PARTIAL REPLACEMENT OF SAND WITH GRAVEL IN SANDCRETE BLOCK PRODUCTION

G. L. Oyekan* & M. T. Isiaka
Civil & Environmental Engineering Department,
University of Lagos, Yaba, Lagos, Nigeria
* Corresponding Author: gloyekan@yahoo.com
Tel. +2348037140029

Abstract:
In the investigation described in this paper gravel has been used to partially replace sand in sandcrete block manufacture. The percentage of gravel by volume of sand was varied in steps of 5 percent to a maximum of 30 percent. The test results showed that the replacement of sand with gravel content in the cement-sand matrix increased the density of the blocks and also has a very significant effect on the compressive strength of the sandcrete blocks. The compressive strength of the blocks increased as the percentage gravel content in the mix increased. The optimum compressive strength of 8.11 N/mm$^2$ was obtained at age 28 days and at 25 percentage gravel content. This value represents an over 100 percent increase over the control value. The 28-day compressive strength obtained is appreciably higher than the 3.45 N/mm$^2$ minimum compressive strength requirement specified for machine-vibrated load-bearing sandcrete blocks in the Nigerian Industrial Standard document for sandcrete blocks. These blocks are thus strong enough to be used for load-bearing purposes in building construction.

Keywords: Gravel, sand, partial replacement, sandcrete blocks

1. INTRODUCTION
We are now in the era of sustainable development and researchers are driven by the growing need to utilize wastes and find suitable alternatives to cement and sand in sandcrete block production so as to reduce the cost of production without any compromise on the required strength. This is no doubt informed by the high cost of cement and sand, the main constituent materials required for sandcrete block manufacture.

Blocks made from a mixture of river sand, cement and water are called “sandcrete” blocks. They are used throughout Nigeria and in most African countries.

Until perhaps a decade ago, these blocks were manufactured without reference to any specifications either to suit local building materials or for good quality work. The situation has since changed as there is now in place the Nigerian Industrial Standard spelling out the specifications for the manufacture and use of these blocks in Nigeria. This document is issued by the Standards Organization of Nigeria (1)

Oyekan and Kamiyo [2] carried out research work on effect of granite fines on the structural and hygrothermal properties of sandcrete blocks. They reported that the compressive strength values at 28 days increased being over 15% for the blocks made with a mix proportion of 1:6 and over 4% for the blocks made with a mix proportion of 1:8. They also observer that the optimum percentage granite fines content was about 15%. Oyekan [3] concluded that the use of granite fines as a partial replacement of sand in the production of the blocks gave blocks with appreciably higher strength values than blocks without granite fines. The compressive strength of sandcrete blocks was reported to fall as the granite fines content went above the optimum value which was found to be about 25% when the mix proportion was 1:6 and between 12 & 15% when a mix proportion of 1:8 was used.
Oyekan [4] concluded that the use of granite coarse aggregate to partially replace sand in sandcrete block production gave blocks with much higher compressive strength values irrespective of the size of the coarse aggregate used for the replacement. He also reported that the optimum aggregate content was 25% when 5mm single size aggregate was used; 30% when 10mm single size was used; 35% when 15mm single size aggregate was used and about 25% when a mixed coarse aggregate (10mm & 15mm) was used. Oyekan [5] carried out research on crushed waste glass as a partial replacement of both sand and cement in sandcrete block production. In his report, he concluded that the optimum crushed waste glass content was found to be 15% for 1:6 mix and 20% for 1:8 mix.

Sampaio et al [6] carried out assessment on performance of concrete obtained with partial replacement with Portuguese rice husk ash in different percentages. It was reported that there was increase in the strength as the percentage of the rice husk ash increased in the mix. Cisse and Laquerbe (7) concluded that the mechanical resistance of sandcrete blocks obtained when unground rice husk ash was added revealed that the use of unground rice husk ash enabled production of a lightweight sandcrete with insulating properties and at a reduced cost. The ash pozzolanic reactivity was responsible for the enhanced strength obtained.

Mehta, P. K. and Pitt, N. (8) in their work on rice husk ash cement concrete used siliceous gravel and crushed limestone as coarse aggregates. Their results showed that using crushed limestone aggregate produced concrete with 23% higher strength than when siliceous gravel was used as aggregate. They explained that the formation of interfacial bond between the cement paste and aggregate was probably responsible for the higher strength.

Oyetola and Abdullahi [9] carried out research work on the use of rice husk ash in low – cost sandcrete block production. In the test conducted, it was concluded that the compressive strength of the blocks for all mixes increased with age and decreased as the rice husk ash content increased and that the maximum compressive strength was obtained at 20% cement replacement with rice husk ash. Okpala (10) concluded that if rice husk ash was found adequate for replacing cement in sandcrete blocks, it would drastically reduce the cost of buildings in Nigeria.

2. CONSTITUENT MATERIALS AND MANUFACTURE OF SANDCRETE BLOCKS

The constituent materials of sandcrete blocks are Ordinary Portland Cement, fine aggregate (sand) and water.

2.1. CEMENT

The cement used was Ordinary Portland Cement from the West African Cement Company, Ewekoro in Ogun State, Nigeria with properties conforming to BS 12 (1971)

2.2. WATER

The water used in the manufacture of the blocks was potable water, which was fresh, colourless, odourless and tasteless water that was free from organic matter of any type.

AGGREGATES (SAND & GRAVEL)

SAND

The sand used was clean, sharp river sand that was free from clay, loam, dirt and organic or chemical matter of any description and was sand passing through 4.70 mm zone of British Standard test sieves. The sand had a specific gravity of 2.65 and an average moisture content of 0.50% The particle size distribution curve of sand is shown in Figure 1.

GRAVEL

The gravel used was clean, hard, tough, strong, durable and of proper grading and was gravel consisting of particles retained on a 5mm sieve. The gravel used was free from silt and clay which may result in increased shrinkage or increased permeability in addition to poor bond characteristics. The particle size distribution curve of gravel is shown in Figure 2.

2.4. GRADING OF AGGREGATES

The grading of an aggregate defines the properties of different sizes in the aggregates. This grading has a considerable effect on the workability and stability of the mix. Dry sieve analysis, which is in accordance with BS 1377 (15), was used in this study.
FIG. 1: PARTICLE SIZE DISTRIBUTION CURVE OF SAND
2.5. MANUFACTURE OF SANDCRETE BLOCKS
Batching of the materials was done by volume. The blocks were manufactured using a vibrating machine. The cement-aggregates were mixed in the ratio 1:6. Hand mixing was employed, and the mixture was turned over a number of times until an even colour and consistency was obtained. Water was added as required through a fire hose and the materials were further turned over to secure adhesion. It was then rammed into metal moulds and smoothed off with a steel face tool. After removal from the metal moulds, the blocks were left on pallets under cover in separate rows one block high and with a space between blocks for at least 24 hours and kept wet during the period by watering through a fine watering hose. Testing for crushing strength was then carried out at ages 3, 7, 14 and 28 days.

3. PRESENTATION AND DISCUSSION OF TEST RESULTS
Results of the tests are presented in graphical form. Figures 3 and 4 show plots of compressive strength against age & percentage gravel content respectively for the 450mm x 225mm x 150mm block size used in the investigation. Fig. 5 shows the plot of compressive strength against percentage gravel content for the 450mm x 225mm x 225mm block size. Fig. 3 shows that the compressive strength of the sandcrete blocks increases generally with age at all percentages of gravel content in the sand cement matrix. Figure 4 also shows that the compressive strength of the blocks increases with percentage gravel content except at 30 % gravel content where there is a slight decrease in the
The optimum gravel content is found to be 25 percent where 28-day strength of 8.11 N/mm² was obtained. This value represents a 167 percent increase over the control value (2.95 N/mm²). When the block size was increased to 450mm x 225mm x 225mm the maximum 28-day strength of 7.86 N/mm² was obtained at a gravel content of 30 percent. This value also represents a 156 percent increase over the control value. In both cases the increase observed may be due to the increase in the density of the blocks produced. Also the use of gravel probably improved the grading of the fine aggregate and may be responsible for the enhanced strength obtained.

Fig 3: PLOT OF COMPRESSIVE STRENGTH AGAINST AGE
Fig 4: PLOT OF COMPRESSIVE STRENGTH AGAINST PERCENTAGE GRAVEL CONTENT (1:6 MIX PROPORTION)
4. CONCLUSIONS

The main conclusions derived from this investigation are as follows:

- Gravel has a significant effect on the compressive strength characteristics of sandcrete blocks. At a mix proportion of 1:6 the compressive strength of the sandcrete blocks increased by 167% over the control value.
- There is an optimum gravel content above which the compressive strength of the blocks began to fall as the percentage gravel content in the mix increased.
- For the 1:6 mix proportion the optimum gravel content was found to be 25%.
- Although the compressive strength of the blocks fell above the 25% gravel content, yet it was observed that the compressive strength obtained was still well above the strength value at zero percent gravel content.
- The compressive strength values of the sandcrete blocks increased with age at all percentages of gravel content in the mix.

REFERENCES