EFFECT OF BLENDING SAND FROM DIFFERENT SOURCES ON COMPRESIVE STRENGTH OF CONCRETE 'CASE STUDY OF WESTERN KENYA'

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A thesis submitted to the School of Environment and the Built Environment in partial fulfillment of the requirement for the award of Degree of Master of Science in Structural Engineering of Masinde Muliro University of Science and Technology

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DECLARATION

This thesis is my original work prepared with no other than the indicated sources support and has not been presented elsewhere for a degree or any other award.

Sign ……………………………………………Date ………………………………

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for approval of Masinde Muliro University of Science and Technology research thesis entitled '**Effect of Blending Sand from Different Sources on Strength of Concrete: Case Study of Western Kenya'**

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DEDICATION

This project is dedicated to my daughters Cynthia and Mary for their much-needed understanding.

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I wish to record my sincere gratitude to all those who contributed in various ways towards the completion of this study.

I am especially grateful to my supervisor, Prof. Khaemba and Dr. Waweru for their guidance and advice. I am also grateful to my lecturers, fellow students,the staff of Materials Testing and Research Department laboratory in Kakamega.

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ABSTRACT

This study revolves around the effect of using blended sand from various sand sources which exhibit different formation process. Previous research has extensively examined sand properties according to standards such as BS 812 and KS-02-21. However, limited information is available concerning the blending of sands from diverse sources, encompassing their properties and contribution of silt content, to optimize concrete production. Therefore, the study is to address the application of blending to enhance a sustainable use of sand within the construction industry. This study aims to assess silt levels of sand in use and its effect on concrete compressive strength. In examining the impact of utilizing blended sands from 13 sources, characterized by varying silt content, on concrete strength within the context of western Kenya. To achieve this objectives, an experimental method approach was adopted, involving the sampling of sands from different formation of pits, river bed, seasonal rivers beds and lake shores in 13 sand mining sites. Silt content analysis on neat sand revealed values ranging from 2.4% to a maximum of 24.1%, with a prescribed limit of 4% as per BS 812. Concrete specimens made solely from the sampled neat sands exhibited compressive strengths of 18.33 kN/m^2. and 28.94 kN/m^2. Blending experiments were conducted using sand mix proportions of 10%, 30%, and 50% blended sand, leading to improvements in silt content of up to an average of 48%, contingent on the initial silt content of the blending sand. Applying a design mix with a target strength of 25 kN/m^2, results indicated that an average of 42% of the blended sand mixtures achieved the specified target strength. To interpret the findings, a Regression analysis tool was employed in the simulations with respect to silt content, water content, workability and compressive strength . This research affirms the presence of silt content within the sands, exerting a discernible influence on concrete strength. Furthermore, blending strategies exhibited a dual benefit of enhancing silt content and improvement on concrete strength. The practical implications of this study extend to the development of sand mix and the guidance it offers to counties in western Kenya, enabling them to establish sand blending standards, formulate sand use guidelines, and identify optimal sand sources within the study region. Consequently, this research contributes to the refinement of concrete production processes and promotes the sustainability of construction practices within the studied area.

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ACRONYMS

ASTM	American Standards of Testing and Materials
BS	British Standards
CEM	Cement
CIDP	County Integrated Development Plan
Cu	Uniformity Coefficient
DIA	Dynamic Image Analysis
DV	Dependent Values
ITCZ	Inter-tropical Convergence Zone
IQSK	Institute of Quantity Surveyors of Kenya
IS	Indian Standards
KEBS	Kenya Bureau of Standards
KNBS	Kenya National Bureau of Statistics
KPHC	Kenya National Population and Housing Census
KS	Kenyan Standards
MFA	Manufactured Fine Aggregates
MS	Marine Sand
M-S	Manufactured Sand
NCA	National Construction Authority
PPP	Public-Private Partnership
SLS	Laser Light Scattering
UTM	Universal Testing Machine
W/C	Water Cement Ratio

CHAPTER ONE

INTRODUCTION

1.1 Background information

The majority of structures in Kenya are characterized by low-rise architecture, particularly within urban centers. The Ministry of Housing is actively advocating for a low-cost, affordable housing strategy, a directive that has greatly influenced the construction landscape. This approach predominantly targets both private and institutional projects falling under the categories of low-cost and low-rise buildings. A pertinent reference, the 2019 Kenya National Bureau of Statistics Census, specifically the Kenya National Population and Housing Census (KPHC) Volumes 1, 11, and III, highlighted that the city of Nairobi alone accommodates approximately 4.3 million residents.

Integral to the Vision 2030 initiative is the comprehensive framework encapsulated in the fourth government action plan. At the heart of this agenda lies the ambitious project of affordable housing, a cornerstone that despite sizeable financial allocations over the past biennium, as reported by Kenya Wall Street on June 14, 2019, amounting to Two Billion Kenya Shillings, still falls short of the burgeoning national housing requirements. This deficiency is being redressed through private sector involvement within the construction investment sector, primarily executed under the Public-Private Partnership (PPP) framework.

Scrutinizing the period spanning from 2003 to 2022, an analysis of building collapses, as documented in the annual reports of NCA Building Audit reports of 2018-2022, draws attention to a recurring issue of substandard construction materials.

Notably, numerous investigative committees have underscored the role of poor-quality materials in these incidents. In march , 2019 the standard newspaper reported a tragic incident unfolded in Butali Kakamega, where a building collapse resulted in the loss of three lives. Initial probes indicated the utilization of subpar materials, resulting in concrete with diminished strength.

The NCA Report for 2021 underscores a distressing trend, revealing that the nation has witnessed 87 building collapses in the past five years, leading to an estimated toll of 200 fatalities and over 1,000 injuries. Among these incidents, residential structures constituted 65%, with commercial and mixed-use developments accounting for 25% and 10%, respectively. Furthermore, an analysis of these occurrences indicates that 66% of collapses transpired post-completion, while 34% transpired during the construction phase. Notably, the quality of materials emerges as a pivotal factor within the context of construction integrity, as per NCA's findings.

The BS 812 standard designates a maximum allowable silt content of 4% in sand. The challenges faced stem from the utilization of sand sourced from unspecified origins. This is compounded by the absence of comprehensive data on sand quality across various sources within the study area and the lack of an established regulatory framework for sand, as highlighted in the Makueni Act of 2015.

In common practice, when sand is procured from its source, it undergoes testing in accordance with BS1377 standards to quantify its silt content. Sand falling within acceptable limits is employed, while that exceeding the specified limits is rejected and removed from the site. This stringent approach is due to the potential consequences of high silt content, which can lead to reduced concrete strength and, consequently, structural failures during service. Instances such as the Huruma Building Collapse (Nairobi,7th June, 2016), Synagogue Church Building Collapse (The Nairobian, 2014), and Tassia Building Collapse (Daily Nation ,9th Nov 2019) underscore the importance of adhering to these quality standards.

Addressing this issue, blending emerges as a prospective solution for engineering practitioners to enhance concrete quality and establish a reliable basis for sand usage, guided by known quality parameters. This approach also lays the foundation for formulating localized guidelines governing the practice of sand blending.

In the context of Kisumu, sand suppliers currently employ a practice of mixing high-quality, clean sand with coarse, contaminated sand gathered from unknown sites and at the very worst the roadside and other locations. Visual inspections and manual silt tests suggest the presence of substantial silt and deleterious materials in these mixed sands.

The blending process typically occurs either at collection points or within material stockpiles managed by vendors. In all the aforementioned scenarios, preliminary investigations consistently highlight concrete as a focal point, thus sparking a profound interest in the quality of constituent materials. This extends to scrutinizing the processes encompassing batching, mixing, and placement, and their subsequent impact on compressive strength. With a multitude of concurrent construction sites, it is conceivable that two sites may share similar concrete specifications and mix designs, yet their production methods could markedly differ. Comprehensive studies have indeed explored these production variations.

There is an imperative to delve into an exploration of the procedural intricacies entailed in the properties of natural materials exploited in construction.

This involves an in-depth examination of the properties and extraction sequence of individual materials up to the point of application. This process-oriented investigation encompasses quality assessment through rigorous testing, with the resultant insights being applied to the active construction sites. It is noteworthy, however, that a deficiency in as-built analysis data exists, as the occupation certificates, while regarded as approved, lack the specific delineation of required tests, as defined by the 1968 Kenyan Building Code.

The elemental components of concrete production primarily encompass aggregates (both fine and coarse), cement, water, and, where relevant, admixtures. The evaluation of the quality of coarse aggregates (ballast) and cement is relatively straightforward, as it hinges upon specifications issued by KEBS or individual factories or quarries. However, assessing the quality of sand necessitates meticulous testing. As the study area was prepared, it became evident that significant attention centered around the quality of sand. This was underscored by practices involving the blending of clean river sand with sand sourced from non-designated origins, including road ditches. This amalgamation of sands, often used in locations like Kisumu, gives rise to an uncertain quality dimension.

This overarching premise fuels the need for comprehensive research, including investigative assessments and rigorous testing. The ultimate objective is to gauge the extent of influence on concrete quality and its potential contribution to structural failures. Notably, while there exist analogous studies characterizing different sand types, the focus on blending clean river sand with non-designated sources, such as road-derived deposits on one end and blending of sand from different sources, remains unexplored. This realization prompted the identification of 16 distinct sand sites across Kisumu, Siaya, Vihiga, and Busia collectively constituting western Kenya—of which 13 were subjected to a comprehensive investigative analysis.

1.2 Problem Statement

An emerging practice involves indiscriminately utilizing sand from various sources, occasionally mixing substandard sand with higher-quality variants to achieve a desired color in the sand. This practice poses a potential detriment to the overall quality of the resultant concrete, and while immediate failure may not be evident, structural issues may become apparent under cyclic loading conditions, particularly concerning serviceability.

To mitigate this concern, there is a need to establish a scientific engineering approach that comprehensively investigates the impact of blending sand from different sources on the compressive strength of concrete. Furthermore, addressing the engineering properties of sand to formulate a well-considered sand design mix is imperative to provide a viable solution."

Fine aggregates are required to originate either from natural resources or be manufactured within facilities producing coarse aggregates, all while adhering to stipulated specifications. Another acceptable source is quarry dust, a byproduct of coarse aggregate production. However, a notable decrease in the availability of sand has been observed over time (Karthikeyan Ganesan et al., 2022), even though the sources remain the same.

Alternative sources for fine aggregates are conspicuously scarce. Notably, aggregate production plants such as Kisumu Concrete, Ndugu Transport, Pride Enterprises, and Gogni Rajpoe Enterprises (Kisumu CIDP 2023) resort to utilizing quarry dust in the production of building blocks within the western Kenyan region, particularly Kisumu. In the study area, the demand for ready-mix concrete significantly outweighs the available supply, contributing to elevated costs which lead to preferences of site concrete production. This is exemplified by the Western Kenya ready-mix concrete uptake (IQSK Building Construction Handbook, 2021/2022).

Furthermore, a persistent scarcity of clean sand that conforms to established standards such as BS 812, ASTM C33, IS 650 (1991), and KS-02-21 prevails throughout the year. Consequently, a concerning practice has emerged: the blending or amalgamation of sand from unregulated and undesignated sources for the in-situ production of concrete.

Unfortunately, this practice introduces unknown levels of silt content into the mixture from various origins, including rivers, blending processes, and pits. In light of the trend to mix clean river sand with potentially harmful sand from any source, this research seeks to investigate its impact on concrete strength. The resultant outcomes yielded lower quality concrete, which, in turn, contribute to the construction of structures characterized by compromised quality and safety.

The research conducted a comprehensive series of tests, encompassing silt content assessment and sieve analysis, on sand from diverse harvesting points. These tests were conducted both on the individual sands and on their blended forms, considering varying proportions. The outcomes yielded sand ratios suitable for producing quality classes of concrete design mix. Additionally, concrete strength was evaluated for all blend ratios, identifying the most suitable mixtures that is most appropriate in concrete manufacturing.

1.3 Research objectives

1.3.1 Main objective

To investigate the effect of blending sand from different sources on strength of concrete in western Kenya.

1.3.2 Specific Objectives

i. To determine the silt content of the sand from different sources used in western Kenya.
ii. To evaluate the effect of silt content on the compressive strength of concrete
iii. To simulate the effect of blending sand on compressive strength of concrete.

1.4 Research Questions

i. What is the silt content in sand currently being used in the study area?
ii. What is the effect of silt content on the strength of concrete?
iii. How does blending sand mix proportions of varying silt content impact the compressive strength of concrete?

1.5 Justification of study

In any construction project within the field of engineering, the paramount consideration is the quality of the materials used. Among the constituents of concrete, sand plays a crucial role, and it is imperative that the sand meets the specified standards outlined in BS812, particularly concerning silt content. Since the source of sand is typically natural, its composition may include silt, which can significantly impact the overall quality of the concrete. Therefore, it is essential to introduce a sand design mix that accommodates the utilization of various types of blending sand, each with differing silt content, in order to enhance the overall quality of the sand and, by extension, the concrete.

An emerging trend involves the blending of clean river sand with other sand sources, including gravel, for construction purposes. This practice inadvertently leads to the generation of substandard concrete, thereby increasing the probability for building collapses. The extent of this phenomenon's repercussions remains to be precisely determined, underscoring the necessity for investigative research aimed at providing data of its magnitude and implications.

The cost of procuring clean river sand has witnessed a recent demand, primarily coupled by the considerable distance separating the sources of river sand. This cost escalation is further compounded by the steady rise in fuel prices, general maintenance expenses, and the mounting demand for sand fueled by housing development projects, supplying to the construction industry's requirements covering both rural and urban centers.

The presence of a viable and adequate alternative material, such as quarry dust, would negate the need for conducting the current study, given its superior grading characteristics. Research has underscored that integrating very fine waste particles from quarries, constituting approximately 10% to 20% of the total fine aggregate content in concrete mixtures, can notably increase the 28-day compressive, tensile, and splitting tensile strength of the resulting concrete (Rathore et al., 2020). A study confirms that a 20% substitution of sand with waste quarry dust yield concrete with a better compressive and flexural strength, with increases of around 10% and 15% in these respective strengths, along with an amplified splitting tensile strength (Imran and Muthu, 2018).

Investigations indicate that the incorporation of waste quarry dust at 20% replacement for sand correlates with a notable 10% enhancement in compressive strength (Imran and Muthu, 2018) within the concrete mixtures.

The present cost of quarry dust sourced from Kisumu Concrete and Gogni Rajope Plants, situated in Kisumu and Awasi respectively, stands at Kshs 1350 per ton. the cost of sand is valued at Kshs 900 per ton, contributing to its increased demand (Building cost construction handbook,2018-2019). The constrained availability of quarry dust can be attributed to limited sources within the scope of the study area.

In the established standards such as ASTM D254 and BS 882, the quality of sand is specified, with silt content capped at 10% and 4% respectively. Though, the prevailing challenges have compelled the utilization of sand containing high silt content. However, the comprehensive impact of this practice remains unquantified through qualitative research investigations.

There are more than 90 documented building collapse within a span of 11 years from 2011 to 2022 with fatalities,(NCA Report, December, 2022). Among these incidents, several stand out as disastrous examples: On April 28, 2006, a five-story building collapse along Ronald Ngala Street claimed the lives of 14 individuals (IRC Bulleting of 25th May 2006). Similarly, on January 10, 2010, a building collapse in Kiambu resulted in the tragic loss of three lives (IRC Bulleting No 2 of 25th May 2006). The calamity repeated itself on September 17, 2011, in Mabona, Lwanda, where a building collapse claimed the lives of four individuals. Another disaster struck on January 4, 2015, as a building collapse in

Huruma resulted in the deaths of seven people. The most recent addition to this disheartening list occurred in 2021, with the collapse of a building in Vihiga.

This study therefore will provide data on the appropriate blending mix ratios which can be applied with respect to the sources of sand, that can achieve the required strength and meet the minimum strengths of concrete. This will close the malpractice of blending of sand and encourage testing of sand.

The research results will assist construction industry experts and the county Governments of Kisumu, Kakamega, Vihiga and Busia and other counties that share the sand sources in the control of sand qualities and levels of silts, help them in mapping out the sources of material with their respective quality data, with readily available information on the sources of sands and their quality.

This study will contribute to the knowledge base in different ways, Engineers will optimize materials properties for specific application by creating material that meets specifications, It will improve and provide the efficient use of locally available materials in many areas by providing an understanding how to Blend materials. This customization can lead to innovative solutions in construction and materials science. Understanding how different sands blend together and affect the quality of concrete or other construction materials is vital for quality control.

This knowledge can lead to more consistent and reliable construction outcomes.

Researchers can explore new mixtures, test their properties, and discover innovative applications that were previously unexplored. Therefore, blending sand from different sources in the engineering industry presents an exciting opportunity to expand our understanding of materials and construction practices. It enables customization, promotes sustainability, and has the potential to lead to innovative solutions and practices that can benefit the industry as a whole.

In summation, the practice of blending sand from diverse sources within the engineering industry represents an exciting opportunity to broaden our comprehension of materials and construction methodologies. It not only facilitates tailor-made solutions but also champions sustainability, while concurrently fostering innovation. These advances have the potential to yield transformative practices and approaches that can ultimately benefit the entire engineering sector.

1.6 Scope of the Study

The study identified 16 distinct sites as sources of sand, encompassing pit sand, river sand, seasonal river beds, and lakeshores. Among these, 13 representative sites were selected based either pit sand, Lake or River sand formation for comprehensive analysis. This involved the collection of sand samples from these 13 sources, which supply areas including Kisumu city, Kakamega, Vihiga, Siaya, and Busia counties. The specific sources were River Yala, Port Victoria, Nyadorera 11, Nyadorera 1, Kibos River, Karunga, Got Nyabondo, Jebrok, Miwani, Port Victoria, Seme, Ogal, and Pap Onditi. The silt content of the samples was assessed, and for those sands that didn't meet the stipulations of BS882 and ASTM standards, a blending and grading process was employed.

All sand samples, including those that underwent blending and grading, were used in the production of concrete aiming for a target strength of 25kN/m². Subsequently, these concrete mixtures were subjected to compression tests to determine their compressive strength. The study sought to establish a correlation between silt content and the compressive strength of both neat sand and blended sand samples. For this purpose, cement 42.5 (CEM I) was utilized. The choice of this cement type was dictated by its prevalence as the most preferred, used in laboratories within the study area. The concrete cubes were meticulously prepared, cast, and subjected to testing at the MTRD Laboratory located in Kakamega.

1.7 Limitations of the Study

i. The study did not cover tests to ascertain the response of concrete produced when under strain and Fatigue when in reinforced composite form
ii. The study did not carry out chemical tests for organic matter that may be present in the sand or photometric color classification
iii. The ratios used in the blending for this purpose may not be the same as the current blending in the different vending locations.
iv. Due to broadness of research, the number of tests carried out and the interval of blending percentage was wide at 10%,30% and 50 %

1.8 Outline of this thesis

This thesis is structured into five chapters, each with a distinct focus and contribution to the research:

Chapter One serves as an introduction, laying the foundation by addressing the problem in need of solutions. It outlines the research objectives, underscores the significance of the study, and identifies its limitations.

Chapter Two digs into the core elements of the study, primarily silt and sand, explaining their characteristics. This chapter conducts a comprehensive review of current conditions and prior studies in a similar vein, highlighting their findings and the research gaps that informs this practice of blending. It also contextualizes the use of other materials like quarry dust and explores alternative procedures involving substances such as glass and MFA (Manufactured Fine Aggregate).

Chapter Three shifts the focus to the study area, unveiling the methods employed for sampling and the battery of tests conducted. These tests encompass grading, zoning, silt content determination, and the blending of sand in varying proportions (10%, 30%, and 50%). Additionally, it details the concrete casting process, targeting a strength of $25kN/m^2$, and introduces the methodology behind destructive testing. The chapter also introduces the use of regression tools to simulate and validate research results, all while characterizing the materials used and the experimental procedures undertaken.

Chapter Four takes center stage by presenting the results and offering a detailed analysis of the experimental research procedures and data collection. This chapter concentrates on the impact of sand blending, particularly in terms of silt content trends and its influence on concrete strength. It provides an exhaustive examination of the performance of diverse concrete samples featuring different blending ratios.

Chapter Five marks the culmination of this research effort, delivering conclusions that are directly tethered to the predefined research objectives. These conclusions are linked to the specific research objectives, including the revelation of excessive silt content in the sand, surpassing the 4% limit, and the notable shifts in silt content resulting from blending, along with their subsequent effect on concrete strength. Additionally, this chapter provides recommendations pertaining to the practical applications and knowledge acquisition stemming from the study.

The appendices, finally, serve to complement the main body of the research, offering supplementary materials such as specific gravity data and mix designs.

CHAPTER TWO:

LITERATURE REVIEW

2.1 Introduction

Ordinarily concrete is composed of aggregates (fine and coarse aggregate) and bonding materials of Cement and water bonded together which hardens (curing) over time to produce strength of desired class. Over the last few years there has been buildings collapse in various parts of the country. The findings from the investigation carried out has mostly pointed to the concrete quality indicating poor quality materials.

In the definition of components, the smaller size aggregates also known as fine aggregates which is further classified as per (BS 882:1992,) as sand sometimes contain Silt. The coarse aggregates are also covered in the same standard with all the required qualitative characteristics.

In Kenyan , there are seven common cement types available, among them 42.5 (CEM I), (CEM II1A-L), and 32.5 (CEM IIIB-P), as well as 32.5 (CEM IV/A) and 32.5 (CEM IVIB-P), which can be sourced locally from their respective companies. Additionally, alternative brands such as 32.5N (CEM-IV) and 32.5N/R (CEM-IV) cements are also present in the market. The function of cement encompasses binding properties and the filling of voids between aggregates through a process termed hydration. The outcome of this process is the formation of calcium silicate hydrate. Concrete, being one of the most extensively utilized construction materials (Henderson, 2000), can be further improved in terms of its properties during production through the incorporation of specific admixtures like plasticizers and hardeners. It's worth noting that the presence of impurities in sand can influence the performance of concrete (Olanitori et al., 2005), underscoring the significance of sand quality in the overall composition.

2.2 Silt

In a recent study, Hao N etal,. (2022), in their research of engineering application of silt they categorized Silt into two distinct types, natural silt and silt produced by human activities. Natural silt arises from the inherent buildup of mud-like substances. Taking the silt found in Savannah Harbor, located in Savannah, Georgia, USA, as an example, it predominantly comprises minerals like kaolinite and quartz, with key constituents being SiO2, Al2O3, Fe2O3, and CaO. Additionally, silt includes elements like potassium, sodium, and calcium oxides, which serve as fluxing agents during the brick firing process, facilitating the fusion of firing materials at lower temperatures. However, natural silt exhibits poor plasticity and minimal reactivity, necessitating active modification before it can be effectively utilized.Silt refers to particles ranging between silts (0.002-0.075 mm), in size, whereas clay constitutes materials with particle sizes less than 0.002 mm (as per BS 882:1992). This standard further advises that in the production of concrete, the aggregate's silt and clay content should not exceed a maximum of 4%. As stipulated by ASTM C3-03 and ASTM C117 1995, the acceptable silt and clay content in sand used for concrete production is limited at 10% by weight.

2.3 Sand and blended sand

The Earth, originally composed of rock, has undergone a transformation into soil through natural weathering processes. Soil texture is not singular but rather comprises a combination of three constituents: sand, silt, and clay, all originating from the same parent rock. While soil is commonly a blend of these three components, certain locations do exhibit significant amounts of natural isolated sand occurrences. The proportion of sands (0.075-2.36 mm) within a soil mass notably impacts its strength characteristics, wielding considerable influence.

The load-bearing capacity of sand becomes a pivotal factor in determining the dimensions and depth of construction projects due to its property of being incompressible. Beyond strength, the introduction of silt and clay significantly alters this characteristic, particularly in the presence of water. However, sand, excluding very fine particles, remains relatively unaffected by water. Consequently, it is imperative to thoroughly investigate the potential impact of silt within sand on the strength of concrete, especially in when used with other materials.

Blended sand, also known as mixed sand, refers to a combination of sands obtained from different sources or with varying properties that are mixed together to create a sand mixture with specific characteristics suitable for various construction or industrial applications. Blended sand is often used in construction, particularly in concrete production, to optimize the properties of the sand and achieve desired performance outcomes. Among the characteristics and properties of blended sand are:

i. Particle Size Distribution: Blended sand typically combines sands with different particle size distributions. The mixture is carefully designed to achieve a specific gradation or grain size distribution that is ideal for a particular application, such as concrete production.

ii. Silt Content: Blended sand may involve the mixing of sands with varying levels of silt content. Silt is fine particles that can affect the workability and strength of concrete. Blending allows for control over the silt content to meet desired specifications.

iii. Consistency: Blended sand can offer a consistent quality that may be more challenging to achieve with single-source sands. Consistency is crucial in construction to ensure uniformity in the properties of materials.

iv. Strength Enhancement: By combining sands with different properties, blended sand can be engineered to enhance the strength and durability of concrete or other construction materials. The blending process can help optimize the proportion of fine and coarse particles for improved performance.

v. Cost Effectiveness: Blended sand can be a cost-effective solution because it allows for the utilization of locally available sands, which may be less expensive than specialty sands obtained from distant sources.

vi. Adaptability: The composition of blended sand can be adjusted to meet specific project requirements. This adaptability is valuable when dealing with variable sand sources or when aiming to achieve certain performance characteristics.

vii. Sustainability: Using blended sand can be a sustainable practice because it can reduce the need for extracting sand from specific sources, potentially minimizing environmental impacts associated with sand mining.

It is important to note that the characteristics of blended sand can vary widely depending on the specific sources of sand being blended and the intended use. Therefore, the properties and composition of blended sand should be carefully considered and tested to ensure that it achieves the required strength .

The attempt to blend fine aggregates from recycling with demolition waste did not yield favorable outcomes when used in recycled aggregate concrete at different proportions of 20%, 40%, 60%, and 80%. The compressive strength did not show improvement in this scenario. However, it was observed that incorporating natural sand into the recycled aggregate concrete resulted in higher compressive strength (Anjay et al., 2022).

2.4 Composition

Sand typically is made up of quartz (SiO_2) it can in fact be composed of almost any mineral or combination of minerals or even sand sized fragments Sand is a common type of soil, which has very fine particle size. The physical components of sand include silica, quartz with traces of other substances like titanium it usually has irregular particle shape. The Particle size is usually very small, but not so small that it can pass through a Sieve No. 200 size 75 µm.

2.5 Texture

The surface characteristics of a sand grain can range from smooth to frosted, with a smooth surface indicating chemical reactions and a frosted surface indicating the influence of wind action. Additionally, the texture of the sand also plays a significant role in shaping the engineering properties, primarily through the frictional resistance arising from factors like particle angularity and tangential resistance during loading, (Juan Rodriguez , 2013).

2.6 Size

In the particle size distribution of this inert substance, sand typically encompasses dimensions ranging from 0.006 to 2mm. The particle size distribution often carries distinctive traits due to the origins of the parent rock, along with its history of weathering and transportation.

2.7 Roundness and Sphericity

Transport does not do much to change the roundness and sphericity of the sand grains (Kuenen, 1960) and it has been shown that the rounding of sand grains is due almost entirely to wind abrasion and that the sphericity of sand grains is inherited from their original crystal structure. With the above background that silt forms fine aggregates passing sieve No. 200 or 75microns sieve size, the material smaller than this has been found to have effect on the strength of concrete, (Samir et al., 2020).

Several similar studies have been carried out on the relationship between various parameters namely, silt content and water cement ratio, silt content and concrete strength, silt content and workability and silt content and slump have been found to have effect on concrete (Olononade et al., 2018). Studies have been carried out on collapse of buildings resulting to injuries, loss of lives and loss of investments has been largely attributed to use of poor-quality concrete ingredients Ngugi, et al., (2014), which also did research on the effects of sand quality on compressive strength of concrete: a case study of Nairobi County and its environs.

Information concerning the influence of silt, clay content, and organic impurities present in the building sand supply within Nairobi County and its adjacent areas, as well as their impact on the compressive strength of concrete, was not covered. The primary aim of their research was to establish the levels of silt, clay, and organic impurities found in building sand and to ascertain their respective effects on the compressive strength of concrete.

The study presented the outcomes obtained from the assessment of building sand quality sourced from eight distribution points in Nairobi County and its surrounding environs. Additionally, it investigated into the consequences of these impurities found in the sand on the resultant compressive strength of concrete. A total of 27 sand samples underwent comprehensive testing to determine their silt and clay contents, as well as organic impurities, adhering to the specifications outlined in BS 882 and ASTM C40.

An important note in their study was that the sand samples analyzed were collected directly from the suppliers and not from the initial collection points. This particular aspect raised a limitation as it did not account for the possibility of any blending that might have occurred with the samples, a concern that this study seeks to address.

In another study (Yalley,2018) did research on the effect of sand fines and Water/Cement Ratio on Concrete properties, Fines content in sand of 2%, 4%, 6%, 8%, 10% and 12% as well as water/cement ratio of 0.55, 0.6 and 0.7 were used. The concrete was prepared using the basic mix 1:2:4. Workability test on fresh concrete as well as compression and split tensile strengths were conducted in accordance with BS 1881. The results showed that, workability of concrete decreased as fines content increases. At the same level of fines content, workability increases when the W/C increased. The study again revealed that up to 4% fines content, compressive strength increased as the fines content increases. There was a decrease in the compressive strength with increase in water/cement ratio. The same trend was found for the tensile splitting strength results. Predicting the effect of fines and Water/Cement ratio on workability and strengths of concrete using regression analysis suggest that, over 80% of the variation in the workability and strengths were influenced by fines and W/C. It was noted from the study that, fines content of 4% in sand and water/cement ratio of 0.55 is appropriate for concrete for structural use. The same study used mix design ratio by volume in the design which is obsolete in a laboratory environment and could give misleading result. This study will be using the batching by weight to achieve more accurate results on the strength of concrete.

The Study carried out on effect of silt fines on the durability properties of concrete (Cho, 2013) on river sands of Taiwan considering the presence of high proportion naturally occurring of silt fines, they investigated the impact of the material on the properties of concrete and concluded that the concrete had reduction on compressive strength. Concrete specimens with a water/cement ratio of 0.48 and different silt content of fine aggregate, ranging from 0% to 9%, were cast and used in the tests.

The investigations also conducted tests for chloride transport encompassed Permeation under applied hydraulic conditions, absorption testing utilizing an exposure approach, and the Capillarity method. These methods facilitate the penetration of chlorides to specific depths and diminish the distance to the rebar. (Thomas et al. ,1995). The study being conducted has not carried out chemical tests since the environment in western

Kenya does not have industrial contamination.

Test results indicated a decrease in durability when the ratio of silt content to fine aggregate exceeds 5%. The compressive strength, however, when silt fine content was less than 5%, showed increment, but decreased when the silt content increased from 7% to 9%. These results could serve as a reference in concrete production as well as quality control of fine aggregate containing a large amount of silt fines.

In exploring the impact of Sand quality on concrete strength, in a case study in Debre Markos and surrounding areas in Ethiopia Adebe, et al., (2020) conducted an investigation in which sand samples underwent testing for silt and clay contents, organic impurities, and chemical composition, following ASTM standards. Concrete cubes were subsequently cast with a mixture ratio of 1:2:3 and subjected to compressive strength tests at both 7 and 28 days.

Further two distinct sand sources were evaluated for chemical Aliyas, with a silt content of 5.33%, and Kuye, with a higher silt content of 12.18%. Compressive strength results ranged from 19.972 MPa for Kuye to 28.957 MPa for Abay Wodeyamado, indicating the lowest and highest strengths, respectively.

The study concluded that sand from Debre Markos Town and its vicinity contained silt, clay, and organic impurities surpassing permissible limits, leading to a significant decrease in concrete strength. The recommendation put forth emphasized the necessity of accounting for these impurities and gradation in concrete mix designs for the region to attain target strength.

Unlike the mentioned study, this research plans to utilize conventional weight batching rather than the volume ratio method, thereby enhancing accuracy in achieving desired concrete compositions.

The effect of clayey impurities in sand on the crushing strength of concrete (a case study of sand in Akure metropolis, Ondo State, Nigeria (Lekan, et al., 2005), the effect of clayey impurities in the sand available in Akure metropolis of Ondo State, Nigeria. Ten samples of sand were collected from ten different locations in the city. The field settling method was used to determine the percentage content of clay in each sand samples.

From each sand sample, 15 concrete cubes were casted. Steel cubes of 150 x 150 x 150cm3 as per American Standard Testing Method (ASTM) C39 / C39M and 1:2:4 mix ratio was used in the casting. Curing of the concrete cubes was done by immersion in water. Portland cement was used. The cubes were crushed out 28 days. It was discovered that the higher the percentage content of clay in the sand samples, the higher the reduction effect on the cube strength. Depending on the percentage content of clay the reduction in strength could be as high as 70% based on 20N/mm2 cube strength at 28 days. This paper proffers recommendations on means of achieving required cube strength when using sand from the study area (Akure, Nigeria). Similarly, study relied on the volume batching method.

Another study of assessment of fine aggregates from different sources in Ibadan and environs for concrete production Ajagbe, et al. (2017), the comprehensive assessment used in this study revealed that fine aggregates from river sources fell within the ASTM limit of standard specifications of the physical properties of aggregates while those from burrow pits were found to deviate from limits in certain respect. ten had water absorption of 2.6% which exceeded maximum 2% specified, the sample was not free from clay lumps and friable and it was concluded that only fine aggregate from river sources can make quality concrete because of their compliance with the requirement of the ASTM, IS and BS standards.

This study avers that the sand from other sources contain deleterious material though they did not mix the samples to deduce the reduction in the level of impurities and strength including comparison of the relationships. Informal construction practices in developing countries are heavily biased against compliance to materials quality standards. Ngugi, et al., (2014) carried a laboratory test on samples of sand collected from different informal construction sites and established that the sand was highly colored and not suitable for manufacture of concrete due to high contents of clay, silt and organic matters. Along similar practices, Oladeji, et al.,(2013) and (Anosike, (2012) noted that block producers produce up to 43 blocks per one cement bag this is an indicator that the practice of use of poor materials is an issue requiring studies to produce the guidelines in the industry (Sanga, 2020). The fine aggregates of high quality have high positive effect on the quality of compressive strength of concrete (Ngugi et al., 2014). The presence of silt/clay above certain percentage in fine aggregates requires more cement to coat other ingredients of concrete (Olanitori , 2005).

In the most recent study, Karthikeyan et al., (2022,) they carried out research on the use of marine sand (MS) by washing of marine sand and improving the quality of manufactured and river sand with it. The purpose of this research was to examine the mechanical, micro-structural and durability properties of concrete and cement mortar made with marine sand as a fine aggregate in partial replacement of manufactured Sand (M-S) from 20% to 100%. For better understanding the characteristics of MS and M-Sand, physical properties of MS and M-Sand, as well as the chemical properties of washed and unwashed marine sand are compared.

In all the research reviewed and their objectives and outcomes above, there are gaps in the studies on blending of sand specifically with another sand of different quality, the gap which this research intends to bridge by determining the extent of the silt content in the sand in use, the Silt levels, with the tests carried out in the laboratory showing the extent that the blending can be carried out without compromising the strength of concrete specifically for western Kenya.

In other studies replacing fine aggregates with manufactured fine aggregates (MFA), showed stability in concrete strength though fineness was a determining factor in this case the raw materials used discarded tires, plastic, glass, burnt foundry sand and Coal Combustion By-Products Buhoria, et al., (2013), in the study of replacement of natural sand in concrete by waste products .In their study on the effect analysis of soil type and silt content on silt-based foamed concrete with different density Zang, et al., (2020), found that the same density and silt content, higher coarse particles content can optimize the physical and mechanical properties of formed concrete.

The intend to address the gaps identified in the above research, include the blending of sand and determining the strength of the concrete from the predetermined blend ratios, The determination of the Sand mix design that is applicable, the strict use of concrete mix design instead of material ratios that have been applied in all the studies and finally producing the most appropriate regression model from simulation of various of sand blends leading to sustainable use of sand in construction. Additional gaps encompass promoting blending as an alternative to substitution, ascertaining the characteristics of the source sand or having prior awareness of its origin, and employing a weight-based material batching approach.

CONCEPTUAL FRAMEWORK

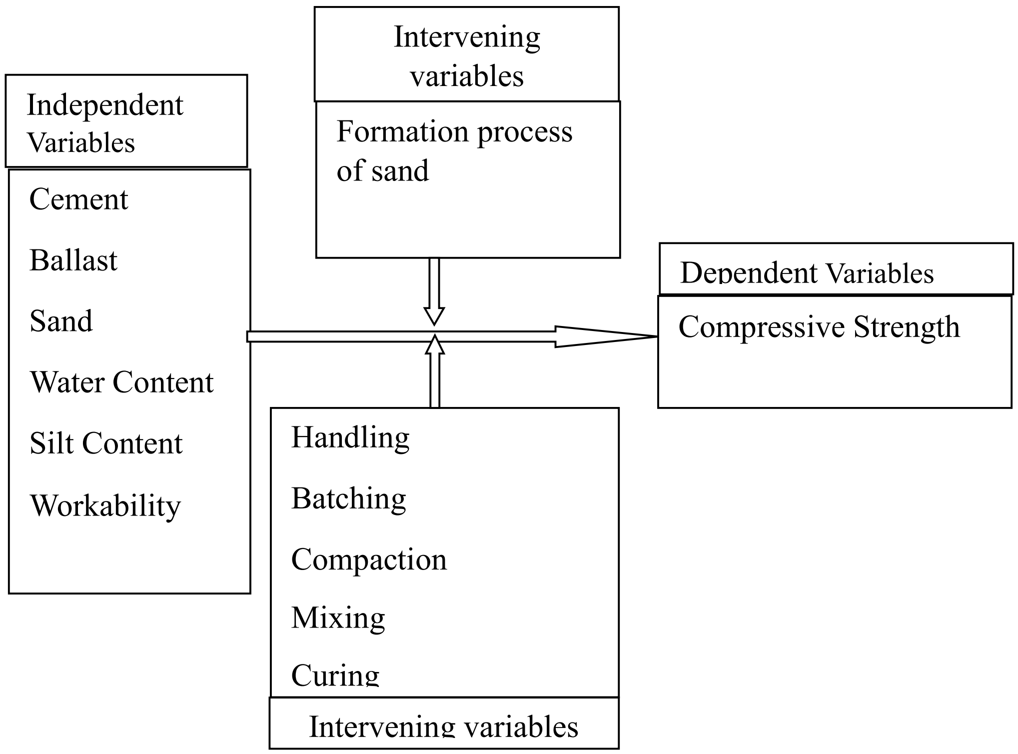


Figure 2. 1: Conceptual Framework

2.8 Conceptual Framework

The independent variables were cement, ballast, Sand, water content, (components of concrete) , silt content and slump which have direct influence on the properties of concrete in terms of compressive strength. The intervening variables were variables related to production process of concrete namely batching, compaction, mixing, curing, and related to location and formation namely, Pit Sand, River Sand, Lake Shore influencing the properties of independent variables. The dependent variable was compressive strength of concrete with properties directly affected by the other variables.

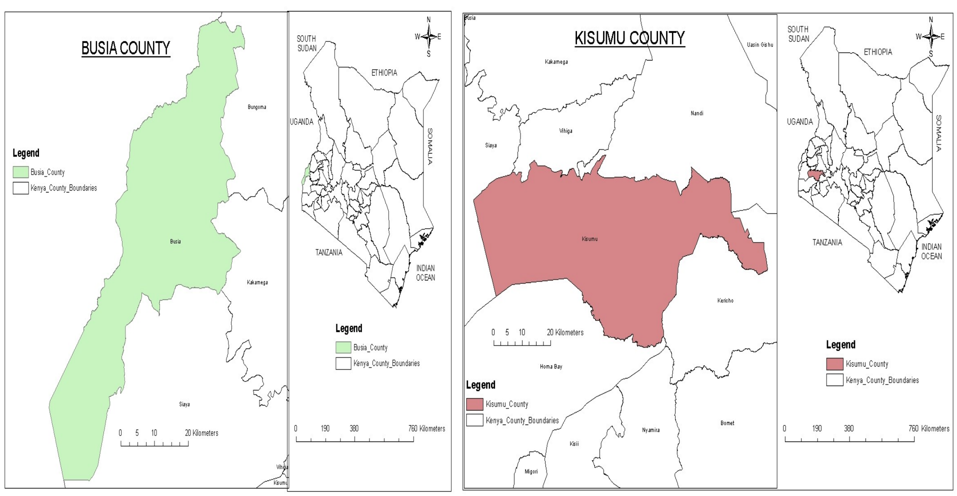
CHAPTER THREE

METHODOLOGY

3.1 Introduction

This chapter presents the detailed data and data sources used in this study, the chapter highlights the study area and presents the methods and equipment employed for material sampling, research design, data analysis, sand grading, determination of silt content, blending of sand, materials mix design, concrete cubes casting, testing and determination of compressive strength. Finally, the tools applied to analysis of the results.

3.2 Study Area



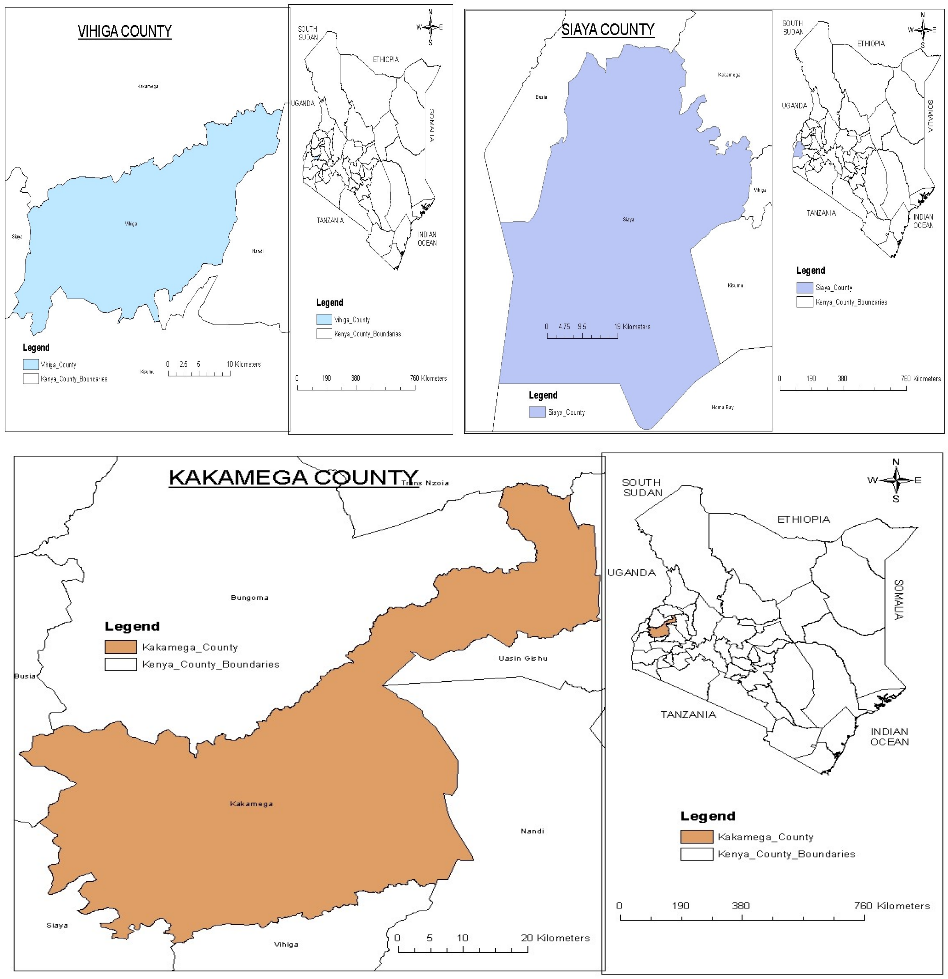


Figure 3. 1: Western Kenya county maps

The drainage topography of western Kenya features an intricate web of rivers, streams, and wetlands due to its diverse geographical makeup. Positioned within the East African Rift System, the region encompasses an array of highlands, valleys, and plateaus. Notable aspects of the drainage topography in western Kenya includes, highland terrain within the western landscape, encountering various elevated areas like the Nandi Hills, Kakamega Forest, and Cherangani Hills.

River Networks includes the prominent rivers of western Kenya, previously mentioned, hold a pivotal role in shaping the drainage topography. Rivers such as Nzoia, Yala, Mara, Sondu, Nyando, originate in the highlands and course through valleys, ultimately converging with Lake Victoria or other water bodies. The valleys that interlink the highland expanses function as channels for water drainage, guiding the flow downwards. Lake Victoria Influence the eastern fringes of Lake Victoria but western Kenya, impacting the drainage patterns.

Certain rivers directly feed into the lake, while others traverse through wetlands prior to their convergence. Deltas and Estuaries, in some rivers, like the Yala River, foster the creation of deltas and estuarine regions upon entering Lake Victoria.

These zones undergo alterations in water levels and the deposition of sediments. Western Kenya's geological composition is diverse and encompasses various rock systems. Key rock systems present in the region encompass Precambrian Basement Complex considered oldest rock system consists of gneisses, schists, granites, and amphibolite. These Precambrian rocks are distributed across areas such as the Nandi Hills, Kakamega Forest, and certain parts of the Rift Valley.

Quaternary Sediments representing more recent deposits, these sediments span a wide spectrum, encompassing river alluvium, lake sediments, and aeolian deposits. Neogene Sediments which dating back to the Neogene period, these sediments can be found in specific regions. They comprise clays, sands, and gravels and are often associated with the Pliocene and Pleistocene epochs.

Western Kenya experiences a bimodal rainfall pattern characterized by two distinct rainy seasons and two dry seasons throughout the year. The rainfall patterns are influenced by the region's location, topography, and the movement of the Intertropical Convergence

Zone (ITCZ).

The study was carried out in western Kenya, covering four counties with Kisumu being a principal town in the region its estimated population of 600,000 with an annual growth rate of 3.28% (Kisumu County CIDP,2018-2022) as the point of interest. The sources that were sampled in the study are also used by other counties like Kakamega, Busia, Saiya and Vihiga county. The sources of Sand are found within and outside the Kisumu County.

The number of sites that were identified to be commonly used sand sources were sixteen in number which was fairly representative within the project area. River Nzoia in Ugenya, Manywanda, Witchlum In Sakwa, Pap Onditi in Nyakach, Jebrok in Kisumu Area, Nyadorera, Kibos River, Karunga, Got Nyabondo, jebrok, Nyadorera, Port Victoria and Nyadorera 2 (Site Upper), Miwani,River Yala, Seme, Ogal Lake shore. The sites were spread over the three counties Namely Vihiga, Siaya, Kisumu and Busia and the sites were selected Randomly but representing the areas of research. 13 Sites were selected representing 81.3% of the total sites.

3.3 Materials Sampling

Sampling methods outlined in ASTM D75, known as the "Standard Practice for Sampling Aggregates," were employed. This American standard offers instructions for aggregate sampling, encompassing sand. It encompasses both manual and mechanical sampling procedures. Meanwhile, the ISO 14688-1:2002, titled "Geotechnical Investigation and Testing - Identification and Classification of Soil - Part 1: Identification and Description," furnishes guidance for identifying and describing soil materials, sand included, along with details on how to carry out the sampling process.

Sand sources providing materials to Kisumu city, those from different formation traits, seasonal rivers, lake shores, and mining deposits, are categorized into two groups as those located within the county and those outside it. Sources like Kibos River, Karunga Got, Nyabondo sand deposit mines, Miwani, Pap Onditi, and Jebrok Ground surface sand mine fall within the county borders. On the other hand, sand from Port Victoria, Nyadorera, River Nzoia, and River Yala originates from Siaya county. Some of these sources are shared by neighboring counties such as Busia, Siaya, and Vihiga.

To conduct testing, samples of sand were collected from these sources using 50kg gunny bags, which were then transported to the laboratory. The chosen sampling method was Grab sampling, a common approach for accessible sources that does not necessitate specialized techniques like Core Sampling, trenching, Sedimentation, or Sieving.

The sampling equipment and bags were kept clean and appropriately labeled based on the sampling plan. Samples were collected from 81.3% of the designated research sites within the study areas. The sand samples were gathered from all the sample locations, taken randomly from different locations within the sand stacks to ensure representativeness. These samples were then labeled with relevant information such as the date and source, carefully transported to the laboratory, and stored for testing purposes.

3.4 Research Design

The method that was applied was experimental research design method. This involved the overall strategy that is used to integrate the different components of the study, thereby addressing the research questions with the platform for the sampling, Testing, and analysis including modeling of results. The research entailed determination of silt content in the sand samples from the sources in use, determination of the quality of sand and the quality of the concrete made from the sand. The study also investigated the improvement on the sand quality by blending it with sand from different source to assimilate silt content and the concrete strength of the subsequent concrete made from the blended sand in the design mix with the objective of modeling the most applicable blending proportions.

The sequence of tests was systematic from grading, silt content concrete strength analyses. The study revolves around the quality of sand and the content of silt and its effect and fundamentally the proportions of the silt improvement using sand of varying Silt content from various sources within the study area.

Sand was sampled, tested to determine the silt content then mixed with other sand with varying quantity of silt. The sand was then blended and the resulting silt content determined.

3.5 Data analysis

3.5.1 Sand grading

The first procedure is to qualify the control material as sand by particle size distribution and grading respectively, by Zoning to bring out the engineering properties using the Wentworth scale introduced by Chester K. Wentworth in his 1922 paper titled "A Scale of Grade and Class Terms for Classic Sediments" and all samples were graded by sieve analysis method to determine the fineness within the sand sample. Grading curves were plotted for all the samples from the sieve analysis the sand was classified to the respective zones based on the percentage passing 600micron sieve as per BS 882: 1992.

Table 3. 1: Data and Data sources

No.	Source Type	Name of location
1	River Sand	Railway sand
2	River Sand	Jebrok
3	Pit sand	Kibos
4	Pit Sand	Karunga
5	River Sand	River Yala
6	Seasonal River	Nyabondo
7	Lakae sand	Port Victoria
8	Lake sand	Port Victoria 2
9	Lake sand	Ogal Lke shore
10	Lake sand	Seme sand
11	Seasona River	Miwani
12	River sand	Pap Onditi
13	Pit sand	Seme

Table 3. 2: Sources of materials and their respective location and their respective classes in terms of formation of the sand particles

3.5.2 Determination of silt percentage

The testing for impurities was determined by washing the samples with water as per BS 812. The sand sample was dried in the sun, and washed with clean water in the sieve No 200 to determine the number of particles passing. The weight of the silt and other organic materials determined and the impurities percentages determined and recorded.

The weight of sand dried sample= W1

Weight after washing and drying= W2

The difference in weight = W1-W2

Silt content= (W1-W2/W1) *100

The results were subsequently compared with the permissible standards outlined in BS812 and ASTM117. Control samples comprised of sand with silt content of 4%, 8%, and 10%. Concrete specimens were prepared for compressive testing for all neat sand samples. For blended sand, six samples were used. The silt content test was conducted to ascertain the proportion of silt and other contaminants, and the results were organized in a tabular format.

3.5.3 Concrete from the Neat Sand samples

The concrete was prepared from selected sand with silt content above 4% using design mix and the concrete strength tabulated: The Target control strength of concrete was 25kN/m2 at 28 days. The type of cement used for all the concrete production was be 42.5 (CEM I) which is the most commonly used cement in all MTRD laboratories.

The procedure was to first determine the specific gravity of the sand to check if the sample fall within the range of specific gravity of sand and can be used in the computation of concrete mix design. The design mix quantities of materials required was determined, with sand having silt content of 2.4%.

In practice, sand is utilized in its natural state, directly sourced without undergoing washing to eliminate impurities. Consequently, to ensure uniformity in the resulting concrete, the water content was minimized to prevent surpassing the quantity specified in the design mix.

Table 3. 3: Materials from Mix Design

materials	Quantity kgs
Cement	3.201
Sand	6.459
Aggregates 10/14	9.504
Aggregates 6/10	4.752
Water	2.081

Table 3. 4: Quantities of materials required from the design mix generated for one cube of test for mould of 150mmx150mmx150mm size

3.5.4 Blending of sand

Sand containing silt content that surpassed the minimum requirement outlined by BS812 and other standards was mixed with the control sand to align it with the specified minimum silt criteria. This data was then organized into a tabular format. The samples were mixed in blending percentages of 10%, 30%, and 50%. Since it was an experimental design, and in order to validate the chosen ratio, a variety of blending percentages were employed to evaluate a broad spectrum of scenarios. This approach was taken to facilitate the derivation of more comprehensive conclusions. Additionally, it was motivated by practical considerations related to the intended application of replacement percentages, ensuring the attainment of desired material properties and performance characteristics. In essence, the process of selecting replacement percentages in the study of blending sand was intricate and had to be aligned with the research objectives and the specific investigative context. The overarching objective was to pinpoint the most appropriate percentages that align with the project's objectives, industry standards, and material requisites.

The initial silt content, resulting silt content, and the improvement in silt factor were assessed, recorded, and tabulated for all the different blends.

3.5.5 Determination of Compressive Strength of Blended Sand

Concrete was prepared by adhering to the prescribed mix quantities determined by weight. Subsequently, the mixture was thoroughly blended, molded into cubes measuring 150x150x150 mm, and then subjected to a curing process in a water bath.

To evaluate the compressive strength, tests were conducted on the concrete cubes that were made using blended sand samples. This comprehensive testing encompassed all the concrete manufactured from each blend, based on the original design mix. The concrete cubes were systematically tested for strength at intervals of 7 days, 14 days, and 28 days. Universal Testing Machine was used for these assessments. The resulting data were organized into table formats for all the tested samples. This included the various blend ratios of 10%, 30%, and 50% that were integrated into all the casted concrete cubes.

For all samples, a set of three cubes were produced. These cubes were subjected to strength tests at 7, 14, and 28 days, involving a procedure where they were crushed after being cured in a water bath. The average strengths obtained from the crushed cubes were recorded.

To evaluate concrete's compressive strength, there were 13 samples from each sand source we prepared three cubes for each test of 7, 14, and 28 days totaling to 117 concrete cubes from neat sand underwent testing using a Universal Testing Machine (UTM). The obtained results were analyzed and interpreted.

Before conducting the test, a cubical sample of the material (usually concrete) was prepared according to specific standards and dimensions. The sample was carefully cast, cured, and prepared to ensure it represents the material's quality and characteristics accurately.

The prepared sample is then mounted within the UTM. In the case of a compressive strength test, the sample is usually positioned vertically between two compression plates or platens.

The UTM was calibrated to ensure accurate measurements. The platens are aligned with the longitudinal axis of the sample to ensure even distribution of force during testing.

A compressive load was applied to the sample by the UTM. The rate of application of loading in a universal testing machine for compression testing of a 150x150x150 mm concrete cube typically follows standard testing procedures. The specific rate can vary depending on the testing standards and specifications, but a common rate for compressive strength testing of concrete cubes is to apply the load at a constant rate of 500 kN/second. This rate allows for a gradual and uniform application of the load until the cube fails, and it is often used to ensure accurate and reliable test results. This load was applied gradually and at a constant rate, typically specified in testing standards. The rate of loading is crucial for obtaining consistent and reliable results. Throughout the loading process, the UTM continuously records data, including the applied force and the corresponding deformation or displacement of the sample. This data is essential for calculating the compressive strength.

The load was applied until the sample reaches its failure point, which is when it can no longer withstand the applied load and begins to deform or fracture. This is the point where the maximum compressive strength is recorded.

The compressive strength of the material is calculated by dividing the maximum load applied to the sample by the cross-sectional area of the sample. The formula is typically expressed as:

Compressive Strength (N/mm^2) = Maximum Load (N) / Cross-sectional Area (mm^2) .The UTM data then recorded, calculate the compressive strength, and generate a stress-strain curve to understand the material's behavior under compression.

The test results, including the compressive strength value and any relevant data or observations, are documented in a test report. These results are often used for quality control, material selection, and structural design purposes.

Using the selected sand samples with minimal silt content, blending was performed with the selected samples. The results were then analyzed and organized into tables, highlighting the improvement trends in sand quality. The resultant sand blends were used to make concrete, The sand from Nyadorera, Miwani, River Yala and port Victoria blended six sample sources while Kibos site blended five samples. which led to the collection of data from 783 cubes. These cubes were subsequently subjected to crushing using a UTM machine, and the resulting data were analyzed and interpreted.

In a comprehensive analysis, the relationships between silt content and concrete compressive strength were simulated through Multiple Regression analysis. These equations aimed to predict the influence of silt content variations on compressive strength. These regression analysis simulations were then interpreted based on the output's subsequent utilization in the sand blending process.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This chapter provides results and discussion on the observations on colour and geological shapes of sand particles, sieve analysis and silt content determination of both neat and blended sand. The chapter also determines the specific gravity, mix design and provides the results on the compressive strength of concrete cast by using neat and blended sand, which is then simulated using regression and correlations analysis and interpretations of the results discussed.

4.1.1 Texture and Particle Shape

The characterization of irregular and angular sand particles was not conducted using established scientific methodologies such as Dynamic Image Analysis (DIA), static Laser Light Scattering (SLS, also known as laser diffraction), or Dynamic Light Scattering (DLS). Instead, these characteristics were inferred based on typical geological traits found in river sands, where irregular shapes result from wave action and attrition forces in water, and rounded particles are observed in sands extracted from pits or mines.

In terms of particle shape, the analysis revealed that 91% of particles were rounded, while the remaining 9% displayed angular shapes. Regarding color distribution, observations indicated that 50% of the particles were of a light brown hue, 33% exhibited a grey-brown coloration, and 17% were brown in color.

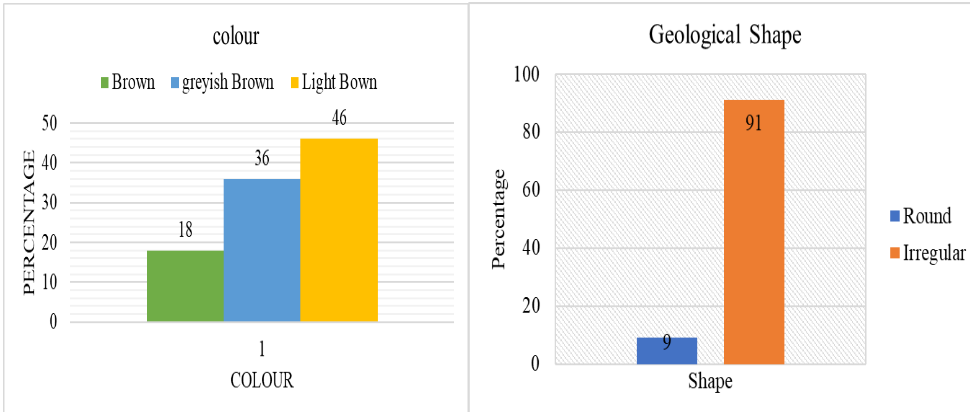


Figure 4. 1: Colour and Shape

Figure 4.1 show the distribution of the significant colour of the material samples and the distribution of shapes of the sand

4.1.2 Geological Shape and Color

Overall, the Thirteen (13) samples distinctly showed three colors, ranging from grey brownish to Light Brown and Brown as shown in Figure 4.1. The dominant colors being brown (50%) and Brown (17%).

4.2 Sieve Analysis

4.2.1 Sand Zones

The sand was divided into Zones as per BS 882:1992 specification for aggregates for fines passing 600 microns. Most of sand samples (67%) fell within Zone II normal sand, 25% being under the coarse sand and 8% falling under fine sand category of geological grading of all tested sand samples. The fineness was determined from the percentage passing Sieve size 600 microns.

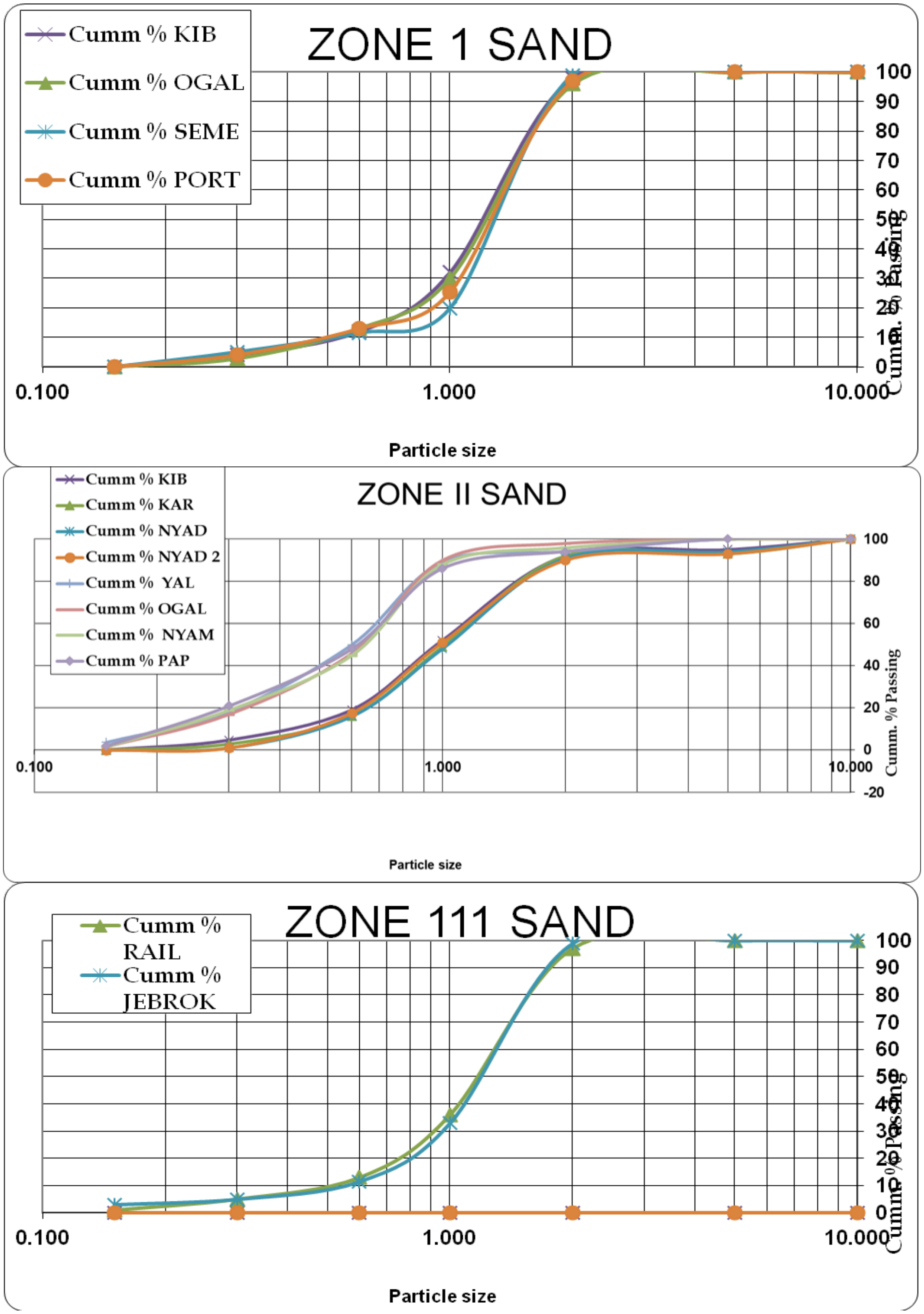


Figure 4. 2: Sand zoning

From figure 4.2, which pertains to coarseness, Zone 1 denotes the coarsest level among the zones. Moving to Zone 2, it exhibits an equilibrium between coarse and fine particles. In Zone 3, a greater ratio of fine particles is present relative to coarse particles. The distinct characteristics of sand within each zone may fluctuate in accordance with regional criteria and specifications.

4.2.2 Particle Size distribution

The particle size distribution was done for the samples that were to be blended as shown in Figure 4.3-4.7, the uniformity coefficient (Cu) represents the variation in soil particle sizes and is defined as the ratio of D60 to D10. D60 corresponds to the diameter at which 60% of soil particles are smaller, and 40% are larger. Conversely, D10 is the diameter where 10% of particles are smaller, and 90% are larger. As a result, Cu is calculated. A soil is considered well graded when Cu exceeds 4, whereas it is deemed poorly graded/uniformly graded when Cu is less than 4.

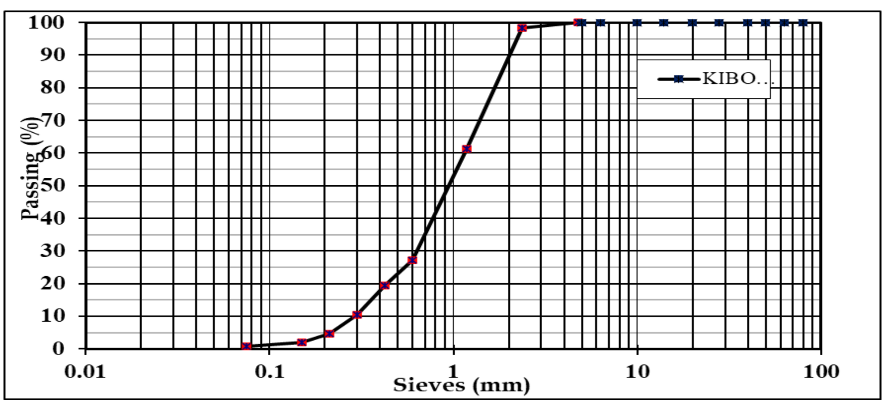


Figure 4. 3: Kibos sand particle size distribution

From figure 4.3, The Cd60=1.15, Cd 10= 0.3 and computed Cu = 3.8 which implies Kibos sand is poorly graded

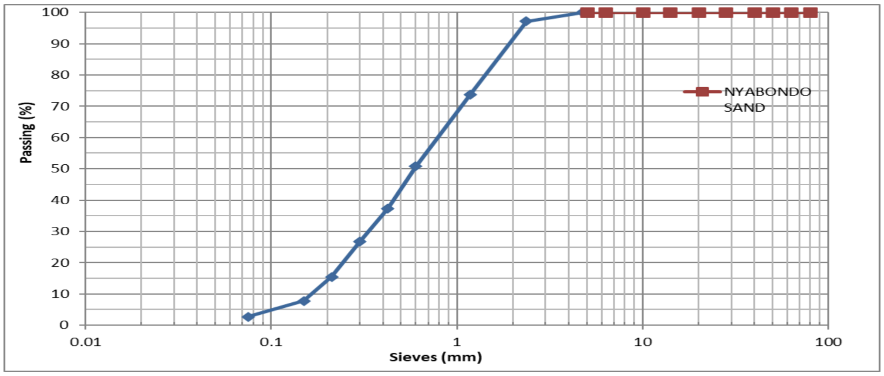


Figure 4. 4: Nyabondo sand particle size distribution

From figure 4.4, Cd60=0.8, Cd 10= 0.19 and computed Cu = 4.2 which implies Nyabondo sand is Well graded

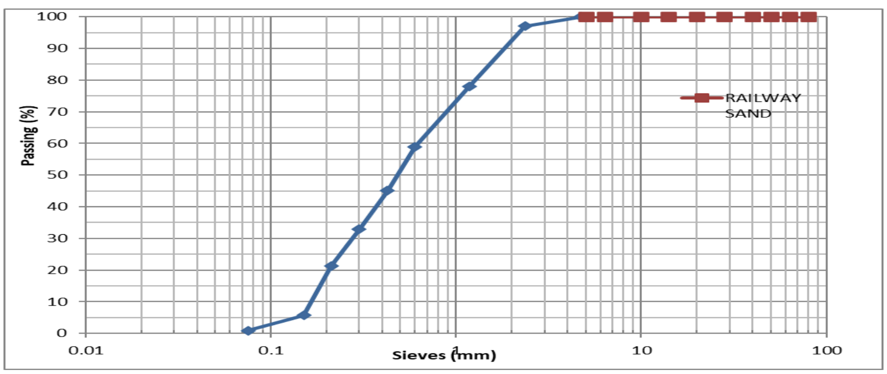


Figure 4. 5: Railway sand particle size distribution

From figure 4.5, Cd60=0.6, Cd 10= 0.2 and computed Cu = 3.0 which implies Railway sand is Well graded

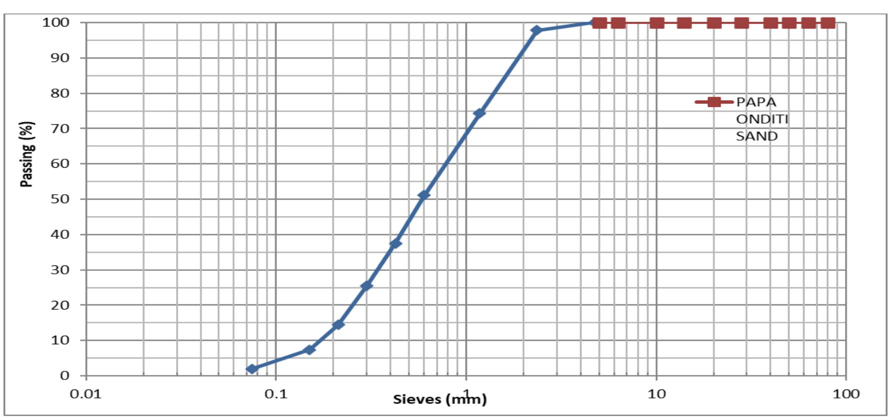


Figure 4. 6: Pap onditi sand particle size distribution

From figure 4.6, the Cd60=0.8, Cd 10= 0.25 and computed Cu = 3.2 which implies that Pap onditi sand is poorly graded

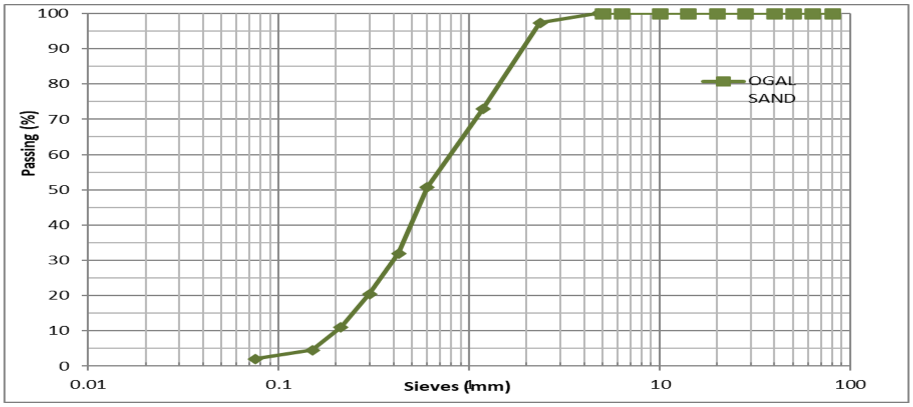


Figure 4. 7: Ogal Particle size distribution

From figure 4.7, the Cd60=0.8, Cd 10= 0.23 and computed Cu = 3.5, which implies that Ogal sand sample is poorly graded.

4.3 Determination of Silt content in neat sand

4.3.1 Silt Content in Neat Sand

The maximum silt content was 24% from the Lower Railway source sampled and the sample with the least impurity content was 2.4% from Port Victoria sand sample.

Table 4. 1: Sand Silt Content

	Source	Initial Wt (g)	Final Wt (g)	Silt content (g)	% age Silt Content (g)
1	Jebrok	750	659	91	12.1
2	Kibos	750	717	33	4.4
3	Karunga	750	700	50	6.7
4	Nyabondo	750	622	128	17.1
5	Lower Railway	750	569	181	24.1
6	Pap Onditi	750	635	115	15.3
7	Ogal Lake	750	654	96	12.8
8	Seme	500	689	61	8.1
9	Nyadorera	500	457	43	8.6
10	Port Victoria	500	488.1	11.9	2.4
11	Nyadorera 2	500	466.3	33.7	6.7
12	River Yala	500	481	19	3.8
13	Miwani	500	485	15	3

The silt content varied between 24.4% and 2.4%, for the selected sand sites. All the collected samples were used for making concrete cubes in accordance with the concrete mix design. Only 23.1% of the total samples adhered to the 4% silt limit

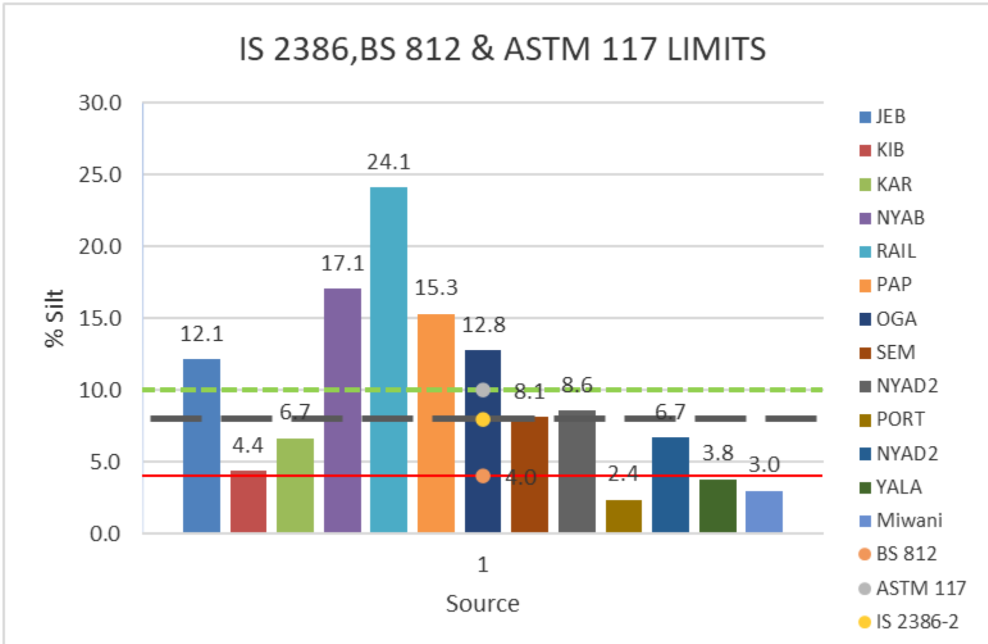


Figure 4. 8: Silt content showing the limits

In Figure 4.8, the maximum recorded silt content attained a substantial 24.1%, the minimum silt content was 2.4%. This indicates that out of one ton of sand, 241 kg consists of silt and clay impurities. Consequently, purchasing such sand for construction leads to direct usage without attaining value for money, as more than a quarter of the sand's quantity is made up of unwanted silt and clay impurities.

4.4 Determination of silt content in Blended Sand

The Figures 4.9-4.13 show the trends of the sand properties in terms of silt content when blended with sand of from different sources

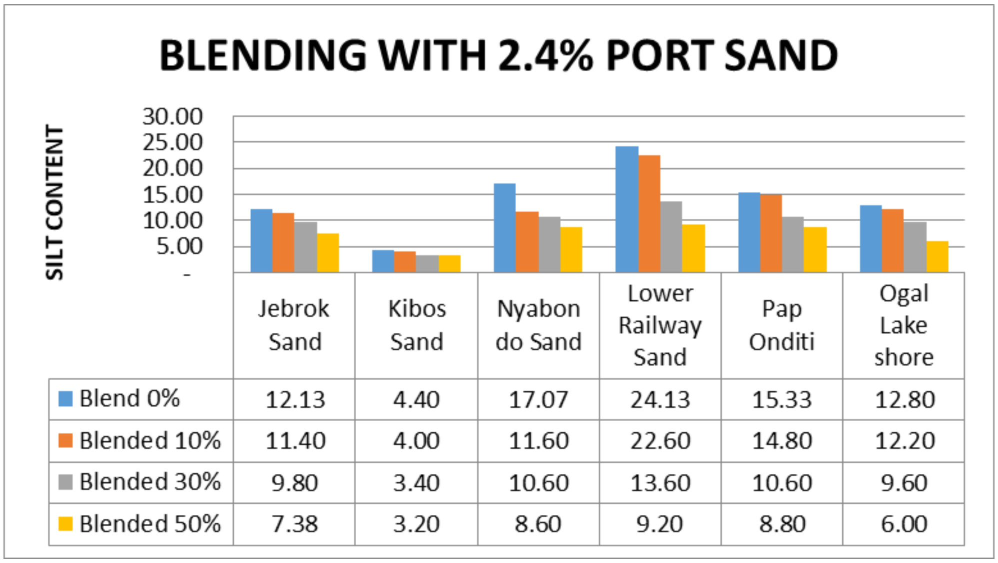


Figure 4. 9: Port Victoria sand blend

Blending by 2.4% Port Sand indicates improvements in sand quality for all sources. Specifically, for Jebrok, the silt content has decreased from 12.3% to 7.38%, and for Nyabondo, it has also reduced from 17.07% to 8.6%. with average of a 48% improvement

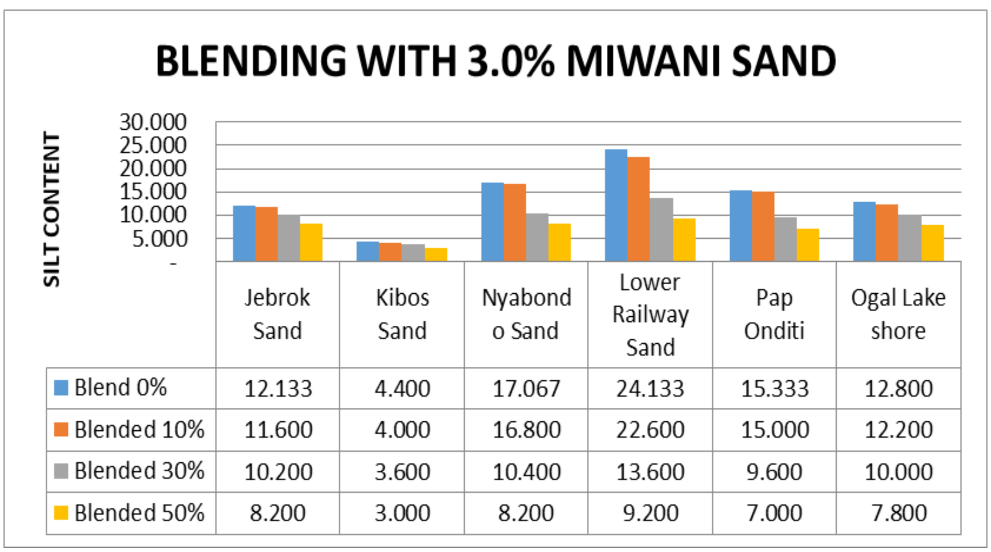
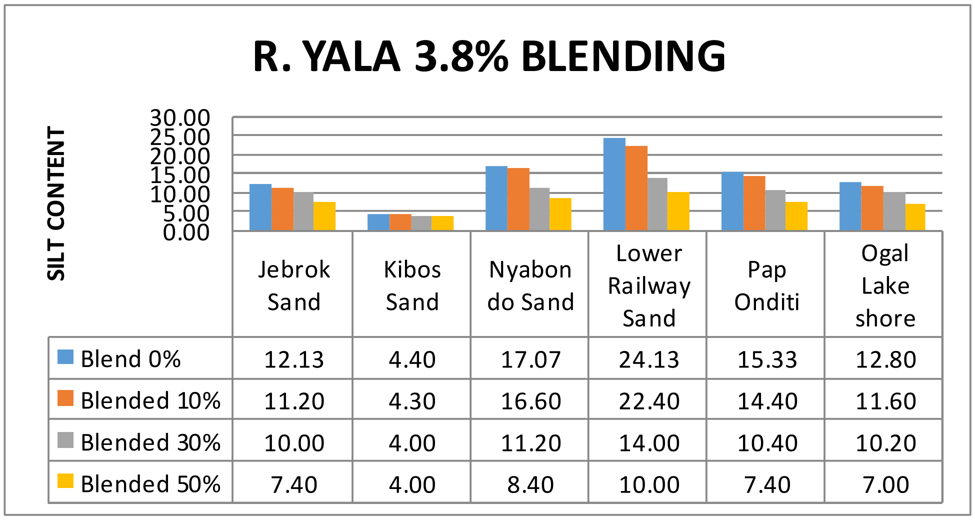


Figure 4. 10: Miwani sand blend

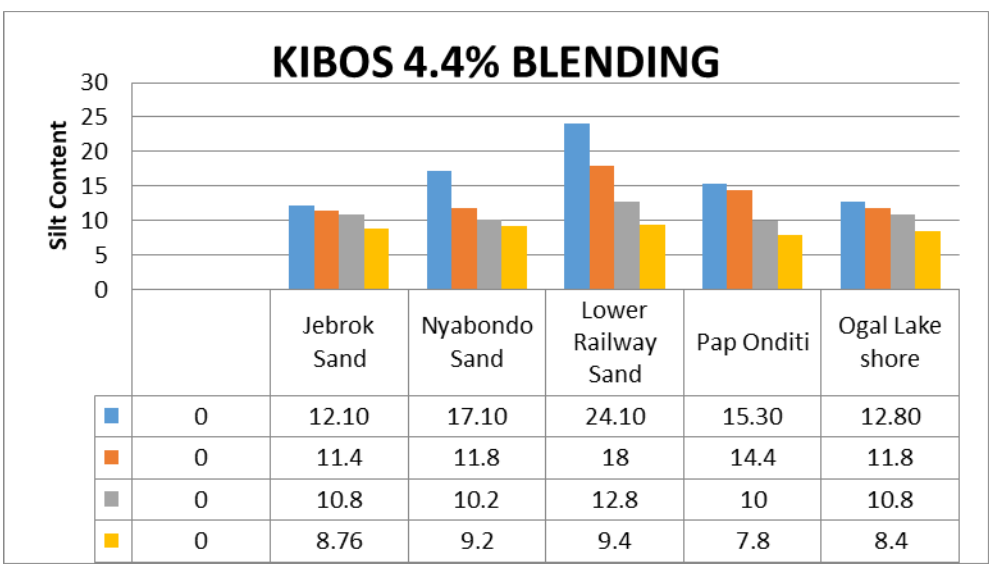
Consistent enhancement is observed in multiple additional low silt content sand samples with similar patterns. A comparable effect is seen with a 3% blending ratio. Jebrok's silt content improved from 12.3% to 8.2%, while Nyabondo's decreased from 17.07% to 9.2%, averaging a 47% improvement.



	Jebrok Sand	Kibos Sand	Nyabon do Sand	Lower Railway Sand	Pap Onditi	Ogal Lake shore
Blend 0%	12.13	4.40	17.07	24.13	15.33	12.80
Blended 10%	11.20	4.30	16.60	22.40	14.40	11.60
Blended 30%	10.00	4.00	11.20	14.00	10.40	10.20
Blended 50%	7.40	4.00	8.40	10.00	7.40	7.00

Figure 4. 11: River Yala sand blend

A comparable effect is seen with a 3.8% blending, Jebrok's silt content improved from 12.3% to 7.3%, while Nyabondo's decreased from 17.07% to 10%, general averaging a 43.5% improvement for all sand samples.



		Jebrok Sand	Nyabondo Sand	Lower Railway Sand	Pap Onditi	Ogal Lake shore
	0	12.10	17.10	24.10	15.30	12.80
	0	11.4	11.8	18	14.4	11.8
	0	10.8	10.2	12.8	10	10.8
	0	8.76	9.2	9.4	7.8	8.4

Figure 4. 12: Kibos Sand blend

A comparable effect is seen with a 4.4% blending ratio. Jebrok silt content improved from 12.3% to 8.76%, while Nyabondo's decreased from 17.07% to 9.2%, general averaging a 43.5% improvement for all sand samples.

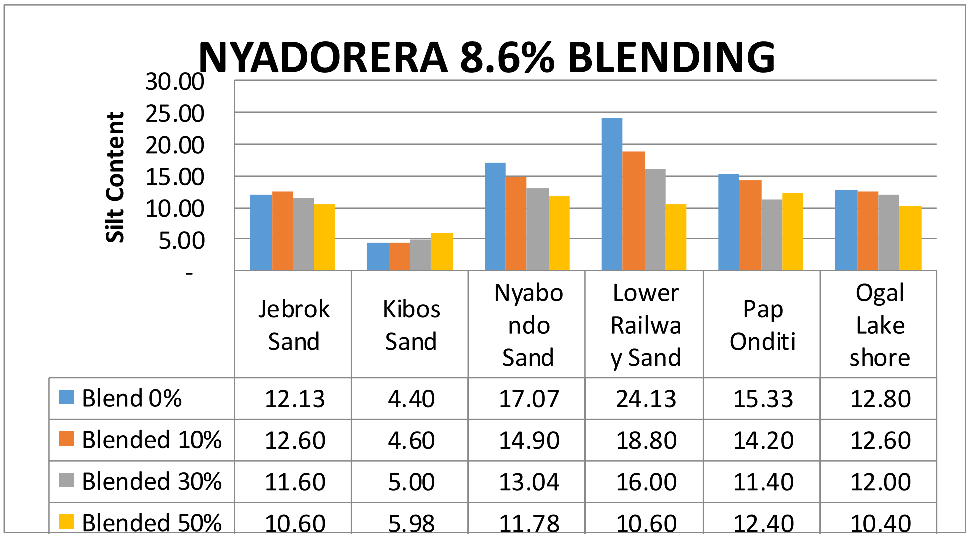


Figure 4. 13: Nyadorera sand blend

A comparable effect is seen with an 8.6% blending ratio. Jebrok silt content improved from 12.3% to 10.60%, while Nyabondo's decreased from 17.07% to 11.78%, general averaging a 30.5% improvement for all sand samples.

In conclusion, blending has resulted in noticeable improvement in silt content.

4.5 Specific Gravity of Sand Samples

Sand samples were subjected to specific gravity tests as detailed in ASTM D854 (2014). Specific gravity of 2.65 was obtained (**table 4.2.**) The expected ranges compare well with the expected specific gravity values of 2.65-2.68 for sand used in concrete which qualify this sample as common normal sand used in concrete making. Bulk specific gravity is used for calculation of the volume occupied by the aggregate in various mixtures such as concrete. Apparent specific gravity pertains to the relative density of the sand making up the constituent particles not including the pore space within the particles that is accessible to water.

The mix proportions in terms of the amount of sand needed to attain the desired workability and strength are influenced by the specific gravity of the sand. Deviations from the originally assumed specific gravity in the mix design can lead to alterations in mix proportions, which may potentially have an impact on the resulting concrete's strength.

Moreover, the specific gravity of sand plays a role in shaping the arrangement of particles within the concrete mixture. This, in turn, can enhance both workability and strength. Furthermore, the specific gravity of sand has implications for the concrete's porosity and permeability, directly affecting its durability.

Table 4. 2: Specific Gravity of sand

	Source	Specific Gravity
1	Jebrok sand	2.78
2	Kibos Sand	2.60
3	Karung sand	2.63
4	Nyabon sand	2.85
5	Railway sand	2.77
6	Pap Onditi Sand	2.73
7	Ogal Sand	2.81
8	Seme Sand	2.81
9	Nyador Sand	2.74
10	Port Victoria Sand	2.66
11	Nyador 2 Sand	2.59
12	Yala Sand	2.64
13	Miwani Sand	2.61

4.6 Mix Design

In determination of the mix design of Class 25 concrete, a systematic process involving various factors was considered. Specifying the desired characteristics of the concrete, such as strength, workability, and durability requirements. Then, selected suitable materials cement, aggregates (both coarse and fine), water, fine aggregates with known silt content. Performed a series of laboratory tests to assess the properties of individual materials, including the grading of aggregates, the water-cement ratio, and the specific properties of cement. Using these data, calculate the mix proportions to achieve the desired concrete properties while adhering to the Class 25 strength requirement. The Department of the Environment (DOE) method for concrete mix design, Was used in approach to designing concrete mixes to achieve the desired concrete properties, including strength.

Mix design in an excel tool to the British Standards Method was used to determine the precise proportions of materials **(Appendix 2),** accounting for factors such as moisture content and aggregate absorption. Iterate and fine-tune the mix design through trial batches and testing to achieve the desired Class 25 concrete performance characteristics. The same quantities of materials determined were simulated in field environment where materials particularly sand is used as delivered.

Table 4. 3: Summary of Mix Designs

DESIGN MIX						
	Cement	Sand	Aggregates 6/10	Aggregates 10/14	Slump	W/C Ratio
	Kgs	Kgs	Kgs	Kgs	mm	
Jebrok Sand	3.201	6.459	9.504	4.752	85	2.241
Kibos Sand	3.201	6.459	9.504	4.752	92	2.681
Karunga Sand	3.201	6.459	9.504	4.752	76	2.081
Nyabondo Sand	3.201	6.459	9.504	4.752	89	2.081
Lower Railway Sand	3.201	6.459	9.504	4.752	98	3.741
Pap Onditi	3.201	6.459	9.504	4.752	94	2.231
Ogal Lake shore	3.201	6.459	9.504	4.752	82	2.289
Seme	3.201	6.459	9.504	4.752	76	2.102
Nyador I Sand	3.201	6.459	9.504	4.752	98	2.435
Port Sand	3.201	6.459	9.504	4.752	81	2.093
Nyador II Sand	3.201	6.459	9.504	4.752	84	2.086
River Yala	3.201	6.459	9.504	4.752	85	2.354
Miwani	3.201	6.459	9.504	4.752	78	2.325

4.7 Neat Compressive Strength results

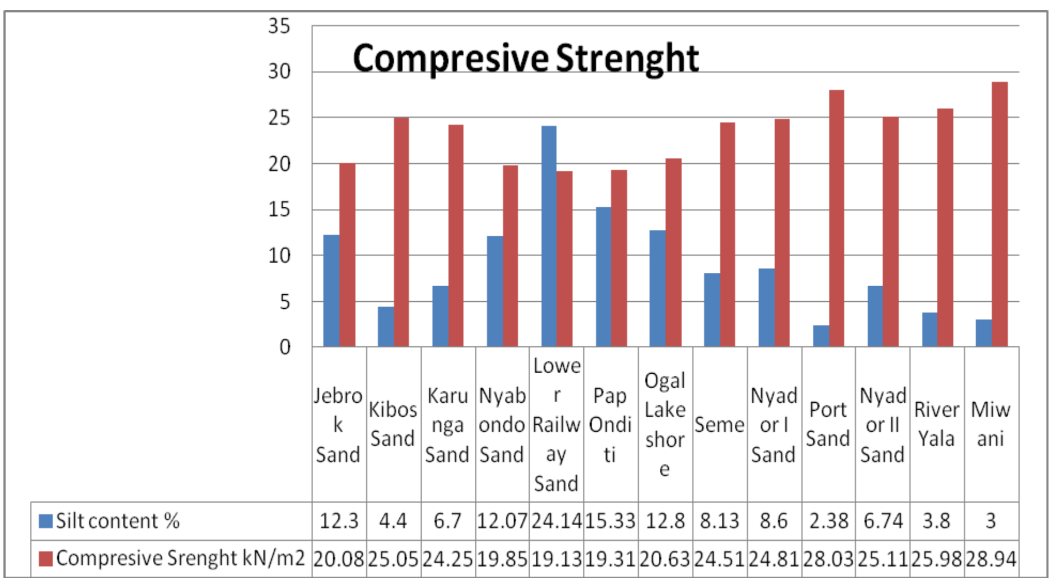


Figure 4. 14: Compressive Strength

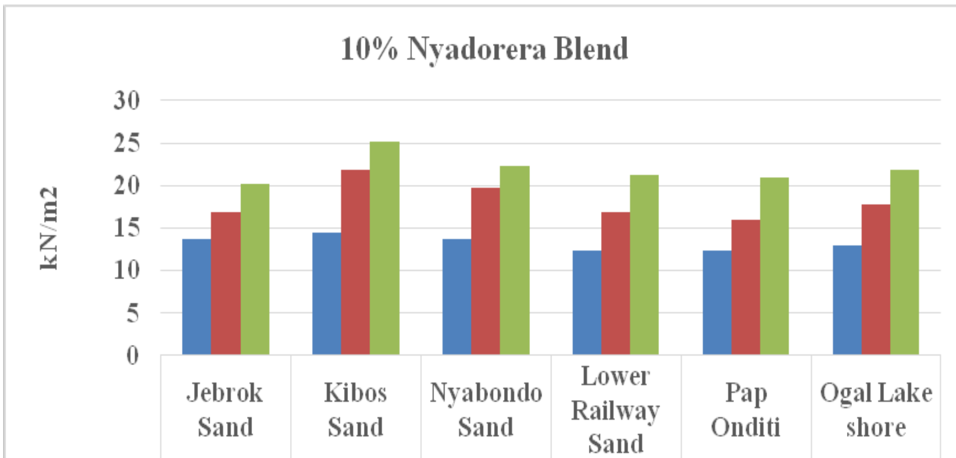
The target strength was 25kN/m^2. The lowest recorded strength was 19.13 kN/m^2, from silt content of 24.1%. the highest strength of 28.94 kN/m^2 was achieved from sand containing 3% silt content.

4.8 Compressive strength Results of Blended sand

The results below have been obtained from the concrete made from the design mix with sand blended with 10%, 30% and 50%. The blending sand are Nyadorera, Port Victoria, Miwani, Kibos and River Yala sand.

4.8.1 Nyadorera Sand site

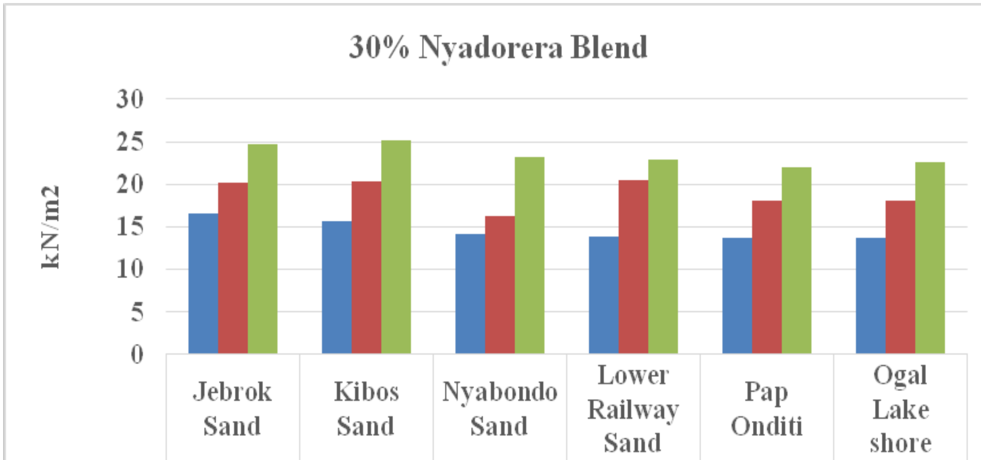
a) 10% Blend



	Jebrok Sand	Kibos Sand	Nyabondo Sand	Lower Railway Sand	Pap Onditi	Ogal Lake shore
7 Days	13.64	14.36	13.67	12.35	12.31	12.96
14 Days	16.87	21.85	19.65	16.85	15.92	17.68
28 Days	20.14	25.09	22.22	21.25	20.98	21.89

Figure 4. 15: Compressive Strength of 10% Nyadorera Sand

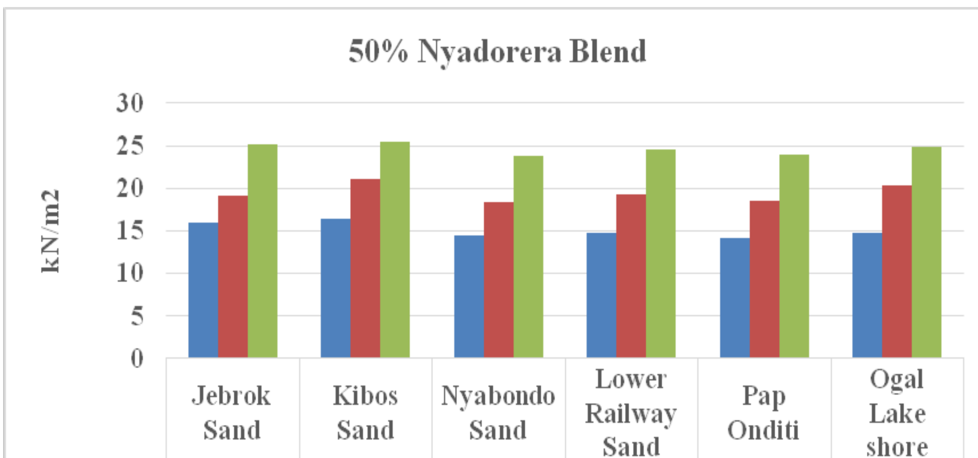
b) 30% Blend



	Jebrok Sand	Kibos Sand	Nyabondo Sand	Lower Railway Sand	Pap Onditi	Ogal Lake shore
7 Days	16.58	15.61	14.14	13.79	13.73	13.7
14 Days	20.11	20.31	16.21	20.44	18.11	17.99
28 Days	24.65	25.22	23.12	22.85	22.02	22.56

Figure 4. 16: Compressive Strength of 30% Nyadorera Sand

c) 50% Blend



	Jebrok Sand	Kibos Sand	Nyabondo Sand	Lower Railway Sand	Pap Onditi	Ogal Lake shore
7 Days	15.95	16.33	14.35	14.66	14.05	14.79
14 Days	19.12	21.12	18.33	19.33	18.45	20.33
28 Days	25.10	25.41	23.87	24.52	23.91	24.82

Figure 4. 17: Compressive Strength of 50% Nyadorera Sand

The improvement of compressive strength observed as the blending volume increase in all the blending percentages.

4.8.2 Port Victoria sand site

a) 10% Blend

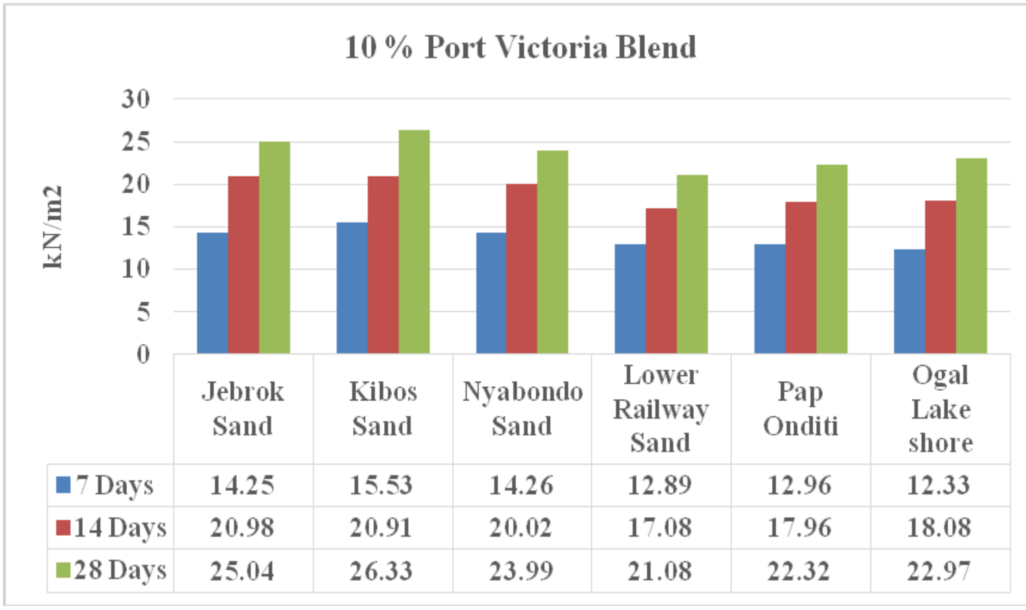


Figure 4. 18: Compressive Strength of 50% Nyadorera Sand

b) 30% Blend

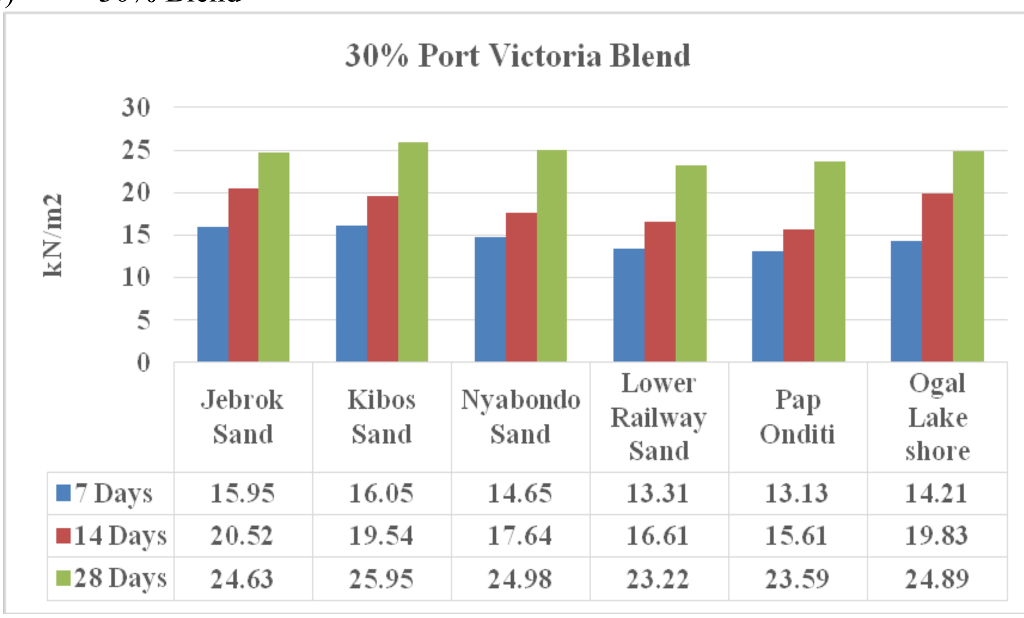
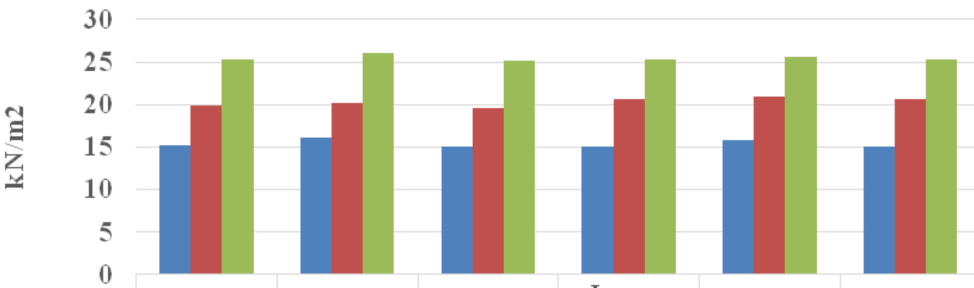


Figure 4. 19: Compressive strength of 30% Port Victoria Sand

c) 50% Blend

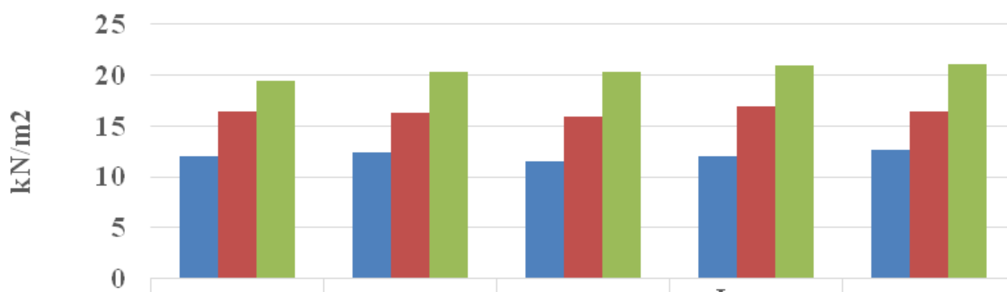


	Jebrok Sand	Kibos Sand	Nyabondo Sand	Lower Railway Sand	Pap Onditi	Ogal Lake shore
7 Days	15.25	16.02	15.08	14.97	15.85	14.97
14 Days	19.85	20.14	19.56	20.68	20.85	20.68
28 Days	25.31	26.01	25.15	25.35	25.68	25.35

Figure 4. 20: Compressive strength of 50% Port Victoria sand

4.8.3 Kibos sand site

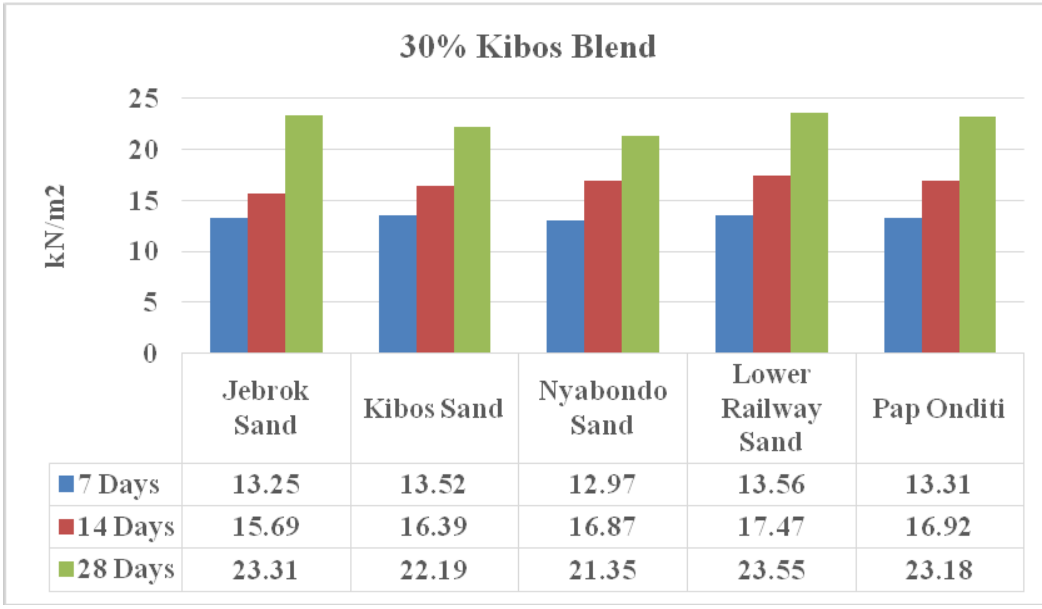
a) 10% Blend



	Jebrok Sand	Kibos Sand	Nyabondo Sand	Lower Railway Sand	Pap Onditi
7 Days	12.07	12.37	11.56	11.99	12.67
14 Days	16.38	16.31	15.95	16.87	16.39
28 Days	19.49	20.31	20.32	20.97	21.08

Figure 4. 21: Compressive Strength of 10% Kibos Sand

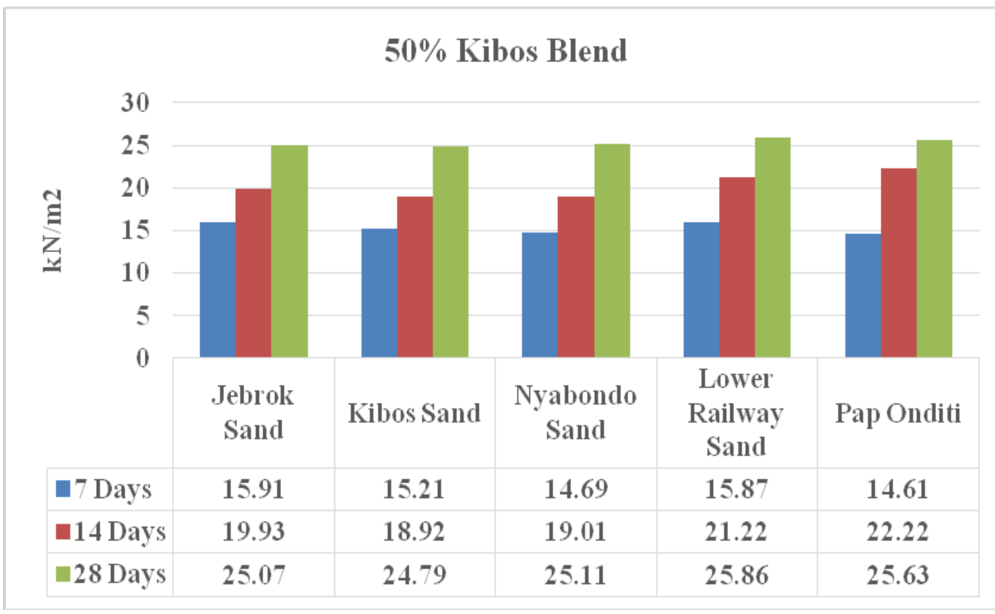
b) 30% Blend



	Jebrok Sand	Kibos Sand	Nyabondo Sand	Lower Railway Sand	Pap Onditi
7 Days	13.25	13.52	12.97	13.56	13.31
14 Days	15.69	16.39	16.87	17.47	16.92
28 Days	23.31	22.19	21.35	23.55	23.18

Figure 4. 22: Compressive Strength of 30% Kibos Sand

c) 50 % Blend



	Jebrok Sand	Kibos Sand	Nyabondo Sand	Lower Railway Sand	Pap Onditi
7 Days	15.91	15.21	14.69	15.87	14.61
14 Days	19.93	18.92	19.01	21.22	22.22
28 Days	25.07	24.79	25.11	25.86	25.63

Figure 4. 23: Compressive Strength of 50% Kibos Sand

4.8.4 Miwani sand site

a) 10% Blend

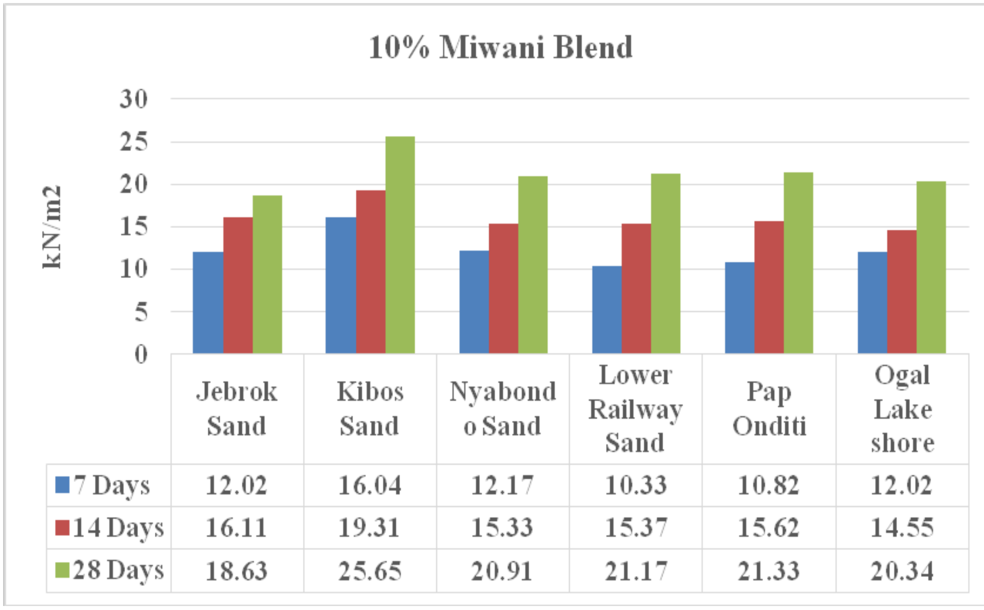


Figure 4. 24: Compressive Strength of 10% Miwani Sand

b) 30%Blend

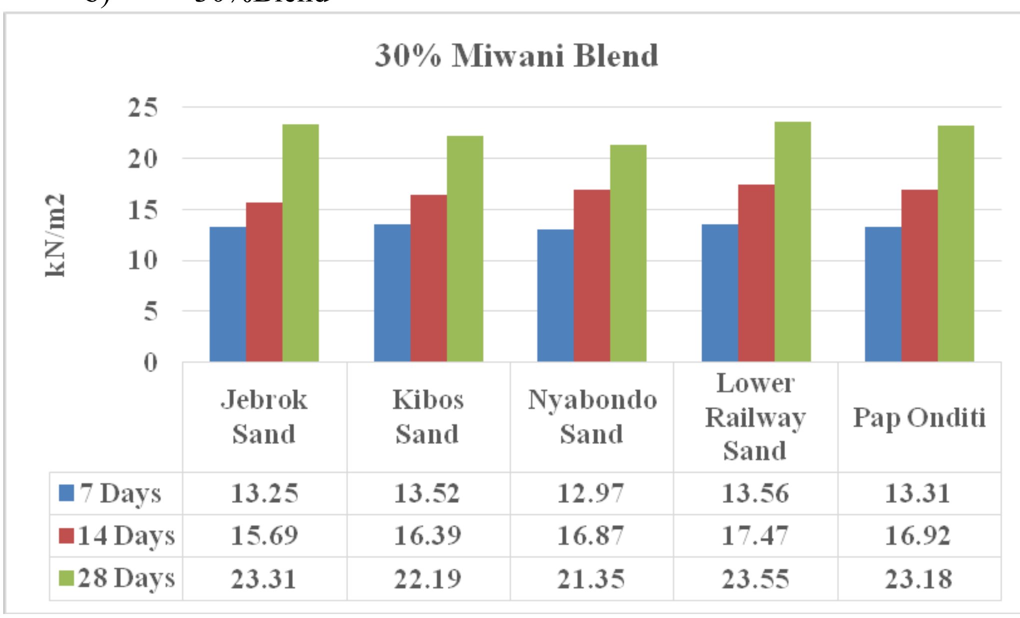


Figure 4. 25: Compressive strength of 30% Miwani Sand

c) 50% Blend

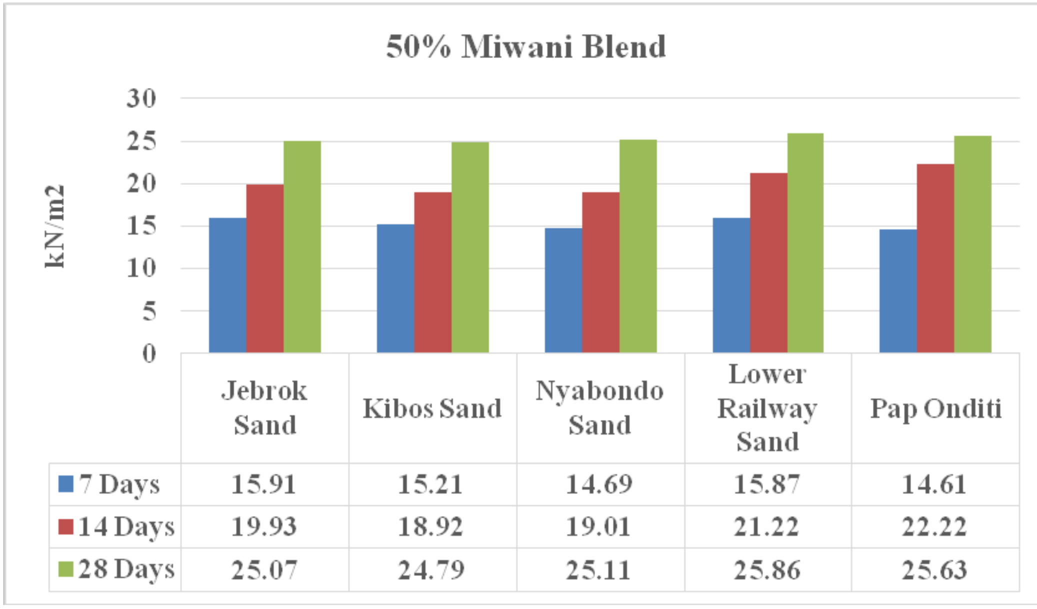


Figure 4. 26: Compressive strength of 50% Miwani Sand

4.8.5 River Yala sand site

a) 10% Blend

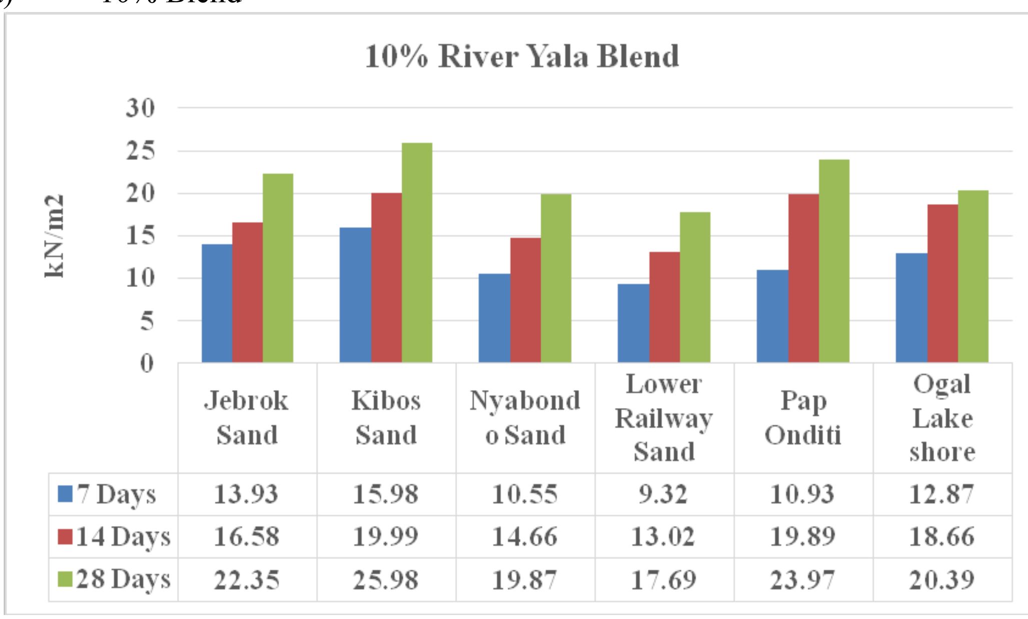


Figure 4. 27: Compressive strength of 10% River Yala Sand

b) 30% Blend

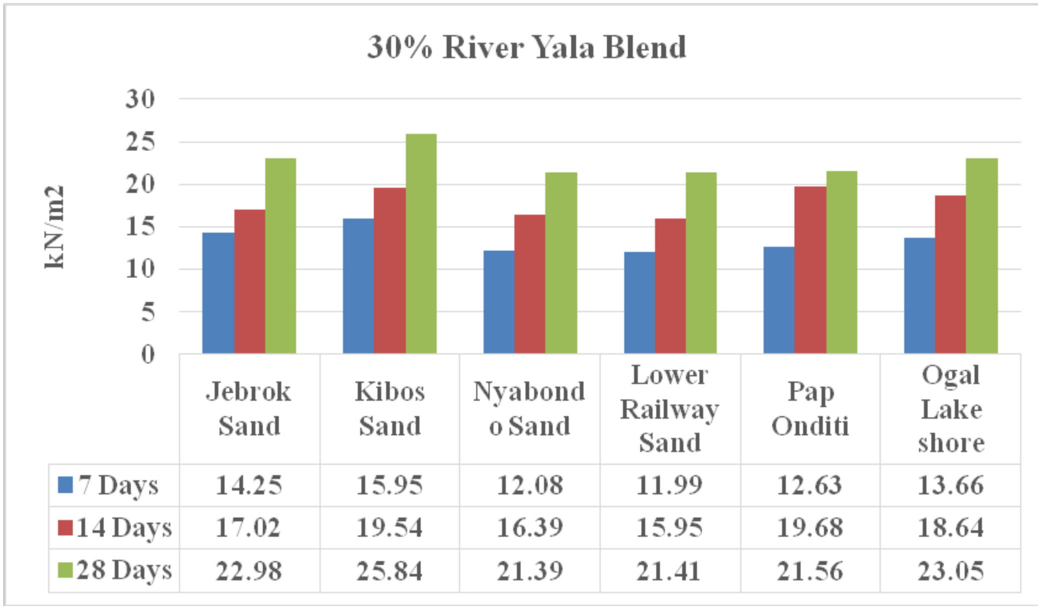


Figure 4. 28: Compressive Strength of 30% River Yala Sand

c) 50% Blend

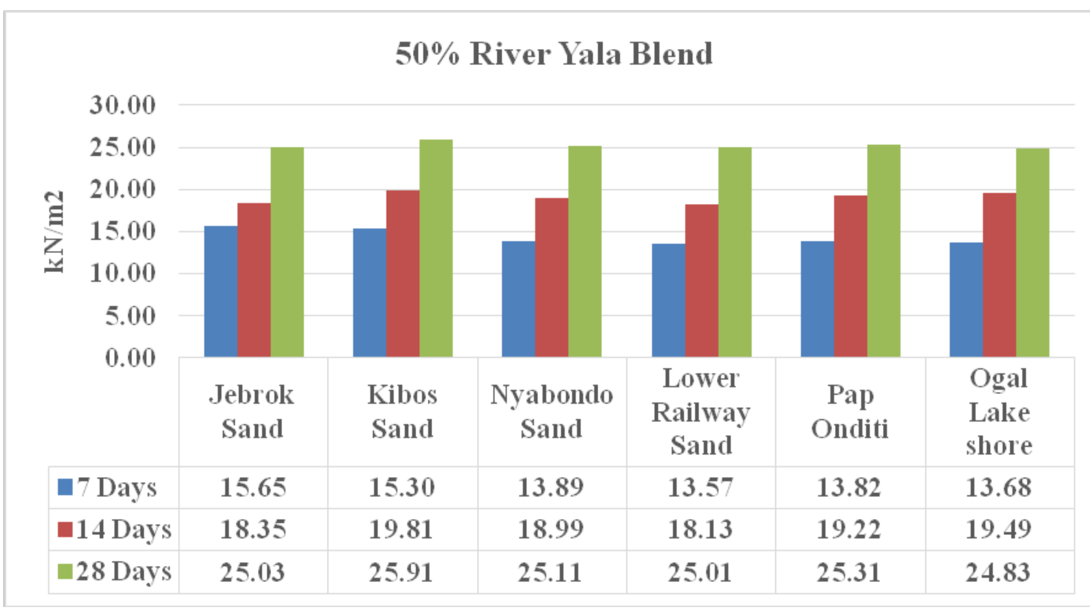


Figure 4. 29: Compressive Strength of 50% River Yala Sand

The blended samples have shown significant increment in strength relative to the initial and the resultant silt content after blending.

4.8 Regression analysis simulations Model.

The objective is to analyze the simulated results, examining coefficient estimates, p-values, and goodness-of-fit metrics, and draw conclusions about the model's performance and its ability to address research objectives. The general equation for this multiple Regression analysis is given by:

$Y = aX1 + bX2 + cX3+d$……………………………………………….. (1)

Where Y= Compressive strength X1=Silt content, X2= workability,

and X3 =water content

a, b c and d Constants

In the context of the regression analysis to factors are key in the overall, In the preceding regression analysis, the P-value (Probability Value) serves as a statistical metric denoting the likelihood of observing the results (or more extreme results) from a regression analysis, given the assumption of no substantial relationship between the independent variable(s) and the dependent variable. Conversely, a low p-value, typically below a chosen significance level like 0.05, implies that the independent variable(s) in the model are statistically significant predictors of the dependent variable. In simpler terms, it suggests that the association between the independent variable(s) and the dependent variable is unlikely to be a product of random chance.

On the other hand, R-squared (R^2) is a statistical gauge that quantifies the extent to which the variation in the dependent variable (Y) can be accounted for by the independent variable(s) (X) in a regression model. It essentially measures how well the model fits the data. R-squared values range from 0-1. A higher R-squared value indicates that a larger portion of the variability in the dependent variable can be elucidated by the independent variable(s). For instance, an R-squared of 0.80 signifies that 80% of the variation in the dependent variable can be attributed to the independent variable(s) in the model.

In normal circumstances high R^2 relates with a low p- value in the interpretation of the results

4.9 Neat sand

Table 4. 4: Regression analysis Data

Regression analysis for neat sand				
Source of sand	Silt content	Slump	Water content	Compressive
	X1	X2	X3	Y
Jebrok Sand	12.13	21	2.241	20.08
Kibos Sand	4.40	14	2.681	25.05
Karunga Sand	6.67	16	2.081	24.73
Nyabondo Sand	17.07	24	2.081	19.85
Lower Railway Sand	24.13	27	3.741	18.13
Pap Onditi	15.33	24	2.231	19.31
Ogal Lake shore	12.80	21	2.289	20.63
Seme	8.13	18	2.102	24.51
Nyador I Sand	8.60	16	2.435	24.81
Port Sand	2.38	12	2.093	28.03
Nyador II Sand	6.74	17	2.086	25.11
River Yala	3.80	15	2.354	25.98
Miwani	3.00	16	2.325	28.94

4.9.1 Regression analysis output for neat sand

Table 4. 5: Regression output for neat sand

Multiple R	R Square	Adjusted	R Square Standard
0.50366909	0.2536	0.0049	8.8291

	Coefficients	Standard Error	P-value
Intercept	25.722	38.512	0.5209
X1	1.2678	1.8164	0.5028
X2	-0.646	2.3955	0.7934
X3	-4.536	7.6477	0.5676

In 13 observations, the properties concrete is influenced by silt content and slump with effects of 70.144% and 2.564% respectively. The p-values are 0.502 for silt, 0.793 for workability, and 0.567 for water content, compared against a significance threshold of 0.05. This suggests that none of the variables hold statistical significance. The R^2 value stands at 25.36%, indicating that the variations in the properties of the independent variable cannot be attributed to the independent variables themselves. This is represented by:

Y=1.267X1+-0.646X2+-4.536X3 +25.722……………………………….. (2)

Table 4. 6: Correlation for Neat Sand

	X1	X2	X3	Y
X1	1			
X2	0.963	1		
X3	0.553	0.433	1	
Y	0.473	0.456	0.135	1

Silt content , Slump and water content has 47.4% , 55.3% and 13.6% effect respectively on the compressive strength of the concrete.

4.10 Blended sand

4.11 Nyadorera Sand site

4.11.1 Regression analysis for 10% Naydorera

Table 4. 7: Regression data for 10% Nyadorera

Regression analysis for 10% Nyadorera sand				
Source of sand	compressive Strength Y	Silt Content X1	Slump mm X2	Water X3
Jebrok Sand	20.14	12.6	24	2.314
Kibos Sand	25.09	8.0	23	2.441
Nyabondo Sand	22.22	11.8	27	3.501
Lower Railway Sand	21.25	17.6	29	2.397
Pap Onditi	20.98	14.2	25	2.451
Ogal Lake shore	21.89	12.6	33	2.241

Table 4. 8: Regression outputs for 10% Nyadorera Sand

Multiple R	R Square	Adjusted	R Square Standard
0.7428	0.551	-0.120	1.811

	Coefficients	Standard Error	P-value
Intercept	25.644	7.8773	0.0828
X1	-0.428	0.289	0.277
X2	0.0577	0.242	0.834
X3	0.0841	1.751	0.966

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=74.28% showing strong relationship R^2 shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R^2 is 55.1% average

The representation equation:

$$Y = -0.428X1 + 0.057X2 + 0.084X3 + 25.644 \text{ with } R^2 = 0.551 \ldots\ldots. (3)$$

The intercept has meaningful and significant part of the regression model since P-value is less than 0.05.

Table 4. 9: Correlation for 10% Nyadorera Sand

	Y	X1	X2	X3
Y	1			
X1	-0.734	1		
X2	-0.219	0.436	1	
X3	0.140	-0.164	-0.093	1

In 6 observations, independent variables are not statistically significant with P-Values above 0.05 and the silt content and Slump has 73.40% and 21.961% influence respectively on the compressive strength of the concrete.

4.11.2 Regression analysis for 30% Nyadorera

Table 4. 10: Regression data for 30% Nyadorera sand

Regression analysis for 30% Nyadorera sand				
Source of Sand	compressive Strength Y	Silt Content X1	Slump mm X2	W/C Ratio X3
Jebrok Sand	24.65	11.6	24	2.314
Kibos Sand	25.22	6.6	23	2.441
Nyabondo Sand	23.12	13.0	27	3.501
Lower Railway Sand	22.85	16.0	29	2.397
Pap Onditi	22.02	11.4	25	2.451
Ogal Lake shore	22.56	12.0	33	2.241

Table 4. 11: Regression outputs for 30% Nyadorera sand

Multiple R	R Square	Adjusted R2	R Square Standard
0.7085	0.502	-0.244	1.399

	Coefficients	Standard Error	P-value
Intercept	29.476	6.083	0.0400
X1	-0.158	0.256	0.599
X2	-0.138	0.209	0.576
X3	-0.192	1.385	0.902

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=70.85% showing strong relationship R^2 shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R^2 is 50.21% average

The regression model Equation

Y = 0.158X1-0.138X2 - 0.158X3+29.476 with R^2 = 0.502…………. (4)

The intercept has meaningful and significant part of the regression model since P-value =0.0400 is less than 0.05.

4.11.3 Correlation for 30% Nyadorera Sand

Table 4. 12: Correlation for 30% Nyadorera Sand

	Y	**X1**	**X2**	**X3**
Y	1			
X1	-0.627	1		
X2	-0.619	0.561	1	
X3	-0.0949	0.158	-0.093	1

From the 6 observations above, silt content and Slump has 62.70% and 61.91% contribution respectively on the properties of the concrete butt R^2=0.505 and P-Value = 0.040 meaning statistically significant Intercept but all X1, X2 and X3 are not statistically due to P-values of 0.599, 0.576 and 0.902 respectively.

4.11.4 Regression analysis for 50% Nyadorera

Table 4. 13: Regression data for 50% Nyadorera sand

Regression analysis for 50% Nyadorera sand				
Source of Sand	compressive Strength Y	Silt Content X1	Slump mm X2	W/C Ratio X3
Jebrok Sand	25.10	10.6	24	2.314
Kibos Sand	25.41	5.6	23	2.441
Nyabondo Sand	23.87	14.9	27	3.501
Lower Railway Sand	24.52	10.6	29	2.397
Pap Onditi	23.91	12.4	25	2.451
Ogal Lake shore	24.82	10.4	33	2.241

Table 4. 14: Regression outputs for 50% Nyadorera sand

Multiple R	R Square	Adjusted R2	R Square Standard
0.887	0.787	0.468	0.457

	Coefficients	Standard Error	P-value
Intercept	26.530	2.081	0.006
X1	-0.176	0.095	0.205
X2	0.006	0.061	0.925
X3	-0.079	0.600	0.906

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=88.70% showing strong relationship R^2 shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R^2 is 78.71% which is high meaning independent variable explain the variation in dependent variable

The regression model equation:

$Y = -0.176X1+ 0.006X2 + -0.079X3+26.530$ with $R^2 = 0.787$………… (5)

Table 4. 15: Correlation for 50% Nyadorera sand

	Y	X1	X2	X3
Y	1			
X1	-0.884	1		
X2	-0.188	0.270	1	
X3	-0.603	0.629	-0.093	1

In these 6 observations, silt content and slump have 88.47% and 18.91% contribution respectively on the compressive strength of the concrete while. The P-values of intercept indicate it has meaningful effect P-Value =0.006 Less than 0.05 while silt water and workability are insignificant with P-values of 0.205, 0.925 and 0.906.

4.12 Port Victoria Sand

4.12.1 Regression analysis for 10% Port Victoria Sand

Table 4. 16: Regression data for 10% Port Victoria sand

Regression analysis for 10% Port sand				
Source sand	compressive Strength Y	Silt Content X1	Slump mm X2	W/C Ratio X3
Jebrok Sand	25.04	7.4	25	2.314
Kibos Sand	26.33	4.0	23	2.441
Nyabondo Sand	23.99	11.4	26	3.501
Lower Railway Sand	21.08	15.8	27	2.397
Pap Onditi	22.32	14.8	25	2.451
Ogal Lake shore	22.97	12.2	31	2.241

Table 4. 17: Regression output for 10% Port Victoria

Multiple R	R Square	Adjusted R2	R Square Standard
0.991	0.981	0.953	0.409

	Coefficients	Standard Error	P-value
Intercept	26.858	2.081	0.006
X1	-0.4145	0.095	0.205
X2	-0.007	0.061	0.925
X3	0.587	0.600	0.906

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=88.70% showing strong relationship R^2 shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R^2 is 98.11% which is high meaning independent variable explain the variation in dependent variable

The equation for regression analysis model:

$Y = -0.176X1+ 0.0179X2 + 0.079X3+26.530$with R2 = 0.981…………. (6)

Table 4. 18: Correlation for 10% Port Victoria

	Y	X1	X2	X3
Y	1			
X1	-0.979	1		
X2	-0.544	0.519	1	
X3	0.098	0.049	-0.163	1

In 6 observations, Silt content and Slump has 97.95% and 54.44% effect respectively on the properties of the concrete. Silt and Intercept have significance P-value =0.0132 and P=0.007 respectively.

4.12.2 Regression analysis for 30% Port Victoria Sand

Table 4. 19: Regression data for 30% Port Victoria sand

Regression analysis for 30% Port sand				
Source of sand	compressive Strength Y	Silt Content X1	Slump mm X2	W/C Ratio X3
Jebrok Sand	24.63	9.8	23	2.241
Kibos Sand	25.95	3.4	23	2.241
Nyabondo Sand	24.98	10.6	27	3.500
Lower Railway Sand	23.22	11.6	28	2.397
Pap Onditi	23.59	10.6	25	2.455
Ogal Lake shore	24.89	9.6	29	2.241

Table 4. 20: Regression outputs for 30% Port Victoria Sands

Multiple R	**R Square**	**Adjusted R2**	**R Square Standard**
0.874	0.764	0.411	0.763

	Coefficients	**Standard Error**	**P-value**
Intercept	24.849	3.803	0.022
X1	-0.326	0.144	0.151
X2	0.0380	0.163	0.837
X3	0.6901	0.735	0.447

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=87.40% showing strong relationship R^2 shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R^2 is 76.4% which is high meaning independent variable explain the variation in dependent variable

The regression model equation:

Y = -0.326X1+ 0.038X2 + 0.690X3+24.849 with R2 = 0.0764………. (7)

Table 4. 21: Correlation for 30% Port Victoria Sand

	Y	X1	X2	X3
Y	1			
X1	-0.805	1		
X2	-0.368	0.571	1	
X3	0.0561	0.319	0.258	1

In 6 observations, Silt content and water content has 80.52% and 36.81% contribution respectively on the properties of the concrete with 30% blending of sand with 2.4% silt content. R2=0.764 and only intercept P-Values =0.02264 is significant the other variables are not significant they have p-value more than 0.05.

4.12.3 Regression analysis for 50% Port Victoria Sand

Table 4. 22: Regression data for 50% Port Victoria sand

Regression analysis for 50% Port sand				
Source of Sand	compressive Strength Y	Silt Content Content X1	Slump mm X2	W/C Ratio X3
Jebrok Sand	25.31	7.4	23	2.241
Kibos Sand	26.01	3.2	23	2.241
Nyabondo Sand	25.15	8.6	27	3.500
Lower Railway Sand	25.35	8.8	28	2.397
Pap Onditi	25.68	8.8	25	2.435
Ogal Lake shore	25.35	6.0	29	2.241

Table 4. 23: Regression outputs for 50% Port Victoria sand

Multiple R	R Square	Adjusted R2	R Square Standard
0.775	0.602	0.005	0.313

	Coefficients	Standard Error	P-value
Intercept	27.334	1.482	0.002
X1	-0.064	0.074	0.478
X2	-0.041	0.059	0.560
X3	-0.135	0.319	0.711

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=77.50% showing strong relationship R^2 shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R^2 is 60.20% which is high meaning independent variable explain the variation in dependent variable

The regression model equation:

Y=-0.064X1-0.041X2-0.135X3+27.334withR2=0.602………………. (8)

Table 4. 24: Correlation for 50% Port Victoria sand

	Y	X1	X2	X3
Y	1			
X1	-0.675	1		
X2	-0.563	0.380	1	
X3	-0.502	0.446	0.260	1

With 6 Observations, Silt content and Slump has 67.535% and 56.33% effect respectively on the compressive strength of the concrete. The correlation coefficient between Y and X1 is -0.675. This indicates a strong negative correlation between the dependent variable Y and the silt content variable X1. All variables are not statistically significant shown by P-values greater than 0.05.

4.13 Kibos Sand

4.13.1 Regression analysis for 10% Kibos Sand

Table 4. 25: Regression data for 10% Kibos sand

Regression analysis for 10% Kibos sand				
Source of Sand	compressive Strength Y	Silt Content X1	Slump mm X2	W/C Ration X3
Jebrok Sand	19.49	11.4	23	2.541
Nyabondo Sand	20.31	11.8	26	2.341
Lower Railway Sand	20.32	18.0	24	3.501
Pap Onditi	20.97	14.4	24	2.397
Ogal Lake shore	21.08	11.8	29	2.514

Table 4. 26: Regression outputs for 10% Kibos sand

Multiple R	R Square	Adjusted R2	R Square Standard
0.973	0.947	0.788	0.293

	Coefficients	Standard Error	P-value
Intercept	14.309	2.081	0.0919
X1	0.335	0.106	0.195
X2	0.229	0.066	0.178
X3	-1.569	0.600	0.232

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=97.30% showing strong relationship R^2

shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R^2 is 97.7% which is high meaning independent variable explain the variation in dependent variable

The regression model equation

Y = -0.033X1- 0.022X2 - 0.1569X3+27.334 with R2 = 0.947…………… (9)

Table 4. 27: Correlation for 10% Kibos sand

	Y	X1	X2	X3
Y	1			
X1	0.149	1		
X2	0.6451	-0.362	1	
X3	-0.1471	0.858	- 0.272	1

In 5 observations, the compressive strength of concrete is significantly influenced by the silt content and slump, with their respective relationship measured at 14.95% and 64.51%. The statistical analysis, indicated by an R-squared value of 94.7% and supported by the significance of all variables' P-values, show the nature of relationships.

4.13.2 Regression analysis for 30% Kibos Sand

Table 4. 28: Regression data for 30% Kibos

Regression analysis for 30% Kibos sand				
Source of Sand	compressive Strength Y	Silt Content X1	Slump mm X2	W/C Content X3
Jebrok Sand	23.31	10.8	24	2.402
Nyabondo Sand	22.19	10.2	25	2.269
Lower Railway Sand	21.35	12.8	27	3.455
Pap Onditi	23.55	10.0	26	2.405
Ogal Lake shore	23.18	10.8	27	2.432

Table 4. 29: Regression out puts for 30% Kibos sand

Multiple R	R Square	Adjusted R2	R Square Standard
0.779	0.607	-0.571	1.156

	Coefficients	Standard Error	P-value
Intercept	27.465	11.397	0.250
X1	-0.448	1.975	0.858
X2	0.051	0.165	0.808
X3	-0.474	4.567	0.934

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=77.90% showing strong relationship R^2 shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R^2 is 60.7% which is high meaning independent variable explain the variation in dependent variable

Regression model equation

Y = -0.448X1+0.0512X2 -0.474X3+27.47 with R2 = 0.607………… (10)

Table 4. 30: Correlation for 30% Kibos sand

	Y	X1	X2	X3
Y	1			
X1	-0.752	1		
X2	0.093	0.127	1	
X3	-0.740	0.964	0.137	1

In the 5 observations, the compressive strength of concrete is impacted by the silt content and slump with effects quantified at 75.263% and 9.34% respectively. The R-squared value of 60.07% signifies the proportion of variability in the dependent variable that can be attributed by the independent variables. However, the P-values of the independent variables, all exceeding the threshold of 0.05, render the dependent variables statistically insignificant.

4.13.3 Regression analysis for 50% Kibos Sand

Table 4. 31: Regression data for 50% Kibos sand

Regression analysis for 50% Kibos sand				
Source of sand	compressive Strength Y	Silt Content Content X1	Slump mm X2	W/C Ratio X3
Jebrok Sand	24.95	9.3	35	2.412
Nyabondo Sand	24.71	9.2	29	2.364
Lower Railway Sand	23.59	9.7	27	3.455
Pap Onditi	25.71	7.8	25	2.405
Ogal Lake shore	25.05	8.6	37	2.514

Table 4. 32: Regression outputs for 50% Kibos sand

Multiple R	R Square	Adjusted R2	R Square Standard
0.987	0.975	0.902	0.241

	Coefficients	Standard Error	P-value
Intercept	32.405	1.535	0.030
X1	-0.627	0.220	0.215
X2	0.0073	0.027	0.833
X3	-0.848	0.363	0.257

Regression model Equation

Y = -0.738X1+ 0.026X2 + 0.393X3+29.979 with R2 = 0.975………. (11)

Table 4. 33: Correlation for 50% Kibos sand

	Y	X1	X2	X3
Y	1			
X1	-0.880	1		
X2	0.104	0.172	1	
X3	-0.864	0.564	-0.310	1

In the 5 observations, the compressive strength of concrete is influenced by the silt content and slump, contributing effects of 89.223% and 10.40% respectively. The R-squared value of 97.50% demonstrates a high level of explained variability in the model. As for the statistical significance of individual variables, the P-values are 0.025 for silt content, 0.105 for workability, and 0.063 for water content, respectively.

4.14 Miwani Sand

4.14.1 Regression analysis for 10% Miwani Sand

Table 4. 34: Regression data for 10% Miwani sand

Regression analysis for 10% Miwani sand				
Source of sand	compressive Strength Y	Silt Content X1	Slump mm X2	W/C Ratio X3
Jebrok Sand	18.63	11.6	21	2.603
Kibos Sand	25.65	4.0	20	2.463
Nyabondo Sand	20.91	16.8	25	2.341
Lower Railway Sand	21.17	22.6	26	3.501
Pap Onditi	21.33	15.0	25	2.301
Ogal Lake shore	20.34	12.2	31	2.503

Table 4. 35: Regression outputs for 10% Miwani

Multiple R	**R Square**	**Adjusted R2**	**R Square Standard**
0.588	0.346	-0.634	2.978

	Coefficients	**Standard Error**	**P-value**
Intercept	22.013	12.874	0.229
X1	-0.247	0.311	0.510
X2	-0.057	0.393	0.896
X3	1.579	3.843	0.720

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=58.80% showing strong relationship R^2 shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R^2 is 34.604% which is low meaning independent variable cannot explaining the variation in dependent variable

Regression model Equation

$Y=-0.247X1-0.057X2+1.579X3+22.013$ with $R2 = 0.346$………… (12)

Table 4. 36: Correlation for 10% Miwani sand

	Y	X1	X2	X3
Y	1			
X1	-0.520	1		
X2	-0.368	0.467	1	
X3	-0.104	0.601	0.117	1

Silt content and Slump has 52.02% and 36.85% effect respectively on the compressive strength of the concrete. R2 =0.346 variability cannot be explained, P- Values shows all the independent variables are not statistically significant.

4.14.2 Regression analysis for 30% Miwani Sand

Table 4. 37: Regression data for 30% Miwani sand

Regression analysis for 30% Miwani sand				
Source of Sand	compressive Strength Y	Silt Content Content X1	Slump mm X2	W/C Ratio X3
Jebrok Sand	21.03	10.2	21	2.573
Kibos Sand	25.75	3.6	20	2.241
Nyabondo Sand	23.54	10.4	25	2.365
Lower Railway Sand	22.85	12.6	26	2.312
Pap Onditi	24.21	9.6	25	2.301
Ogal Lake shore	23.95	10.0	31	2.321

Table 4. 38: Regression outputs for 30% Miwani sand

Multiple R	R Square	Adjusted R2	R Square Standard
0.988	0.976	0.942	0.376

	Coefficients	Standard Error	P-value
Intercept	45.946	5.137	0.012
X1	-0.271	0.086	0.088
X2	0.059	0.063	0.446
X3	-9.060	1.965	0.043

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=98.80% showing strong relationship R^2 shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R^2 is 97.60% which is high meaning independent variable explain the variation in dependent variable

Regression model equation

Y=-0.271X1+ 0.059X2-0.906X3+45.946 with R2= 0.976………… (13)

Table 4. 39: Correlation for 30% Miwani sand

	Y	X1	X2	X3
Y	1			
X1	-0.7014	1		
X2	0.02564	0.54706	1	
X3	-0.9069	0.38732	-0.2446	1

In the 6 observations, the silt content and slump contribute effects of 70.144% and 2.5685%, respectively, to the compressive strength of concrete. Additionally, the water content exerts an influence of 90.6%. The R-squared value of 97% underscores the substantial degree to which the model explains variability. Nevertheless, when assessing the statistical significance of the variables, it is observed that the intercept has a P-value of 0.012, the silt content has a P-value of 0.088, and the water content has a P-value of 0.0439. These results indicate that intercept: P-value of 0.0122 (less than 0.05) the intercept is statistically significant. silt content: P-value of 0.0884 (greater than 0.05) - The silt content is not statistically significant.

Water content: P-value of 0.043 (less than 0.05) - The water content is statistically significant.

4.14.3 Regression analysis for 50% Miwani Sand

Table 4. 40: Regression data 50% Miwani sand

Regression analysis for 50% Miwani sand				
Source of Sand	compressive Strength Y	Silt Content X1	Slump mm X2	W/C Ratio X3
Jebrok Sand	25.79	8.2	22	2.352
Kibos Sand	26.98	3.0	29	2.241
Nyabondo Sand	25.18	8.2	26	2.314
Lower Railway Sand	23.19	9.2	27	2.329
Pap Onditi	25.11	7.0	25	2.301
Ogal Lake shore	25.49	7.8	32	2.331

Table 4. 41: Regression outputs for 50% Miwani sand

Multiple R	R Square	Adjusted R2	R Square Standard
0.9719	0.944	0.861	0.254

	Coefficients	Standard Error	P-value
Intercept	16.205	17.045	0.442
X1	-0.405	0.131	0.091
X2	-0.038	0.035	0.390
X3	5.862	7.651	0.523

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=97.19% showing strong relationship R^2 shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R^2 is 94.40% which is high meaning independent variable explain the variation in dependent variable

The equation

Y =-0.405X1-0.038X2+5.862X3+16.205 with R2 = 0.944…………… (13)

Table 4. 42: Correlation for 50% Miwani Sand

	Y	X1	X2	X3
Y	1			
X1	-0.940	1		
X2	0.0724	0.291	1	
X3	-0.798	0.919	-0.344	1

In the 6 observations, the silt content, slump, and water content contribute effects of 94.02%, 7.24%, and 79.80% respectively to the compressive strength of the concrete.

The associated P-values for these variables are 0.09144 for silt content, 0.39055 for slump, and 0.52363 for water content.

The high R-squared value of 97% indicates that a significant portion of the variability in the dependent variable can be explained by the model. However, when considering the statistical significance of the variables, none of them exhibit significance. This means that, at a significance level of 0.05, there is insufficient evidence to conclude that any of these variables have a statistically significant effect on the compressive strength of the concrete.

4.15 River Yala Sand

4.15.1 Regression analysis for 10% River Yala Sand

Table 4. 43: Regression data for 10% River Yala

Regression analysis for 10% River Yala sand				
Source of sand	compressive Strength Y	Silt Content X1	Slump mm X2	W/C Ration X3
Jebrok Sand	22.35	11.2	23	2.241
Kibos Sand	25.98	3.8	19	2.463
Nyabondo Sand	19.87	16.6	24	2.341
Lower Railway Sand	17.69	22.4	30	3.501
Pap Onditi	23.97	14.4	27	2.241
Ogal Lake shore	20.39	11.6	31	2.265

Table 4. 44: Regression for River 10% Yala sand

Multiple R	R Square	Adjusted R2	R Square Standard
0.880	0.774	0.436	2.252

	Coefficients	Standard Error	P-value
Intercept	31.705	8.346	0.06281
X1	-0.297	0.266	0.3806
X2	-0.170	0.302	0.6305
X3	-0.660	2.640	0.8257

The regression equation thus

Y=-0.297X1-0.170X2-0.660X3+31.705with R2 = 0.94……… (14)

Table 4. 45: Correlation for 10% River Yala Sand

	Y	X1	X2	X3
Y	1			
X1	-0.857	1		
X2	-0.711	0.675	1	
X3	-0.5847529	0.626	0.351	1

With the 6 observations, the properties of the concrete are influenced by the silt content, slump, and water content, with effects measured at 85.74%, 71.171%, and 58.4% respectively. The R-squared value of 77% indicates the extent to which the model accounts for variability.

When assessing the statistical significance of the variables, the P-values are as follows:

Intercept: 0.0628, Silt Content: 0.380637893, Workability: 0.630

Water Content: 0.825

At the commonly used significance level of 0.05, only the intercept and silt content exhibit statistical significance, as their corresponding P-values are below this threshold. The workability and water content, on the other hand, are not statistically significant based on the given P-values.

4.15.2 Regression analysis for 30% River Yala Sand

Table 4. 46: Regression outputs for 30% River Yala Sand

Regression analysis for 30% River Yala sand				
Source of sand	compressive Strength Y1	Silt Content X1	Slump mm X2	W/C Ratio X3
Jebrok Sand	22.98	10	24	2.241
Kibos Sand	25.84	3.4	22	2.46
Nyabondo Sand	21.39	11.2	23	2.241
Lower Railway Sand	21.41	11.4	28	3.025
Pap Onditi	21.56	10.4	33	2.241
Ogal Lake shore	23.05	10.2	31	2.561

Table 4. 47: Regression outputs for 30% River Yala

Multiple R	**R Square**	**Adjusted R2**	**R Square Standard**
0.972	0.945	0.863	0.815

	Coefficients	Standard Error	P-value
Intercept	34.418	3.385	0.009
X1	-0.646	0.137	0.042
X2	0.126	0.092	0.303
X3	-3.732	1.202	0.090

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=97.20% showing strong relationship R2 shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R2 is 94.50.4% which is high meaning independent variable explain the variation in dependent variable

The regression analysis equation thus:

Y = -0.646X1+0.126X2-3.732X3+34.946 with R2 = 0.945…………… (15)

Table 4. 48: Correlation for 30% River Yala sand

	Y1	X1	X2	X3
Y1	1			
X1	-0.81102826	1		
X2	-0.24513438	0.47262	1	
X3	-0.56499348	0.10069	0.1705	1

With 6 observations, the compressive strength of concrete is influenced by the silt content, slump, and water content, contributing effects of 81.11%, 24.513%, and 56%, respectively. The R-squared value stands at 0.945, reflecting a high degree of variation explained by the model. In terms of statistical significance, the results are as follows:

Intercept: P-value = 0.009, Silt Content: P-value = 0.0424, Workability: P-value = 0.090, Water Content: P-value = 0.043. These P-values are close to the significance threshold of 0.05, indicating a potential statistical significance for the intercept, silt content, and water content. The R-squared value of 94.58% underscores that a substantial portion of the variation in the independent variable's properties can be attributed to the independent variables.

Table 4. 49: Regression data for 50% River Yala Sand

Regression analysis for 50% River Yala sand				
Source of Sand	compressive Strength Y1	Silt Content X1	Slump mm X2	W/C Ratio X3
Jebrok Sand	25.03	9.2	25	2.241
Kibos Sand	25.91	2.8	21	2.324
Nyabondo Sand	25.11	8.4	24	2.241
Lower Railway Sand	25.01	9.6	33	2.684
Pap Onditi	25.31	7.4	31	2.241
Ogal Lake shore	24.83	7.4	29	2.561

Table 4. 50: Regression outputs for 50% River Yala

Multiple R	R Square	Adjusted R2	R Square Standard
0.895	0.802	0.505	0.268

	Coefficients	Standard Error	P-value
Intercept	27.175	1.514	0.003
X1	-0.135	0.062	0.164
X2	0.008	0.041	0.861
X3	-0.497	0.796	0.595

The multiple R shows the correlation between the dependent variable Y and the dependent variables X1,X2 and X3 in this case R=89.50% showing strong relationship R2 shows the proportion of the variation in Y that is explained by independent variables X1,X2 and X3 in this case R2 is 80.20% which is high meaning independent variable explain the variation in dependent variable

The regression analysis equation thus

$Y = -0.135X1 + 0.008X2 - 0.479X3+27.175$ with $R2 = 0.976$……… (15)

Table 4. 51: Correlation for 50% River Yala sand

	Y1	X1	X2	X3
Y1	1			
X1	-0.871	1		
X2	-0.583	0.606	1	
X3	-0.390	0.226	0.601	1

The compressive strength of concrete is impacted by the silt content, slump, and water content, contributing effects of 87.109%, 58.336%, and 39.05%, respectively. The R-squared value of 82.20% indicates the proportion of variability in the dependent variable that the model accounts for. Regarding the statistical significance of the variables, the P-values for the intercept, silt content, workability, and water content are as follows: Intercept: P-value = 0.003, Silt Content: P-value = 0.164

Workability: P-value = 0.861, Water Content: P-value = 0.595

At a significance level of 0.05, only the intercept holds statistical significance due to its P-value being below the threshold. The silt content, workability, and water content, however, are not statistically significant according to the provided P-values.

Summary of the regression simulations

Based on the extensive range of tests conducted throughout this study, encompassing evaluations of both neat samples and their constituents, it can be inferred that the silt content in 48% of the sample size exceeded the established limits set forth by BS 812, IS 1189, or ASTM C117 (1995). While any of these standards could be applicable, it's worth noting that in Kenya, the specifications are predominantly aligned with BS 812.

The empirical assessment of projected concrete compressive strength values at the 28-day mark revealed distinct failure patterns that indicated a discernible association with silt content, water content, and slump (or workability) of the concrete. Furthermore, the introduction of blended sand yielded an enhancement in the correlation between the concrete's strength properties. This enhancement implied a notable increase in strength as the replacement of low silt content sand escalated.

A comprehensive regression analysis encompassing all cluster tests established distinct independent relationships among the parameters within each replacement cluster of 10%, 30%, and 50%. These relationships provide valuable insights into the dynamics between the parameters and their influence on the concrete's behavior and properties.

Among the complete set of results obtained from testing all 13 samples, 12 samples consisted of blended sand, while the remaining set comprised solely of neat samples. This arrangement led to the development of 12 distinct regression analysis simulation models, each accompanied by a corresponding correlation model. These models underwent thorough analysis and interpretation to identify the most suitable model that offers optimal outcomes pertinent to this study.

The interpretation of the regression equations and their corresponding correlations facilitated the identification of the model that best encapsulates the interplay between concrete strength, silt content, water content, and workability.

This assessment ensured that the chosen model clearly captures the extent to which concrete strength is reliant on the interrelation of these parameters, preventing an undue emphasis on any single factor.

In the initial examination of the results, the focus was on assessing the significance of the impact of silt content and slump. It was assumed that the factor of slump encompassed two components: water content and water-cement ratio. The regression equation took the form of Y = AX1 +BX2 + CX2 + D, yielding an R-squared value of R^2. In the case of neat samples, considering solely silt content and workability, it emerged that silt content significantly influenced the property of concrete strength. The significance was remarkably low at P = 5.88x10^-6, deviating significantly from the standard P value of 0.05. On the other hand, the impact of slump on concrete strength was relatively minimal. Although the contribution of slump was modest, it provided further validation of the interrelation between materials and their partial contribution to the properties of concrete strength.

Subsequently, the same neat sample underwent a regression analysis for each individual parameter: silt content, water content, and slump. This was conducted to discern the significance of each parameter's influence on concrete properties. Observations indicated that the influence of silt content retained significance at a P value of 0.05, reduced.

The comprehensive analysis of blending tests, with a focus on the outcomes derived from 50% River Yala blend sand as the enhancing component, yielded the most reliable and realistic predictive model for assessing the effects of Silt, Water content, and Slump properties. The resulting regression equation, $Y = -0.645X1 + 0.127X2 - 3.73X3 + 34.418$, exhibited a commendable R-squared value of 0.945.

Within this context, the silt content exhibited a significant P value of $P = 0.009$, while Slump's P value was recorded at 0.105 and Water content at 0.06. This amalgamation of parameters collectively constituted the most representative and comprehensive model among all the outcomes. Therefore, the regression formula $Y = -0.645X1 + 0.127X2 - 3.73X3 + 34.418$, accompanied by an R-squared value of 0.945, stands as the essential tool for predicting the compressive strength of concrete across varying degrees of silt content, water content, and slump. This simulation can be applicable to concrete compositions encompassing different blending proportions, specifically in scenarios where the blend comprises 50% silt content and silt content does not exceed 25%.

The regression equation illustrates that when employing a design mix corresponding to concrete class $25kN/m^2$, which integrates a combination featuring 30% sand with silt content not exceeding 3.8% and a maximum of 24%, the impact of silt and water content becomes apparent, constituting approximately 94.5% of the influence exhibited by sand at 30% River Yala Blend. Hence, the utilization of clean sand becomes imperative, unless specific constraints dictate otherwise. In such cases, a permissible alternative is the use of a 50% blend with high-quality sand, provided that the silt content in the blended sand remains below 24.5%.

It can be inferred that the influence of silt content and other unaddressed impurities can be mitigated effectively through appropriate blending, which necessitates stringent quality control tests for the materials involved in concrete production.

Additionally, the blending of sand leads to enhanced concrete strength, as demonstrated across all 12 tests conducted with various blends. The increment in strength is both notable and progressive as the percentage of blending increases. A notable example is the sand sample with an initial 24.1% silt content, which experienced a remarkable enhancement in compressive strength from 20.32kN/m^2 to 25.11kN/m^2 after blending with 10%, 30%, and 50% sand with a lower silt content of 4.4%.

Derived from the study's objectives and the comprehensive test results, it is evident that 48% of the sample exhibited silt content surpassing 4%, exceeding the compressive strength limits established by BS 882 and BS 812. The recorded range of silt content varied from 2.4% to 24.1%. Notably, a silt content of 2.4% corresponded to a concrete strength of 28.94kN/m^2, while a silt content of 24.1% yielded a lower concrete strength of 18.13kN/m^2 for the same design mix. This indicates an inverse relationship between higher silt content and lower concrete strength.

The blended sand samples exhibited a positive trend, particularly within the silt content threshold of 4%. For instance, sand with an initial silt content of 12.1% improved when blended with 2.38% silt content sand, resulting in a reduced 8.76% silt content. Furthermore, with the target of 25kN/m^2, the same sand at a 50% blend elevated the concrete strength from 19.5kN/m^2 to 25.1kN/m^2.

CHAPTER FIVE:

CONCLUSSIONS AND RECOMENDATIONS

5.1 Introduction

The study was focused on three objectives determination of the existing silt content of the study area, the effect of the existing silt content on strength of concrete and the effect of blending the sand from different sources and its effect on compressive strength of concrete .

This chapter covers conclusions drawn from the study based on the objectives, suggestions for practical applications, and potential avenues for future research exploration.

5.2 Conclusions

The sand utilized in concrete projects within western Kenya indicate that a significant proportion of sources exhibit silt content exceeding the permissible thresholds outlined by BS812, which is the principal standard. The recorded silt content is between 2.4% and 24.1%. Remarkably, 76.92% of the samples subjected to testing failed to conform to the stipulated content limit of 4%, as stipulated in BS 812.

Based on the results, with proper control of quality and handling of materials on site, 8.6% of silt content sample with compressive strength of 25N/mm2 has been achieved

Presence of silt content and water content have significant influence to the property of concrete and blending of sand have shown that sand design mix can be applicable in the construction industry with positive outcomes.

The blending of sand showed reduction in silt content, which resulted to improvement on the quality of sand in terms of silt content and increase in concrete compressive strength.

In the simulation of the effect of blending of sand on the compressive strength of concrete, in the river Yala sand, the compressive strength of concrete is influenced by the silt content, slump, and water content, contributing effects of 81.11%, 24.513%, and 56%, respectively.

The R-squared (R^2) value stands at 0.945, reflecting a high degree of variation explained by the simulation model. In terms of statistical significance, Intercept: P-value = 0.009, Silt Content: P-value = 0.042, Workability: P-value = 0.090, Water Content: P-value = 0.043.

These P-values are close to the significance threshold of 0.05, indicating a potential statistical significance for the intercept, silt content, and water content in the simulation.

5.3 Recommendations

The outcomes of the regression model simulation provide potential sand blending ratios. A mixture consisting of 50% of sand with silt content below 4% can effectively combine with any sand having silt content not exceeding 24% when considering the blending proportions. This combination is expected to achieve the desired target strength of 25 kN/m^2.

The study provides the possibility to have sand design mix for each quality of sand for engineering application. Based on the findings the region can carry out sand mapping on all the possible sources and populate the document with sand attributes

From the study, the western region can formulate and map out all the possible sand sources and provide the attributes of each for use in blending sand .

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APPENDICES

APPENDIX 1: MIX DESIGN OUT PUTS

APPENDIX 1									
DESIGN MIX									
		wt1	wt 2	silt	CEMENT	SAND	Aggregates 6/10	Aggregates 10/14	W/C Ratio
1	Jebrok Sand	750.0	659.0	91.0	3.201	6.459	9.504	4.752	2.241
2	Kibos Sand	750.0	717.0	33.0	3.201	6.459	9.504	4.752	2.681
3	Karunga Sand	750.0	700.0	50.0	3.201	6.459	9.504	4.752	2.081
4	Nyabondo Sand	750.0	622.0	128.0	3.201	6.459	9.504	4.752	2.081
5	Lower Railway S	750.0	569.0	181.0	3.201	6.459	9.504	4.752	3.741
6	Pap Onditi	750.0	635.0	115.0	3.201	6.459	9.504	4.752	2.231
7	Ogal Lake shore	750.0	654.0	96.0	3.201	6.459	9.504	4.752	2.289
8	Seme	750.0	689.0	61.0	3.201	6.459	9.504	4.752	2.102
9	Nyador I Sand	500.0	457.0	43.0	3.201	6.459	9.504	4.752	2.435
10	Port Sand	500.0	488.1	11.9	3.201	6.459	9.504	4.752	2.093
11	Nyador II Sand	500.0	466.3	33.7	3.201	6.459	9.504	4.752	2.086
12	River Yala	500.0	481.0	19.0	3.201	6.459	9.504	4.752	2.354
13	Miwani	500.0	485.0	15.0	3.201	6.459	9.504	4.752	2.325

APPENDIX 2: GENERATION OF MATERIALS QUANTITY

Mix Design for Concrete Grade = M 25

C1.Design stipulation:

i	Characteristic Compressive strength	=	25	N/mm2
ii	Maximum size of aggregate	=	20	mm
iii	Degree of workability	=	0.8	
iv	Degree of quality	=	Good	
v	Type of Exposure	=	Mild	

C2. Test data for materials

(i)	Cement used	=	PPC	
(ii)	Specific gravity of Cement	=	3	
(iii)	Specific gravity			
	Fine Aggregate	=	2.65	
	Coarse Aggregate	=	2.61	
(iv)	Water absorption			
	Fine Aggregate	=	2.1	%
	Coarse Aggregate	=	0.78	%
(v)	Free Surface Moisture			
	Fine Aggregate	=	2.1	%
	Coarse Aggregate	=	Nil	%
(vi)	Fine Aggregate confirming the table 4, IS 383- Zone	=	2	Zone

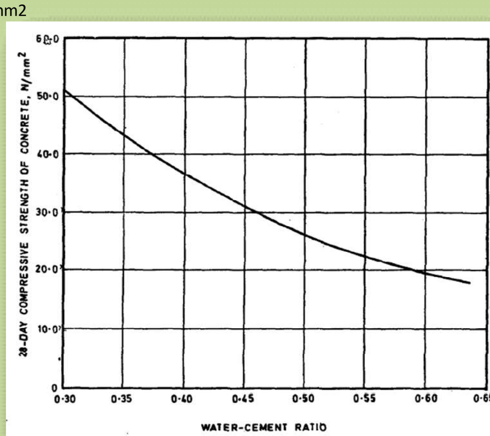

Fig. 1 Generalised Relation Between Free Water-Cement Ratio and Compressive Strength of Concrete

C3.Target mean strength

= 31.60 N/mm2

C4. Selection of Water Cement ratio

Water Cement ratio = 0.44 (From fig. 1, Is 10262)

C7. Determination of Fine & Coarse aggregate

Air entrapped in concrete = 2 % (From Table 3, IS 10262)

Actual quantity of concrete "V" = 0.98 Cum

Materials required for concrete

Grade M 25

Concrete quantity = 1 Cum

Sl. No	Material name	Quantity	Unit
1	Cement	422.73	kg
2	Fine Aggregate	561.92	kg
3	Coarse Aggregate 20mm	694.44	kg
4	Coarse Aggregate 10mm	462.96	kg
5	Water	183.51	ltr
6	Slump	75 - 100	mm
7	W/C ratio	0.44	

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APPENDIX 3: SPECIFIC GRAVITY

APPENDIX 3									
DETERMINATION OF SPECIFIC GRAVITY									
	Source of sand samples	Weight of dry sample (g)	Weight of saturated and surface dry sample (g)	Weight of bottle+Sample+Water (g)	Weight of bottle + water (g)	Weight of oven dried sample (g)	Specific gravity (oven dried)	Specific gravity (saturated and surface dry)	Apparent specific gravity
			C	A	B	D	D / (C - (A-B))	C / (C - (A-B))	D / (D - (A-B))
1	Jebrok Sand	500	484	1696.5	1390.5	477.5	2.68	2.72	2.78
2	Kibos Sand	500	472	1679.5	1390.5	470	2.57	2.58	2.60
3	Karunga Sand	500	477	1687.5	1395.5	471	2.55	2.58	2.63
4	Nyabondo Sand	500	419	1663.3	1390.5	420	2.87	2.87	2.85
5	Lower Railway S	500	490	1723.8	1419.5	476	2.56	2.64	2.77
6	Pap Onditi	500	466	1681.2	1380.5	475	2.87	2.82	2.73
7	Ogal Lake shore	500	476	1687	1390.5	460	2.56	2.65	2.81
8	Seme	500	460	1692	1390	469	2.97	2.91	2.81
9	Nyador I Sand	500	456	1677.7	1392	450	2.64	2.68	2.74
10	Port Sand	500	460	1684	1392	430	2.56	2.74	3.12
11	Nyador II Sand	500	431	1651.9	1412	401	2.10	2.26	2.49
12	River Yala	500	432	1652	1392.1	429	2.49	2.51	2.54
13	Miwani	500	475	1683.7	1394	481	2.60	2.56	2.51
	Overall Average						2.62	2.65	2.72