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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

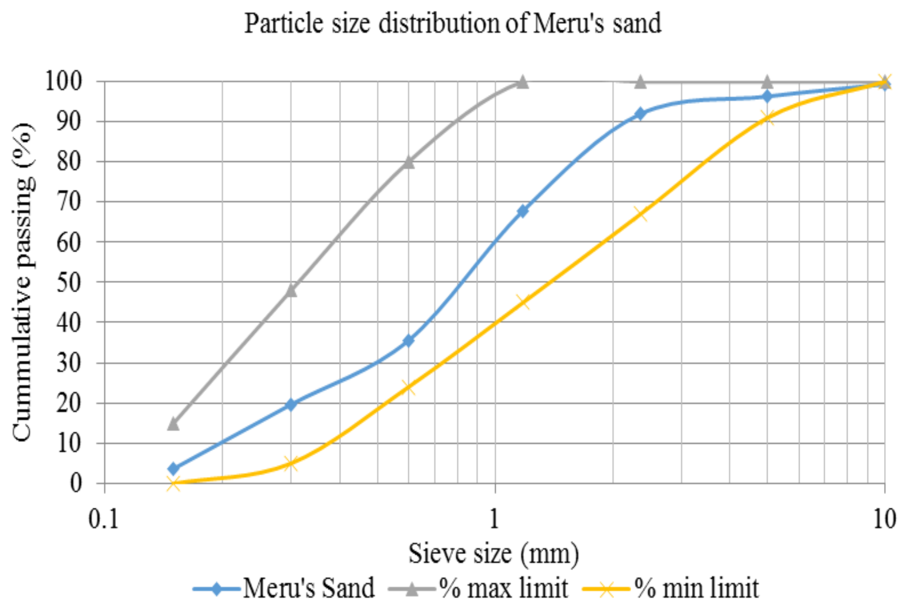

Figure 1. Particle sizes distribution curves of river sand.

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

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:

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

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

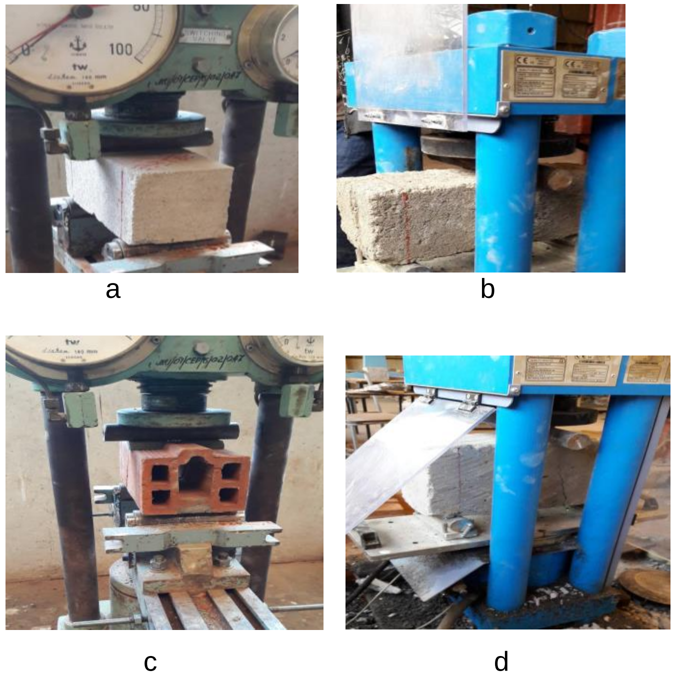

Figure 5. Flexural strength testing in a universal testing machine: (a) silicate limestone bricks; (b) concrete block; (c) clay brick, and (d) natural stone.

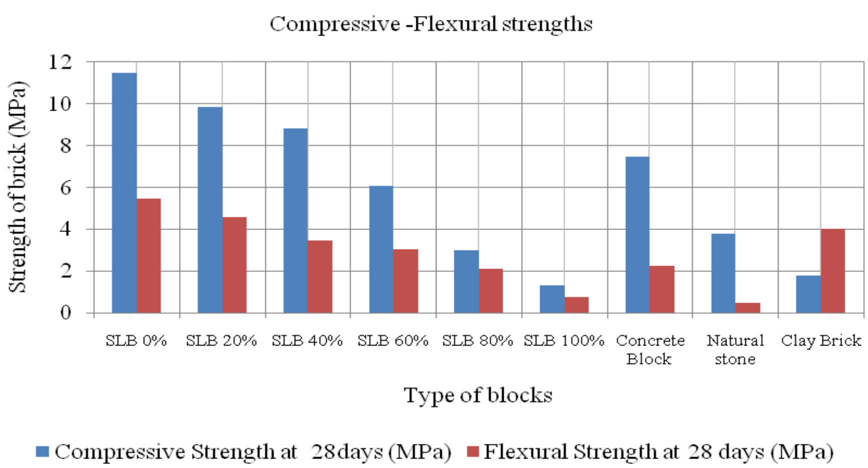

Figure 6. Structural performance of Silicate Limestone Brick (SLB) with varying percentages of lime and other blocks.

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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Journal of Civil Engineering and Construction Technology

Full Length Research Paper

Study of brick mortar using sawdust as partial replacement for sand

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The paper reports results of study on standard masonry mortar containing sand and sawdust as aggregates in a mix proportion of 1:3 and water-cement ratio of 0.55. A modified mortar of same design mix proportion (1:3) but varying water/cement ratio and constant slump of 74.3 mm to achieve higher workability was also evaluated. Six different percentages (5, 10, 15, 20, 30 and 50%) of sand replacement were investigated. The flexural tensile strength, compressive strength, dry density, masonry wallet compressive strength, water absorption and slump were evaluated. The British code recommended masonry wallet compressive strength of 5.3 N/mm^2 was achieved with 8 and 13% sawdust contents in the standard and modified mortars, respectively. Such mortars can be used as jointing and rendering materials on interior walls of buildings where water absorption by the mortar would be reduced.

Key words: Sawdust, mortar, wallet, masonry compressive strength, water absorption.

INTRODUCTION

The demand for new building structures in developing countries is exceedingly high due to ever-increasing population growth. This demand cannot be met as the cost of construction is untenable due to the ever-increasing cost of building materials. Construction depends heavily on conventional materials such as cement, sand and stones for the production of mortar and concrete. Their ever-increasing costs has led to research into the use of alternative locally available building materials, especially wastes from industry, building construction and agricultural activities. Quarry dust (Galetakis et al., 2016), glass powder (Afshinnia and Rangaraju, 2016), laterite (Falade, 2001), wood ash (Cheah and Ramli, 2011), rice husk ash (Antiohos et al., 2014), coconut shells (Ali et al., 2013), palm kernel shells (Acheampong et al., 2016) and concrete wastes from demolition (Gastaldi et al., 2015) are a few of the materials which have been studied. In spite of the numerous publications on wood/cement composites such as Berra et al. (2015), Dilip et al. (2014), Horsakulthai et al. (2011), Ramos et al. (2013), Sarkar et al. (2012), Torkaman et al. (2014), Turgut (2007) and Yong et al. (2013), none seems to address the possibility of using sawdust-mortar as masonry mortar. A study by Jelle et al. (2001) revealed that a small wood village in Kumasi of Ghana alone generates 100-150 metric tonnes of sawdust

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per day. On a larger scale, the annual wood waste generated from the timber industry in Ghana is about 0.8 million m^3 which accounts for 62% of the initial wood input to the timber industry.

Sawdust is usually disposed of by open burning, producing harmful smoke that threatens human health. A more environmentally desirable way of disposing it is to use it in cement composites. The overwhelming volumes of sawdust generated as waste from the timber industry could be used as a partial replacement of fine aggregates in mortar and concrete production to alleviate the pressure on the scarce available natural resources. Sawdust composites are characterised by low mechanical performance, low durability and bad compatibility (Lei et al., 2006). Attempts have been made by researchers to overcome these weaknesses. Mixing with synthetic fibres, addition of additives and modification of sawdust and so on are some researches that have been conducted to overcome these weaknesses. The inclusion of sawdust in concrete and mortar production may not only mitigate environmental damage, but could also preserve the conventional concrete/mortar materials. It exhibits many benefits over the traditional concrete including reduction in weight of the structure (thereby reducing the dead loads transmitted to the foundation), high economy compared to normal weight concrete, reduced damage and prolonged life of formwork due to lower exerted pressure, easy handling, mixing and placing as compared with other types of concretes, improved absorbent properties due to its high void ratio (Dilip et al., 2014; Yong et al., 2013).

Notwithstanding these advantages, sawdust-concrete exhibits irregular setting times and poor adaptation to dimensional variation as major set-backs (Adeagbo, 1999).

EXPERIMENTAL PROGRAMME

Materials

Ordinary Portland cement with a 28-day compressive strength of 42.5 N/mm^2 was used in the study. River sand with maximum aggregate size of 2 mm and specific gravity of 2.53 was used as fine aggregate. Sawdust obtained from a saw-milling company was also used as partial replacement for the fine aggregates. Standard brick mortar with a mix design ratio of 1:3 (cement: sand) and w/c ratio of 0.55 was prepared for the experiment. The fine aggregate was partially replaced with the sawdust. The percentage replacements considered were 5, 10, 15, 20, 30 and 50. Approximately square wallets were also constructed using the prepared mortar as the jointing material.

Details of specimens

With each percentage replacement, 2 prisms (to be tested on the 28^{th} day of curing), 9 cubes (to be tested on the 7^{th}, 14^{th} and 28^{th} day of curing), and 3 wallets (to be tested on the 28^{th} day of curing) were made. The total test samples comprised 28 prisms (40 mm x40 mm x 160 mm) for the flexural tensile strength test, 126 cubes (100 mm) for compressive strength, and 42 wallets of approximate dimensions 1.2 m x 1.5 m were constructed for masonry compressive strength test. Fifty percent of all test specimens were cast from each mortar.

Preparation of specimens

A standard mix design ratio of 1:3 (cement: sand) with water-cement ratio of 0.55 was used to prepare the standard mortar. For each percentage replacement, a harsher (dry) mortar with rapid slump loss was obtained. In view of this a modified mortar with same workability (slump) as the control mortar was also prepared for the study. The underlying aim was to strike a reasonable balance between the workability, strength, durability and cost of mortar. The modified mortar had a constant slump of 74.3 mm (same as that of the control specimen) to make it workable, easily mixed and placed. The materials were batched by weight into a mixing bowl and thoroughly dry-mixed before water was added. With each percentage replacement the above procedures were repeated. Metallic and wooden moulds were used for the casting of the cubes and prisms respectively. Wallets were prepared from blocks of dimension 450 mm x 225 mm x 100 mm (l x b x h) and compressive strength of 15 N/mm^2 using 10 mm thick mortar joints.

Test procedures

The particle size distribution test was carried out on both sawdust and sand in accordance with BS EN 1015-1. The slump and bulk density of fresh mortar were determined in accordance with BS EN 1015-3 and BS EN 1015-6 respectively. In addition the bulk density (BS EN 1015-10), compressive strength, flexural tensile strength (BS EN 1015-11), water absorption (BS EN 1015-18) of hardened mortar, and masonry compressive strength (BS EN5628-1) were studied. The flexural tensile strength of the mortars was carried out by simply supporting the test specimens on a stiff steel frame in the Civil Engineering Laboratory of the KNUST, Kumasi. Monotonic loads were applied through a steel spreader beam to the test specimen at a rate of 0.10 kN/s. A typical loading configuration is also shown in Figure 1.

The compressive strength of masonry wallets was obtained from the ultimate strength of brickwork or block work panel tested to destruction in accordance with BS EN5628-1. The compressive strength of the masonry block units was determined. Three identical panels (approximately 1.2 m height x 1.5 m length) were constructed for each percentage replacement. Approximately square panels were chosen to avoid the problem of bending while being loaded. Also the steel frame structure could not accommodate panels of dimensions larger than what was chosen. The panels were loaded uniformly over the whole area of the top and bottom faces with the aid of a cross-head. A monotonic load was applied at a rate of 0.20 kN/s until the panel ruptured. A schematic sketch of the set-up is shown in Figure 2 while a typical loading configuration is shown in Figure 3. This was done for both mortar sets.

RESULTS AND DISCUSSION

Aggregate grading

The sawdust as fine aggregate had sizes that ranged from 0.15 to 2 mm. The sand on the other hand had particles ranging from 0.075 to 2.0 mm. In terms of

Figure 1. Set up for flexural tensile strength test.

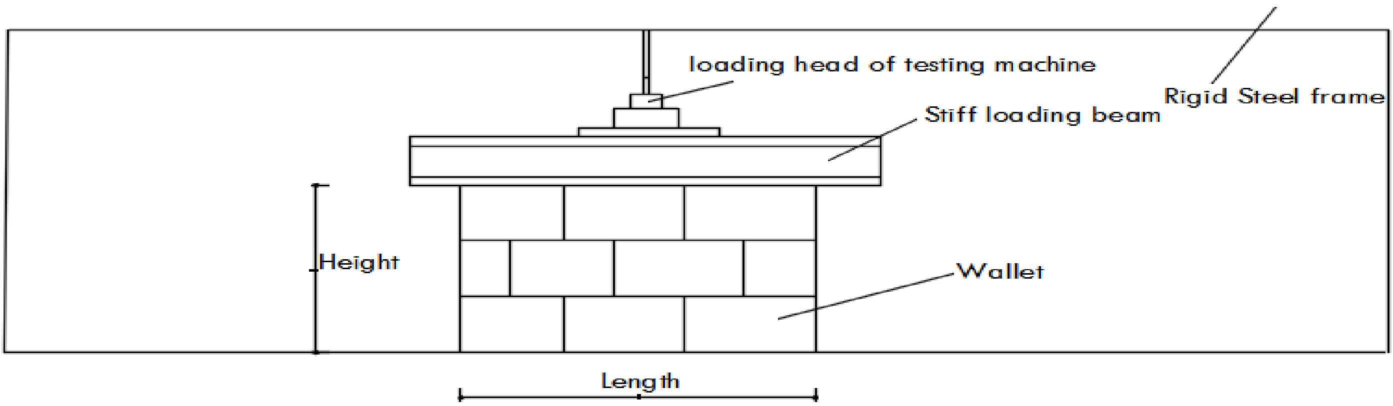

Figure 2. Schematic diagram of the experimental set-up.

Figure 3. Test Set-up for masonry wallets compressive strength.

particle size distribution both sand and the sawdust had similar properties. Percentages of the aggregates retained on each sieve were similar. For instance the highest percentage retained was 22.4 and 21.61% for the sand and sawdust, respectively, on the 0.3 mm sieve. Therefore with respect to the aggregate grading the addition of the sawdust was not expected to largely influence the properties of the mortar.

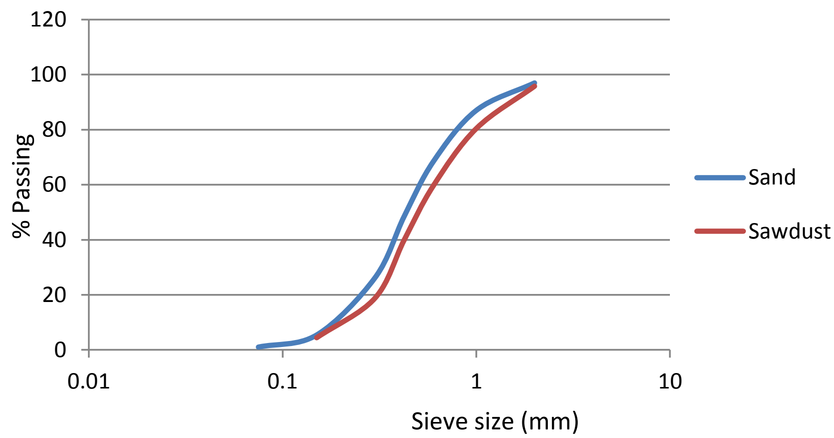

Figure 4. Grading curve for fine aggregates.

The grading curve for the sand and sawdust are presented in Figure 4.

Slump test

The workability of mortar/concrete is generally influenced by water content, cement content, aggregate grading and other physical characteristics, and admixtures (Mehta and Monteiro, 2006).

Comparatively, rough-textured, angular and elongated particles need more cement paste to produce workable masonry mixtures. The slump for the control mortar was 74.3 mm. It reduced consistently to 71.8, 63.65, 52.65, 48.95, 47.3, and 45.05 mm when the percentage of sawdust content increased to 5, 10, 15, 20, 30 and 50% respectively. This observation was also made by Shen et al. (2016) when they studied the influence of the various properties of river sand and manufactured sand on the properties of concrete. They found that high amount of fines, angular particle shape, and relatively higher void content of the manufactured sand resulted in concrete with higher water demand for the same slump. Also Qasrawi et al. (2009) acknowledged that concrete with more than 50% replacement of sand with steel slag had a negative impact on the workability of the concrete and therefore required more water to achieve a desirable workability. The low workability of the mortars could be attributed to the higher affinity for water by the sawdust. The woody nature of sawdust unlike the crystalline sand causes it to absorb water thereby reducing the free water available for hydration.

Compressive strength

There was a general reduction in the compressive strength for both sets as the percentage of sawdust increased. Similar observations have been made by Alnuaimi (2012) and Rashad (2016) as the fine aggregate of concrete is partially replaced with other materials. Nevertheless the modified mortars always possessed relatively higher compressive strength for each replacement. For instance at 5% replacement, the 28th day compressive strengths for the modified and standard mortars were 7.45 and 6.99 N/mm^2 respectively. These values decreased steadily to 2.76 and 2.33 N/mm^2 respectively at 50% replacement (Tables 1 and 2). The sudden decline in the compressive strength (7.31 N/mm^2 at 0% to 1.13 N/mm^2 at 50%) in the standard mortar could be attributed to the inability to compact the mortar adequately due to poor workability. Strength resides in the solid part of a material; hence the presence of voids is inimical to strength development. In multiphase materials such as mortar, the porosity of each component of the material could be a source of strength degradation. Conventional (natural) aggregates are generally dense and strong due to their crystalline nature whilst sawdust is woody and soft. Figure 5 shows a plot of the 28th day compressive strength for each percentage replacement.

It has also been discovered that strength and permeability of hydrated cement pastes are mutually connected via capillary porosity, which is influenced by the water-cement ratio and the degree of hydration. As hydration process proceeds, the capillary pores get narrower and this tends to reduce the coefficient of absorption. Tables 1 and 2 indicate that as the sawdust content increased, the coefficient of absorption also increased whilst the compressive strength reduced. Concrete with high water absorption coefficient possesses lower strengths (Basar and Deveci, 2012).

Dry density

There was a general reduction in the bulk dry density which became more significant at higher sawdust contents (Tables 1 and 2). The modified mortar however

Table 1. Experimental results on standard mortar.

Replacement of sand with sawdust (%)	Slump	Dry density of hardened mortar (kg/m^3)	Water absorption coefficient (%)	28th day Comp. Strength (N/mm^2)	28th day Flexural Tensile Strength (N/mm^2)	5 months Comp. Strength (N/mm^2)
0	74.30	2128.91	11.97	7.52	2.54	7.33
5	71.80	1742.19	12.13	6.99	2.45	6.87
10	63.65	1432.29	12.96	6.72	2.13	6.51
15	52.65	1252.6	14.55	4.71	1.5	3.57
20	48.95	1071.61	16.72	4.02	1.13	2.87
30	47.30	964.84	18.92	2.61	1.01	2.40
50	45.05	878.91	20.54	2.33	0.47	1.04

Table 2. Experimental results on modified mortar.

Replacement of sand with sawdust (%)	Slump (mm)	Dry density of hardened mortar (kg/m^3)	Water absorption coefficient (%)	28th day Comp. Strength (N/mm^2)	28th day Flexural Tensile Strength (N/mm^2)	5 months Comp. Strength (N/mm^2)
0	74.30	2130.02	11.97	7.52	2.56	7.73
5	74.30	1802.23	12.02	7.45	2.51	7.59
10	74.30	1504.14	12.36	7.23	2.25	7.34
15	74.30	1312.04	12.97	5.78	1.62	4.66
20	74.30	1104.54	13.69	4.92	1.34	2.97
30	74.30	1010.23	14.25	3.54	1.20	2.51
50	74.30	905.73	15.77	2.76	0.85	1.01

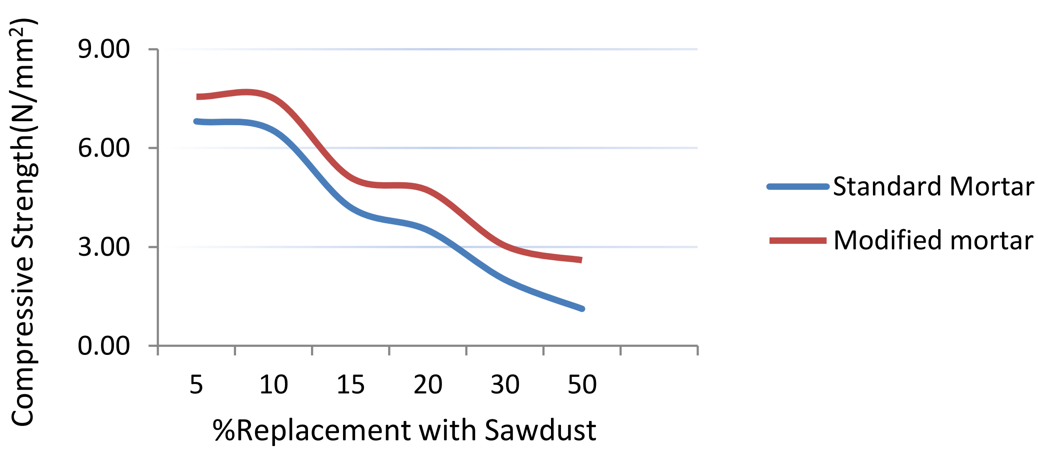

Figure 5. Compressive strength of standard and modified mortar.

had relatively higher (about 5 to 20%) dry density values for all the levels of replacement. Singh and Siddique (2014) made a similar observation and predicted the loss in compressive strength of concrete to vary linearly with the loss in mass while studying the properties of concrete incorporating coal bottom ash as partial or total replacement of sand.

Flexural tensile strength

The flexural tensile strength of mortars decreased with increasing sawdust content (Tables 1 and 2). In general, there was a significant improvement in the flexural tensile strength (2.56 N/mm^2 at 0% and 0.85 N/mm^2 at 50%) of the modified mortars compared with the standard mortar

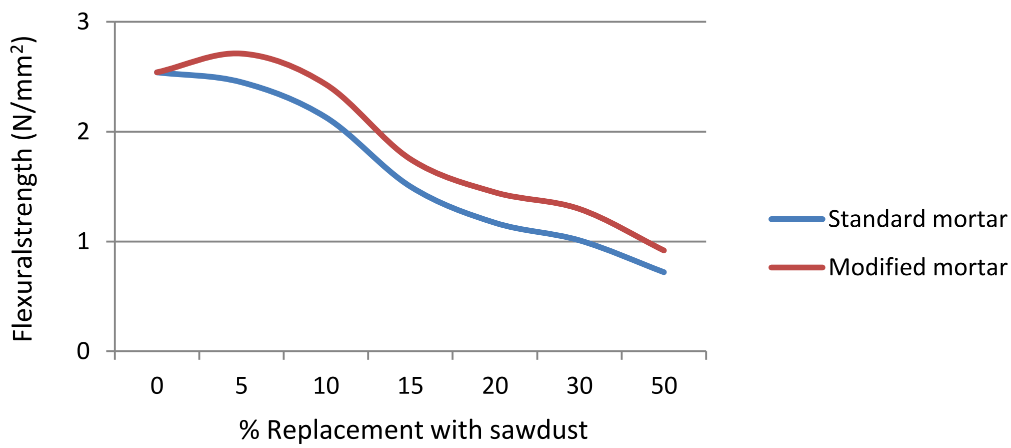

Figure 6. 28th day flexural tensile strength of standard and modified mortar.

(2.54 N/mm^2 at 0% and 0.52 N/mm^2 at 50%). The material geometry also affects the tensile strength of the mortar. The sawdust specimen had some aggregate with elongated nature which is believed to have a positive influence on the flexural tensile strength of the mortar prism. Figure 6 presents the 28th day flexural tensile strength of both mortars.

An observation was also made that whereas factors leading to a decrease in the porosity of the mortar lead to a general improvement of both the compressive and flexural tensile strengths of mortar, the result depicts that the magnitude of decrease in the flexural tensile strength remained relatively higher as shown in Tables 1 and 2

Durability

Samples of test specimen for the compressive strength test were subjected to cycles of wet and dry conditions for a period of 5months and later tested for their compressive strength to assess the mortar durability. As expected, most cement based products exhibit increase in strength with age. There was an increase (about 4.7%) in compressive strength for the 5 and 10% replacements for the modified mortar. This could be attributed to the formation of more products of hydration which presumably filled up the few voids in the hardened mortar. However the other samples (15, 20, 30 and 50% of replacements) showed a decline in compressive strength (Tables 1 and 2). The cycles of expansion and contraction of the sawdust could have caused a dimensional instability which is believed to have weakened the sawdust-cement interfacial bond. The decline in the compressive strength could again be attributed to the higher water absorption at higher percentages of replacement. This indicates the presence of voids in the hardened mortar. The porous nature of the sawdust actually made the hardened mortar also porous and weak at higher percentages of replacement. And since voids are inimical to strength development, the compressive strength declined as expected. Similar observations were made by Shafigh et al. (2014).

Masonry wallet compressive strength

Generally for each type of mortar, the masonry wallet compressive strength reduced with increased sawdust content. With no sawdust, both standard and modified mortars had masonry compressive strength of 6.41 N/mm^2. This reduced to 1.30 and 1.42 N/mm^2 at 50% replacement respectively as illustrated in Figure 7. Basically there was an increase in the masonry compressive strength for the modified mortar compared with the standard mortars for all replacements. With the exception of the 30 and 50% sawdust whose masonry wallets failed along the joint, the remaining percentage replacements for the modified mortar were characterized by failure cracks along the masonry units. With increase in consistency the bond strength at the block-mortar interface was presumably improved which led to an increase in the compressive strength of the masonry.

A comparative study of the masonry compressive strength of the specimen and the expected masonry compressive strength of BS 5628 reveals that 8 and 13% replacements with sawdust for the standard and modified mortars respectively gave a masonry compressive strength of 5.3 N/mm^2 which could be classified as Type II mortar of the same code.

Conclusion

Mortar prepared with sawdust as partial fine aggregates was investigated. Standard mortar of mix ratio of 1:3 and water/cement ratio of 0.55 adopted in the study resulted

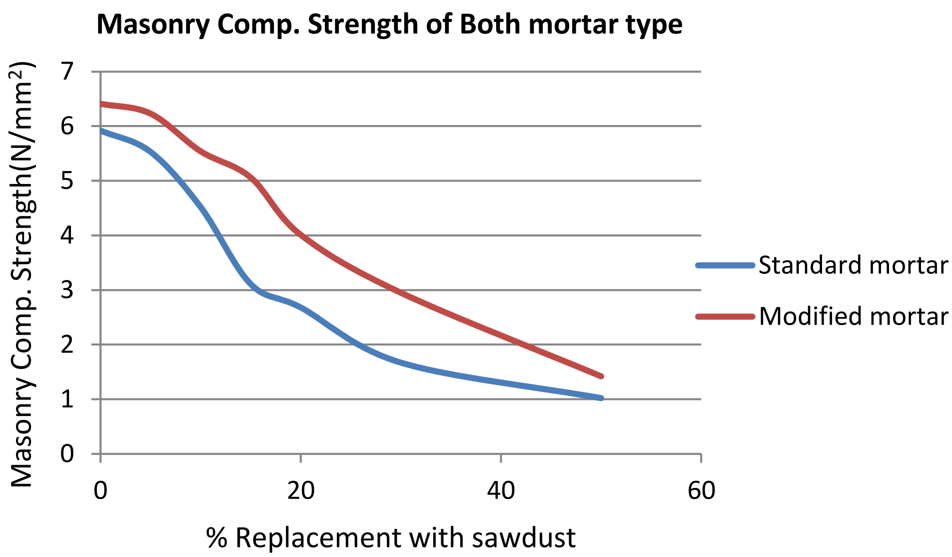

Figure 7. Compressive strengths wallets.

Figure 8. Crack patterns of failed wallets.

in inadequate workability. In view of that a modified mortar of better workability with constant slump of 74.3 mm was also prepared. The compressive strength and flexural tensile strength of the mortar and masonry compressive strength of wallets were assessed from test specimens. The results showed that the sawdust possessed the characteristics of a well-graded aggregate. The dry density, compressive strength and flexural tensile strength were observed to decrease with increasing sawdust content. A more porous mortar was produced with increased sawdust content. However the modified mortar was slightly impervious compared with the standard mortar. Therefore in terms of durability the modified mortar could be presumed to be more durable. At higher percentages of sawdust the crushing of the cubes was not sudden compared to the control for both mortar types. Failure of masonry wallets for the modified mortar was characterized by cracking along the masonry units whilst that of the standard mortar was observed to fail along the brick-mortar joint. This can be observed in Figure 8. The better bonding in the case of the modified mortar could be attributed to the improved workability which led to better adhesion between the bricks and the mortar. On a micro-scale the better adhesion could be also be due to sawdust fibres penetrating into the block surfaces. The densities of both mortars decreased considerably with each percentage replacement. Low density mortar could be achieved by the partial replacement of the fines with sawdust. A thorough examination of the above results and discussions shows that there is a possibility of replacing fine aggregates with sawdust in masonry mortar preparation. With 8 and 13% percentages of replacement, the standard and modified mortars respectively produced mortars with properties which compare adequately well with theoretical values of BS 5628:1992 Code.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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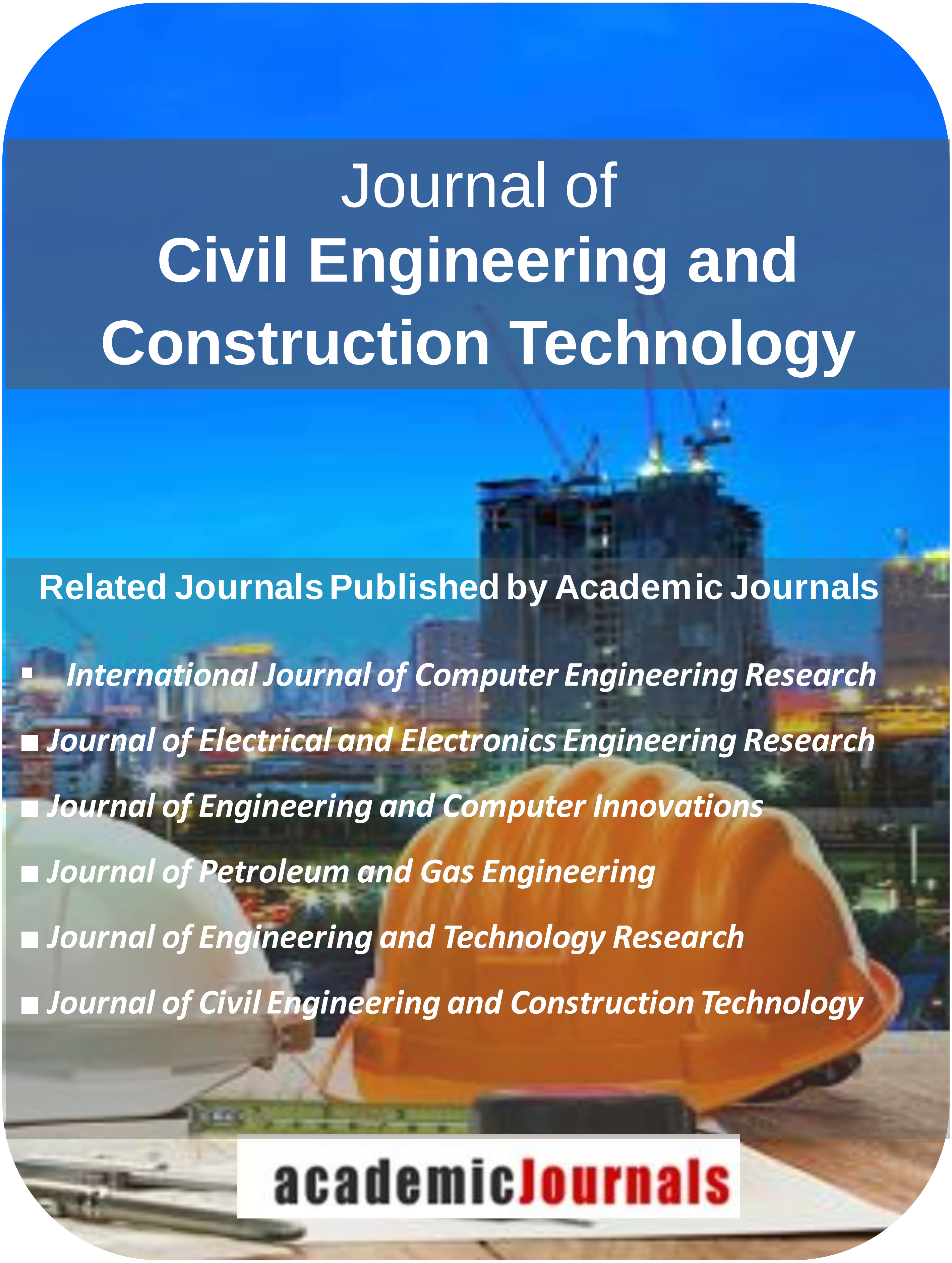
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