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Effect of Admixtures on the Compressive Strength of Sandcrete Blocks

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Abstract: Sandcrete blocks are extensively used for cladding, load-bearing purposes and for demarcating properties in Nigeria and other nations around the world. The need to produce high quality sandcrete blocks of low cost in an impoverished economy like we have in Nigeria has necessitated research into the use of locally available raw materials in sandcrete block production. This study reports on the investigation carried out to determine the effect of admixtures (sawdust and sugar) on the compressive strength of sandcrete blocks. Results showed that sawdust did not significantly enhance the compressive strength of sandcrete blocks. The results on the use of sugar showed that that sugar had a significant effect on the compressive strength of the blocks increasing it by 17% at 28 days. Both admixtures slowed down the setting and early stiffening of the mortar mix.

Key words: Admixtures, sawdust, sugar, compressive strength, sandcrete blocks

INTRODUCTION

Sandcrete blocks are blocks made from a mixture of sand, cement and water. They are used is Nigeria and in virtually all African countries. For a long time until perhaps a few years ago these blocks were manufactured in many parts of Nigeria without any reference to any specifications either to suit local building requirements or for good quality work. It is comforting to observe that the situation in Nigeria has since changed as the Standards Organization of Nigeria now has a document in place giving the specifications both for the manufacture and use of these blocks in Nigeria ((NIS, 2004). After compaction normal concrete is likely to contain about 1% of air voids, this unwanted entrapped air being evenly distributed and consisting of bubbles of irregular shape and size. Intentional air-entrainment introduces a controlled amount of air (usually about 5% by volume) in the form of millions of tiny bubbles of uniform size and uniformly distributed throughout the concrete mix. Air-entrainment is known to improve the properties of concrete in both the fresh and hardened states. In fresh concrete, the minute air bubbles act as small ball-bearings and greatly improve the workability of the concrete. But the more workable concrete loses about 20% of its strength because every 1% of air entrapped produces about 4% loss in strength.

Sawdust concrete has received some attention in the last few years as a lightweight concrete in building construction. Paramaswam and Loke (1978), in their study of sawdust concrete obtained some encouraging results. Compressive strength values of up to 31N mm^{-2} at 28 days were obtained for a mix proportion of 1:1 that is one part by volume of cement to one part by volume of sawdust. When the mix proportion was changed to 1:2, the 28 days compressive strength reduced to 8.5N mm^{-2} and a mix ratio of 1:3 (cement/sawdust) by volume reduced the 28 days strength value further toonly 5N mm^{-2}. Ravindrarajah *et al*. (2001), conducted experiments on concrete mixes containing sawdust as an air-entraining admixture in order to develop sawdust concrete for sandcrete block making. Volume proportion was used to determine the quantity of individual components in the experimental mix. They observed from the results obtained that sawdust concrete for sandcrete block making, with a sawdust content of 3% by volume and a wet density of 1,920 kg m^{3-1} producedbest results for compressive strength. Ashworth (1965), in his study on the use of sugar as an admixture to concrete concluded that the addition of small quantities of sugar to a Portland cement concrete mix had a number of beneficial effects. For example, a concrete mix made with Portland cement, 0.05% sugar retarded the setting time by 4 h, increased the 7 and 28 days compressive and flexural strengths by approximately 8% and even increased the workability of the mix.

Oyekan (2003) observed that when sugar was added in small quantities to laterized concrete, there was a significant increase in the compressive strength. About 0.05% sugar added to a laterized concrete mix containing 25% fine laterite increased the 28 days compressive strength by nearly 17%. When the fine aggregate was wholly fine laterite, a 50% increase in compressive strength was obtained at percentage sugar content (by weight of cement) of 0.05%. Other research carried out at the National Ready Mixed Concrete Association Research Laboratory (Bolem, 1959), showed that the addition of 0.2% sugar (by weight of cement) to a mortar mix increased the 28 days strength by 30%. But they observed that the sugar as a retarder prevented the specimens from being handled for several days after casting. Smaller proportions of sugar gave correspondingly smaller increases in the 28 days strength and less retardation. Tuthill *et al.* (1960), in their work showed that the addition of sugar to an air-entrained mix designed for constant slump gave an increase in the 28 days compressive strength from 24.66 N mm^{-2} to 26.77 N mm^{-2}, an increase of about 8.6% for a mix containing 0.03% sugar (by weight of cement). When the sugar content was increased to 0.06%, the compressive strength increased to 27.12 N mm^{-2}, an increase of 10%.

MATERIALS AND METHODS

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 the 4.75 mm zone of British Standard test sieves. The sand had a specific gravity of 2.57.

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

Water: The water used was potable water, which was fresh, colourles, odourless and tasteless water that was free from organic matter of any type.

Sawdust: The sawdust used consisted of fine particles that passed through 4.76 mm BS test sieve.

Manufacture of sandcrete blocks: The blocks were manufactured using approved metal moulds. Two different sizes of blocks, namely, 450×225×225 mm and 450×150×225 mm were used. Two mix proportions (1:6 and 1:8 cement/sand ratios) were used in the investigation involving the use of sugar while only one mix proportion, namely 1:6 was used in the investigation involving the use of sawdust. Hand mixing was employed and the materials were turned over a number of times until an even colour and consistency was attained. Water was added as required through a fire hose and the materials were further turned over to secure adhesion. It was then rammed into the metal moulds, compacted 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 h and kept wet during this period by watering through a fine watering hose. Testing for crushing strength was then carried out at ages 3, 7, 14 and 28 days.

Compaction: Since, the blocks were manually produced using metal moulds, the compaction was done manually using approved standard procedure.

RESULTS AND DISCUSSION

Use of sawdust in the mix: Results are presented in graphical form. Figure 1 shows the plot of 28-days compressive strength values against percentage sawdust content for the 450×150×225 mm blocks used in this study (1: 6 mix proportion).

Effect on setting time: Sawdust has been known to contain substances which retard the hydration and the hardening of cement. Results confirm that sawdust acts as a retarder because the blocks could not be handled for some days after manufacture.

Effect on compressive strength: The compressive strength values show that the inclusion of sawdust in the cement matrix did not appreciably enhance the compressive strength of the sandcrete blocks. At the mix proportion of 1:6, the compressive strength increased by only 7% at 28 days for the 450×225×225 mm blocks. At 2% sawdust content in the mix, the compressive strength of the blocks increased by only 2.5% at 28 days. As the percentage sawdust content increased in the mix the compressive strength decreased. For the 450×150×225 mm blocks however, the sawdust inclusion did not appear to affect the compressive strength of the sandcrete blocks. At 1% sawdust content only the 28 days strength increased by 1.1%. The low values of the compressive strength of the sandcrete blocks used in this investigation

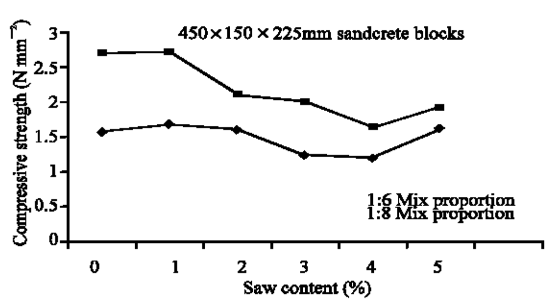

Fig. 1: Variation of compressive strength with sawdust content (28 days)

could be attributed to the fact that sawdust contains some substances (poisons) which are injurious to the cement. These substances actually inhibit the hydration of cement and hence the development of early strength. Furthermore the low compressive strength values could be due to the air entrapped in the mortar mix which is known to cause a reduction in strength. In addition it is difficult to obtain sawdust which is not a mixture of several species. As a result there is bound to be a considerable variation in the results obtained from batch to batch.

Use of sugar in the mix: The results are presented in graphical form. Figure 2 shows the plot of compressive strength against percentage sugar content at ages 3, 7, 14 and 28 days for the 450×150×225 mm blocks used in the investigation (1: 6 mix proportion). From Fig. 2 it can be seen that at a percentage sugar content of 0.10%, the compressive strength of the 150 mm blocks increased by 17% at 28 days. For the 225 mm blocks however, the percentage increase in strength was lower, being only 9% at 28 days at 0.2% sugar content in the mix but 56.6% increase at 14 days. For the 225 mm blocks further increases in strength were recorded at 0.05% sugar content, these being 29.9% at 7 days and approximately 7% at 14 days. The most noticeable effect of sugar is its influence on the rate of setting and consequently on early strength. The chemical reactions giving rise to this retardation effect are very complex and not really fully understood. It has been suggested (Hansen, 1952) that admixtures such as sugar containing the group HO-C-H act by forming a layer on the grains of cement compound, so preventing hydration from taking place rapidly. Once the initial retardation is over, the concrete or mortar mix hardens at the normal rate. According to Prior and Adams (1960), retarding admixtures like sugar are surface active agents which reduce the interfacial tension between molecules and also give a negative charge to the cement particles thereby causing an electrostatic repulsion which

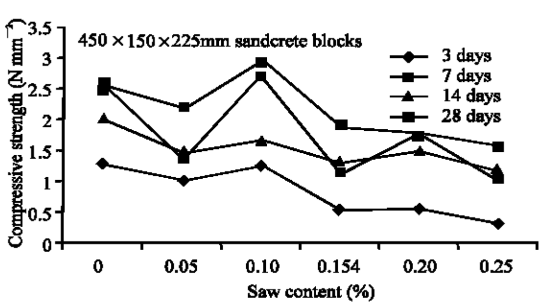

Fig 2: Variation of compressive strength with percentage sugar content

reduces the natural flocculating tendency of the particles and leads to greater dispersion within the system. In his research, on the use of water-reducing and set-retarding admixtures, Larch (1961), said that the negative charge caused by the presence of sugar in the mix normally results in a protective sheath of oriented water dipoles around each cement particle and this frees water from the system, which becomes available to lubricate the mix. The large anions and molecules absorbed on the surface of the cement particles partially reduce the hydration process so that the setting and hardening processes are retarded. As reactions take place to form new products, hydration also proceeds in the normal manner, but owing to the greater dispersion of cement particles, it becomes more effective and this produces an increase in strength when compared with the reference mix without sugar. The increases recorded in this investigation could be due to the phenomenon described above.

CONCLUSION

The main conclusions derived from this investigation are as follows:

- Sawdust as an air-entraining agent has no appreciable effect on the compressive strength of sandcrete blocks. Compressive strength increase of about 7% at 28 days was obtained for blocks manufactured using a mix proportion of 1:6.
- 450×225×150 mm sandcrete blocks generally gave higher compressive strength values than the 450×225×225 mm blocks irrespective of the mix-proportion used in the sandcrete block manufacture.
- Sawdust addition should not exceed 1% of the weight of cement for best results.
- Variation in the compressive strength results is traceable to the fact that it is difficult to obtain sawdust which is not a mixture of several species.
- Sugar has a retarding effect on the sandcrete block and hence some of the blocks at 0.25% sugar content could not be handled 2 days after casting.
- A small quantity of sugar (0.1% by weight of cement) increased the compressive strength of the 450×150×225 mm sandcrete blocks. 0.1% sugar content (by weight of cement) increased the compressive strength of the blocks by nearly 17% at 28 days. At 0.2% sugar content (by weight of cement) the 28 days strength of the 225 mm blocks was increased by only 9% but the 14 days strength of the blocks was increased by 56.6%.
- The 450×150×225 mm sandcrete blocks generally had higher compressive strength values than the 450×225× 225 mm blocks particularly in the range 0-0.1% sugar content in the mix.

- Sugar in the cement-sand mix did not affect the density of the blocks.

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