management practices for local bulk construction materials at construction sites in Uganda. Uganda's construction sites face significant challenges in ensuring the quality of local bulk construction materials, compromising the safety, durability and sustainability of construction projects. A mixed methods approach was used, incorporating surveys, interviews, and document review at sites across all cities. Questionnaires were distributed to 169 site professionals and managers, 56 key stakeholders were interviewed and 56 project files were reviewed. Quantitative data were analysed using SPSS version 20.0, while qualitative data were examined by content analysis. Findings revealed critical gaps in on site quality control practices, with only 30.1% of sites receiving regular inspections from regulatory bodies. Architects (84.3%) and engineers (96.4%) were actively involved in quality management, deficiencies persisted in documentation, issue resolution, and enforcement of standards. Key challenges included client preferences for cheaper materials, delays due to rejected materials and corruption. The study underscores systemic inefficiencies, inconsistent practice, and poor collaboration among stakeholders. It proposes a framework to strengthen site quality management, emphasizing stakeholder collaboration, enhanced regulatory oversight and comprehensive quality management practices. Recommendations include improving oversight, fostering profession collaboration and providing targeted training. Adoption of these measures can significantly improve construction quality, safety and durability in Uganda.

Keywords: Construction materials, Quality, management, Regulatory oversight, site, framework.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the study

The construction sector is crucial for national development, significantly impacted by the quality of infrastructure (ILO, 2019). It serves as an economic indicator, reflecting national global growth (World Bank, 2024). Employing millions worldwide, the sector contributes to development in both developed and developing countries by providing essential infrastructure (Kirchberger, 2020). Uganda's construction sector has grown substantially over the past decade. As of 2024, the preliminary results of the National Population and Housing Census conducted by the Uganda Bureau of Statistics (UBOS) indicate that Uganda's population is approximately 47.3 million people, and according to reports of 2024 by the African Development Bank (AfDB) and the World Bank, the construction sector contributed 51.4% to GDP. The construction sector, under the industrial category, is emphasized as a significant contributor, accounting for about 25% of Uganda’s economy in FY2024.

The sector includes a wide range of activities like residential, commercial and infrastructure construction and maintenance. Stability in local housing construction is key for sustainable development, requiring improvements in business, professions and technical skills (Gardner, *et al*, 2020). Uganda's National Development Plan III (2020/21-2024/2025) forecasts an urbanization rate of 5.6% annually, with urban households expected to increase from 2.9 million in 2020 to 3.8 million by 2025 (NPA, 2020).

Key activities such as concrete work, block work and roofing are influenced by material quality and labor skills. However, quality management remains a challenge in Africa, leading to inconsistent construction outcomes *et al*., 2021). Material quality often varies due to local availability, resulting in substandard construction and costly repairs (Faremi, *et al*., 2020).

In Uganda, limited access to quality building materials, rapid population growth and insufficient enforcement of construction standards impede decent housing access (Mukiibi, 2015). This study states that 71% of Ugandans use affordable local materials, which are often untested and non-standardized, causing more construction accidents, faster structural deterioration, and higher maintenance costs (Mukiibi, 2015). Inefficient construction practices further waste resources (Fapohunda *et al.*, 2016). This research evaluates the impact of site management practices on the quality of locally sourced building materials and suggests solutions to mitigate the negative effects of using unsuitable materials.

(a) Materials quarry site

(b) Materials storage on a construction site

(c) Material handling on a construction site

(d) Material placement during construction

(e) Collapsed building in Kampala

(f) *Collapsed building in Jinja city*

Figure 1-1: *Photographs of some construction sites*

1.2 Problem Statement

The construction sector is crucial to Uganda's economic progress, contributing 51.4% to GDP in 2016/17 (UBOS, 2021). However, poor quality management practices in material selection, testing, transportation, storage, handling and workmanship result in inconsistent quality, project delays, increased costs and higher risks of construction accidents (Alinaitwe, 2008). Due to the high cost of modern materials, 71% of Ugandans use cheaper, untested local materials, compromising safety and structural integrity (Mukiibi, 2015). A survey by the Uganda National Building Review Board found that 88% of construction sites were non-compliant with regulations, endangering users and increasing fatal accidents. Over the last decade, there have been challenges related to cost variations, timeliness, and delays in maintenance and construction of building structures and other civil physical infrastructures (Lawrence, *et al*,. 2021).

To address these issues, enhancing site quality management practices for bulk materials is essential to ensure compliance with building codes and enforce quality standards for all projects. Stakeholders must actively engage in quality control to minimize defects and mitigate risks associated with poor material quality. The continued use of raw bulk materials and poor quality management at construction sites, coupled with insufficient regulatory oversight leads to increased safety risks, structural failures, economic losses, erosion of stakeholders' trust, and heightened environmental impact.

This research aimed at evaluating the impact of site management practices on the quality of locally sourced bulk materials in Uganda, identifying challenges contributing to poor construction outcomes, and proposing solutions to improve construction quality and safety.

1.3 Research Objectives

1.3.1 Main Objective

The main objective of this research aimed at enhancing building quality by improving site materials management practices, thereby increasing the safety, strength, and durability of building structures.

1.3.2 Specific Objectives

The specific objectives were:

i. To identify bulk material management practices affecting raw material quality at construction sites in Uganda
ii. To assess the impact of bulk materials management practices on the quality of raw bulk materials during construction activities in Uganda.
iii. To examine the roles of relevant professionals and local authorities in ensuring timely quality assurance, monitoring, and enforcement on construction sites in Uganda and ;
iv. To develop an effective framework designed to enhance the quality of local bulk materials used at construction sites in Uganda.

1.4 Research Questions

The following research questions guided the study:

i. What are the current bulk material management practices that influence the quality of raw bulk materials used during construction at sites in Uganda?
ii. What is the impact of bulk material management practices on the quality of raw bulk materials utilized in construction activities in Uganda?
iii. What are the responsibilities and roles of relevant professionals and local authorities in ensuring timely quality assurance and monitoring of raw bulk materials on construction sites in Uganda?
iv. What framework can be developed to enhance the quality of locally sourced bulk materials used at contruction sites in Uganda?

1.5 Research Justification

This study investigates current bulk material management practices affecting raw material quality in Ugandan construction. Understanding these practices is crucial for assessing their impact on material quality and construction outcomes. The roles and responsibilities of relevant professionals and local authorities in ensuring timely quality assurance and monitoring will also be examined. This analysis is essential for identifying gaps and improving accountability. Additionally, the research explores initiatives aimed at enhancing bulk material quality, offering insights into effective strategies. Overall, this study will contribute to developing improved material management frameworks, and raising construction standards in Uganda (Tukundane and Yang, 2024).

1.6 Significance of the Study

This research aimed to enhance quality management practices for bulk materials at construction sites, ensuring high-quality materials, reducing costs and improving the structural integrity and durability of buildings and infrastructure (Radziszewska-Zielina, *et al*,.2019). The study's findings contribute significantly to the academic field by providing a structured approach to quality control that aligns with modern engineering practices and addresses critical challenges in material management. It identifies key findings and gaps for further studies, thus paving the way for future research on advanced methodologies in construction material management, furthermore, the research played a pivotal role in the academic development of the researcher by fostering enhanced qualifications, credibility and the ability to contribute meaningfully to the body of knowledge. It advanced research skills, critical thinking, and problem-solving abilities in engineering, equipping the researcher to address complex issues in construction management. This underscores the interdisciplinary importance of integrating practical engineering challenges with academic inquiry, promoting innovation and professional development.

1.7 Study Scope

1.7.1 Geographical scope

Increasing construction pressures in Ugandan cities have led to more construction accidents. A survey by the National Building Review Board (NBRB) indicated low compliance with building standards at active construction sites in major cities in Uganda, which are crucial for infrastructure development (Caleb, *et al*,.2023). The research covered all the cities in Uganda namely; Arua, Mbarara, Gulu, Jinja, Fort Portal, Mbale, Masaka, Hoima, Lira, Soroti and Kampala.

Figure 1-2: *Cities and Towns in Uganda*

Source: Research gate (https://www.researchgate.net/figure/Map-of-Uganda)

1.7.2 Content and Time Scope

The study investigated crucial construction practices, including materials management, workers' technical skills and workmanship, rework and defect frequency and professional roles in specification development, supervision and quality assurance. It also examined local authorities' responsibilities in monitoring building standards, material properties, and existing quality control and assurance frameworks. Data collection spanned three months, from July 1, 2024, to September 30, 2024, with two months for data gathering and one month for analysis, processing and report writing.

1.8 Conceptual Framework

The conceptual framework delineates the research trajectory and anchors it within established constructs. Its primary purpose is to enhance the significance and theoretical relevance of research findings, thereby ensuring their generalizability within the field (Adom, 2018). In this study, the independent variables include quality control methods, materials management practices, professional involvement, and regulatory oversight. The dependent variable (Quality of materials) comprises material testing and inspection methods, as well as the level and quality of supervision. Additionally, the moderating variables encompass the ethical conduct and professionalism of construction site personnel and the overall construction environment.

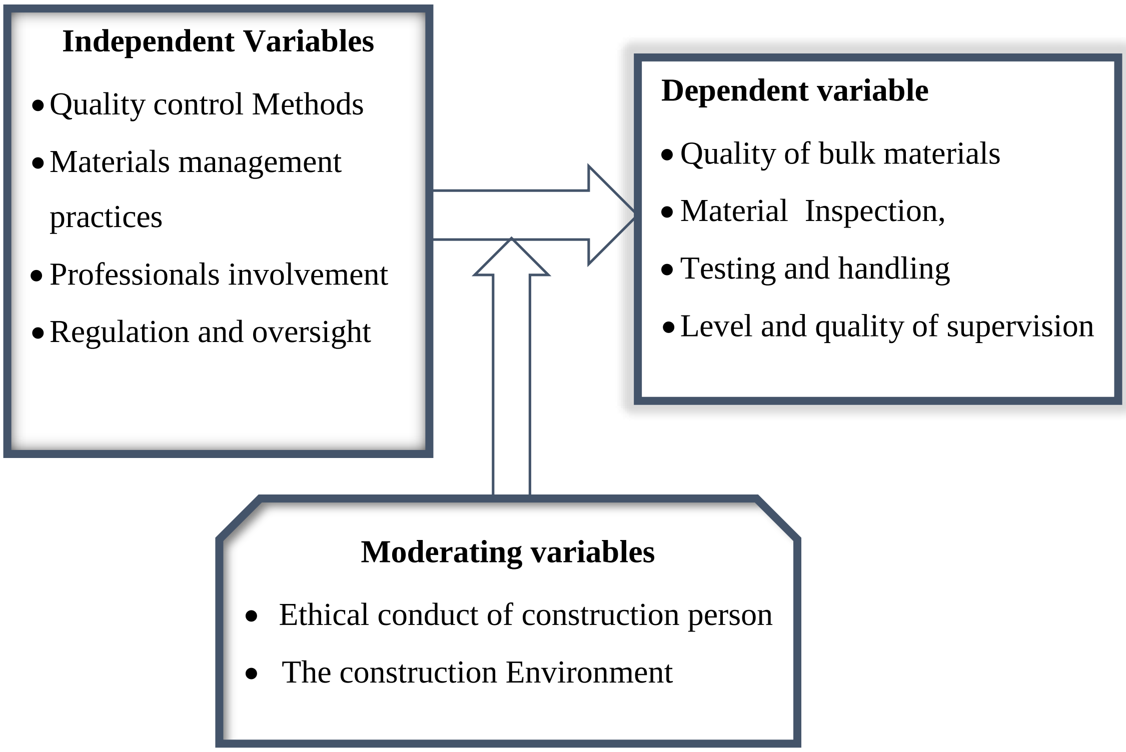

***Figure 1-3**: Conceptual framework of the study*

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

According to Turner *et al.*, (2009), the standard mantra for judging project success is that it should be completed within cost, time, and quality expectations as illustrated in Figure 2-1 .

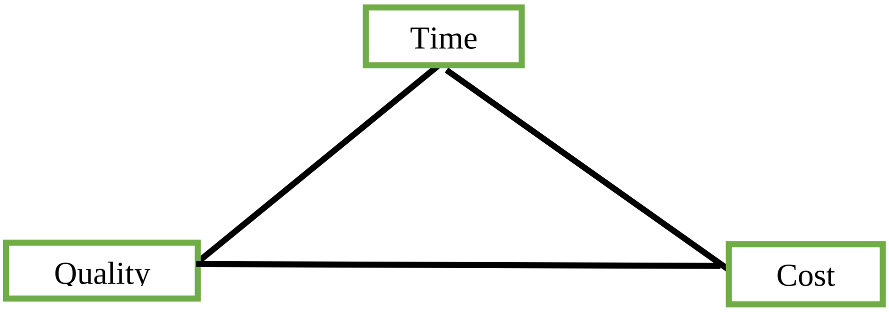

Figure 2-1: *The Project Management Triangle*

Source: Rodney (2009)

2.2 Quality management

Quality management involves identifying and executing activities to achieve an organization's quality objectives, encompassing quality, planning, control, systems, assurance and improvement (Fischgrund and Omachonu, 2014). The four stages include inspection, quality control, assurance, and total quality management (Senthil Vadivel *et al.*, 2016). Non-compliance with quality control and assurance can increase risks for workers and the public on construction sites, raising accident likelihood (Fischgrund and Omachonu, 2014). Quality management requires collaboration from the client, contractor and government, with the contractor primarily responsible for adhering to plans, specifications and industry standards (Coffelt, 2017).

2.2.1 Quality Management Systems

Quality management systems encompass activities involved in producing a product, process, or service, including prevention and appraisal (Ismail, 2021). These activities involve establishing quality policy, objectives and responsibilities, implemented through planning, control, assurance and improvement within the quality system (Aim Single Ecar QMS, 2016). In construction projects, quality deviations account for an average of 12.4% of total costs. Poor quality in new buildings can arise from various factors (Khan, Imran, and Hussain, 2019). Construction Quality Management (CQM) ensures tasks are performed according to plans and specifications, on time, within budget and in a safe environment. Thus, the designer sets quality standards, and the contractor ensures work quality as per plans and specifications .

2.3 Construction Materials Management

Materials management is an integrated process involving people, organizations, technology, and procedures to identify, quantify, acquire, expedite, inspect, transport, receive, store and preserve materials, equipment, and related information throughout a capital project's life cycle. The aim is to ensure the correct quality and quantity of materials and equipment are effectively procured, reasonably priced and available when needed (Chattopadhyay, 2009).Implementing a comprehensive materials management program leads to more predictable project outcomes, reduced costs, improved productivity and quality, and a safer work environment (Faremi, *et al*,.2020). Materials are a critical component of any project, accounting for 60-80% of the total cost. Effective material management can significantly reduce overall project costs, whereas poor management can increase construction expenses.

2.3.1 Standardisation of Materials

Local building materials are often used in their raw form, exposing them to weather and making them temporary. There is a lack of research on their standardization and improvement. Quality control measures for most local construction materials are primarily visual and subjective, leaving them unstandardized. Construction processes such as storage, transportation, handling, and workmanship are frequently impacted by poor management of material quality, manpower, and construction detailing, often due to the use of cheap and unqualified labor (Ahzahar *et al*,.2011). All project participants must minimize defects through proactive total quality control management, emphasizing compliance with building laws, regulations, and guidelines. Proper supervision by professionals, including consultants, local authorities, and quality management teams, can improve the safety, strength, and durability of buildings, thereby reducing defects, reworks, accidents, and long-term maintenance costs.

2.3.2 Acceptability of Local Building Materials

Concrete strength is primarily derived from the design mix, with sand and coarse aggregates constituting significant portions (Caldas *et al.*, 2015). Defects can occur on hardened concrete surfaces. Construction materials are categorized as bulk or standard off-shelf materials. Bulk materials, ordered, stored, issued, and sold by weight or volume, refer to granular or lumpy mixtures in a free-flowing form (Caldas *et al.*, 2015). Aggregates are divided into coarse (greater than 4.75 mm, retained on a No. 4 sieve) and fine (less than 4.75 mm, passing the No. 4 sieve) types, with gradation and type significantly influencing concrete properties.Aggregates are crucial in determining the strength of normal concrete. Essential aggregate properties include shape, texture, size gradation, moisture content, specific gravity, reactivity, soundness, and bulk unit weight. These properties, along with the water/cementitious material ratio, influence concrete strength, workability, and durability. Specifically, the shape and texture of aggregates impact fresh concrete properties more than those of hardened concrete (Malak *et al.*, 2023).

2.4 Construction Regulations and its importance in Uganda

Regulations, synonymous with administrative laws, are essential for the implementation of government laws and agency objectives (Dudley and Brito, 2015). The Building Control Act 2013 and Article 163(3) of the 1995 Ugandan Constitution assign the Ministry of Works and Transport and the National Building Review Board (NBRB) the responsibility for regulating Uganda's construction sector.

The Ministry establishes standards, laws, and policies and ensures the coordination and monitoring of key industry stakeholders. Despite the legislative requirement for compliance with building regulations, literature indicates that regulation remains a significant challenge for sustainable development in the construction industry (Omollo, 2019). Construction regulations play a critical role in ensuring the safety, quality, and sustainability of construction projects. In Uganda, construction regulations are vital due to rapid urban growth and safety challenges. They guide building design, construction and maintenance to ensure safety, quality and environmental protection. Key aspects include building codes and standards, regulatory bodies, health and safety rules and environmental regulations, which are all essential for sustainable and compliant infrastructure development.The Uganda National Building Code (UNBC) and other regulations such as the Uganda National Standards (UNBS) and the Building Control Act are essential in ensuring that construction projects meet safety, quality and environmental standards. These codes provide technical specifications for construction materials, structural design, and construction practices that must be adhered to to prevent defects, accidents and structural failures (Kasule, 2019). According to Kasule (2019), enforcement of these standards remains a challenge, often leading to substandard materials and unsafe buildings. The Regulatory bodies are the Ministry of Works and Transport, Uganda National Roads Authority (UNRA), and local governments and are responsible for enforcing building codes and overseeing construction activities. The Ministry of Lands, Housing and Urban Development is specifically tasked with issuing building permits, monitoring compliance and ensuring that developers adhere to the required construction standards. However, Asiimwe (2020) notes that regulatory bodies in Uganda are often under-resourced and face challenges such as corruption, lack of trained personnel, and limited capacity for conducting regular inspections. These shortcomings can lead to non-compliance, resulting in poor construction practices, defective buildings, and delays in projects Mugisha (2021), some developers opt to bypass regulatory requirements to reduce costs or meet deadlines. Construction health and safety regulations in Uganda are intended to reduce workplace accidents and protect construction workers from hazards. These regulations include requirements for personal protective equipment (PPE), site safety plans, and proper training for workers.

The Occupational Health and Safety Act (2006) provides guidelines for ensuring that construction sites meet safety standards. According to Lukwago (2018), enforcement still remains inconsistent at construction sites in Uganda. This lack of compliance results in both human and economic costs, with delays in projects and the loss of skilled labor. Environmental protection regulations are increasingly relevant in construction projects; they are designed to minimize the environmental impact of construction, such as controlling pollution, managing waste, and conserving natural resources (Musoke,2020).

Despite the presence of comprehensive regulations, Uganda's construction industry faces several challenges in its effective implementation. Some of the main issues include inconsistent enforcement, corruption, political interference and lack of awareness: Many stakeholders in the construction industry, including small contractors and local developers, are unaware of the latest construction regulations and standards.

2.5 Construction Specifications

The Ministry of Works and Transport, as the regulator, is tasked with policy development, monitoring and oversight of Uganda's construction sector. It ensures efficient regulations by developing laws and policies and coordinating with other stakeholders in the industry. All construction projects must adhere to the ministry's specifications (MoW&T, 2013). Construction specifications are crucial documents in the construction industry that provide detailed descriptions of the materials, methods and standards required for a building project. These specifications are vital in ensuring that the work is performed to the desired quality standards, that it meets regulatory requirements and that it adheres to the safety, environmental and technical guidelines.

In Uganda, construction specifications play an important role in maintaining project quality and ensuring compliance with regulations. They serve as a key reference for contractors, architects, engineers and suppliers to understand the precise expectations for materials and construction techniques. The absence or inadequacy of construction specifications can lead to substandard construction work, delayed projects, increased costs and safety hazards (Kasule, 2019). The key roles of construction specifications are quality assurance, regulatory compliance, risk management, cost control, and stakeholder coordination.

2.6 Building construction process

The building construction process comprises three primary phases: design, construction, and operation. Architects and engineers collaborate to create environmentally sustainable designs. The construction phase is situated between the design and operation stages, significantly influencing building performance and operational costs (Elzomor and Parrish, 2016). The building construction process is a complex series of stages that transform an initial concept into a physical structure. These stages include planning, design, procurement, construction and post-construction activities, each involving different professionals and stakeholders. In Uganda, the building construction process is fundamental to the development of infrastructure, housing and commercial projects. However, challenges in this process, such as delays, cost overruns and quality issues, often arise due to various systemic inefficiencies, including poor coordination, inadequate training and limited enforcement of regulations. The key stages of the building construction process are Planning and feasibility, design phase, procurement phase, construction phase, post-construction and handover. In Uganda, inadequate feasibility studies and a lack of proper land use planning often contribute to delays and inefficiencies in the construction process (Kasule, 2019). Lack of integration between the design and construction phases, which leads to problems during execution, such as poor construction quality, cost escalations and delays (Tumusiime & Ssemwogerere, 2022), procurement processes are often marred by inefficiencies, such as corruption, lack of transparency and insufficient vetting of contractors (Mugisha, 2021).The post-construction phase is often neglected, with many projects failing to undergo thorough inspections before they are handed over (Lukwago, 2018).

Globally, the building construction process is better regulated and more efficient due to well-established standards, practices and technologies. In developed countries, construction projects are often supported by digital tools such as Building Information Modeling (BIM), which streamlines project management, enhances coordination and reduces errors during construction (Kavuma, 2020).

2.7 Ethical conduct in the construction industry

Transparency International (2015) defines corruption as the misuse of entrusted power for personal gain. The Oxford Advanced Learner’s Dictionary (2015) characterizes corruption as dishonest or illegal behavior, especially by those in authority (Dindi *et al.*, 2019).Ethics in the construction industry should be guided by "personal ethics," balancing client needs with public impact. The New Oxford Dictionary of English (1998) defines a "professional" as someone engaged in a profession, which is a paid occupation requiring extended training and formal qualifications. Professionals should possess the necessary knowledge and skills in their field and use their expertise to serve humanity (Republic of Uganda Ministry of Public Service, 2005).In the construction sector, professionals include Architects, Engineers, Quantity Surveyors, Facility Managers and Project Managers (Irumba and Mwakali, 2007).Ethical conduct in the construction industry is not only the responsibility of individual professionals but also of regulatory bodies, clients, and the wider community. Regulatory bodies, such as the National Environment Management Authority (NEMA) and local construction boards, play a crucial role in enforcing ethical standards by conducting regular inspections, issuing fines for violations, and promoting compliance with environmental and safety regulations. Clients, too, can influence ethical behavior by selecting contractors based on reputation and past performance rather than simply choosing the lowest bid (Kiggundu, 2018). Industry associations and professional organizations, such as the Uganda Institute of Architects (UIA) and the Uganda Association of Consulting Engineers (UACE), can also promote ethical conduct by setting professional standards, offering training, and advocating for best practices.

2.8 Research gaps

From the literature review, the following research gaps emerge regarding the improvement of site quality management practices for local bulk construction materials in Uganda:

- Lack of Standardization for Local Materials: Limited research focuses on standardizing and improving the quality of local bulk construction materials, leaving room for non-uniform quality standards and subjective assessments.
- Inadequate Material Management Practices: While material management is emphasized, there is insufficient exploration of localized, effective strategies to manage bulk materials at construction sites, especially regarding storage, handling and quality assurance.
- Weak Enforcement of Regulations: Despite the existence of regulatory frameworks, enforcement remains inconsistent due to resource constraints, corruption and lack of awareness. There is a gap in strategies to enhance compliance and oversight specifically for bulk materials.
- Limited Focus on Collaborative Quality Management Systems: There is minimal emphasis on developing quality management systems that

integrate client, contractor, and government roles to ensure compliance with quality standards in Uganda.

- Inadequate Professional Supervision: Poor supervision and lack of qualified labor are recurrent issues, but detailed studies on enhancing the role of professionals in managing bulk materials on-site are scarce.

2.9 Conclusion

To address these gaps an appropriate research methodology was designed such that there is integration to ensure the research is both grounded in the existing literature and actionable for improving practices on construction sites.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter outlines the study's methodology, detailing the research design and approach, study population, sample size and selection, data collection methods, and instruments. It also covers data management and analysis procedures, along with measures to ensure validity, reliability and variable measurement.

3.2 Research Design and Research Approach

A mixed-method approach, comprising quantitative and qualitative methods, including descriptive, correlative and analytical designs, was employed in this research plan for data collection, measurement, sampling, analysis and interpretation.

The descriptive research was used for exploring the current construction materials quality control practices and challenges, identifying areas of improvement. The correlative research designer was used for examining relationships between variables and identifying potential causes of quality issues and finally analytical research designs for identifying factors influencing construction site quality management practices and interactions between the variables. These research designs were suitable for the study because questionnaires, observational studies, document reviews, correlation analysis and SWOT analysis were good tools to give the required study outputs.

The design effectively addressed the research questions while mitigating potential bias and enhancing reliability. The study utilized questionnaires, observation and interviews, which facilitated simultaneous data collection from numerous participants and the examination of multiple variables, thus optimizing time and resources.

3.3 Study Population

The study targeted 298 respondents , purposively selected based on their professional roles and relevance to the construction industry across Ugandan cities. This number represents key stakeholder categories architects, engineers, site supervisors, contractors and local authority officials deemed to possess critical insights on the study variables. The selection ensured balanced, credible and sector wide representation necessary for informed data collection and analysis . The population included various professionals as shown in Table 3-1.

***Table 3-1**: Target population*

Categories of respondents	**Target Population**
Architects	20
Design Engineers	10
Supervising Engineers	70
Construction Site Supervisors (Engineers, Technologists and Technicians or Trades men),	110
Local Authority (Engineers/Building Control Officers)	10
Contract managers (Contractors)	80
Total	**298**

3.4 Sample Size Determination

Sampling involves choosing enough elements from a population to study the sample and infer its properties or characteristics for the entire population (Sekaran, 2013). The study sample included 244 respondents, determined using Krejcie and Morgan's (1970) sample size Table A-3 (See Appendix iv) for sample size with a known population, as shown in Table 3-2.

***Table 3-2:** Sample Size Determination*

Category	**Population size**	**Sample size (N)**	**Sampling technique**
Architects	20	19	Random sampling
Design Engineers	10	10	Random sampling
Supervising Engineers	70	59	Random sampling
Construction Site Supervisors (Engineers, Technologists and Technicians or Trades men)	108	80	Random sampling

Regulators (Local Authority Engineers / Building Control officers,NBRB)	10	10	Random sampling
Contract managers (contractors)	80	66	Random Sampling

3.5 Sampling Techniques and Procedure

Random sampling identified various construction sites for the study in Ugandan cities, prompted by NBRB report in 2021 indicating low compliance with building standards and increasing construction accidents. Data were collected from selected active construction sites from all of Uganda's cities. Simple random and purposive sampling methods were employed to gather information from the different categories, selected based on their experience in building construction projects. These respondents were chosen for their technical and specialized knowledge pertinent to the study.

3.6 Data collection Methods

3.6.1 Questionnaire Survey Method

The study employed the questionnaire method for data collection. The questionnaire was utilized to gather quantitative responses from Architects, Design Engineers, Supervising Engineers, Construction Site Supervisors (Engineers, Technologists and Technicians or Tradesmen), Local Authority (Engineers/Building Control Officers) and Contract Managers (Contractors). The questionnaire was structured to include questions that addressed the variables in the conceptual framework. Such data were deemed to be most effectively obtained using a closed-ended questionnaire, which facilitates the generation of frequencies and percentages, as suggested by Amin (2005). The data were subsequently validated with responses to the related questions in the questionnaire.

3.6.2 Interview Method

The study also employed the interview method. Interviews in this study facilitated the researcher's acquisition of additional information from the Architects, Design Engineers, Supervising Engineers and Contract Managers (Contractors) on the topic under investigation. This method provided the researcher with an opportunity to formulate questions, ensure clarity through appropriate language use, address uncertainties, establish rapport, and probe for further information. The questions involved ascertaining the background, designation, qualification and age of the respondents, as well as obtaining details on material management at various construction sites.

3.6.3 Document Review

Bowen (2009) states that documentary review facilitates data collection by examining pre-existing reports or documents for relevant information. This method involved analyzing quarterly reports, monitoring reports, and correspondences among architects, engineers, contractors, and site managers. These documents offered secondary data on construction site quality management practices in selected cities, complementing other data collection methods to assess the impact of construction management practices on building quality.

3.7 Data Collection Instruments

3.7.1 Self-Administered Questionnaire

The study employed a questionnaire comprising closed-ended questions for data collection. This approach facilitated expeditious respondent decision-making and simplified data coding for analysis, thereby minimizing errors, as recommended by Sekaran (2013). The questionnaire initially addressed respondents' backgrounds and designations, subsequently examining technical aspects of performance measurement methods in construction projects, including knowledge, frequency, reasons, effectiveness and efficiency.

3.7.2 Interview Guide

Interviews were conducted with a selected cohort of participants, including site managers, architects, engineers and city authorities. An interview guide ensured quality and consistency, allowing for follow-up questions alongside pre-planned inquiries to extract comprehensive and precise information, facilitating a deeper exploration of the issues Kothari (2004).

3.8 Validity and Reliability of the Research Instruments

3.8.1 Validity

To ensure validity, the questionnaire was developed and given to three expert professionals to score the relevance of each question in providing answers to the study. Thereafter, a content validity index (C.V.I) was computed using

Equation 3.1; the number of items declared valid was divided by the number of items in the questionnaire. A CVI of an average value of 0.987 is greater ≥ 0.700 was obtained which is acceptable according to Amin, (2005).

$$CVI = \frac{Number\ of\ valid\ items}{Number\ of\ total\ items\ in\ the\ questionnaire} \ldots\ldots\ldots (\boldsymbol{Equation\ 3.1})$$

$$CVI = \frac{82}{83} = 0.987$$

3.8.2 Reliability

A pre-test was conducted on 15 respondents excluded from the final study. Data were coded and entered into a computer. Cronbach's Alpha Reliability Coefficients were calculated using SPSS version 20, to assess questionnaire reliability. The alpha coefficient, ranging from 0 to 1, describes the reliability of factors from dichotomous or multi-point formatted questionnaires or scales (For example, 1 = poor to 5 = excellent). The obtained Cronbach's alpha was 0.895 (see Table 3.3), deemed acceptable (coefficient > 0.70) per Sekaran (2013). Thus, the data were considered reliable, suggesting dependable findings.

Table 3-3: *Reliability Statistics*

Cronbach's Alpha	**Cronbach's Alpha Based on Standardized Items**	**No. Items**
0.895	0.91	83

3.9 Research procedure

A letter of introduction from Kyambogo University was obtained and presented to the authorities at the construction sites and professional bodies in the cities of Masaka, Mbarara, Lira, Mbale, Jinja, Gulu, Arua, Kampala, Forportal, and Hoima. A self-administered questionnaire was utilized to collect data from the aforementioned respondents. Data was analysed and a report made.

3.10 Achievement of specific objectives

3.10.1 Identifying bulk materials management practices influencing the quality of raw bulk materials used during construction at sites in Uganda.

The study identified bulk materials management practices influencing raw materials quality in Uganda construction by surveying 125 suppliers and site supervisors, interviewing 98 experts and regulators, conducting site observations and reviewing project documents. Data were analysed using descriptive statistics with Statistical Package for the social Sciences (SPSS)

3.10.2 Assessing the impact of bulk materials management practices on the quality of raw bulk materials during construction activities in Uganda.

The second objective was achieved by processing data collected through questionnaires analyzed using descriptive statistics using SPSS (Statistical Package for Social Science and Microsoft Excel to obtain statistical figures that helped to describe, correlate and establish the impact of the current bulk materials management practices at the construction. Bulk materials laboratory tests were also conducted on coarse aggregates to establish the strength and durability, presence of deleterious materials, particle shape and size, fine aggregates to determine the gradation and silt content and on the water to determine the presence of chlorides, sulfates, pH, and alkalinity, ten samples taken from one construction site in each of the cities were taken to Getlab materials laboratory and materials results obtained as attached (Appendix vi). Data were collected using questionnaires, interviews, observations and document reviews. targeting construction professionals and managers. Purposive and simple random sampling were used, with tools including survey questionnaires, interview guides, observation checklists and document review templates. Data were processed to establish the relationship between bulk materials management practices and raw materials quality, thereafter establishing the impact of bulk material management practices on the quality of raw bulk materials and the challenges faced regarding bulk materials management.

***Table 3-4**: Materials tests and Test methods used in the Labaratory*

Test	**Test methods**
Organic compounds	
Organic Impurities Test	ASTM C40/C40M
Organic Content Test	ASTM D2974
Particle Size distribution	
Sieve analysis	ASTM C136/C136M

Particle size distribution (PSD)	ASTM C117
Gradation Test	ASTM C33/C33M
Specific gravity Test	ASTM C127/C127M
Absorption Test	ASTM C128/C128M

3.10.3 Examining the roles of relevant professionals and local authorities in ensuring timely quality assurance, monitoring, and enforcement on construction sites in Uganda.

The third objective was to examine the role of the relevant relevant professionals and local authorities in ensuring timely quality assurance, monitoring, and enforcement on construction sites in Uganda. This objective was achieved through findings of data analysis from the questionnaire. Interviews and document reviews using descriptive statistics and content analysis data analysis methods. Data were analyzed using SPSS and soft Excel software. The roles of professionals and local authorities in raw material quality assurance were established through surveys with site professionals, including building control and enforcement officers as well as through site observations and reviews of project files, quality control reports and regulatory documents

3.10.4 Developing an effective framework designed to enhance the quality of local bulk materials used at construction sites in Uganda

The fourth objective was achieved by the use of information obtained from the findings and results of the three objectives to come up with an effective framework to enhance the quality of local bulk materials used in the construction of engineering structures in Uganda. Data were analyzed, identifying core issues and improvement areas, to determine the root causes and the issues prioritized based on their impacts and the findings mapped to the improvement areas. A comprehensive framework document was created with all components, guidelines and monitoring processes. Based on the study findings from the three specific objectives, a framework aimed at improving site quality management practices at construction sites in Uganda was developed. The framework focuses on improving site materials management practices, quality assurance mechanisms and regulatory compliance to enhance the overall quality of construction projects, particularly in the context of bulk materials.

3.11 Data Analysis

3.11.1 Analysis of quantitative data

The statistical analysis for this study was performed using SPSS version 20.0. Descriptive statistics, specifically frequency counts and percentages, were employed to analyze the respondents' demographic characteristics, while means and standard deviations were utilized to analyze the respondents' opinions sites (Appendix vii)..

3.11.2 Analysis of qualitative data

Qualitative data were analyzed using content analysis, wherein responses from key informants were categorized into recurrent themes. The recurrent themes that emerged about each guiding question were presented in the results, accompanied by selected direct quotations from participants to provide illustrative examples.

3.11.3 Analysis of materials labartory test results

The lab test results for coarse aggregates,sand and water collected from the construction sites were analysed from the various tests to understand the physical properties and organic composition of these materials and their effect on the quality of concrete (Appendix vi).

The correlation between materials management practices and the quality of bulk materials was analyzed using SPSS software, based on data collected from questionnaires.

3.12 Measurement of variables

Data on the respondents' views and opinions were obtained utilizing scaled variables from a self-developed questionnaire. The variables were measured by operationally defining concepts. The questionnaire was designed to query respondents, employing guidelines proposed by Mete *et, al,.* (2010) and Genchev *et. al.,* (2011). These were subsequently translated into observable and measurable elements to facilitate the development of an index of the concept.

Measure - SPSS's default measurement scale for variables depends on the data type. For numeric variables, the default is a continuous or interval scale (referred to as "scale"). For string variables, it defaults to a nominal scale. The "ordinal" option applies to categorical variables with ordered categories but is not used by default. Assigning the highest appropriate measurement scale to each variable ("scale" > "ordinal" > "nominal") is recommended, as it affects applicable statistical methods. This default setting can be adjusted by highlighting the respective cell in the tenth column and selecting the appropriate option from the drop-down list. The next chapter will discuss the analysis and results.

CHAPTER FOUR

PRESENTATION OF RESULTS AND DISCUSION

4.1 Introduction

This chapter presents, analyzes and interprets the study's findings derived from questionnaires, interviews, primary data and observations.The initial section covers response rate, professional roles, qualifications, experience, and survey information, while the second section discusses empirical findings.

4.2 Response rate

Out of 207 issued questionnaires, 159 were returned, resulting in an 76.80% response rate, suggesting a robust sample size that captures the views of the key professional groups in the construction sector. According to Babbie (2007), a response rate of 50% is adequate,60% is good,and 70% or higher is very good, Dillman *et al,.* (2014) and Groves *et al,.* (2009), emphasize that achieving higher response rates (for example, over 70%) helps reduce non-response bias and enhances the reliability of the results, implying that these findings can be considered both comprehensive and representative of the population under study. In this survey (Appendix Table 15-A), the highest representation was from Engineers (29.8%), followed closely by Architects (26.2%) and Site Foremen (22.4%). This distribution of roles reflects a balanced inclusion of technical expertise (Engineers and Architects) together making up 56%) and oversight roles (Site foreman,Site manager and Contractors together at 44%. This balance indicates that insights from both design and management perspectives are well-represented, which is essential in analyzing cross-functional issues in construction. However, the Quality Control Officers constituted only 1.2% of the sample, pointing to an underrepresentation in quality management perspectives, which could highlight challenges in prioritizing quality control within the workforce composition of the sector.

When comparing this with similar studies, it’s common to see varied response rates and professional distributions based on regional focus, project type, and company size. Studies focusing on construction quality, for example, often have a higher representation of Quality Control or Assurance roles to provide insight into quality management issues. For instance, a study by Akintoye (2015) in the

United Kingdom's construction industry showed a more significant inclusion of quality officers (10%) to understand quality practices, indicating a more balanced view in contexts where quality is a central concern.

In studies with a broader scope on project management and outcomes, however, it's typical to see a distribution similar to this one, with higher participation from roles that are integral to project execution and design. For instance, Kamarazaly *et al*. (2018) found that Engineers and Site Managers were the largest represented roles, suggesting that these roles play key functions in both technical and oversight activities in construction projects.

The limited presence of Quality Control Officers in this study could imply a need to integrate more quality management perspectives to better understand how quality issues are perceived and managed across various roles. This gap might indicate a larger trend within the industry or could suggest that quality management is seen as secondary in the workforce composition relative to engineering and management functions.

4.3 Characteristics of Respondents

4.3.1 Education Level of the Respondents

The respondents' educational qualifications highlight a relatively well-educated workforce in Uganda's construction industry, with 43.3% holding a Bachelor's degree in Civil Engineering and 38.6% holding a Diploma in building construction as indicated in Figure 4.1 and Table 18-A (Appendix)

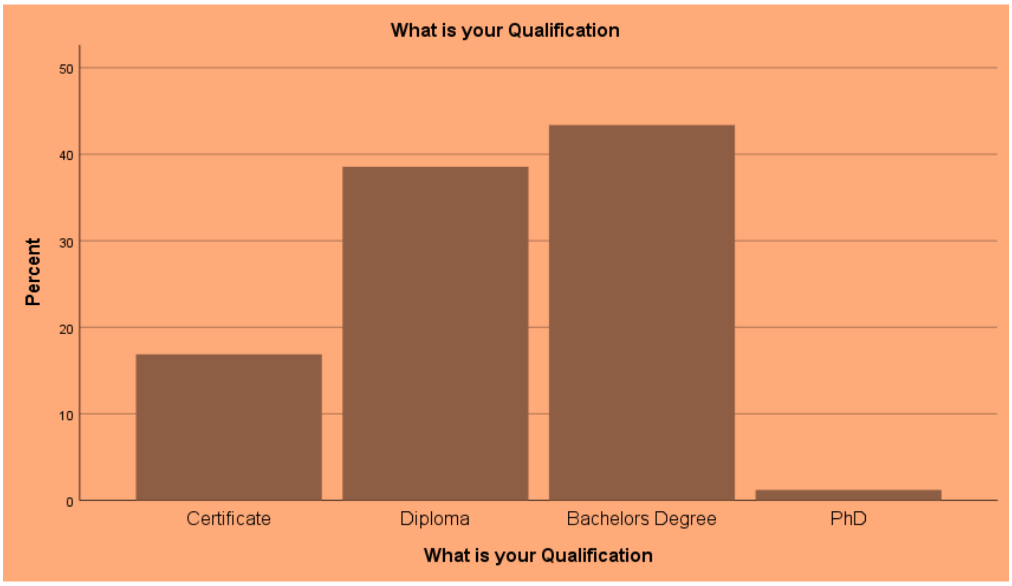

***Figure 4-1**: Respondents' educational qualifications*

This suggests that approximately 80% of the workforce has achieved tertiary education, indicating a foundational level of technical knowledge essential for construction work. However, the presence of only 1.2% of respondents with PhDs suggests scarcity of personnel with high level research skills and advanced specialisation which might limit the integration of cutting-edge research and innovative technologies into everyday site management practices.

The scarcity of advanced degrees aligns with findings in other studies across various countries, where higher education, such as PhDs, is less common among on-site professionals due to the field's emphasis on practical experience and technical skills at the bachelor's or diploma level. For example, a study by Rahman *et al*. (2016) in the Malaysian construction sector similarly found a high proportion of bachelor (12%) and high school diploma (38%) holders but very few (less than 1%) with PhDs, leading to similar challenges in technology adoption, advanced project management, and compliance with international standards.

This educational profile suggests potential limitations in implementing specialized skills such as structural analysis, advanced project management, and construction technology. The limited number of highly specialized experts could result in inadequate quality control and compliance with construction regulations and standards, leading to issues in construction quality, project delays, and additional costs due to rework. Other studies, such as one by Lim *et al*. (2018), link a lack of specialized qualifications to increased risk of defects, safety incidents, and cost overruns, as well as limited growth in industry innovation due to an absence of advanced expertise.

4.3.2 Experience of the Respondents

This subsection gives detail of the respondents' years of experience in their positions at the time of the interview. The data shows that the majority of respondents (37.3%) have between 6-10 years of experience figure 4-2 and Table A-19 (Appendix), suggesting a strong presence of mid-level professionals on construction sites. The experience profile is fairly balanced, with substantial representation across the 6-20 year range, but with fewer early-career individuals (0-5 years at 12%) and only 6% of respondents having 21 or more years of experience. This distribution suggests that while there is a solid base of mid-career professionals, there may be a shortfall of highly experienced individuals who can offer advanced expertise in critical areas like materials management, quality control, and operational efficiency.

Figure 4-2*: Respondents' years of experience*

Comparing these results with similar studies reveals that many construction industries face a similar trend, where the workforce is concentrated within the mid-level experience range. For instance, a study by Dainty *et al*. (2017) in the UK found that most construction professionals had between 5 and 15 years of experience, but that fewer highly experienced individuals (with 20+ years) were available on-site. This pattern, as seen both in Uganda and in other regions, may limit the degree of knowledge transfer and mentorship opportunities on sites, which could otherwise strengthen quality management practices and enhance younger professionals' skill development. Having a limited number of highly experienced professionals may impact the ability to handle complex challenges on-site, such as nuanced quality control issues, troubleshooting, and strategic decision-making, which often benefit from seasoned insight. Experienced professionals contribute through their technical skills and sharing best practices, identifying potential quality and safety issues early, and guiding less experienced team members. Studies such as that by Olanipekun *et al*. (2019) have found that sites with a higher proportion of experienced professionals often have better quality control outcomes, lower rework rates, and fewer safety incidents, as seasoned individuals bring a deeper understanding of regulatory compliance, site safety, and resource optimization. The relative scarcity of highly experienced personnel in this study could also imply challenges in maintaining consistent quality and efficiency across projects. It suggests a possible need for increased emphasis on retaining senior professionals or providing additional training to mid-career individuals to bridge the gap in high-level expertise. This shift could enhance quality management outcomes and help transfer essential skills, such as those related to materials management and advanced quality practices, to newer generations in the workforce.

4.4 Empirical Findings

The study examined materials management practices in improving construction quality in Ugandan cities. Quantitative data were collected via questionnaires, while qualitative data were generated from interviews to provide empirical evidence. Four objectives guided the study. Analysis was conducted for each objective in sequence, presenting descriptive results, significances, and correlations. Interview findings and documentary reviews were discussed in a triangulated manner.

4.4.1 Quality management practices that influence the quality of bulk materials during construction at construction sites

This section presents examination of the state of quality management practices at construction sites using survey data. The findings underscored the roles of Architects, Engineers, Quality control officers, Contractors, and Regulatory bodies in ensuring effective quality management processes. The key variables found were the procedures for receiving and storing materials, Regulatory and Oversight Practices, and Professional Practices of Architects and Engineers.

Using SPSS and descriptive statistics, the study’s frequency analysis revealed key study findings. Inspection for visible defects or contamination with (mean=1.08, SD = 0.28) is a common practice, ensuring basic quality checks. Designated storage areas (mean = 1.14, SD = 0.35) are generally provided, reducing material mixing and contamination risks. Proper lifting and handling (mean = 1.58, SD = 0.50) showed variability, potentially causing material damage. Covering materials during transportation or storage (mean = 1.52. SD = 0.50) was inconsistently applied, exposing them to rain and moisture, affecting durability. Site cleanliness and organization (mean = 1.50, SD = 0.50) are emphasized but unevenly implemented, compromising material integrity. Regulatory enforcement gaps were evident only 30.1% of respondents viewed enforcement as effective, while 69.9 % cited insufficient inspections and 77.1% reported delayed responses to quality issues. Although architects and engineers conduct site visits,31.3% of architects do not leading to gaps in material quality verification.

Regular inspections for defects and contamination are fundamental to maintaining quality. With reference to Table A-22, the low mean score (1.08) reflects the widespread adoption of these basic practices, which aligns with findings from studies like Juran and Gryna (2017) that Highlight inspection as a key component in quality management, Proper storage (mean = 1.14) minimizes contamination risks, but gaps in handling (mean = 1.58) and coverage during transportation/storage (mean = 1.52) indicate areas needing improvement. Improper handling and exposure to moisture have been linked to durability issues, as noted by Love *et al*. (2018). Clean and organized sites (mean = 1.50) promote efficiency and reduce risks of material degradation. However, inconsistent practices compromise these benefits. Sufficient inspections and weak enforcement by regulatory bodies create opportunities for non-compliance, echoing the findings of Smith *et al*. (2020) in the South African construction industry, where frequent inspections correlated with improved quality standards. Architects and Engineers require additional training to bridge gaps in advanced quality management practices, as supported by Olanipekun and Sutrisna (2019), who found that training improves professional capacity for risk identification and response.

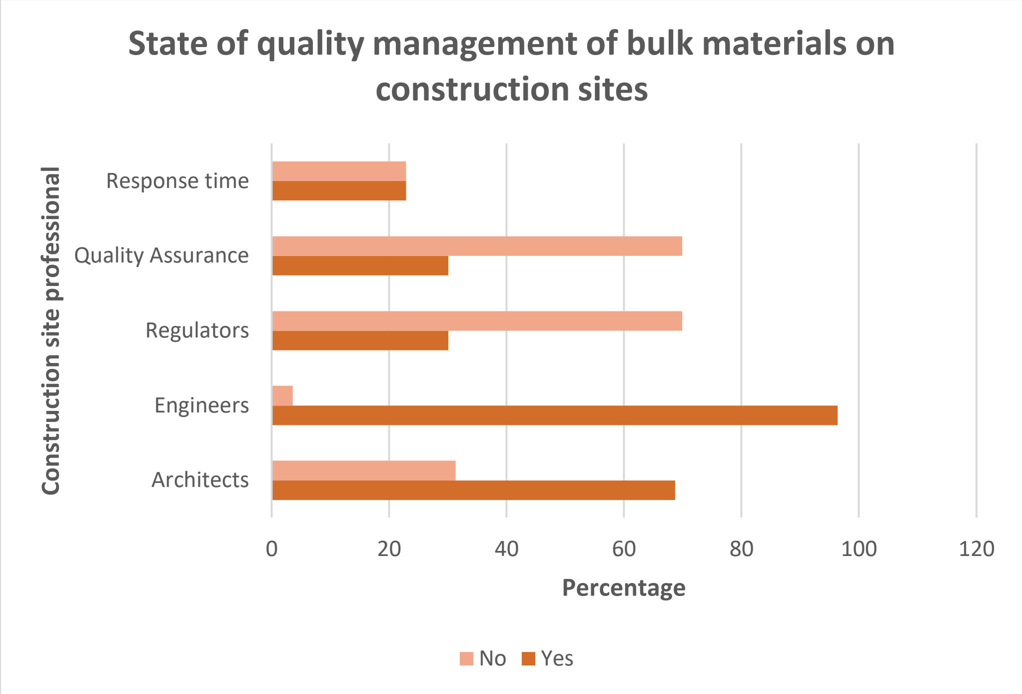

Figure 4-3: *State of quality management of bulk materials on construction sites*

The figure depicts current quality management practices in construction based on survey data. While most architects conduct site visits (Appendix Table A-21) 31.3% do not, potentially causing discrepancies. Engineers actively visit sites for quality assurance, but 69.9% of respondents reported that regulatory bodies fail to conduct regular inspections, leading to overlooked issues and compliance concerns. Only 30.1% believe regulatory bodies effectively enforce quality standards. Moreover, 77.1% reported that bulk material quality issues are not promptly addressed, increasing costs and safety risks. Despite many architects and engineers being confident in ensuring quality, 77.1% were dissatisfied with existing quality assurance measures, and only 22.9% felt response times to quality issues were adequate. Enhanced training for architects and engineers, stricter regulations, active enforcement through audits and inspections, and improved communication channels among stakeholders are needed to address these challenges and improve construction quality management.

4.4.2 Establishing the impact of bulk material management practices on the quality of raw bulk materials at construction sites in Uganda

This section examines survey data on quality management practices and the conditions of raw bulk materials at construction sites, as well as their associated impacts. Table 4-1, highlights the critical issues encountered in bulk materials management. The most significant problem reported is the lack of proper grading, which adversely affects batching, workability and concrete strength (20.5%). This is followed by contamination and unclean materials (15.7%), while poor concrete surfaces finish and cracking are also notable concerns (9.6%). These issues compromise structural safety, strength, and durability, emphasizing the urgent need for enhanced management practices.

Table 4-1: *Conditions of raw bulk materials at construction sites*

Issue description	**Frequency**	**Percentage**	**Rank**
Materials are not well graded	17	20.5	1
Materials are contaminated and unclean	13	15.7	2
Not Applicable	12	14.5	3
Poor concrete surface and cracking floors	8	9.6	4
Poor quality materials compromise safety and strength	4	4.8	5

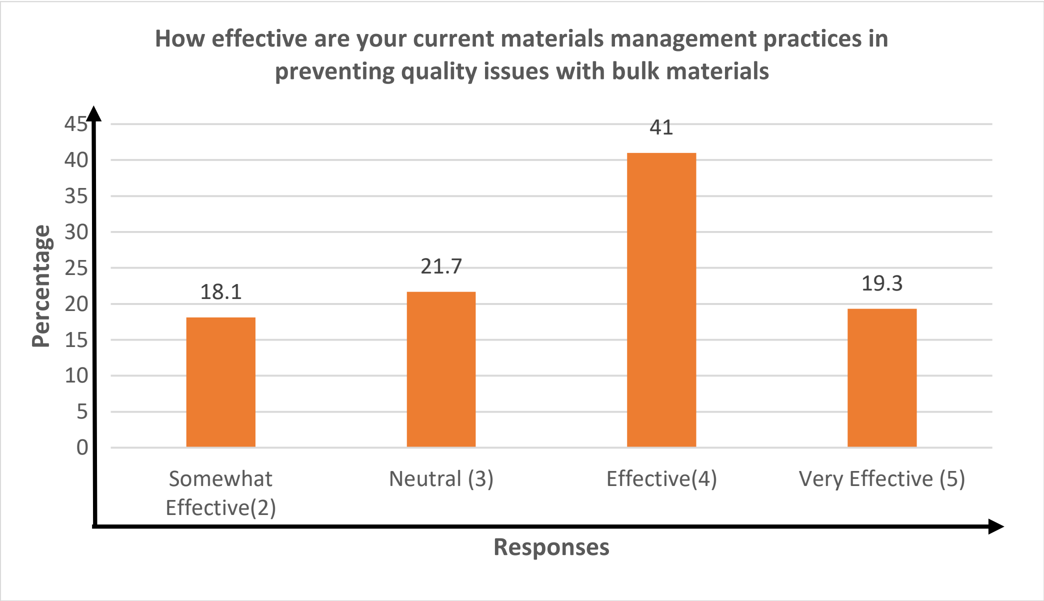

Figure 4-4: *Level of effectiveness of materials management practices*

The Survey results represented in figure 4-4 on quality management practices' effectiveness revealed that 41% rated them effective, 19.3% very effective, and 34.9% neutral.

__Table 4-2:__ Challenges in Enforcing Quality Standards

Challenge Identified	Frequency	Percent	Cumulative Percent	Rank
Delays due to rejected materials	14	16.9	16.9	1
Enforcement leading to delays and material wastage.	12	14.5	31.4	2
Client preferences for cheaper materials.	11	13.3	44.7	3
Corruption and political interference	3	3.6	48.3	4
Lack of quality management officers on-site	4	4.8	53.1	5
Other challenges (combined)	36	46.9	100.0	-

Delays resulting from material rejections (16.9%) and wastage (14.5%) reference Table 4-2, are primary challenges in enforcing quality standards. These issues are further exacerbated by clients' preferences for lower-cost materials and the absence of on-site quality management officers (4.8%), which hampers effective management. Descriptive statistics (Table A-22), indicate that most quality inspections rely heavily on visual assessments (Mean = 1.91,SD = 0.28), with document reviews being the least utilized method (Mean = 1.19, SD = 0.39).Testing and sampling, which are critical for ensuring quality, are conducted infrequently (Mean = 1.90, SD = 0.29).

The frequency of quality control checks (Mean = 1.90, SD = 1.04) suggests that inspections are conducted irregularly, increasing the likelihood of defective materials going unnoticed or unaddressed. While the detection rate of defective materials is relatively high (Mean = 1.95,SD = 0.97), follow up actions to resolve these issues are limited,as evidenced by the low rates of materials rejection. Over the past six months,materials rejection rates remained low (Mean = 1.87, SD = 1.04), reflecting insufficient enforcement of quality standards and highlighting the need for more stringent quality management practices.

Table 4-3: *Quality inspections reliance*

Inspection Method	**Mean**	**Standard Deviation (SD)**
Visual inspection	1.91	0.28
Document review	1.19	0.39
Testing and sampling	1.90	0.29
comparison with specifications	1.69	0.46
Frequency of quality control checks	1.90	1.04
Percentage of defective materials detected	1.95	0.97
Times materials rejected in the last six months	1.87	1.04

The findings from the results summarized in the Table 4-3, reveal a statistically significant negative correlation between materials management practices (independence variable) and quality of bulk materials (dependent variable). This is evidenced by Spearman's rho ($\rho = -0.416$, $p < 0.001$), Pearson correlation ($r = -0.317$, $p = 0.003$), and Kendall's tau b ($\tau = -0.394$, $p < 0.001$). (Table A-24).These results indicate that poor materials management practices have detrimental effect on the quality of bulk materials. Table 4.4 shows significant correlations between materials management practices the independent variable and the quality of bulk materials the dependent variable.

Table 4-4*: Correlation between materials management practices and the quality of bulk materials*

Correlation Method	**Correlation Coefficient**	**Significance (2-tailed p-Value)**
Spearman's rho	-0.416	0.000
Pearson	-0.317	0.003
Kendall's tau b	-0.394	0.000

Laboratory test results indicate that coarse aggregates exceeded strength and durability requirements, with low Aggregate Crushing Value (ACV) and Aggregate Impact Value (ATV), signifying a high resistance to mechanical forces. However, the presence of clay and friable lumps, though within permissible limits, necessitates regular monitoring. Fine aggregates gradation results indicate confirm compliance with established standards. However, silt content in some samples exceeded recommended levels, highlighting the need for washing or blending to meet quality requirements. The water used for construction complies with quality standards, ensuring no adverse effects on concrete strength or durability. Laboratory test results are indicated in appendix Tables 4-5,4-6 and 4-7

Table 4-5: *Summary of material test results: Coarse aggregates*

Test/Parameter	Results
Ten Percent Fines Value (TFV)	131.2 – 204.3 kN (wet); 142.3 – 210 kN (dry)
Aggregate Crushing Value (ACV)	19.1 – 21.5%
Aggregate Impact Value (AIV)	14.5 – 19.9%
Sodium Sulphate Soundness	0.94 – 3.17%
Clay and Friable Lumps	1.17 – 2.12%
Specific Gravity	Oven dry: 2.53 – 2.78; Apparent: 2.56 – 2.81
Water Absorption	0.249 – 0.473%
Loose Bulk Density	1.559 – 1.595 g/cc
Flakiness Index	12.34 – 17.32%
Particle Size Distribution	Conforms to 20 – 5 mm grading

Table 4-6: *Summary of material test results: Fine Aggregates*

Test/Parameter	Results
Particle Size Distribution	Conforms to grading requirements
Silt Content	0.9 – 10.2%
Deviation in Finer Particles	Noted in some samples

***Table 4-7**: Summary of materials test results:Water quality*

Parameter	**Results**
Chlorides	0.0050%
Sulfates	0.0356%
pH	6.68
Alkalinity	0.0083%
Oils and Grease	None
Deleterious Materials	0.0042 mg/L

These findings are consistent with similar studies. For instance Tam *et al*. (2015) investigated the Hong Kong construction industry and identified inadequate grading and contamination as leading causes of concrete defects, resulting in visible surface flaws, cracking and compromised strength. Similarly research by Enshassi *et al*. (2014) in the Middle East revealed that poorly managed bulk materials contributed to structural failures and increased maintenance costs, emphasizing the critical need for controls during procurement and delivery of bulk materials. Studies by Mensah and Ofori, (2020) on Sub-Saharan Africa further support these findings, highlighting inadequate quality management frameworks and an overreliance on visual inspections as significant challenges. Agyekum *et al*. (2019) also demonstrated that comprehensive testing and strict adherence to standards substantially improve the quality and durability of materials, reducing structural failures.by enforcing rigorous quality standards and integrating structured management frameworks, the negative impacts of poor-quality management practices can be significantly mitigated.This approach reduces rework, improves project outcomes, and ensures safer, more durable structures.

4.4.3 Establishing the level of participation of Professionals and Authorities in Quality Assurance in Ugandan Construction Sites

This section gives an analysis of the roles of Quality Control Engineers, Architects and Regulatory Bodies in quality management at Ugandan construction sites , drawing on survey data to highlight key findings. Descriptive statistics illustrate the degree of involvement of various stakeholders in quality assurance activities.

__Table 4-8:__ Roles of Proffessionala in Quality Control manegement

Question	Mean	Interpretation (Scale 1-2)
Is the site manager actively involved in quality management?	1.2289	High participation
Are quality control engineers conducting regular inspections and tests?	1.7229	Moderate participation
Are regulatory bodies conducting site inspections?	1.6988	Moderate participation
Are regulatory bodies enforcing quality standards and regulations?	1.6988	Moderate participation
Are quality issues and resolutions being documented?	1.6506	Moderate participation
Are quality issues being shared and addressed promptly?	1.4819	Moderate participation
Are relevant professionals trained in quality management?	1.4819	Moderate participation
Are relevant professionals Staying up to date with industry developments and best practices?	1.4819	Moderate participation
Are relevant professionals up to date with industry developments and best practices?	1.5904	Moderate participation

The results suggest that while site managers have high involvement,the overall participation of other stakeholders varies, with moderate engagement in most areas.

Specific roles and activities carried out by professionals and regulatory authorities

__Table 4-9__: Findigs roles of proffessionala in quality control manegement

Profession/Body	Findings	Percentage participation
Quality Control Engineers	Conduct regular inspections	27.7%
	Document and report quality issues	36.1%
	Collaborate with other professionals	34.9%
Architects	Involved in quality management during the design phase	84.3%
	Conduct site visits for compliance	68.7%
	Address quality issues related to design	68.7%
Engineers	Involved in quality management during the construction phase	96.4%
	Conduct site visits for compliance	96.4%
Regulatory Bodies	Conduct regular site inspections	30.1%
	Enforce quality standards and regulations	30.1%
	Address quality issues promptly	22.9%

The results reveal significant deficiencies in proactive monitoring and enforcement , potentially jeopardizing project quality. Survey findings on the roles of construction professionals and regulatory bodies in quality management highlight substantial discrepancies in participation and oversight, which may compromise the quality and safety of construction projects in Uganda. A high level of participation by engineers (96.4%) in quality management during construction and site visits demonstrates strong engagement in on-ste quality assurance. Similarly , architects (84.3%) actively contribute during the design phase, ensuring compliance with quality standards.However,regulatory bodies show limited involvement,with only 30.1% conducting inspections and enforcing standards, underscoring the need for stronger enforcement mechanisms. Participation by quality control engineers in inspections (27.7%) and reporting (36.1%) is notably low, indicating significant gaps in continuous quality assurance efforts. The limited collaboration (34.9%) and insufficient engagement of quality control engineers in regular inspections and documentation point to the absence of a comprehensive quality assurance process.

These findings align with research from Oxford University, which emphasized the importance of establishing both qualitative and quantitative standards alondside proactive monitoring. The study highlighted that clear benchmarks and systematic inspection protocols are critical for maintaining high standards and achieving reliable project outcomes. Similar conclusions were drawn by Ofori and Toor (2015) in their study on government involvement in construction control in South Asia. They identified that limited regulatory engagement led to compromised project quality, reduced compliance with safety standards, increased risks of structural defects. Additionary, research by Love *et al*. (2018) demonstrated that timely responses to quality issues are essential for preventing defects,reducing rework, and maintaining project schedules. The importance of conducting regular site visits is further supported by findings from Tam *et al*. (2015), who concluded that early involvement of design and construction teams in quality control significantly reduces the occurrence of defects. However,without complementary engagement from quality control engineers and regulatory bodies, the efforts of architects and engineers alone may be insufficient to ensure consistent quality across all projects.

4.4.4 Framework to Enhance the quality of local bulk materials on construction sites in the construction industry in Uganda

Table 4-10*: Quality management practices on construction sites*

Quality Pracise Issue Description	**Percent**	**Rank**
Lack of quality management officers on-site	53.1	1
level of participation of Regulatory Bodies- Enforce quality standards and regulations	30.1	2
Quality Control Engineers- Conduct regular inspections	27.7	3
Materials are not well graded affecting batching, workability, and concrete strength	20.5	4

Delays due to rejected materials	16.9	5
Materials are contaminated and unclean and not well-graded	15.7	6
Client preferences for cheaper materials	13.3	7
Clear communication and materials specifications	4.8	8
Site meetings and documentation	1.2	9

Based on the study findings in the Table 4.10 above, improving site quality management practices at construction sites in Uganda can be done following a framework focusing on improving site materials management practices, quality assurance mechanisms, and regulatory compliance to enhance the overall quality of construction projects, particularly in the context of bulk materials. Interestingly, the relatively low prioritization of structured frameworks for materials quality management suggests that some sites may be missing opportunities for a more systematic approach to quality. In summary, the findings underscore the need for a multi-faceted approach to quality enforcement in Uganda's construction industry, including client education, stronger anti-corruption measures, and improved training on quality standards. By addressing these areas, construction projects can better align with quality goals, minimize delays, and ultimately deliver safer, more durable, and cost-effective structures. Structured frameworks, as explored by Ghanem *et al*. (2018) in the Middle East, provide consistency in quality control practices and ensure that quality checks are standardized across projects.

The framework developed provides a structured approach for enhancing the quality of bulk materials aiming at improving the quality of local bulk materials used in construction projects in Uganda. It is based on findings from research highlighting gaps in materials management practices, quality assurance, and regulatory enforcement.

The Framework addresses key issues in receiving, handling, storage, testing, and professional collaboration with clear objectives of;

- Standardise bulk materials management practices at construction sites
- Improve quality assurance processes to reduce defects and rework.

- Enhance collaboration among professionals and regulatory bodies.
- Build capacity through training and adoption of best practice

Table 4-11: *Framework to Enhance the quality of local bulk materials on construction sites*

Component	Key Outputs	Expected Outcomes
Receiving materials	✓ Conduct detailed inspections for visible defects and contamination ✓ Verify material type and quantity against delivery documents ✓ Document material specifications, sources, and receipt conditions	✓ Improved defect detection ✓ Accurate inventory ✓ Enhanced traceability
Storage and Handling	✓ Designate storage areas ✓ Proper lifting techniques ✓ Cover materials ✓ Maintain cleanliness	✓ Reduced contamination ✓ Minimized damage ✓ Weather protection ✓ Safety compliance

Testing and quality control	✓ Routine lab testing ✓ Defect thresholds ✓ Record inspections/results	✓ Reliable compliance data ✓ Fewer substandard materials ✓ Transparent QA processes
Collaboration and Oversight	✓ Define responsibilities ✓ Regular meetings ✓ Strengthen inspections	✓ Clear accountability ✓ Faster issue resolution ✓ Better enforcement
Capacity Building	✓ Professional training ✓ Certification programs ✓ Digital tracking tools	✓ Skilled workforce ✓ Higher standards ✓ Efficient monitoring
Technology adoption	✓ Inspect for defects/contamination ✓ Verify material type/quantity ✓ Document sources/specifications	✓ Improved defect detection ✓ Accurate inventory ✓ Enhanced traceability

***Table 4-12**: Reliability Testing of the Framework*

Component	**Reliability Test (Feasibility & Practicality)**	**Evidence it Works (Indicators / Benchmarks)**	**Verdict**
Receiving Materials	• All actions (inspection, verification, documentation) are low-cost and can be executed with existing staff (store clerks, site engineers). • Requires checklists and training (easy to implement).	• Past studies (Musonda et al., 2020) show that routine receipt inspections reduce non-conforming deliveries by 20 - 30%**.** • MCI (% lots meeting specs) improves when receipt documentation is enforced.	**Reliable** Practical and proven in field QA/QC.
Storage & Handling	• Requires site space, pallets, covers, and training on lifting techniques. • Cost is moderate but justified (cheaper than rework).	• Research shows storage compliance ≥85% reduces contamination-related defects by 25% (ETASR, 2023).	**Reliable** Storage control consistently reduces wastage and quality failures.
Testing & Quality Control	• Needs certified labs and field kits (MDD/OMC, moisture, compressive strength). • Costs exist but manageable if budgeted in contracts.	• Routine testing improves defect detection; baseline vs. post-intervention data often show >30% fewer material failures.	**Reliable** Works where lab/field testing capacity exists.

		• Transparency improves accountability.	
Collaboration & Oversight	• Meetings, defined roles, and regulatory enforcement require coordination, not large capital. • Relies on governance culture.	• Frequent oversight reduces non-compliance by up to 40% in documented municipal cases. • Role clarity prevents responsibility gaps.	**Reliable** Strong governance multiplier effect.
Capacity Building	• Training/certification is feasible via CPDs (Continuous Professional Development). • Workshops can be donor/government supported.	• Trained professionals apply best practices better; evidence shows trained QA officers reduce rework by 15–20%**.**	**Reliable** Skills development always correlates with better site quality.
Technology Adoption	• Requires upfront investment in software/systems, but scalable. • Prefabrication needs supply chain readiness.	Digital tools reduce reporting delays and errors. Prefab adoption reduces variability and defects by >25% in controlled trials (UN-Habitat reports).	**Reliable** Works if ICT adoption barriers are addre

Table 4-13: *Monitoring and Evaluation Framework*

Evaluation Area / Results Chain	**Key Performance Indicators (KPIs)**	**Baseline Module (Per Site & Material)**	**Evaluation Method /Data Source**	**Frequency**	**Target**	**Responsibility**
Inputs (Resources, systems, staff, labs)	• Number of staff trained in QA/QC • Availability of testing equipment	– Current sourcing practice – Available testing capacity – Storage/handling practices	Training records, inventory logs	Quarterly	100% staff trained; labs equipped	Project QA Manager / Division Engineer
Activities (Testing, inspection, training)	• % of planned material tests conducted • % of site inspections completed	– Material test results (PSD, FM, silt %, moisture, MDD/OMC) – Inspection coverage	Test reports, inspection checklists	Weekly	≥95% planned tests & inspections done	Site Engineer / Clerk of Works
Outputs (Immediate deliverables: test results, compliance scores)	• Material Compliance Index (MCI % lots meeting specs) • Storage compliance score (0-100)	– Non-conformities/100 deliveries – Storage/handling scores	Receiving test records, storage checklists	Weekly	MCI ≥90% Storage ≥85%	QA Officer / Store Supervisor

Outcomes (Performance improvements on site)	• Moisture deviation for sand (±%) • Defects linked to materials (/1000 m^2 or m^3)	– Unit strength/absorption values – Rework/defect incidence	Field & lab test reports, site QA logs	Daily / Monthly	Sand moisture ≤±2% and spec absorption Defects reduced by 30% from baseline	QA Engineer / Site Manager
Impact (Long-term results: efficiency, compliance, cost)	• Reduction in material-related project delays • Compliance rate with regulatory inspections • Enforcement actions for non Cost/time delays due to materials • Audit findings - compliance reduced		Project timelines, regulatory inspection reports	Quarterly / Annual	≥90% compliance Delays reduced by 25%	

Conclusion

The proposed framework addresses the critical gaps in bulk materials management, quality assurance and professional collaboration identified in the research. By implementing this framework, construction stakeholders in Uganda can significantly enhance the quality of local bulk materials, reduce project delays and costs, and ensure sustainable construction practices.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study investigated site quality management practices for local bulk construction materials in Uganda, and concluded that there are significant gaps in quality control processes, particularly in regulatory oversight, with only 30.1% of sites regularly inspected. Challenges such as inadequate documentation, delays from rejected materials, client preferences for cheaper options, and corruption adversely impact quality. The study further concluded that despite the active engagement of architects and engineers in quality management, there is a lack of collaboration among quality control personnel and other professionals, leading to inconsistent practices across sites. The study emphasizes the critical influence of bulk materials management practices on construction material quality and the need for coordinated efforts among stakeholders to foster a culture of quality. Limited involvement of regulatory bodies in site inspections and enforcing quality standards highlights systemic inefficiencies that jeopardize project quality. The research has proposed an effective framework to enhance the quality of local bulk materials used in construction through comprehensive quality management practices and improved stakeholder collaboration, leading to safer and more durable engineering structures in Uganda's construction sector.

5.2 Recommendations

To improve bulk materials management and raw material quality in construction, the study recommends enhancing regulatory oversight. This involves more frequent site inspections by regulatory bodies, stricter enforcement of quality standards, and harsher penalties for non-compliance. These measures will ensure adherence to quality benchmarks and improve accountability.Implementing robust quality management systems is crucial. Standardizing documentation and reporting, establishing clear protocols for material testing and inspection, and using technology for tracking and monitoring will streamline operations and address documentation deficiencies. This organized approach will improve quality management on construction sites.

Enhancing collaboration among professionals is vital. Communication platforms for architects, engineers, quality control personnel and regulatory bodies will improve coordination and joint inspections. Regular site meetings and feedback mechanisms will foster continuous improvement, enhancing overall quality assurance.

Lastly, targeted training and improved matwrials procurement and handling practices are essential. Training programs for quality control engineers and educating clients on the benefits of quality materials will encourage better material selection. Stricter prequalification of material suppliers and clear guidelines for material specifications will strengthen procurement practices, ensuring the use of high-quality materials in construction.

5.3 Limitations

Some participants did not attend data collection sessions due to busy schedules. This was addressed by asking respondents to specify a convenient day for the study before administering questionnaires or conducting interviews.

Not all respondents disclosed critical issues about the study problem due to fear of damaging their organization's image and structure intergrity. This was mitigated by assuring respondents that the study was strictly for academic purposes, promising confidentiality and conducting the study anonymously, ensuring no names or titles would appear in the report and not to conducting quantitative or qualitative tests on the completed structural elements so to expose the structural intergrity of their buildings.

Control over respondents' attitudes during the study was not difficult. They were encouraged to feel free and avoid bias while answering the questions.

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APPENDIX (I): Krejcie and Morgan Table A-3

N	S	N	S	N	S	N	S	N	S
10	10	100	80	280	162	800	260	2800	338
15	14	110	86	290	165	850	265	3000	341
20	19	120	92	300	169	900	269	3500	246
25	24	130	97	320	175	950	274	4000	351
30	28	140	103	340	181	1000	278	4500	351
35	32	150	108	360	186	1100	285	5000	357
40	36	160	113	380	181	1200	291	6000	361
45	40	180	118	400	196	1300	297	7000	364
50	44	190	123	420	201	1400	302	8000	367
55	48	200	127	440	205	1500	306	9000	368
60	52	210	132	460	210	1600	310	10000	373
65	56	220	136	480	214	1700	313	15000	375
70	59	230	140	500	217	1800	317	20000	377
75	63	240	144	550	225	1900	320	30000	379
80	66	250	148	600	234	2000	322	40000	380
85	70	260	152	650	242	2200	327	50000	381
90	73	270	155	700	248	2400	331	75000	382
95	76	270	159	750	256	2600	335	100000	384

Krejcie, Robert V., Morgan, Darlye W., *"Determining Sample Size for ResearchActivities"*

Education and Psychological Measurement, (1970).

Note: "N" is population size

"S" is sample size

APEENDIX (II): QUESTIONNAIRE

Table A-4: Questionnaire

	SECTION 1: GENERAL INFORMATION				
1	What is your role at the construction site? Please tick appropriately.				
	Site manager	Quality control officer	Engineer	Contractor	Architect
	Building control Officer	Consultant Engineer	Materials Engineer	Quality control specialist	Site Foreman
	Materials Supplier				
	If others, please specify;……………………………………………………….				
2	What are your qualifications? Please tick appropriately.				
	Certificate	Diploma	Bachelors degree	Masters Degree	PhD
	If other(Please, specify,………………………………………………….				
3	How many years of experience in the construction industry? Please tick appropriately.				
	0-5 yrs	6-10 yrs	11-15 yrs	16-20 yrs	21 and above yrs
	SECTION 2:MATERIALS MANAGEMENT PRACTISES				
4	Who is responsible for managing materials on this construction site. Please tick appropriately.				
	Site manager	Contractor	Engineer	Quality control officer	
	If others; Please specify				
5	What procedures are in place for receiving and storing the bulk materials. Please tick appropriately.				
		Yes	No		
	Inspect for visible defects or contamination				
	Designate a specific storage area				
	Verification of the quantity and type of materials delivered				
	Proper lifting and handling using proper lifting techniques and equipment				
	Is there a designated area for storing material separate from others				

	Are materials covered during transportation and storage to protect from rain and moisture				
	Site cleanliness and organization of the storage area				
	If others; Please specify				
6	How are materials inspected and tested for quality compliance? Please tick appropriately.				
				Yes	No
	Visual Inspection				
	Document review				
	Testing and sampling				
	Comparison with specification				
	If others; Please specify				
7	What quality control measures are in place for the Bulk materials? Please tick appropriately.				
	Inspection	Testing		Certificatin	
	If others (Please specify);				
	Quantitative questions				
8	How often do you conduct quality control checks on the bulk materials				
	Daily	Weekly	Monthly	Quarterly	If others (Please specify)
9	What is the average percentage of defective bulk materials detected during quality control				
	0-5%	6-10%	11-15%	16% or higher	
10	How many times have you rejected Bulk materials due to quality issues in the past six months?				
	0-2 Times	3-5 Times	6-8 Times	9 Times or more	
11	What is the average cost of replacing defective bulk materials				
	UGX Shs 1-500,000	UGX Shs 500,000-1.9M	UGX 2,0M-3,49M	UGX 3.5M-4.9M	UGX 5M or Higher
	Qualitative Questions				
12	Can you describe the procedures you have in place for managing Bulk materials on this construction site?				
13	How do you ensure that bulk materials meet required quality standards?				
14	Have you experienced any challenges in managing Bulk materials on this construction site?				
15	If yes, Please describe				

16	How do you think Materials management practices could be improved to better support the quality of bulk materials?					
	Open -Ended Questions					
17	Can you share any notable experience or incidents related to materials management and quality of Bulk materials on this construction site?					
18	How do you think the quality of bulk materials impacts the overall quality of the construction project?					
	Scale rating					
20	How important is materials management in ensuring the quality of bulk materials? Please tick appropriately using Scale 1-5					
	Not Important at all (1)	Somewhat important (2)	Neutral (3)	Important (4)	Very Important (5)	
21	How effective are your current materials management practices in preventing quality issues with bulk materials? Scale 1-5					
	Not effective at all (1)	Somewhat effective (2)	Neutral (3)	Effective (4)	Very effective (5)	
	SECTION 3 MATERIAL QUALITY IMPACT					
					YES	NO
22	Have you experienced any issues with quality of bulk materials during this project? Tick appropriately					
23	If yes, please describe.					
24	Have you noticed any correlation between materials management practices and the frequency of quality issues with bulk materials?				Y	No
25	If yes, please elaborate more on the correlation					
27	Can you describe a recent instance where you identified a quality issue at a construction site?					
28	How did you address it?					
28	How do you collaborate with other professionals (e.g Architects, engineers, contractors) to ensure quality management at the construction site?					
29	What challenges do you face in enforcing quality standards at construction sites?					
30	How often do you conduct site inspections to ensure quality control					
	Daily	Weekly	Monthly	Quarterly	Others Specify	
31	What percentage of construction projects have you worked on that had quality issues?					

	0-20%	21-40%	41-60%	61% or higher	Others Specify
32	How effective do you think regulatory bodies are enforcing quality standards at construction sites?				
	Very effective (5)	Somewhat effective (4)	Neutral (3)	Somewhat ineffective (2)	Not effective at all (1)
33	How important is quality management in your work?				
	Very Important (5)	Somewhat important (4)	Neutral (3)	Somewhat unimportant (2)	Not important at all (1)
34	How confident are you in your ability to identify quality issues at construction sites?				
	Very confident (5)	Somewhat confident (4)	Neutral (3)	Somewhat unconfident (2)	Not confident at all (1)
35	How effective do you think quality management is preventing defects and rework?				
	Very confident (5)	Somewhat confident (4)	Neutral (3)	Somewhat unconfident (2)	Not confident at all (1)
37	How do you think roles of relevant professionals and regulators can be improved to better support quality management at the construction site?				

Table A-5: Observational Check List

	Site management	Yes	No	Others specify
1	Is the site manager actively involved in quality management?			
2	Are they conducting regular site inspections?			
3	Are they addressing quality issues promptly?			
	Quality control engineers			
4	Are quality control engineers conducting regular inspections and test?			
5	Are they documenting and reporting quality issues?			
6	Are they collaborating with other professionals to address quality issues?			
	Architects			
7	Are Architects involved in quality management during the design phase?			
8	Are they conducting site visits to ensure compliance with design specifications?			
9	Are they addressing quality issues related to design?			

	Engineers			
10	Are engineers involved in quality management during the construction phase?			
11	Are they conducting site visits to ensure compliance with engineering specifications?			
12	Are they addressing quality issues related to engineering?			
	Contractors			
13	Are contractors following quality management procedures?			
14	Are they conducting regular inspections and tests?			
15	Are they addressing quality issues promptly?			
	Regulation bodies			
16	Are regulatory bodies conducting regular site inspections?			
17	Are they enforcing quality standards and regulations?			
18	Are they addressing quality issues promptly?			
	Documentation and record keeping			
19	Are quality management documents and records being maintained?			
20	Are quality issues and resolutions being documented?			
21	Are records being kept up-to-date?			
	Communication and collaboration			
22	Are relevant professionals communicating and collaborating effectively?			
23	Are quality issues being shared and addressed promptly?			

APPENDIX III : MATERIAL LAB TEST RESULTS

Table A-6: Water sample test results

GETLAB LTD
YOUR RELIABLE ENGINEERING LABORATORY

Plot 1234, Block 197, Namirembe Hillside Road
P.O. Box 10000, Kiteezi Cell, Kasangati Town Council
Tel: +256392175833
Email: info@getlab.co.ug
Web: www.getlab.co.ug

TEST CERTIFICATE

CLIENT: MR.MUGAGGA DAVID

PROJECT: RESEARCH STUDY ON BUILDING MATERIALS

Issue Date: 5-Aug-23

Narrative Description:
One (1) Sample of Water was delivered to the Laboratory by the Client.

Serial No: P2023138-03

Test Report: GETL/TR/MGG/23/003

Received Date: 31-Jul-23

Location: Not Specified

Test Date: 1-Aug-23

SUMMARY OF THE LABORATORY TESTS ON WATER SAMPLE

S/No.	Test Parameter	Unit	Test Method	With Reference to Ministry of works specifications	Test Results
1	Chlorides	%	ASTM D512-12	Max. 0.01	0.005
2	Sulphates	%	ASTM D516-12	Max. 0.2	0.0356
3	pH	-	ASTM E70-19	5.0 - 8.0 @25°c	6.68
4	Alkalinity	%	ASTM D1067-16	0.015	0.0083
5	Oils and Grease	-	ASTM D3921-96	Not more than visible traces	No visible traces
6	Deleterious materials (Organic Impurities)	mg/L	LOI	0.03 - 0.05	0.042

Prepared by:
Laboratory Engineer (A.L.)

Checked by:
Senior Laboratory Engineer (O.T.A.)

Approved by:
Technical Manager (Eng. Dr. S.B.)

GETLAB
05 AUG 2023
Geotechnical Engineering & Technology Laboratory Ltd
P. O. Box 9529, K'la (U)

Notes:

1. DISCLAIMER-The results provided herein apply only to the samples that were tested
2. This test report shall not be reproduced except in full, without written approval of the laboratory
3. Interpretation of the results will be made at the request of the client/customer
4. NA-Not Applicable

---------END OF TEST CERTIFICATE---------

UNBS
Recognition No. UNBS/LRS/0015

Page 1 of 12

Table A-7: Coarse Aggregates Test results **,**Sample 1

GETLAB LTD

TEST CERTIFICATE

CLIENT: MR. MUGAGGA DAVID

PROJECT: RESEARCH STUDY ON BUILDING MATERIALS

Issue Date: 16-Sep-23

Serial No: [illegible]

Narrative Description:

One (1No.) Sample of Coarse aggregates was delivered to the Laboratory by the Client for Laboratory Analysis

Test Report: GETL/TR/MGG/23/217-001

Sample source: Not Specified

Sample Descriptions: 5-20mm Aggregates

SUMMARY OF THE LABORATORY TESTS ON COARSE AGGREGATES

S/No.	Test Parameter	Unit	Test Method	With Reference to project specification	Coarse Aggregates(5-20mm)
					[illegible]
1a	Ten Percent Fines Value (Wet)	kN	BS 812: PART 111:1990	Min.110	204.3
1b	Ten Percent Fines Value (dry)	kN	BS 812: PART 111:1990	Min.110	210.7
2	Aggregate Crushing Value (ACV)	%	BS 812: PART 110:1990	Max. 45	21.1
3	Water Absorption	%	ASTM C127	Max. 2	0.34

Prepared by: Laboratory Engineer (A.L.)

Checked by: Senior Laboratory Engineer (D.T.A.)

Approved by: Technical Manager [illegible]

GETLAB LTD

16 SEP 2023

Geotechnical Engineering & Technology Laboratory Ltd

P. O. Box 9529, K'la (U)

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3. Interpretation of the results will be made at the request of the client/customer
4. NA-Not Applicable

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Recognition No. UNBS/LRS/0015

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Table A-8: Coarse Aggregates Test results

GETLAB LTD
YOUR RELIABLE ENGINEERING LABORATORY

[illegible]

TEST CERTIFICATE

CLIENT: MR. MUGAGGA DAVID

PROJECT: RESEARCH STUDY ON BUILDING MATERIALS

Issue Date: 16-Sep-23

Serial No: [illegible]

Narrative Description:

One (1No.) Sample of Coarse aggregates was delivered to the Laboratory by the Client for Laboratory Analysis

Test Report: GETL/TR/MGG/23/217-002

Sample source: Not Specified

Sample Descriptions: 5-20mm Aggregates

SUMMARY OF THE LABORATORY TESTS ON COARSE AGGREGATES

S/No.	Test Parameter		Unit	Test Method	Specifications (BS 882, ASTM C33, EN 1744, EN 13620 and EN 206)	Coarse Aggregates(5-20mm)
						[illegible]
1a	Ten Percent Fines Value (Wet)		kN	BS 812: PART 111:1990	Min.110	121.2
1b	Ten Percent Fines Value (dry)		kN	BS 812: PART 111:1990	Min.115	159.7
2	Aggregate Impact Value (AIV)		%	BS 812: PART 112:1990	Max. 45	18.9
3	Aggregate Crushing Value (ACV)		%	BS 812: PART 110:1990	Max. 45	20.2
4	Deleterious materials (Clay and Friable Lumps)		%	ASTM C142	Max. 3	1.86
5	Bulk Density		g/cc	BS 812: PART 2:1995	-	1.587
6	Bulk Specific Gravity (Oven Dry)		-	ASTM C127	-	2.838
7	Bulk Specific Gravity (Saturated Sample)		-		-	2.544
8	Apparent Specific Gravity		-		-	2.655
9	Water Absorption		%		Max. 2	3.249
10	Flakiness Index		%	ASTM D 4791	Max. 40	12.34
11	Sodium Sulphate Soundness		%	BS 812: Part 121: 1995	Max. 12	0.84
12a	Particle Size Distribution (PSD)	Test sieve (mm)	% finer	With Reference to project specification	5-20mm	
12b		40			100	100.00
12c		20			85-100	78.09
12d		16			-	31.93
12e		12.50			-	22.59
12f		10.00			0-20	5.82
12g		4.75			0-5	0.38
12h		2.36			-	0.35

Prepared by:

Laboratory Engineer (A.L.)

Checked by:

Senior Laboratory Engineer (O.T.A.)

Approved by:

Technical Manager (Eng. Dr. S.B.)

GETLAB LTD

16 SEP 2023

Geotechnical Engineering & Technology Laboratory Ltd

P. O. Box 9529, K'la (U)

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4. NA-Not Applicable

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Table A-9: Coarse Aggregates Test results

GETLAB LTD

TEST CERTIFICATE

CLIENT: MR. MUGAGGA DAVID

PROJECT: RESEARCH STUDY ON BUILDING MATERIALS

Issue Date: 21-Sep-23

Serial No: [illegible]

Narrative Description:

One (1No.) Sample of Coarse aggregates was delivered to the Laboratory by the Client for Laboratory Analysis

Test Report: GETL/TR/MGG/23/217-003

Sample source: Not Specified

Sample Descriptions: 5-20mm Aggregates

SUMMARY OF THE LABORATORY TESTS ON COARSE AGGREGATES

S/No.	Test Parameter		Unit	Test Method	Specifications (BS 882, ASTM C33, EN 1744, EN 13520 and EN 206)	Coarse Aggregates(5-20mm)
						[illegible]
1a	Ten Percent Fines Value (Wet)		kN	BS 812: PART 111:1990	Min.110	190.8
1b	Ten Percent Fines Value (dry)		kN	BS 812: PART 111:1990	Min.110	178.4
2	Aggregate Impact Value (AIV)		%	BS 812: PART 112:1990	Max. 45	14.5
3	Aggregate Crushing Value (ACV)		%	BS 812: PART 110:1990	Max. 45	21.5
4	Deleterious materials (Clay and Friable Lumps)		%	ASTM C142	Max. 5	1.17
5	Loose Density		g/cc	BS 812: PART 2:1995	-	1.588
6	Bulk Specific Gravity (Oven Dry)		-	ASTM C127	-	2.58
7	Bulk Specific Gravity (Saturated Sample)		-		-	2.59
8	Apparent Specific Gravity		-		-	2.61
9	Water Absorption		%		Max. 2	0.316
10	Flakiness Index		%	ASTM D 4791	Max. 40	14.75
11	Sodium Sulphate Soundness		%	BS 812: Part 121:1995	Max. 12	3.17
12a	Particle Size Distribution (PSD)	Test sieve (mm)	% finer	With Reference to project specification	5-20mm	
12b		40			100	100.00
12c		20			85-100	88.42
12d		16			-	45.01
12e		12.50			-	18.58
12f		10.00			0-20	1.58
12g		4.75			0-5	0.29
12h		2.36			-	0.12

Prepared by: Laboratory Engineer (A.L.)

Checked by: Senior Laboratory Engineer (D.T.A.)

Approved by: Technical Manager (Eng. Dr. S.B.)

GETLAB LTD
21 SEP 2023
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P. O. Box 9529, K'la (U)

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4 NA-Not Applicable

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Table A-10: Coarse Aggregates Test results

ISSUE 01

GETLAB LTD

[illegible]

TEST CERTIFICATE

CLIENT: **MR. MUGAGGA DAVID**

PROJECT: **RESEARCH STUDY ON BUILDING MATERIALS**

Issue Date: 24-Sep-23

Serial No: [illegible]

Narrative Description:

One (1No.) Sample of Coarse aggregates was delivered to the Laboratory by the Client for Laboratory Analysis

Test Report: GETL/TR/MGG/23/217-006

Sample source: Not Specified

Sample Descriptions: 5-20mm Aggregates

SUMMARY OF THE LABORATORY TESTS ON COARSE AGGREGATES

S/No.	Test Parameter		Unit	Test Method	Specifications (BS 882, ASTM C33, EN 1744, EN 12620 and EN 206)	Coarse Aggregates(5-20mm)
						Results
1a	Ten Percent Fines Value (Wet)		kN	BS 812: PART 111:1990	Min.110	169.5
1b	Ten Percent Fines Value (dry)		kN	BS 812: PART 111:1990	Min.110	142.3
2	Aggregate Impact Value (AIV)		%	BS 812: PART 112:1990	Max. 45	17.3
3	Aggregate Crushing Value (ACV)		%	BS 812: PART 110:1990	Max. 45	19.1
4	Deleterious materials (Clay and Friable Lumps)		%	ASTM C142	Max. 5	2.12
5	Loose Density		g/cc	BS 812: PART 2:1995	-	1.586
6	Bulk Specific Gravity (Oven Dry)		-	ASTM C127	-	2.64
7	Bulk Specific Gravity (Saturated Sample)		-		-	2.66
8	Apparent Specific Gravity		-		-	2.68
9	Water Absorption		%		Max. 2	0.473
10	Flakiness Index		%	ASTM D 4791	Max. 40	15.60
11	Sodium Sulphate Soundness		%	BS 812: Part 121: 1989	Max. 12	3.11
12a	Particle Size Distribution (PSD)	Test sieve (mm)	% finer	With Reference to project specification	5-20mm	
12b		40			100	100.00
12c		20			85-100	97.90
12d		16			-	60.10
12e		12.50			-	21.80
12f		10.00			0-20	6.80
12g		4.75			0-5	0.38
12h		2.36			-	0.10

Prepared by:

Laboratory Engineer (A.L.)

Checked by:

Senior Laboratory Engineer (O.T.A.)

Approved by:

GETLAB LTD

Technical Manager (Eng. Dr. [illegible])

24 SEP 2023

Geotechnical Engineering & Technology Laboratory Ltd
P. O. Box 9529, K'la (U)

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4. NA-Not Applicable

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Table A-11: Coarse Aggregates Test results

GETLAB LTD

TEST CERTIFICATE

CLIENT: MR. MUGAGGA DAVID

PROJECT: RESEARCH STUDY ON BUILDING MATERIALS

Issue Date: 24-Sep-23

Serial No: [illegible]

Narrative Description:

One (1No.) Sample of Coarse aggregates was delivered to the Laboratory by the Client for Laboratory Analysis

Test Report: GETL/TR/MGG/23/217-006

Sample source: Not Specified

Sample Descriptions : 5-20mm Aggregates

SUMMARY OF THE LABORATORY TESTS ON COARSE AGGREGATES

S/No.	Test Parameter		Unit	Test Method	Specifications (BS 882, ASTM C33, EN 1744, EN 12620 and BS 206)	Coarse Aggregates(5-20mm)
						[illegible]
1a	Ten Percent Fines Value (Wet)		kN	BS 812: PART 111:1990	Min.110	168.5
1b	Ten Percent Fines Value (dry)		kN	BS 812: PART 111:1990	Min.110	142.3
2	Aggregate Impact Value (AIV)		%	BS 812: PART 112:1990	Max. 45	17.3
3	Aggregate Crushing Value (ACV)		%	BS 812: PART 110:1990	Max. 45	18.1
4	Deleterious materials (Clay and Friable Lumps)		%	ASTM C142	Max. 5	2.12
5	Loose Density		g/cc	BS 812: PART 2:1995	-	1.595
6	Bulk Specific Gravity (Oven Dry)		-	ASTM C127	-	2.53
7	Bulk Specific Gravity (Saturated Sample)		-	ASTM C127	-	2.54
8	Apparent Specific Gravity		-	ASTM C127	-	2.56
9	Water Absorption		%	ASTM C127	Max. 2	0.442
10	Flakiness Index		%	ASTM D 4791	Max. 40	14.82
11	Sodium Sulphate Soundness		%	BS 812: Part 121: 1989	Max. 12	2.71
12a	Particle Size Distribution (PSD)	Test sieve (mm)	% finer	With Reference to project specification	5-20mm	
12b		40			100	100.00
12c		20			85-100	98.75
12d		10			-	48.75
12e		12.50			-	23.40
12f		10.00			0-20	7.40
12g		4.75			0-5	2.20
12h		2.36			-	

Prepared by:

Laboratory Engineer (B.L.)

Checked by:

Senior Laboratory Engineer (D.T.A.)

Approved by:

Technical Manager (Eng. [illegible])

GETLAB LTD

24 SEP 2023

Geotechnical Engineering & Technology Laboratory Ltd

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4. NA-Not Applicable

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Table A-12: Coarse Aggregates Test results

GETLAB LTD
YOUR RELIABLE ENGINEERING LABORATORY

Plot 1234, Block 197, Namirembe Hillside Road.
P.O. Box 10000, Kitetika Cell, Kasangati Town Council.
Tel: +256392175833
Email: info@getlab.co.ug
Web: www.getlab.co.ug

TEST CERTIFICATE

CLIENT: MR. MUGAGGA DAVID

PROJECT: RESEARCH STUDY ON BUILDING MATERIALS

Issue Date: 27-Sep-23

Serial No: P2023-217-007

Narrative Description:

Four (4No.) Samples of aggregates were delivered to the Laboratory by the Client for Laboratory Analysis

Test Report: GETL/TR/MGG/23/217-007

Sample source: Not Specified

Sample Descriptions : 5-20mm Aggregates

SUMMARY OF THE LABORATORY TESTS ON COARSE AGGREGATES

SNo.	Test Parameter	Unit	Test Method	Specifications (BS 882, ASTM C33, EN 1744, EN 12620 and EN 206)	AGGREGATE SIZES			
					20/14mm	14/10mm	10/6mm	6/0mm
1	Ten Percent Fines Value (Wet)	kN	BS 812: PART	Min.110	-	192.7	-	-
2	Ten Percent Fines Value (dry)	kN	BS 812: PART	Min.110	-	195	-	-
3	Aggregate Impact Value (AIV)	%	BS 812: PART	Max. 25	-	19.9	-	-
4	Aggregate Crushing Value (ACV)	%	BS 812: PART 110:1990	Max. 30	-	24.4	-	-
5	Los Angeles Abrasion Test (LAA)	%	ASTM 539 - 89	Max. 50	-	-	26.4	-
6	Sodium Sulphate Soundness	%	ASTM C88-90	Max. 12	-	-	3.41	-
7	Stripping And coarting	%	EN1269-2005 PART B	20-100	-	-	98	-
8	Stripping And coarting	%	EN1269-2005 PART C	20-100	-	-	96.7	-
9	Bulk Specific Gravity (Oven Dry)	-	ASTM C127	-	2.638	2.631	2.609	2.66
10	Bulk Specific Gravity (Saturated Sample)	-	ASTM C127	-	2.667	2.644	2.624	2.67
11	Apparent Specific Gravity	-	ASTM C127	-	2.667	2.666	2.65	2.7
12	Water absorption	%	ASTM C127	Max. 2	0.41	0.51	0.59	0.56
13	Flakiness Index	%	ASTM 4791-10	Max. 40	13.87	16.9	12.23	-
14	Elongation index	%	ASTM 4791-10	-	14.3	19.2	4	-
15	Atterberg's Limits	Liquid Limit	%	BS 1377: Part 2: 1990 -	-	-	-	16.3
16	Atterberg's Limits	Plastic Limit	%	BS 1377: Part 2: 1990 -	-	-	-	NP
17	Atterberg's Limits	Plasticity Index	%	BS 1377: Part 2: 1990 -	-	-	-	NP
18	Atterberg's Limits	Linear Shrinkage	%	BS 1377: Part 2: 1990 -	-	-	-	1.4
19	Silt Content	%	BS EN 933-1:2012	Max. 5	-	-	-	7.2
20	Sand Equivalent	%	AASHTO T176-96	Min. 75	-	-	-	93.6
21	Particle Size Distribution (PSD)	Test sieve (mm)	% finer	BS 812-103.1 1985	20/14mm	14/10mm	10/6mm	6/0mm
22		37.5		-	100.0	100.0	100.0	100.0
23		20		-	100.0	100.0	100.0	100.0
24		14		-	44.4	96.9	100.0	100.0
25		10		-	10.6	26.1	97.9	99.4
26		5		-	3.1	0.6	3.5	95.2
27		2.36		-	0.6	0.4	0.3	75.0
28		1.18		-	0.3	0.3	0.2	60.8
29		0.6		-	0.2	0.3	0.1	48.0
30		0.3		-	0.1	0.3	0.1	29.3
31		0.15		-	0.1	0.3	0.1	12.7
32		0.075		-	0.0	0.2	0.0	6.1

Prepared by: Laboratory Engineer (A.L.)

Checked by: Senior Laboratory Engineer (O.T.A.)

Approved by: Technical Manager (Eng. Dr. S.B.)

GETLAB LTD 27 SEP 2023 Geotechnical Engineering & Technology Laboratory Ltd P. O. Box 9529, K'la (U)

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Table A-13: Coarse Aggregates Test results

FITR /07 ISSUE 01

GETLAB LTD
YOUR RELIABLE ENGINEERING LABORATORY

TEST CERTIFICATE

CLIENT: MR. MUGAGGA DAVID

PROJECT: RESEARCH STUDY ON BUILDING MATERIALS

Issue Date: 17-Oct-2023

Narrative Description:
One (1) Sample of CRS was delivered to the Laboratory by the client for Laboratory Analysis

Serial No: P2023-217-008

Test Report: GETL/TR/MGG/23/217-008

Location: Not Specified

Test Date: 11-Oct-2023

Date Received: 6-Oct-2023

SUMMARY OF THE LABORATORY TESTS ON CRS MATERIAL

S/No.	Test Parameter		Unit	Test Method	With Reference to project specification	Coarse Aggregates (CRS)
						[illegible]
1	Ten Percent Fines Value (dry)		kN	BS 812: PART 111:1990	Min.110	340.0
2	Aggregate Crushing Value (ACV)		%	BS 812: PART 110:1990	Max. 45	23.6
3	Flakiness Index		%	ASTM D4791	Max. 25	16.50
4	Soluble Salts (Chlorides)		%	ACI-318	Max. 0.15	0.037
5	Soluble Salts (Sulphates)		%	ACI-319	Max. 0.20	0.018
6	Bulk Specific Gravity (Oven Dry)		-	ASTM C127	-	2.67
7	Bulk Specific Gravity (SSD)		-		-	2.67
8	Apparent Specific Gravity		-		-	2.68
9	Water Absorption		%		Max. 2	0.22
10	Maximum Dry Density and Optimum Moisture Content		kg/m^3 and %	BS 1377-Part 4:1990	-	2.316 and 5.5
11	Particle Size Distribution (PSD)	Test sieve (mm)	% finer	MoWT General Specification (Coarse CRS)	Limits	Percentage Passing
11.1		50.00			100	100.0
11.2		37.50			90-100	100.0
11.3		28.00			75-95	94.1
11.4		20.00			60-90	65.5
11.5		10.00			40-75	36.5
11.6		5.00			29-65	23.8
11.7		2.00			20-45	16.9
11.8		1.180			17-40	14.4
11.9		0.425			12-31	10.9
11.10		0.075			5-12	6.0

Prepared by: Laboratory Engineer (A.L.)

Checked by: Senior Laboratory Engineer (D.T.A.)

Approved by: Technical Manager (Eng. Dr. S.B.)

GETLAB LTD
17 OCT 2023
Geotechnical Engineering & Technology Laboratory Ltd
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4. NA-Not Applicable

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Table A-14: Coarse Aggregates Test results

FTR /07 ISSUE 01

GETLAB LTD
YOUR RELIABLE ENGINEERING LABORATORY

Plot 1234 Block 197, Namasere Hillside Road
P.o Box 100001, Kitetika cell, Kasangati Town council
Tel: +256 392175660
Email: info@getlab.co.ug
Web: www.getlab.co.ug

TEST CERTIFICATE

CLIENT: MR. MUGAGGA DAVID

PROJECT: RESEARCH STUDY ON BUILDING MATERIALS

Issue Date: 22-Oct-2023

Narrative Description:

One (1) Sample of CRS was delivered to the Laboratory by the client for Laboratory Analysis

Serial No: P2023-217-010

Test Report: GETL/TR/MGG/23/217-010

Location: Not Specified

Test Date: 16-Oct-2023

Date Received: 11-Oct-2023

SUMMARY OF THE LABORATORY TESTS ON CRS MATERIAL

S/No.	Test Parameter		Unit	Test Method	With Reference to project specification	Coarse Aggregates (CRS)
						GA/23/187
1	Ten Percent Fines Value (dry)		kN	BS 812: PART 111:1990	Min.110	314.4
2	Aggregate Crushing Value (ACV)		%	BS 812: PART 110:1990	Max. 45	25.5
3	Flakiness Index		%	ASTM D4791	Max. 25	17.80
4	Soluble Salts (Chlorides)		%	ACI-318	Max. 0.15	0.0019
5	Soluble Salts (Sulphates)		%	ACI-318	Max. 0.20	0.0042
6	Bulk Specific Gravity (Oven Dry)		-	ASTM C127	-	2.68
7	Bulk Specific Gravity (SSD)		-		-	2.69
8	Apparent Specific Gravity		-		-	2.69
9	Water Absorption		%		Max. 2	0.14
10	Maximum Dry Density and Optimum Moisture Content		kg/m^3 and %	BS 1377-Part 4:1990	-	2.237 and 7.7
11	Particle Size Distribution (PSD)	Test sieve (mm)	% finer	MoWT General Specification (Coarse CRS)	Limits	Percentage Passing
11.1		50.00			100	100.0
11.2		37.50			90-100	100.0
11.3		28.00			75-95	98.2
11.4		20.00			60-90	75.0
11.5		10.00			40-75	41.8
11.6		5.00			29-65	27.8
11.7		2.00			20-45	19.8
11.8		1.180			17-40	16.9
11.9		0.425			12-31	12.8
11.10		0.075			5-12	6.8

Prepared by:

Laboratory Engineer (A.L.)

Checked by:

Senior Laboratory Engineer (O.T.A.)

Approved by:

Technical Manager (Eng. Dr. S.B.)

GETLAB LTD
22 OCT 2023
Geotechnical Engineering & Technology Laboratory Ltd
P. O. Box 9529, K'la (U)

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4. NA-Not Applicable

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Table A-15: Coarse Aggregates Test results

GETLAB LTD

TEST CERTIFICATE

CLIENT: MR. MUGAGGA DAVID

PROJECT: RESEARCH STUDY ON BUILDING MATERIALS

Issue Date: 16-Sep-23

Serial No: [illegible]

Narrative Description:

One (1No.) Sample of Coarse aggregates was delivered to the Laboratory by the Client for Laboratory Analysis

Test Report: GETL/TR/MGG/23/017-011

Sample source: Not Specified

Sample Descriptions: 5-20mm Aggregates

SUMMARY OF THE LABORATORY TESTS ON COARSE AGGREGATES

S/No.	Test Parameter		Unit	Test Method	Specifications [illegible]	Coarse Aggregates(5-20mm)
						[illegible]
1a	Ten Percent Fines Value (Wet)		kN	BS 812: PART 111:1990	Min.110	112.5
1b	Ten Percent Fines Value (dry)		kN	BS 812: PART 111:1990	Min.110	126.9
2	Aggregate Impact Value (AIV)		%	BS 812: PART 112:1990	Max. 45	27.6
3	Aggregate Crushing Value (ACV)		%	BS 812: PART 110:1990	Max. 45	26.3
4	Deleterious materials (Clay and Friable Lumps)		%	ASTM C142	Max. 5	0.58
5	Bulk Density		g/ml	BS 812: PART 2:1995	-	1.578
6	Bulk Specific Gravity (Oven Dry)		-	ASTM C127	-	2.69
7	Bulk Specific Gravity (Saturated Sample)		-	ASTM C127	-	2.71
8	Apparent Specific Gravity		-	ASTM C127	-	2.73
9	Water Absorption		%	ASTM C127	Max. 2	0.438
10	Flakiness Index		%	ASTM D 4791	Max. 40	14.19
11	Sodium Sulphate Soundness		%	BS 812: Part 121: 1995	Max. 12	0.94
12a	Particle Size Distribution (PSD)	Test sieve (mm)	% Pass	With Reference to project specification	5-20mm	
12b		40			100	100.00
12c		20			85-100	75.88
12d		16			-	24.84
12e		12.50			-	11.51
12f		10.00			0-20	3.83
12g		4.75			0-5	0.94
12h		2.36			-	0.33

Prepared by: Laboratory Engineer (A.L.)

Checked by: Senior Laboratory Engineer (O.T.A.)

Approved by: Technical Manager (Eng. Dr. [illegible])

GETLAB LTD

16 SEP 2023

Geotechnical Engineering & Technology Laboratory Ltd P. O. Box 9529, K'la (U)

Notes:

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2. This test report shall not be reproduced except in full, without written approval of the laboratory
3. Interpretation of the results will be made at the request of the client/customer
4. NA-Not Applicable

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Table A-16: Fine Aggregates Test results

GETLAB LTD
YOUR RELIABLE ENGINEERING LABORATORY

Plot 1234, Block 197, Namirembe Hillside Road
P.O. Box 10000, Kitetika Cell, Kasangati Town Council
Tel: +256392175833
Email: info@getlab.co.ug
Web: www.getlab.co.ug

TEST CERTIFICATE

CLIENT: **MR. MUGAGGA DAVID**

PROJECT: **RESEARCH STUDY ON BUILDING MATERIALS**

Issue Date: 30-Oct-23

Serial No: P2023-217-012

Narrative Description:
One (1No.) Sample of Coarse aggregates was delivered to the Laboratory by the Client for Laboratory Analysis

Test Report: GETL/TR/MGG/23/217-012

Sample source: Not Specified

Sample Descriptions : Fine Aggregates

SUMMARY OF THE LABORATORY TESTS ON FINE AGGREGATES

S/No.	Percent Passing Sieve (mm)																Silt Content
	75.0	50.0	37.5	28.0	20.0	14.0	10.0	6.3	5.0	2.0	1.2	0.6	0.425	0.3	0.15	0.075	(%)
1	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5	99.1	90.8	72.2	32.1	20.8	14.8	5.7	2.1	3.7
2	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.5	99.1	90.7	72.1	31.9	20.3	14.3	5.2	1.8	3.4
3	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.1	98.1	86.5	72.2	53.5	40.3	27.2	9.4	6.1	3.8
4	100.0	100.0	100.0	100.0	93.5	91.8	90.9	90.1	89.2	80.2	65.4	36.1	19.2	9.9	2.3	1.2	4.0
5	100.0	100.0	100.0	96.9	93.6	92.0	91.2	90.4	89.5	80.7	66.2	37.7	21.2	12.1	4.7	3.6	2.6
6	100.0	100.0	100.0	100.0	100.0	99.1	98.4	96.9	96.1	90.8	81.0	54.5	30.6	15.2	2.4	1.1	0.9
7	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.9	98.6	91.2	76.3	57.9	23.9	16.3	10.2
8	100.0	100.0	100.0	100.0	100.0	98.8	96.2	91.2	88.2	60.5	43.6	27.3	21.2	15.3	6.9	5.4	4.7
9	100.0	100.0	100.0	100.0	100.0	99.2	96.8	93.1	90.8	75.0	63.1	49.0	41.4	33.5	20.9	15.5	9.3
10	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.8	98.2	79.5	59.7	43.6	20.5	14.3	6.7
11	100.0	100.0	100.0	100.0	100.0	100.0	100.0	99.9	99.5	91.9	73.9	34.4	19.6	12.7	7.0	5.7	5.2
12	100.0	100.0	100.0	100.0	95.0	93.3	91.8	90.8	90.3	77.2	65.5	52.6	45.7	38.6	22.0	16.3	8.6
13	100.0	100.0	100.0	100.0	97.5	96.6	93.6	91.1	89.5	76.0	62.3	48.0	42.4	35.2	2.8	1.0	2.7

Prepared by:

Laboratory Engineer (A.L.,)

Checked by:

Senior Laboratory Engineer (O.T.A.)

Approved by:

Technical Manager (Eng. Dr. S.B.)

GETLAB
30 OCT 2023
Geotechnical Engineering & Technology Laboratory Ltd
P. O. Box 9529, K'la (U)

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APPENDIX IV : Data Analysis Tables

Table A-17: Role of Respondent at the construction site

What is your role at the construction site					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	site manager	19	12.0	12.0	12.0
	Quality control officer	2	1.2	1.2	13.3
	Engineer	63	29.8	29.8	53.0
	Contractor	13	8.4	8.4	61.4
	Architect	58	26.1	26.1	97.6
	Site Foreman	4	22.4	22.4	100.0
	Total`	159	100.0	100.0	

Table A-18: Qualification of respondent at construction site

Qualification of construction site workers					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Certificate	26	16.9	16.9	16.9
	Diploma	51	38.6	38.6	55.4
	Bachelors Degree	63	43.3	43.3	98.8
	PhD	19	1.2	1.2	100.0
	Total	159	100.0	100.0	

Table A-19: Years of experience of respondent in the construction Industry

Years of experience in the construction Industry					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	0-5	19	12.0	12.0	12.0
	6-10	59	37.3	37.3	49.4
	11-15	38	24.1	24.1	73.5
	16-20	33	20.5	20.5	94.0
	21 and above	9	6.0	6.0	100.0
	Total	159	100.0	100.0	

Table A-20: Response of Regulatory bodieson conducting regular site inspections

Regulatory bodies conducting regular site inspections					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	3	30.1	30.1	30.1
	No	7	69.9	69.9	100.0
	Total	10	100.0	100.0	

Table A-21: Response from Architects conducting site visits to ensure compliance with design specifications

Architects conducting site visits to ensure compliance with design specifications					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	13	68.7	68.7	68.7
	No	6	31.3	31.3	100.0

	Total	19	100.0	100.0	

Table A-22: Descriptive Statistics

Descriptive Statistics				
Description	Min	Max	Mean	SD
What is your role at the construction site	1	10	3.7229	1.64771
What is your Qualification	1	5	2.3012	0.79226
How many years of experience in the construction Industry	1	5	2.7108	1.11015
Who is responsible for managing materials on this construction site	1	3	2.2289	0.90156
What procedures are in place for receiving and storing the bulk materials:Inspect for visible defects or contamination	1	2	1.0843	0.27958
What procedures are in place for receiving and storing the bulk materials;Designate a specific storage area	1	2	1.2169	0.41462
what procedures are in place for receiving and storing the bulk materials:Verification of the quantity and type of materials	1	2	1.1446	0.35381
What procedures are in place for receiving and storing the bulk materials:proper lifting and handling using proper lifting techniques and equipments	1	2	1.5783	0.49683
What procedures are in place for receiving and storing the bulk materials:Is there a designated area for storing material separate from others	1	2	1.241	0.43027
What procedures are in place for receiving and storing the bulk materials:Are materials covered during transportation and storage to protect from rain and moisture	1	2	1.5181	0.50271
What procedures are in place for receiving and storing the bulk materials:Site cleanliness and organiation of the storage area	1	2	1.506	0.503
How are materials inspected and tested for quality compliance :By Visual Inspection	1	2	1.9157	0.27958
How are materials inspected and tested for quality compliance:Document review	1	2	1.1928	0.39687

How are materials inspected and tested for quality compliance:Testing and sampling	1	2	1.9036	0.29691
How are materials inspected and tested for quality compliance:Comparison with Specification	1	2	1.6867	0.46664
How are materials inspected and tested for quality compliance:Others	1	2	1.6627	0.47568
What quality control measures are in place for the bulk materials	1	4	1.1446	0.44537
How often do you conduct quality control checks on the bulk materials	1	5	1.9036	1.04315
What is the average percentage of defective bulk materials detected during quality control	1	5	1.9518	0.9741
How many times have you rejected bulk materials due to quality issues in the past six months	1	5	1.8795	1.04061
What is the average cost of replacing defective bulk materials	1	5	2.8554	1.51523
Have you experienced any challenges in managing bulk materials on this construction site	1	2	1.29	0.458
How important is materials management in ensuring the quality of bulk materials	4	5	4.8554	0.35381
How effective are your current materials management practices in preventing quality issues with bulk materials	2	5	3.6145	0.99794
Have you experienced any issues with quality of bulk materials during this project	1	4	1.3373	0.54721
Have you noticed any correlation between materials management practices and the frequency of quality issues with bulk materials	1	2	1.0602	0.23938
How often do you conduct site inspections to ensure quality control	1	3	1.3902	0.60361
What percentage of construction projects have you worked on that had quality issues	1	5	1.6747	0.81313
How effective do you think regulatory bodies are in enforcing quality standards	1	5	2.747	1.22816
How important is quality management in your work	1	4	1.3494	0.75601
How confident are you in your ability to identify quality issues at construction sites	1	4	1.5422	0.78556
How effective do you think quality management is preventing defects and rework	1	5	1.3012	0.83717

Is the site manager actively involved in quality management	1	2	1.2289	0.42269
Are they conducting Regular site Inspections	1	2	1.1687	0.37674
Are they addressing quality issues promptly	1	2	1.4458	0.50007
Are quality control engineers conducting regular inspections and tests	1	2	1.7229	0.45029
Are they documenting and reporting quality issues	1	2	1.6386	0.48334
Are they Collaborating with other proffessionals to address quality issues	1	2	1.6506	0.47968
Are Architects involved in quality management during the design phase	1	2	1.1566	0.36566
Are they conducting site visits to ensure compliance with design specifications	1	2	1.3133	0.46664
Are they addressing quality issues related to design	1	2	1.3133	0.46664
Are Engineers involved in quality management during the construction phase	1	2	1.0361	0.18778
Are they conducting site visits to ensure compliance with engineering specifications	1	2	1.0361	0.18778
Are they addressing quality issues related to engineering	1	2	1.1687	0.37674
Are contractors following quality management procedures	1	2	1.4819	0.50271
Are they conducting regular inspections and tests	1	2	1.4578	0.50125
Are they addressing quality issues promptly	1	2	1.6024	0.49238
Are regulatory bodies conducting regular site inspections	1	2	1.6988	0.46157
Are they enforcing quality standards and regulations	1	2	1.6988	0.46157
Are they addressing quality issues promptly	1	2	1.7711	0.42269
Are quality management documents and records being maintained	1	2	1.4578	0.50125

Are quality issues and resolutions being documented	1	2	1.6506	0.47968
Are records being kept up-to-date	1	2	1.6024	0.49238
Are relevant proffessionals communicating and collaborating effectively	1	2	1.4096	0.49476
Are quality issues being shared and addressed promptly	1	2	1.4819	0.50271
Are there clear lines of communication and authority	1	2	1.5422	0.50125
Are relevant professionals trained in quality management	1	2	1.4819	0.50271
Are they competent in their roles and responsibilities	1	2	1.3253	0.47134
Are they staying up to date with industry developments and best practices	1	2	1.5904	0.49476
Is a quality management system in place	1	2	1.6265	0.48667
Are procedures and protocols being followed	1	2	1.7108	0.45613
Are quality objectives being met	1	2	1.6627	0.47568

Table A-23:Description of challenges in managing bulk materials on this construction site

Challenges in managing bulk materials on this construction site						
		Frequency	Percent	Valid Percent	Cumulative Percent	Rank
Valid	Clients prefer procuring cheap aand poor quality materials	2	1.2	1.2	1.2	7
	Construction delays due to reworks and rejected materials	2	1.2	1.2	2.4	7
	Grading ,cleanliness and contamination	12	8.4	8.4	10.8	5
	Limited and unprotected Storage space at the construction sites	26	13.3	13.3	24.1	4
	Materials are sometimes not well graded and contaminated	2	1.2	1.2	25.3	7
	Materials storage in unprotected environment	7	4.8	4.8	30.1	6
	Materials vary according to source and sometimes not meet the required specifications	33	21.7	21.7	51.8	2
	Not applicable	37	24.1	24.1	75.9	1

	Not Applicable	4	2.4	2.4	78.3	
	Scarcity and expensive good quality materials	28	18.1	18.1	96.4	3
	Some materials supplied are not well graded and contaminated	2	1.2	1.2	97.6	7
	Suplied materials not conforming to specifications	2	1.2	1.2	98.8	7
	Thefty of materials from site	2	1.2	1.2	100.0	7
	Total	159	100.0	100.0		

Table A-24: Correlations

Correlations									
	Have you experienced any issues with quality of bulk materials during this project	Have you noticed any correlation between materials management practices and the frequency of quality issues with bulk materials	How often do you conduct site inspections to ensure quality control	What percentage of construction projects have you worked on that had quality issues	How effective do you think regulatory bodies are in enforcing quality standards	How important is quality management in your work	How confident are you in your ability to identify quality issues at construction sites	How effective do you think quality management is preventing defects and rework

Have you experienced any issues with quality of bulk materials during this project	Pearson Correlation	1	-0.064	0.003	-0.189	-.325**	-0.112	-.317**	0.095
	Sig. (2-tailed)		0.566	0.981	0.087	0.003	0.316	0.003	0.393
	N	159	159	159	159	159	159	159	159
Have you noticed any correlation between materials management practices and the frequency of quality issues with bulk materials	Pearson Correlation	-0.064	1	.259*	0.039	0.135	0.017	0.213	0.091
	Sig. (2-tailed)	0.566		0.019	0.725	0.222	0.878	0.053	0.414
	N	159	159	159	159	159	159	159	159
How often do you conduct site inspections to ensure quality control	Pearson Correlation	0.003	.259*	1	-0.112	-.245*	-0.035	0.037	0.03
	Sig. (2-tailed)	0.981	0.019		0.318	0.026	0.752	0.739	0.787
	N	159	159	159	159	159	159	159	159
What percentage of construction projects have you worked on that had quality issues	Pearson Correlation	-0.189	0.039	-0.112	1	.393**	.505**	-0.026	.217*
	Sig. (2-tailed)	0.087	0.725	0.318		0	0	0.816	0.048
	N	159	159	159	159	159	159	159	159
How effective do you think regulatory bodies	Pearson Correlation	-.325**	0.135	-.245*	.393**	1	.359**	.346**	0.158

are in enforcing quality standards	Sig. (2-tailed)	0.003	0.222	0.026	0		0.001	0.001	0.154
	N	159	159	159	159	159	159	159	159
How important is quality management in your work	Pearson Correlation	-0.112	0.017	-0.035	.505**	.359**	1	0.108	.256*
	Sig. (2-tailed)	0.316	0.878	0.752	0	0.001		0.329	0.02
	N	159	159	159	159	159	159	159	159
How confident are you in your ability to identify quality issues at construction sites	Pearson Correlation	-.317**	0.213	0.037	-0.026	.346**	0.108	1	-0.029
	Sig. (2-tailed)	0.003	0.053	0.739	0.816	0.001	0.329		0.796
	N	159	159	159	159	159	159	159	159
How effective do you think quality management is preventing defects and rework	Pearson Correlation	0.095	0.091	0.03	.217*	0.158	.256*	-0.029	1
	Sig. (2-tailed)	0.393	0.414	0.787	0.048	0.154	0.02	0.796	
	N	159	159	159	159	159	159	159	159
**. Correlation is significant at the 0.01 level (2-tailed).									
*. Correlation is significant at the 0.05 level (2-tailed).									

APPENDIX V : Pagiarism Report