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Durability of Laterite/Sand Hollow Blocks in Magnesium Sulphate Environment

ATA Olugbenga
Department of Building, Obafemi Awolowo University, Nigeria

ABSTRACT: *The effects of exposure of laterite/sand block to magnesium suphate environment were studied. Change in compressive strength of machine compacted hollow block specimens of mix 1:6 and 10% laterite content were measured after 56 days of continuous immersion in 1%, 3% and 5% of magnesium sulphate solutions. Test results showed that the compressive strength significantly reduced with increase in magnesium sulphate concentration and immersion period. Laterite/sand block made with ordinary Portland cement cannot be recommended for use in sulphate-laden environment since it produced a compressive strength of less than 2.07N/mm^2, as required by the Nigerian Standards, after 28 days of immersion in magnesium sulphate solution.*

KEYWORDS - *compressive strength, laterite, magnesium sulphate, sand*

I. INTRODUCTION

Sulphate attack is one of the most aggressive environmental deteriorations that affect the long-term durability of cement-based structures and can cause huge economic loss. The production of cement-based structures consumes a large amount of natural resources. As a step in ensuring the availability of resources for future generations, it is necessary to adopt engineering practices which focus on the conservation of non-renewable resources and energy. Researchers have been formulating new technologies, which provide a sustainable approach in the construction industry. One of such is the use of laterite as partial or whole replacement for sand as fine aggregate in cement-based structures production. Laterite is a cheap, environmentally friendly and abundantly available building material in the tropical region [1 ,2 ,3]. Laterite has other advantages which make it potentially a very good and appropriate material for construction, especially for the construction of rural structures in the less developed countries [4]. These advantages include: no specialized skilled labour is required for the production of laterized concrete and for its use in the construction of structures and also, laterized concrete structures have potentially sufficient strength compared with that of normal concrete. Despite these advantages, laterite is sometimes considered to be a construction material for the poor and hence undesirable. Loss of traditional knowledge resulting in deterioration in the quality of recent lateritic constructions has, in many cases, compounded these beliefs. This fact might not be unconnected with the non-availability of accepted standards and codes as regards its performance.

Although studies on the compressive strength of stabilized laterized block have shown encouraging results, the lack of sufficient technical data, especially about its long-term performance, has limited its wider application in construction work. This dearth of research data informed the need for this further work to evaluate the durability of cement stabilized laterized block to enhance a safe application of the material.

II. MATERIALS AND METHODS

The major materials used in this study are sharp sand, laterite and ordinary Portland cement conforming to British standard, BS 197-1, [5]. All the materials were sourced from within Ile-Ife in Ife Central Local Government Area of Osun State, Nigeria. Aggregates gradation conformed to BS 932 [6] and the maximum particle size of the fine aggregates (sand and laterite) used was 2.36 mm. Having been previously adjudged [7] to be suitable for building construction; machine compacted sandcrete hollow blocks made from mix (1:6) and 10% laterite content was adopted for this study. Batching was by volume. The mix was such that mix (1:6) at 10% laterite content means one volume of cement and six volumes of aggregate with 10% of the aggregate being laterite, while the remaining 90% was sand. Water was added until reasonable workable mix was obtained to simulate field conditions. This means that the amount of water added was not measured but was just added till the mix was workable. Practical experiences from the rule of thumb have revealed that different batches of the same mix will experience little or no significant variation in compressive strength [4]. As a matter of fact, this is the practice in the production of commercial blocks in Nigeria. Water sprinkling curing method was used. The size of the block samples was 450x150x225mm.

Some selected samples of sand and laterite used as fine aggregate in this research work were subjected to various tests and analyses in order to ensure their compliance with various established standards. Sample grading, moisture content determination, specific gravity test and Atterberg limit determination are some of the tests carried out on the samples.

Figure 3: A diesel powered engine machine-compacted mould

The machine compacted equipment (Fig. 3) is built for easy use and can be operated by unskilled labour. It requires little maintenance and hence the design is very suitable for remote areas [8]. Both electric motors and diesel engines can support it. Its design principle includes the use of solid frames for safe handling and stability. Three levers operate it and produce a hydraulic pressure, which as constant. The framework is about 1.85m high. It operates on a motor placed underneath the wooden pallet upon which the mould rests. The diesel types incorporate the use of a fan belt fixed over the motor and a roller, which actually turns the roller. Actual vibration occurs when the fixture on the motor, a metallic mass, hits underside of the wooden pallet. The moulded unit is removed by the operation of the longest lever, which is normally on the right side of the machine. Actual compaction is achieved by bringing the “presser” down to bear on the cement/aggregate mixture in the mould below. This is done by the operation of the highest lever. A second lever turns off the vibration. The operation of the last lever, the longest on the right hand side slowly lifts the mould for a quick removal of the compact unit. Pressure applied is fairly constant.

The sulphate-water proportion required for 0%, 3% and 5% sulphate concentrations were volumetrically determined. The blocks were immersed in the various magnesium sulphate concentrations. At the end of the immersion periods of 7days, 14days, 28days and 56days three blocks were removed from each of the different concentrations of the sulphate medium, wiped dried and tested for their compressive strengths. The compressive strength test was carried out at 7, 14, 28 and 56 days immersion age using ELE 2000kN compressive testing machine. Three specimens were crushed. All crushings were done on the edge face with a 3mm thick flat steel plate placed at top and bottom of sample for even distribution of load. The compressive strength was then calculated for each block sample.

III. RESULTS AND DISCUSSION

Visual inspection of the specimens did not show any distinctive visual features of damage such as cracking and spalling. Previous studies of external sulphate attack on ordinary Portland cement (OPC) based structures show that the reactions involve calcium silicate hydrate (C-S-H) and the aluminate component of hardened cement paste [9, 10, 11,12]. As a result of these reactions, expansion and cracking are caused directly or indirectly, by ettringite formation, while softening and disintegration are caused by destruction of C-S-H. Therefore, the presence of ettringite was very remote [13]. This is in conformity with identified behavioural pattern of magnesium sulphate by [10] that unlike the attack of other alkali sulphates, attack by magnesium sulphate is characterized mainly by a loss of strength and disintegration of the concrete under attack, rather than by an expansion and scaling. This type of sulphate attack falls into first form of sulphate attack according to [14] which is akin to eating away of the hydrated cement paste and progressively reducing it to cohesionless granular mass leaving the aggregates exposed. He concluded by saying that this type of deterioration may lead to reduction in the cross-sectional area of the structural component (i.e. loss in weight of concrete) and decrease in strength. This mode of failure which is attributed mainly to the formation of gypsum and it is known as the acidic type of sulphate attack.

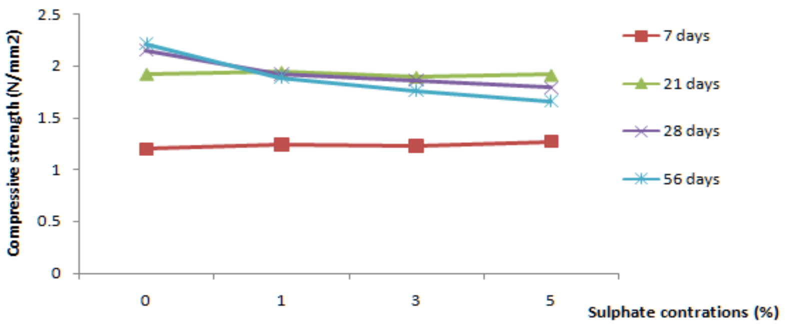

Figure 1: Compressive strength at various sulphate concentrations

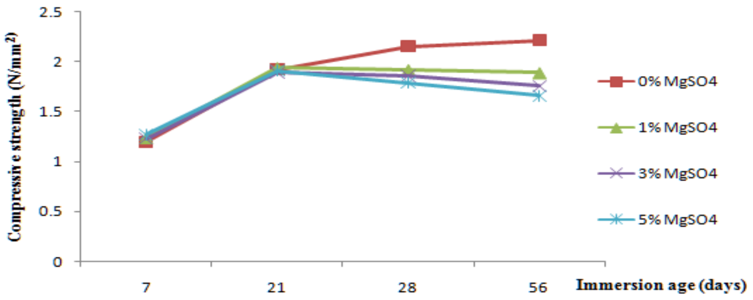

Figure 2: Compressive strength at various immersion ages

Figs. 1 and 2 show the compressive strengths of lateritic blocks immersed in different concentrations of magnesium sulphate over a period of 56 days. Generally, specimens immersed in magnesium sulphate solution exhibited relatively slightly high compressive strengths at early age. Though in all cases, specimens continuously stored in water exhibited higher compressive strength. This initial increase in compressive strength of specimens exposed to sulphate solution might be due to continuing hydration of cement in magnesium sulphate solution at the early part of the exposure period. This increase in strength stopped as soon as complete hydration of cement was achieved and should not be interpreted as increased resistance to magnesium sulphate attack. Another likely reason for the initial increase in compressive strength according to [15] and [16] occurs as result of the action of alkali sulphates on concrete made with Portland cement which is brought about by development of early hydrated microstructure as well as filling of the existing pores with secondary ettringite and gypsum. However, as the formation of this phase continues and the available pore space loses its capacity to accommodate additional amounts of ettringite, potential damaging expansion forces start to be generated within the material. This explains the reason for subsequent relative reduction in strength.

Figs. 1 and 2 show that increasing the solution concentration increases its rate of attack. At the early period of exposure, there was no pronounced difference in the rate of attack due to increase in concentration. However, after 28 days, the specimen immersed in 5% magnesium sulphate concentration had the least compressive strength whereas the one immersed in 1% magnesium sulphate concentration had the highest compressive strength after the control specimen. It can thus be said that the rate of deterioration increased with increasing solution concentration. The higher the magnesium sulphate solution concentration, the lower the specimen compressive strength. This is also in line with [17] assertion that the rate of sulphate attack increases with an increase in the strength of the solution.

IV. CONCLUSION

The study was conducted to evaluate the durability of laterite/sand hollow block in magnesium sulphate environment. Based on the extensive experimental test results it can be concluded that the compressive strength of laterite/sand block decreased with increasing magnesium sulphate concentration and the exposure period. Laterite/sand block made with ordinary Portland cement cannot be recommended for use in sulphate-laden environment since it produced a compressive strength of less than 2.07N/mm^2, as required by the Nigerian Standards, after 28 days of immersion in magnesium sulphate solution.

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