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Full Length Research Paper

Strength performance of silicate limestone compressed Bricks

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This research work investigates and evaluates the effects of varying lime composition on the compressive and flexural strength of compressed silicate limestone bricks and compares the results to the local blocks and bricks used in the Kenya market. The mix ratio used to make limestone bricks was binder (cement replaced with hydrated lime powder), sand and water cement in ratio of 1:5:0.4. The results showed that an increase in the lime content results into a decrease in the strength properties of the bricks. Clay brick, natural stone block and concrete blocks were bought in the local market and crushed for comparison. It was observed that the optimum strength performance was obtained at 60% cement replacement with lime which corresponds to 6.08 and 3.05 MPa, respectively for compressive and flexural strength.

Key words: Clay brick, natural stone block, silicate limestone compressed bricks, compressive strength and flexural strength.

INTRODUCTION

Africa has infinite quantities of various raw materials such as bauxite and clay from which refined materials are made such as aluminum, bricks and tiles for civil engineering and construction related works but these are not optimally and economically used in such constructions. Materials such as silica, limestone, and sand when combined with water suitably may make bricks used in various building construction. The term “lime” refers to products derived from limestone by heating to various degrees of temperatures, including quicklime and slaked lime. In the past, it was a very common construction material used over many years for almost all types of constructions instead of timber, sand and concrete (Azzez et al., 2012). Aubert et al. (2013), in their study on earth blocks said that researchers have sought to apply procedures developed for other construction materials (concrete, fired bricks, stone, etc.) to earth construction materials. Silicate-limestone bricks are obtained by mixing hydrated limestone with sand and water in appropriate proportions. They are pressed under high pressures to form the required size of bricks/blocks, after that they are autoclaved for a specified time, specified temperature and pressure to harden the green bricks. Silicate limestone bricks have numerous advantages, such as: (a) they offer a good acoustic insulation; (b) they have a good thermal insulation

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Table 1. Physical properties of river sand.

Designation	Results	Limit	Stage	Code
Silt content (%)	3.56	<6	Good	BS 1377 – 1:1990
Moisture content (%)	0.1	<3	Good	BS 1377 – 1:1990
Fineness modulus	2.86	2.6-2.9	Good	BS 1377 – 1:1990

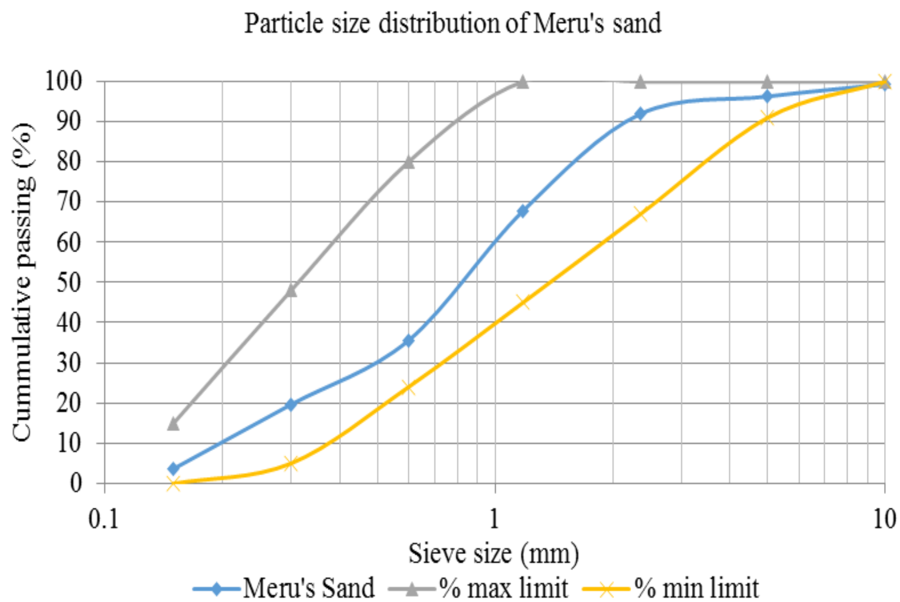

Figure 1. Particle sizes distribution curves of river sand.

because they respire (this characteristic contributes to healthy interior climate and prevents nuisances caused by moulds and humidity; (c) they also accumulate the heat and afterwards liberate it (in this way, at any season it will always have a good climate in the interior of building; (d) they are fire-proof materials due to silicates that they contain; and (e) they are sustainable and ecological.

This material is not widely used as a construction alternative in Africa; however, its application as an alternative construction material is possible.

MATERIALS AND METHODS

Sand, cement and hydrated lime

The river sand used (Figure 2a) in the experimental study was obtained from Meru County, Kenya. Sieve analysis, water absorption, moisture content and specific gravity tests were carried out according to Standard British (BS1377–1:1990). The river sand was sieved through 5 mm sieve before use. The results of the river sand were satisfactory as shown in Table 1 and the grading was within the lower and the upper limits as shown in Figure 1.

Cement used was Ordinary Portland Cement (OPC) of class 42.5 as per KS EAS 18-1 (2001) from Bamburi cement factory in Kenya (Figure 1b). OPC was selected because it has a good binding capacity and is widely available in Kenya. Lime used in the experimental study, manufactured by Coast Calcium Company (Figure 1c), was obtained from Juja in Kiambu County, Kenya. Lime is widely available and used in Kenya.

Natural stone block, clay bricks and concrete blocks

Natural stone blocks (machine cut), clay bricks (manufactured by Kenya Clay Products) and concrete blocks were sourced locally in Kiambu County, Kenya (Figures 2a, 2b and 2c). The natural stone used was machine cut. Concrete blocks were made using 1:5:6 ratios of cement (class 32.5): sand: gravel (with crushed aggregates). The composition of the clay brick is 25% Alumina, 55% silica, 5% lime, 5% oxide iron and 10% magnesia.

Methods of manufacturing bricks

Materials used to produce silicate limestone bricks were (a) the binder (cement replaced with lime), (b) river sand and (c) water in the ratio 1:5:0.4 by weight. The bricks were produced by mixing the cement, lime, sand and water together, filling the mixture in a manual block compressing machine and pressing until maximum pressure was achieved. The bricks were removed, covered with tissue sheets and cured in a dry cool place protected against rain, direct sun and wind. Curing was by spraying water for 28 days

a b c

Figure 2. Materials for brick manufacture: (a) river sand, (b) ordinary portland cement, and (c) hydrated lime.

a b c

Figure 3. Various types of blocks: (a) natural stone blocks, (b) clay bricks, and (c) concrete blocks.

before carrying out the compression and flexural tests in accordance to BS 1881 part 166 and BS 6073-1, 2008, respectively. Table 2 shows the variation of the binder ranging from 0 to 100%.

The dimensions of blocks and bricks tested are shown in Table 3.

Compressive strength tests

The compressive strength tests of the blocks were carried out using a Universal Testing Machine according to BS 1881 part 166: Standard British, 1983. The compression loading was applied continuously to failure at a uniform rate of 0.2 MPa/s using block specimens at 28 days. A total of 10 specimens for each block type were tested in compression. Figure 4a to d shows the experimental setups and tests. The compressive strength of each specimen was then calculated using the formula:

$$\sigma_C = \frac{F}{A} \tag{1}$$

where σ_c = compressive strength in N/mm^2, F = total load at which the specimen was failed in Newton, and A = the surface area on which the load was applied in mm^2.

Flexural strength tests

The flexural strengths of the blocks were tested in the Universal Testing Machine according to BS 6073-1, 2008 using transversal loading as shown in Figures 5a to d. A total of 10 specimens of

Table 2. Binder variations.

Lime (%)	0	20	40	60	80	100
Cement (%)	100	80	60	40	20	0

Table 3. Dimensions of blocks and bricks.

Designation	Length (mm)	Width (mm)	Height (mm)
Silicate limestone bricks	290	140	140
Natural stone block	395	140	200
Clay brick	300	150	115
Concrete block	395	140	140

a b c d

Figure 4. Compressive strength testing in a universal testing machine: (a) silicate limestone brick; (b) concrete block; (c) natural stone; and (d) clay brick.

each block type were tested. The flexural strength of each specimen was then calculated using the formula:

$$\sigma_F = \frac{3Fl}{2bd^2} \quad (2)$$

where σ_F = flexural strength in MPa, F = total load at which the specimen was failed in N, l = the length of the specimen in mm, b = the width of the specimen in mm, and d = the height of the specimen in mm.

RESULTS AND DISCUSSION

Figure 6 shows the strength (compressive and flexural strengths) performance of silicate limestone bricks

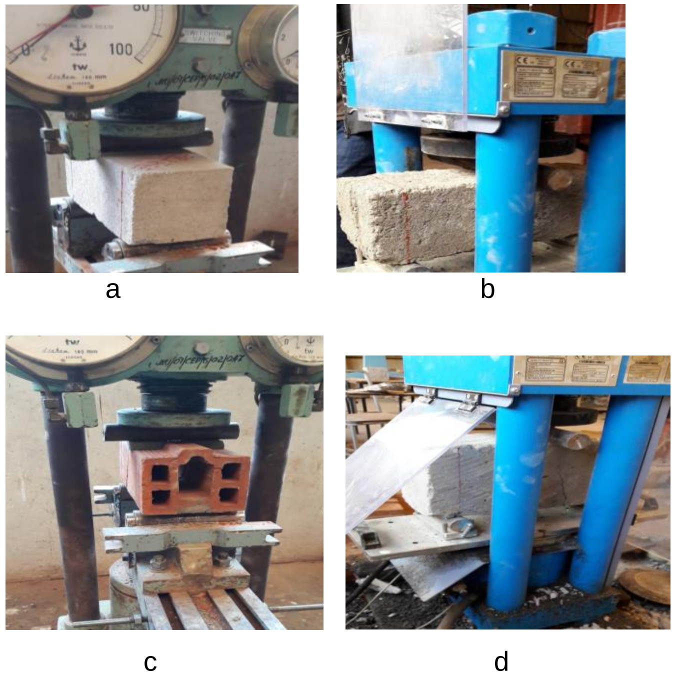

Figure 5. Flexural strength testing in a universal testing machine: (a) silicate limestone bricks; (b) concrete block; (c) clay brick, and (d) natural stone.

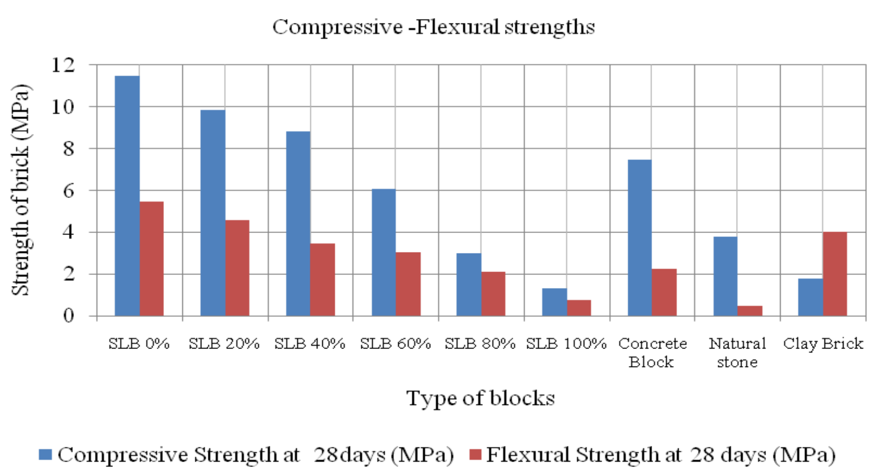

Figure 6. Structural performance of Silicate Limestone Brick (SLB) with varying percentages of lime and other blocks.

prepared with various percentages of lime ranging from 0 to 100%. The blocks were compared to concrete blocks, natural stone (machine cut) blocks and clay bricks.

It is noted that:

(1) With increasing lime content in the bricks, the strength properties decrease. This can be explained by increased water absorption and a decreased density of the blocks.

(2) The blocks have higher compressive strength than the flexural strength, except for clay brick, which the flexural strength is higher than compressive strength. This is due to the voids inside the bricks.

(3) In terms of compressive strength silicate limestone blocks with up to 80% of lime content have better strength characteristics than clay brick, but the clay brick has a better flexural strength than SLB from 40% up to 100% of lime.

(4) Silicate limestone bricks with up to 60% lime have

better strength characteristics than natural stone (machine cut), in term of compressive and flexural strength. Natural stone is very weak in flexure due to their composition, that is, they are not homogenous. The silicate limestone with 100% of lime has better bending strength than natural stone which means that natural stones should not be used as flexural structural element such as beams, slabs and columns. They are low load bearing elements as in wall infills because the minimum value for the load bearing element is 8 MPa.
(5) The concrete blocks used in Kenya have very good compressive strength but they are weaker than silicate limestone bricks with 40% of lime. This is due to their composition, because the ratio of concrete block was 1:5:6 (cement: sand: ballast). The cement used in making concrete blocks has strength of 32.5 MPa which is less than the cement in making of silicate limestone bricks (42.5 MPa). Nevertheless, the use of this concrete is for the non-load bearing structures due to its strength which is less than the minimum value (8 MPa).
(6) The optimum percentage of lime for silicate limestone bricks was found to be 60% for good strength.
(7) The compression strength of the mortar cement-river sand, without lime, at 28 days is very weak: it is 11.5 MPa for a mechanical class of the cement of 42.5. It is due to the production method of bricks, they were made by compaction and cured by spraying water instead of making by vibration and cured inside the water.
(8) The compression strength of the concrete blocks of 7.5 MPa at 28 days is weak. This is due to the mechanical class of cement used which is 32.5 and the higher amount of aggregates present.

Conclusions

From the results and discussions, it may be concluded that:

(1) The minimum percentage of lime in silicate limestone bricks required to achieve the minimum required compressive strength of 2.5 MPa after 28 days was 80% as a partial replacement of cement by weight. These blocks could be used in the building construction but as non-load bearing elements.
(2) It was found that with up to 60% of lime replacement, the bricks can be used as load bearing element in the building construction.
(3) Silicate limestone bricks with 100% of lime are not recommended for any type of construction works.

RECOMMENDATIONS FOR FUTURE SCOPE OF STUDY

It is recommended that further research work be carried out to establish the effect of the environment (wind, acoustic, thermal) on the compressed silicate limestone bricks.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

Aubert JE, Fabbri A, Morel JC, Maillard P (2013). An earth block with a compressive strength higher than 45MPa!. Constr. Build. Mater. 47:366-369.
Standard British 1377-1 (1990). Methods of Test for Soils for Civil Engineering Purposes. General Requirements and Sample Preparation. BSI Group.
Standard British 1881-Part-116 (1983). Testing concrete. Method for determination of compressive strength of concrete cubes. BSI Group