

A Comparative Study on the Properties of Concrete Containing Blended Pit and River Sands of Western Kenya

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Abstract:

This comparative study examines the properties of Pit sand and River sand as used in the construction industry in the Western Kenya by determining the existing silt content which varies from 2.4% to 24.1%. The study also determines then concrete strength that relates to the respective silt contents. The Blending of sand from different sources with silt content from 2.4% and 8.6% are used to blend Pit sand containing silt from 12.1% to 24.1%. Significant improvement is observed with silt content reduction. Consequently, concrete derived from blended pit with river sands has shown concrete achieving the target strength of 25KN/M2. The research assesses the suitability of these sand sources for construction purposes, and blending considering factors such as compressive strength, workability, and durability. Through comprehensive testing and analysis, our study reveals significant variations in concrete properties between the two sand types. The study also finds that the blended sand as an alternative to improving in the economical use of natural sand by producing sand design mix These findings have practical implications for the construction industry in Western Kenya, where the choice of sand source directly influences the quality and performance of concrete structures. This research contributes to the ongoing efforts to optimize construction materials in the region, ultimately enhancing the sustainability and resilience of building projects. It further contributes to the mapping of sand sources and their attributes that can be used by the counties in western Kenya. It would add to the knowledge base of the practitioners in the effective use of sand.

Keywords: *Blending, sand Mix, Compressive strength.*

Introduction

In Kenya Like any other country, and specifically western Kenya sand is highly used as fine aggregate. Concrete is composite material, a major construction material used in general construction. quality of concrete depends on the properties and quality of individual material properties and handling., Proper Mix Design, the quality of the raw materials used in concrete production, Water-Cement Ratio, Workability, Testing among other properties.

Aggregates mainly act as the filler. The entire requirement of aggregates is provided by coarse and fine portion; where coarse aggregate, and sand is used. They must conform to standard of American Society for Testing and Materials (ASTM) specifically standard specification C33 for aggregate in producing concrete.

Most of the sands used in the construction industry in western Kenya are from either the river beds, or pit sand sources, while there are other

sand sources within the area of study. These sources display different properties, and therefore must affect the property of concrete. Since this are locally available materials sources, they are the most used sources of sand in construction work. The applicable quality control procedures in Kenya are BS 812 and the building code 2000. The minimum silt content is specified as 4% and further escalated in the code that when that 4%value is exceeded then the sand should be removed from site and replaced.

Silt being the most deleterious materials in sand quality that affect the compressive strength of the concrete produced with locally available it is important to investigate the properties of the sand from the two sources with emphasis on the silt content and the option of blending them to check the viability of improving of pit sand for optimum compressive strength.

This study identified different locations with three sand sources under the pit sand category and sand sources under the river sand category, collected

sand samples from all the sources., the pit sands among others were Kibos , Jebrok, and Lower Railways while Nyadorera , Port Victoria and River Yala were the River sand sources and were tested in the laboratory as to whether they meet the standard requirements or not.

River sand and Pit sand which have different geological formation process and distinct shapes which also have influence on the property as fine aggregate, since it was originally rock and has been transformed to soil by natural forces of weathering process where fine sand particle having a diameter in the range of 0.074 mm (retained on U.S. standard sieve no. 200) to 0.42 mm (passing U.S. standard sieve no. 40).

The process of blending sand with another sand from different Formation source and different quantity of impurities silt content in this case to produce sand mix that is below 10% as per IS 650 (2002) and produce concrete from it that can be used in the building construction industry

Literature Review

Sand as an aggregate can be defined generally as inert mineral used in the production of concrete and is composed of uncrushed or crushed gravel, crushed stone or rock, sand, or artificially produced inorganic materials (Crag 2004), the presence of SILT in sand has influence the overall strength and performance of concrete (Olanitori et al., 2005). As studies are being carried out on the physical and chemical properties of sand and with the rapid urbanization, industrialization and infrastructure development in last few decades there is depletion of the construction materials (Abhisheck, Etal.2020).

Most of the studies have been focusing on replacing the natural sand with different alternative sand in concrete and mortar, and further demonstration that recycling and use of alternative sand in construction sector is appropriate since physical properties of studied alternative sands such as specific gravity, grain size distribution, bulk density are almost comparable to natural sand.

Silt

Silt refers to particles ranging between 0.06 mm and 0.002 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.

Sand from a Pit

Pit sand is a coarse sort of sand that can be found about 2-3 metres underground. When deep enough trenches are dug on the earth's surface, this type of sand is naturally obtained. Sharp, angular, rough, and coarse grains are the most common results. These characteristics allow the sand to form strong connections with surfaces.

Unlike sea sand, which has a high salt content, pit sand is normally salt-free, reducing the risk of efflorescence and excessive moisture absorption when utilized in building. When utilizing pit sand, it's critical to examine the degree of coarseness to make sure it's not too coarse.

Sand from the river

River sand is extremely unsustainable, and it is becoming increasingly scarce as construction activity increases. River sand, also known as natural sand, is a fine sand that is commonly found around streams and river banks. River sand's softness makes it suitable for use in concrete and brickwork. Plastering, RCC, and a variety of other block works benefit from river sand.

The biggest disadvantage of river sand is that it contains a lot of silica. As a result, it's a good idea to check the silica content of river sand before utilizing it in building to make sure it's less than 5%. River sands also have a high moisture content, which means they don't require a lot of water to build with.

Blended Sand

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:

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.

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.

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.

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.

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.

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.

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.

Several studies are continuously being carried out

in an attempt to improve the properties of Recycled aggregate concrete by blending of Refined Fine Aggregates with copper slag to form blended sand (Vaishnav & Trivedi, 2022). The study investigated the use of recycled fine aggregate (RFA) and blended sand (RFA + CS) separately in high strength concrete M-40 grade of concrete using 20%, 40%, 60%, 80% and 100% replacement of natural sand. Then concrete mixes are checked for workability (slump value) and compressive strength at 7, 14 and 28 days of curing. The results did not achieve the target strength.

In another investigates the use of crushed rock sand as viable alternative to Natural River sand that is being conventionally used as fine aggregate in cement concrete (Mundra, et al. 2016). Design mixes were produced and the resulting strength properties of concrete was similar to the concrete from natural sand. Manufactured sand and offshore sand can be considered as the principal alternatives which are consumed by most of the contractors for substituting river sand in the construction activities at 50% replacement (Branavan et al., 2016). In a separate investigation, an effort to entirely substitute river sand with a combination of manufactured sand and offshore sand in lime-cement masonry mortars demonstrated that both the blended sands and the manufactured sand resulted in a deterioration of the initial performance of the mortars compared to those composed of river sand (Branavan et.al 2021.). Sand was also partially replaced with Class F fly ash. The sand was replaced in percentages of 10%, 20%, 30%, 40%, and 50% of Class F fly ash by weight and there was significant increase in the strength of concrete. 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 which is characterizing property of pit sand.

In their research on inappropriate sand (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).

There are gaps in the various studies that have been carried out which are specific to the alignment to replacement of sand with manufactured and processed sand which may not be cost-effective. The concrete produced was conventional mixes of 1:2:4 or 1:1.5:3 which was by volume and not by weight as required by BS 8500 is the British Standard for specifying and producing concrete. Which is the complementary British Standard to EN 206. The blending of natural sand with regard to the source has very limited information, which forms the basis of this research.

Methodology

The experimental methods that were deployed included the determination of different physical properties of sand samples from different sources, according to respective ASTM standards. Material properties. Sieve analysis was conducted according ASTM C136, Specific gravity was as per ASTM C127.

Pit Sand containing silt content that has been determined to the requirement outlined by BS812 and other standards was blended with the river I

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

The respective Slump test of concrete as per ASTM C143 and Compressive strength of concrete ASTM C39 determined.

Comprehensive analysis of the relationships between silt content and concrete compressive strength was the interpreted.

Results And Discussion

Sieve Analysis

The sieve analysis process adhered to the specifications outlined in the British standards (BS 1377-2:1990). The sieves were ranging from 4.75mm to 75 microns. Subsequently, a particle size distribution curve was generated by plotting the sieve mesh sizes along the x-axis and the corresponding percentage of each material passing through each sieve on the y-axis.

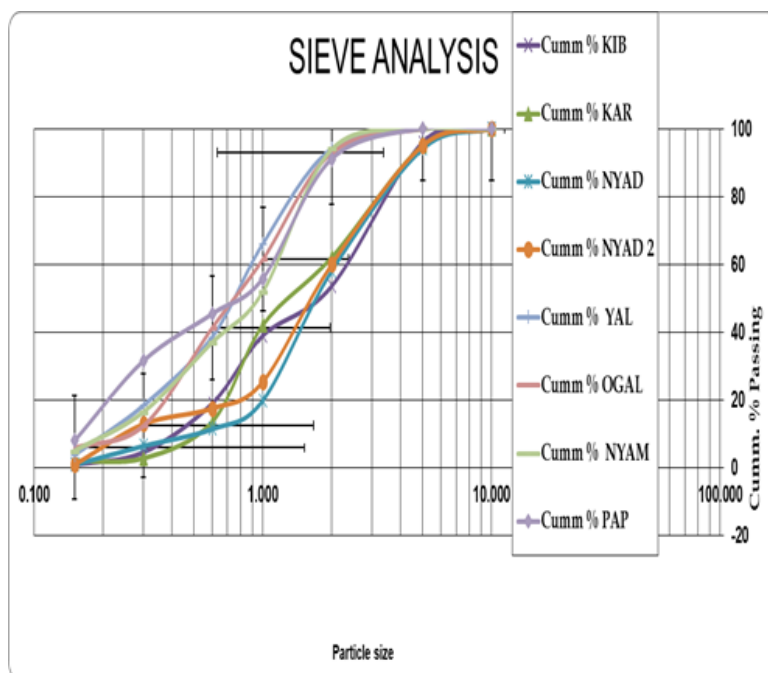


Figure 1: Sieve Analysis

Silt Content Determination and their Compressive Strength

The Gravimetric Method was employed, the

difference in weight provided an approximation of the silt content. the silt content levels and neat compressive strength were determined is shown below.

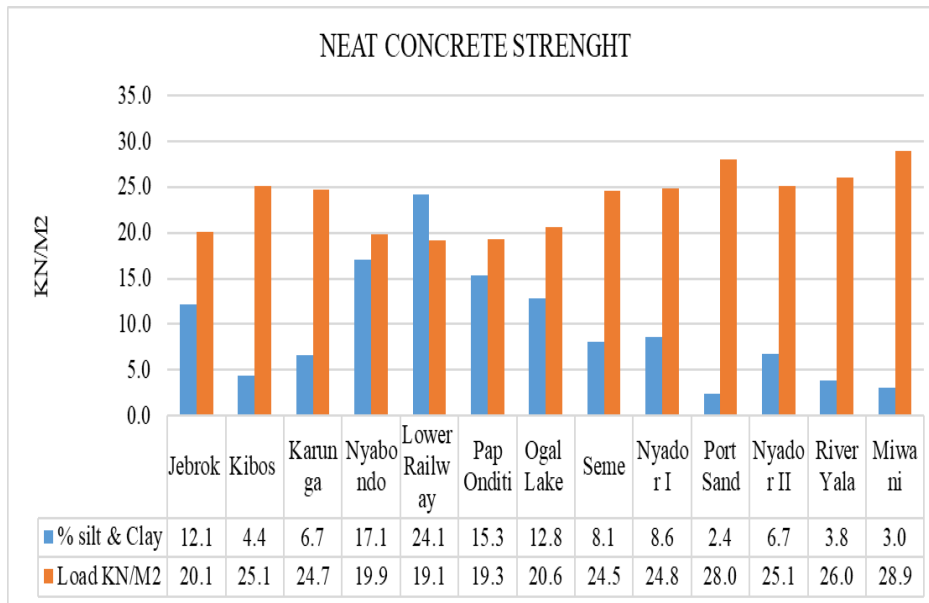


Figure 2: Compressive Strength of Concrete from Neat Sand

Data Sources and Type

Table 1: Sources of Sand

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 2 shows the sand source that were sampled for this study. The river sand sources that were used for blending were River Yala sand, Port Victoria sand, Miwani sand and Kibos sand which fell under Pit sand.

Blending of Sand

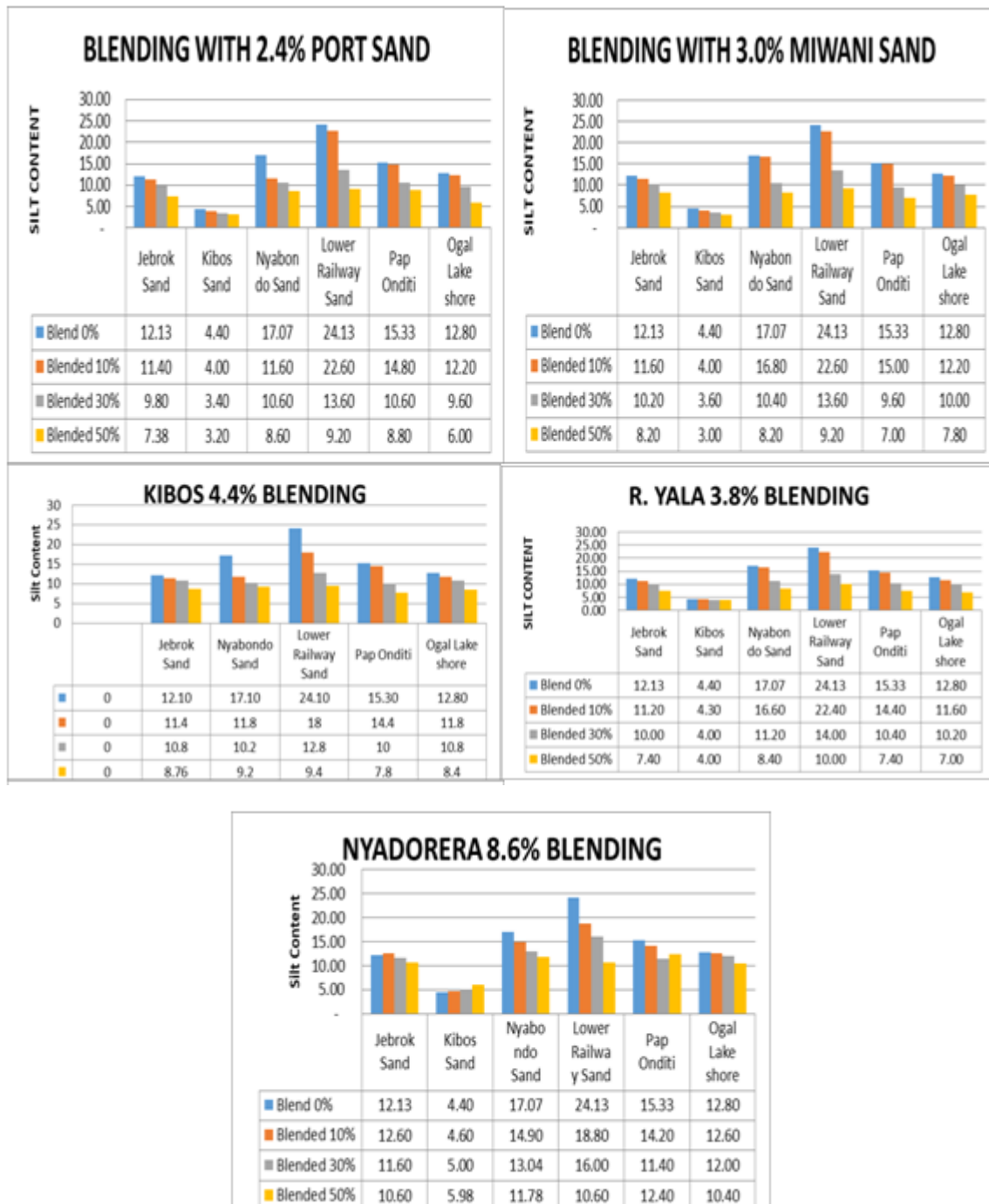


Figure 3: Blending Results

The trend indicated a consistent decrease in silt content across all samples that were blended in proportion compared to the initial silt content of the sand samples.

Compressive Strength from Blended of Sand

Out of the 13 sand samples, those from Miwani, Port Victoria, and River Yala sources exhibited silt content that fell below 4%. Conversely, sand

samples from Nyadorera I, Nyadorera II, Kibos, and Karungu demonstrated silt content ranging from above 4% to below 10%. Utilizing this information, the sand originating from these sources was chosen for blending with selected sand samples at weight proportions of 10%, 30%, and 50%. The results represented in in histogram that were

obtained, contained the Compressive strength of concrete at the 10% blending, 30% blending and at 50% blending using the selected River sand. The results show the averages of the silt content, the slump and the water content for the various mixes. The target strength was 25KN/M2.

The Results

a) River Yala Sand

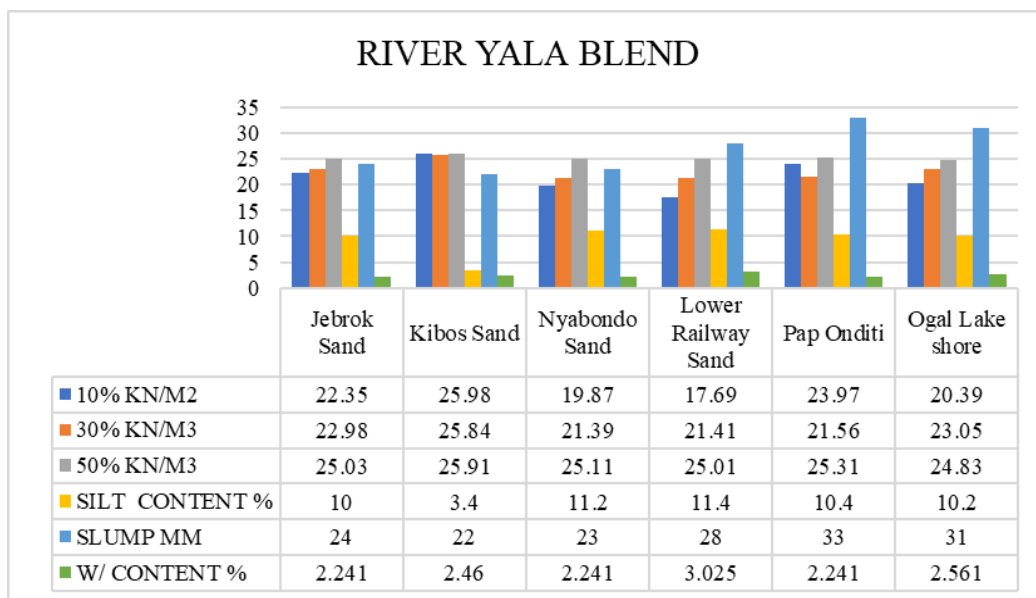


Figure 4: Blended Results from River Yala Sand

There is significant improvement trend as the blending increases

b) Miwani sand

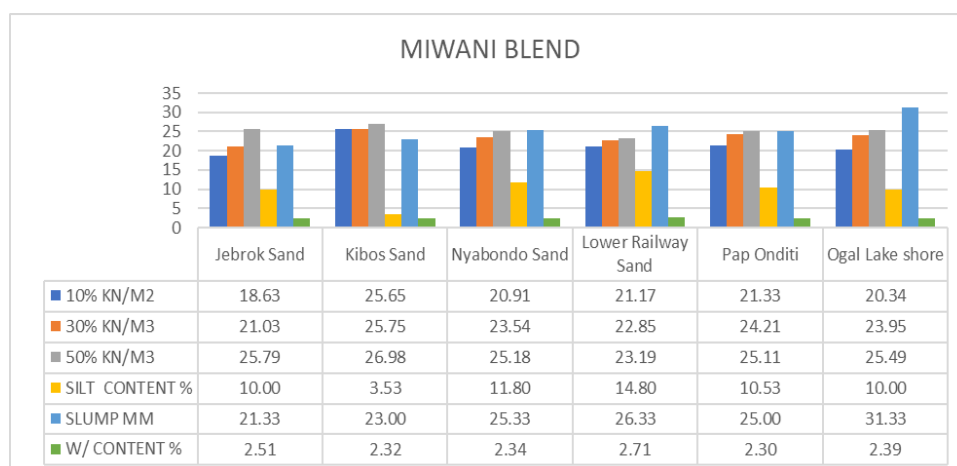


Figure 5: Blended Results from River Yala Sand

There is significant improvement trend as the blending increases

c) Kibos Sand

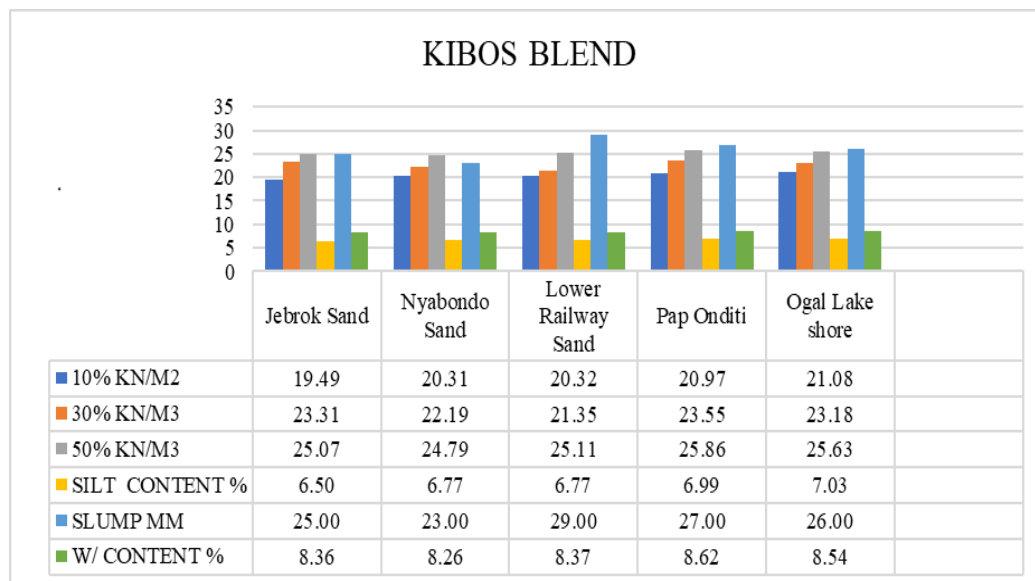


Figure 6: Blended Results from Kibos Sand.

There is significant improvement trend as the blending increases

d) Port Victoria Sand

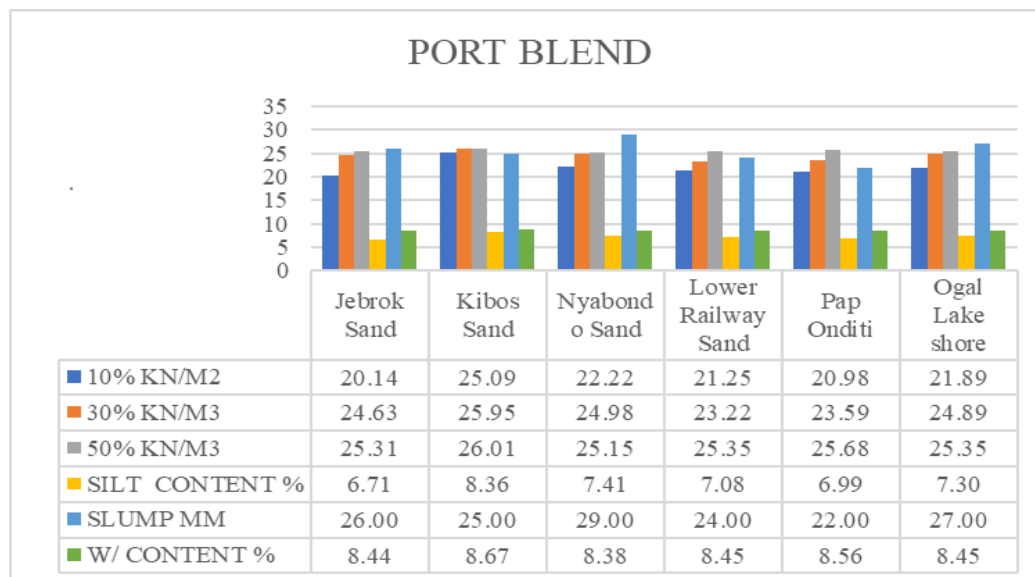


Figure 7: Blended Results from Port Sand.

There is significant improvement trend as the blending increases.

e) Nyadorera Sand

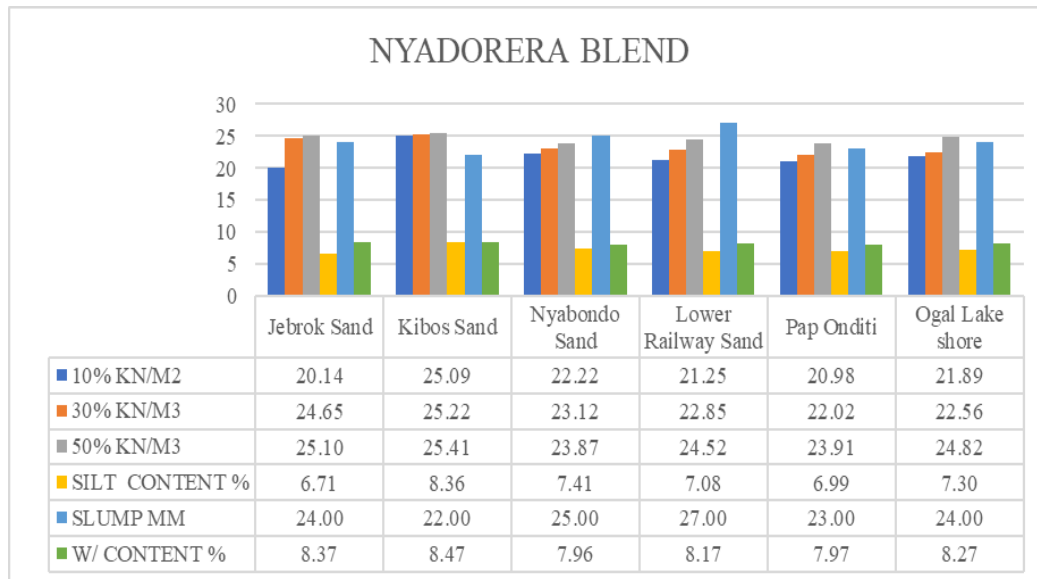


Figure 8: Blended Results from Nyadorera Sand

There is significant improvement trend as the blending increases

Conclusions

From the above the sand utilized in concrete projects within western Kenya indicate that a significant proportion of sources exhibit silt content exceed 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 clear improvement on the quality of sand in terms of silt content and the subsequent increase in concrete strength.

The blending of sand showed clear improvement on the quality of concrete in relation to silt content.

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