EFFECT OF PARTIAL REPLACEMENT OF SAND WITH QUARRY DUST ON THE COMPRESSIVE STRENGTH OF SANDCRETE BLOCKS

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ABSTRACT

This paper provides the results of an experimental investigation into the effect of partial replacement of sand with quarry dust in production of sandcrete blocks using mix ratio of 1:6. Physical properties of sand and quarry dust were determined in the laboratory in accordance with BS 1377-9 (1990). Blocks were produced using 0, 5, 10, 15, 20, 25, 30, 35, 40, 45, and 50% partial replacement of sand with quarry dust. Compressive strength tests were carried out on the blocks after curing for 7, 14, 21 and 28 days respectively. It was found that optimal compressive strength was achieved at 45% replacement of sand with quarry dust corresponding to a compressive strength of 2.6N/mm^2.

Keywords: *Optimum Compressive strength, Partial replacement, Quarry dust, and Sandcrete blocks.*

1. INTRODUCTION

Sandcrete blocks are man-made composite materials consisting of measured proportions of cement (as hydraulic binder), sand and water, moulded into different sizes for walling and foundations Barry (1969). They are some times referred to as concrete blocks. Although usually larger in size than fired bricks, they are however stabilized by removing the centre cores to reduce the weight, thereby gaining sufficient strength setting and hardening to be used as walling units. The quality of blocks differs from one manufacturer to the other. This is due to high cost of cement, quantities and properties of aggregate used as well as method of proportion adopted.

They are of sizes and weights that can be handled easily by masons and placed in succession vertically and horizontally in the wall. Blocks as load bearing walls perform the task of transferring part of the actual load from overlaying structural element to the foundation and must therefore conform to standard recommendation for compressive strength of blocks. The most popular building block sizes recommended in accordance with Nigeria Industrial Standard (NIS 87:2004) include the following; 450mm×225mm×113mm, and 450mm×225mm×150mm. Thus 450mm×225mm×150mm was used for this research work.

However, the popularity of sandcrete blocks and their extensive application as wall materials cannot be over emphasized. Sandcrete blocks when properly produced meet the recommendation of BS 2028, 1364 (1968) for density and compressive strength of structural masonry. Sandcrete block walls are not usually designed to support load other than their own weight. One of the earliest warning sign of failure is often manifested by the formation of serious critical crack long before the actual failure (Dio and Morries, 2009).

A research work carried out by Abdullahi (2005) on the compressive strength of sandcrete blocks in some selected block industries in Minna revealed that the compressive strengths of their blocks fall bellow the standard. The study therefore suggested improvement on the selection of the materials and curing. In recent past good attention has been placed on the successful utilisation of various industrial by-products such as fly ash, silica fume, rice husk ash, foundry waste to save environmental pollution.

Quarry dust which is a by-product from crushing process during quarrying activities is one of those materials that have recently gained attention to be used as fine aggregates in the production of concrete (Sivakumar and Prakash, 2011). It is against this background that this study is aimed at finding the extent of partial replacement of sand with quarry dust to achieve maximum compressive strength in sandcrete blocks production. Some of the objectives are; to determine the index properties of sand and quarry dust, to produce sandcrete blocks with 0,5,10,15,20,25,30,35,40,45,and 50 % of quarry dust, to cure the blocks for 7, 14,21 and 28 days and to carry out compressive strength tests on the blocks.

2. METHODOLOGY

2.1 Materials

Cement;

The cement referred to in this work is the Ordinary Portland cement produced from Dangote group of company in accordance to NIS 87:2004 part 1. The cement was bought from Usmaniyya Nigeria Ltd cement depot located at Gidakangu Minna, Niger state Nigeria. The cement were kept on a raised platform and adequately protected from external damage by weather.

Sharp sand;

The sharp sand was obtained from a river bed at Gidan-mangoro, Minna, Nigeria. The sand was clean and sharp, free from clay, loam, dirt or organic matters and conforms to the grading requirement in zone 4 (BS EN 12620 : 2008).

Quarry dust;

The quarry dust was collected from Abubakar Umar Investment Ltd (quarry site) located along Anguwandaji by-pass Minna, Nigeria. The aggregate was clean and sharp, free from clay, loam, clay, loam, dirt or organic matters and conforms to the grading requirements in zone 2 (BS EN 12620 : 2008).

Water;

The water used was obtained from the borehole at convocation square Federal University of Technology Minna (Gidan kwano Campus) Nigeria. The physical examination of the water revealed that it was clean, free from deleterious materials and fit for drinking as recommended by BS EN 1008:2002

2.2 Production of block samples

Laboratory tests were carried out on both aggregate (sand and quarry dust) in accordance with BS 1377-9 (1990) Standard, to determine their respective physical properties, such as specific gravity, sieve analysis, bulk density and moisture content. Mix proportions were carried out and were strictly adhered to during the block production.

Two hundred and forty (240) 150mm ×225mm×450mm (6") sandcrete blocks were produced manually using the mix ratio of 1:6 (cement: sand/quarry dust) and cured for 7, 14, 21 and 28 days respectively. Twenty (20) numbers of blocks were produced at each replacement level.

2.3 Curing

The curing of the blocks was carried out using the spraying method. Spraying was done morning and evening for the period of five days. However, the weight of each block was taking with the aid of weighing balance to determine the dry density of each block before compressive strength test.

2.4 Compressive strength test

Compressive strength test on the block samples was determined using the standard procedure for pre-cast sandcrete blocks. Sixty (60) numbers of blocks were subjected to compressive strength test at each curing day. The weight of the block samples was always taken before the compressive strength was conducted. Five (5) blocks were tested at each replacement level for the period of 7, 14, 21 and 28 days after casting, using manual 150KN compressive strength testing machine in the Laboratory of Civil Engineering, Federal University of Technology, Minna, Nigeria.

2.5 Physical properties

The physical properties of both aggregate (sand and quarry dust) were determined in accordance with BS 1377-9 (1990). These include; Specific gravity, Compacted Bulk density, Uncompacted bulk density, moisture content and sieve analysis.

3. RESULTS AND DISCUSSIONS

3.1 Preliminary test for sand and quarry dust

The properties of sand and quarry dust used for the study are summarized in Table 1. While Figure 1 shows their particle size distribution curves.

Table 1: Physical Properties of Constituent Materials

Parameters	Sand	Quarry dust
Specific gravity	2.62	2.67
Compacted Bulk density	1618.30kg/m³	1991.88 kg/m³
Uncompacted bulk density	1467.30kg/m³	1811.41kg/m³
Moisture content	7.68%	0.4%
Coefficient of uniformity (C_u)	1.67	8.67
Finess modulus	4.28	6.01
Coefficient of concavity (C_c)	1.45	0.46

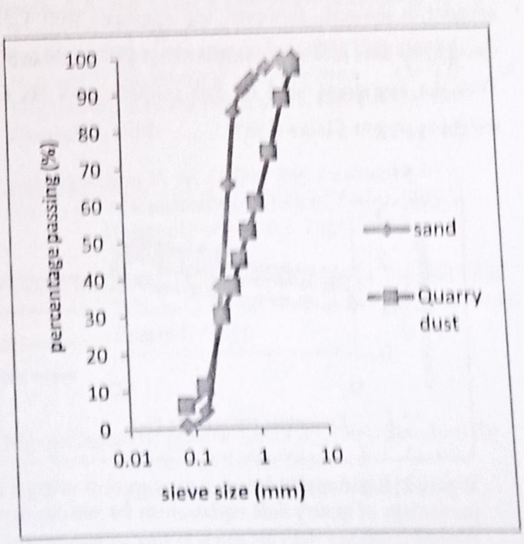

Figure 1: Result of sieve analysis of fine aggregates (sand and Quarry dust).

From the curve, it is clearly shown that the sand is uniformly graded and classified in zone 4 in accordance with BS EN 12620 (2008) classification for aggregate, while quarry dust is well graded, and was classified in zone 2 in accordance with BS EN 12620 (2008) classification for aggregate. The fineness moduli of sand and quarry dust are presented in Table 1. The higher the value of fineness modulus of aggregate, the coarser it is (Lambe and Robert, 2000). The fineness modulus of quarry dust is greater than that of sand which indicates that the quarry dust is coarser than the sand. Also their specific gravities are shown in that table respectively, these values obtained fall within the limit for natural aggregate with the value of specific gravity between 2.6 and 2.7 Neville (1995). The compacted and uncompacted bulk densities of sand and quarry dust are shown in Table 1. The density depends on how densely the aggregate are packed and it is influenced by the nature of compaction adopted in the mix. However, any aggregate with a particle density less than 200kg/m^3 is defined as light weight aggregate. Thus the aggregates used for this research work are normal weight aggregate Clarke (1993).

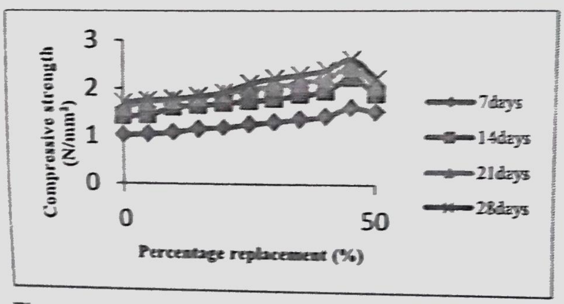

Figure 2: Relationship between compressive strength and percentage of quarry dust replacement for various days.

Figure 2 indicates that the compressive strength increased steadily as the quantity of quarry dust increased up to 45 % replacement where the highest compressive strength of 2.60 N/mm^2 was achieved, and latter decreased beyond the 45 % replacement to the strength of 2.21 N/mm^2 at 50 % replacement. The Standards Organization of Nigeria recommends the minimum compressive strength of [illegible] N/mm^2 and 2.5 N/mm^2 for non-load bearing and load bearing hand compacted hollow blocks respectively. The strength of 2.60N/mm^2 obtained at 45 % is very consistent to the standard.

It was also noted that, the strength and density of the block increase along with the increase in quarry dust replacement and curing age. According to Hamza and Yusuf (2009) Curing is the process of preventing the lost of moisture from the blocks, while maintaining a satisfactory temperature required. Preferably, sandcrete blocks should be moist air cured for the first seven days. This is obvious because curing and protection produce very good blocks.

Thus the quarry dust improves the strengths of the blocks made with the sand in zone 4. The increase in strength in all cases can be attributed to better bonding achieved with the surrounding cement matrix which in turn is caused by the reaction of lime in the cement with the roughness and phase angle of the crushed granite surface. Crushed granite consists of either angular, rounded or irregular shaped individual pieces therefore a change in shape of quarry dust from one shape to another will improve the workability and strength considerably unless the mix proportion are changed.

Dio and Morris (2009) recommended the density of light weight blocks to be less than 1500 kg/m^3 and must be greater than 625 kg/m^3, while that of dense weight blocks to be greater 1500 kg/cm^3. Hence, the value obtained for this work as shown in Table 1. is within the required limit of dense weight blocks. It is obvious from Figure 3 that the dry density of the blocks increased along with increase in curing age and the percentage quarry dust replacement.

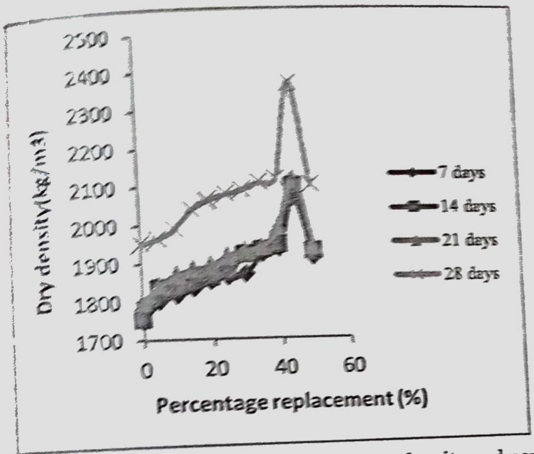

Figure 3: Relationship between Dry density and percentage of quarry dust replacement for various days.

4. CONCLUSION

The compressive strength increased with the increase in quantity of quarry dust up to 45% and there after decreased. That means that replacement of sand with quarry dust beyond 45% of quarry dust is counter productive as the compressive strength started to decrease. Sand in zone 4 which is generally not good for production of sandcrete blocks can be improved by partial replacement with quarry dust.

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