iJET EXPLORE International Journal of Engineering & Technology
CENTRE OF PROFESSIONAL RESEARCH PUBLICATIONS
ISSN 2049-3444

International Journal of Engineering and Technology Volume 4 No. 1, January, 2014

Effect of Variation in Temperature on Some Properties of Cement Stabilized Lateritic Interlocking Bricks

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ABSTRACT

The effect of variation in temperature on the compressive strength and water absorption of lateritic interlocking bricks stabilized with 6% and 8 % cement, subjected to temperatures of 100ºC, 200ºC, 300ºC, 400ºC and 500ºC, over a period of one hour was investigated. 28 day compressive strength and water absorption test was performed on bricks before and after the bricks were subjected to temperature variation. Results of test showed that bricks stabilized with 6 % and 8 % cement content increased from 2.24N/mm^2 and 2.72 N/mm^2 at room temperature (35ºC) to 4.03N/mm^2 and 4.16 N/mm^2, respectively when subjected to a temperature of 500 ºC. However, when bricks were immersed in water for 24 hours, after heating, 28 day compressive strength of bricks stabilized with 6 % and 8 % cement decreased from 1.09 N/mm^2 and 2.10 N/mm^2 at room temperature (35 ºC) to 0.76 N/mm^2 and 1.36 N/mm^2 respectively when subjected to a temperature of 500ºC. Water absorption values of bricks stabilized with 6 % and 8 % cement increased from 1.91 % and 2.00 % at room temperature (35ºC) to 21.72 % and 17.44 % respectively when bricks were subjected to a temperature of 500 ºC. Based on results of test the use of water based fire extinguishers is not recommended for use in fire associated with walls made with lateritic interlocking bricks.

Key words: *Temperature, Variation, Interlocking bricks, Compressive strength.*

I. INTRODUCTION

Fire incidents associated with buildings, are common occurrences and harsh conditions that buildings experience almost every time, during such incident, the flame of fire transmit heat into the walling material, while combustible component of the building go up in flames. In most cases, the wall made up of building blocks is left standing due to its non combustible nature. Recognising the need for building elements to be safeguarded against fire, the concept of fire resistance was incorporated into building elements during the design stage, through appropriate provision of cover to reinforced elements. In the case of walls, screeds apply to the wall as plaster is expected to reduce the impact of heat arising from temperature variations on the walls.

There is a wide range of walling materials available in the construction industries, such materials included bamboo, timber frames, blocks, bricks, stones, mould concrete, glasses, sheet metal, interlocking bricks etc. The choice of a particular material depends largely on its availability, nature of project, individual preference, durability, proximity and economic considerations.
According to Raheem et al (2010) the use of lateritic interlocking bricks as another alternative to sancrete bricks in building houses, with the advantage of not requiring cement mortar for the bonding of bricks during construction, thereby ensuring economy in construction. The bricks are made from locally available material such as laterite normally stabilized with cement, which further enhances economy in the unit cost of the bricks as compared with sandcrete blocks of the same strength.

The production of interlocking bricks is an adoption of the principle and technology of soil stabilization, as the mixing of cement and laterite in the presence of water which is compressed using a mechanical or manual compression machine, is a combination of cement and mechanical stabilization. Cement stabilization as explained by O'Flaherty (2008) is the addition of cement to a soil to enhance strength through a chemical reaction known as hydration, which occurs when water is added to cement in the presence of the soil, the hydration reaction also leads to the formation of lime which reacts with the silica and alumina component of the clay mineral in the latetritic soil. The use of a manual or motorized press machine to compress and densify, the mixture of laterite, cement and water to form a hard mass is referred to as mechanical stabilization. This according to O'Flaherty (2008) is done to artificial increase the unit weight of a material, normally accomplished by expelling air from the soil mass, thereby decreasing the void ratio.

When interlocking bricks are produced, strength is derived from three major sources, from the clay particles that moves into alignment with each other to act as binder after compaction, the clay particles act as binder due to its non rounded or angular, particles, which are in the form of flakes, that sticks together like sheets of paper when saturated with the appropriate amount of water. Strength is also contributed from the hydration of cement, which normally produce a cementing gel that binds the caly, silt and sand size particle of laterite together and pozzoanic reactions between CaO (lime) liberated during the hydration of cement and the clay where the Calcium Oxide from lime is exchanged with the metal ions in the clay as well as pozzolanic reactions within the material with the insoluble metal oxides that are present.

As good as the technology of interlocking bricks may look, and the advantages associated with its usage being economy in production and building coupled with adequate strength, not much is known on the response of this walling material to variation in temperature, normally occasioned by fire incidents. This research is aimed at x-raying the consequences of increased temperature on the strength properties and resistance to water absorption of interlocking bricks.

II. MATERIALS AND METHODS

Materials used in the production of interlocking bricks comprises of laterite, cement and water. Laterite used was obtained from Ikpayongo, a distance of 22km from Makurdi the state capital, along Makurdi- Aliade road, at a distance of 800 m from the centre line of the road and a bearing of N085ºW, where an outcrop of laterite showing some relics of Makurdi sandstone was observed. Ordinary Portland cement as obtained from the open market at Makurdi was used for this work, portable water as obtained in the Civil Engineering Department laboratory was used. Laterite sample was stabilized with 6 % and 8 % cement by dry weight of laterite, the percentage of cement range recommended for use by Hydraform (2004) and commonly used in interlocking brick production in Makurdi metropolis, The mixture of latrite and cement was then used to produce interlocking bricks which were subjected to compressive strength and water absorption test. All the processes were carried out with reference to the International labour organization manual (1987) Nigerian Building and Road Research institute (NBRRI, 2006), and Hydraform (2004) guideline on the production of interlocking bricks.

III. PREPARTION OF LATERITE SAMPLES

The laterite sample obtained from site were air –dried for seven days in a cool, dry place, before samples were taken for sieve analysis test Atterberg's limits test, which were performed in accordance with specification of BS 1377 (1990). Sample for brick production was sieved using a wire mesh screen with aperture of 6 mm in diameter. Fine materials passing through the sieve were collected for use in brick production, while those retained were discarded.

IV. PRODUCTION OF LATERTIC INTERLOCKING BRICKS

Interlocking bricks were produced using a locally fabricated press machine, fitted with mould to produce bricks with dimension of 230mm x230mm x120 mm. The production process comprises of batching, mixing and compaction of Laterite. Batching of laterite, cement and water was done as presented in Table 1.

Table 1: Batching information for Laterite samples Stabilized with cement

Cement content (%)	Laterite (kg)	Cement (kg)	Water (kg)
6	263.2	16.80	20
8	257.6	22.40	20

Prescribed quantity of dry laterite and cement were thoroughly mixed together using shovels on a clean concrete platform. The dry mixture was spread again to receive water which was added gradually while mixing, using a watering can, until the optimum moisture content of the mixture was attained in addition to a uniform consistency. The optimum moisture content (OMC) of the mixture was determined by progressively wetting the soil and taking handful of the soil, compressed firmly in the fist, to drop on a hard flat surface from a height of about 1.10 m. When the soil breaks into 4 or 5 parts, the water is considered right (National Building Code, 2006). The mixture of cement, laterite and water was then poured into the lubricated mould of the interlocking brick moulding machine, and was compressed at a pressure of 100kpa, after which the brick was ejected from the machine. The green bricks were cured by covering of bricks with tarpaulin after sprinkling of water twice a day (morning and evening). This exercise started twenty four (24) hours after moulding for 28 days, in line with Adam (2001). After the curing duration of 28 days the bricks were removed from the curing point, and placed in an oven and subjected to temperatures of 100ºC, 200ºC, 300ºC, 400ºC and 500ºC for one hour, being fire resistance duration, specified for residential building as reported in Mosely et al (2008). The bricks were then removed from the oven and allowed to cool for six hours, before the bricks were subjected to compressive and water absorption test. Five bricks each were used for the dry compressive strength test, while five were used for the soaked compressive strength test, which involved the immersion of bricks in water for 24 hours, after heating at the different temperatures, the bricks were removed, and allowed to drain for two hours before the test was conducted, to normalize the temperature and make the brick relatively dry or free from moisture. The weight of each brick was determined before the test, which was performed using an ELE compressive testing machine. The brick was sand witched between two plates such that the top and bottom as moulded lie on a flat metal plate and the recessions filled with metal plate of the exact size to prevent sheaving of the brick during testing, the brick sand witched between the two metal plate was then inserted into the compartment of the compressive machine before being subjected to load. The load at failure was recorded and divided by the sectional area of the brick to arrive at the compressive strength.

Water absorption test was performed using five bricks each, subjected to the different temperatures, after removal from the oven. Dry weight of each brick was determined using a balance, after which the bricks were then immersed completely in water for 24 hours; the percentage water absorption was estimated using equation (1).

$$Wa = \frac{Ws - Wd}{Wd} X\, 100$$

.... (1)

Where: W_a is the percentage moisture absorption, W_s is the weight of soaked brick, W_d is the weight of dry brick.

V. DISCUSSION OF RESULTS

Particle size distribution of laterite used in brick production is as presented in Figure 1,

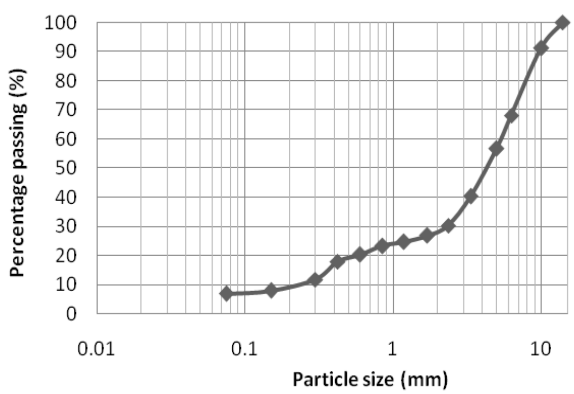

Fig. 1: Particle size distribution curve of laterite.

while the Atterberg's limits properties of the laterite stabilized with cement is as presented in Table 2.

Table 2: Atterberg's Limits test result of laterite stabilized with cement

Cement content (%)	6	8
Liquid limit (LL) %	39.0	36.0
Plastic limit (PL) %	22.0	21.0
Plasticity Index (PI) %	17.0	15.0

The maximum plasticity index value of 15 %, specified by Hydarform (2004) for brick production was attained when laterite was treated with 8 % cement content.

VI. COMPRESSIVE STRENGTHS

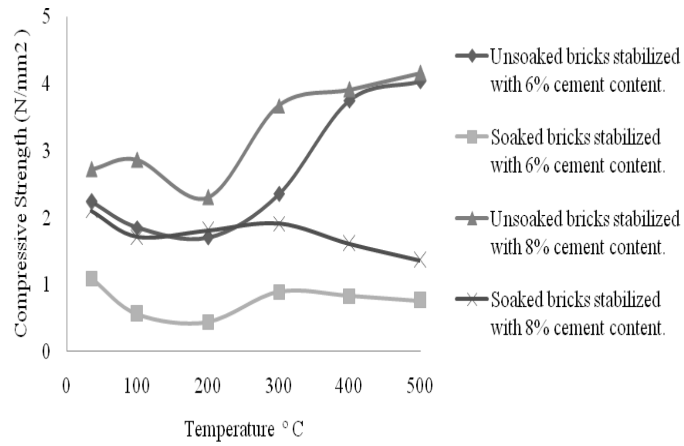

Fig. 2 : Variation of compressive strength with Temperature.

Compressive strength result reflected in Fig. 2 showed that the unsoaked compressive strength of bricks stabilized with 6 % and 8 % cement increased from 2.24N/mm^2 and 2.72 N/mm^2 at room temperature (35^{o}C) to 4.03N/mm^2 and 4.16 N/mm^2, respectively when subjected to a temperature of 500 ^{o}C. When bricks were immersed in water for 24 hours after heating for an hour, the compressive strength of bricks treated with 6 % and 8 % cement decreased from 1.09 N/mm^2 and 2.10 N/mm^2 at room temperature (35 ^{o}C) to 0.76 N/mm^2 and 1.36 N/mm^2 respectively when subjected to a temperature of 500 ^{o}C.

Gradual decrease in compressive strength of bricks was observed, when subjected to temperature range of 35^{o}C (room temperature) and 200^{o}C for unsoaked bricks at 6 % and 8 % cement content. This was due to dehydration of the clay fraction of brick as water retained in the pores of the clay fraction after heating evaporated, while the clay fraction loses its plasticity, resulting in voids which affected the strength of bricks, while the sand fraction undergo a progressive expansion on heating. The hydrated products of cement, beyond the point of maximum expansion, undergo shrinkage, these two opposing actions progressively weaken and crack the brick. Decrease in strength between 35^{o}C (room temperature) and 200 ^{o}C for bricks soaked .

Increase in compressive strength of bricks subjected to temperature range of 200^{o}C to 300^{o}C for both soaked and unsoaked bricks can be attributed to oxidation of ferrous iron, of the laterite component to the ferric form and heat that soften the clay and causes it to expand and close up pores in the brick thereby resulting in strength increase, even though the hydrated product of cement was further weaken with increased heat.

Between 300 ºC and 500 ºC, the weakening of the hydrated product of cement still continue, while the first irreversible reaction dehydroxylation takes place, as part of the actual caly structure (the hydroxyl groups) is driven off as steam, resulting in further expansion of the brick, a factor responsible for strength increase of the unsoaked bricks, however, decrease in compressive strength of the soaked bricks can be attributed to the failure of hydrated product which created voids in the bricks resulting in low strength. The failure of hydrated product above 300 ºC is due to the loss of water molecules from the hydrated product of calcium hydroxide, leaving behind calcium oxide; when exposed to moisture and air rehydrates to calcium hydroxide which result in accompanied expansion in volume.

Results of test clearly showed that when lateritic interlocking bricks are subjected to heat, non water based fire extinguishers should be used as water based fire extinguishers will make the bricks mosit there by affecting strength after heating as reflected in low compressive strength value associated with soaked bricks. Unsoaked Compressive strength values of bricks after heating at all the temperature studied are within the minimum 28 day dry compressive strength value of 2.0 N/mm^2 recommended by NBRRI (2006). This compressive strength requirement however was not satisfied by bricks after immersion in water for 24 hours after heating at all temperatures, when stabilized with 6 % and 8 % cement content.

VII. WATER ABSORPTION TEST RESULT

Water absorption is a measure of the pore in hardened specimen which is occupied by water in saturation condition. Water absorption test result of stabilized bricks is as presented in Figure 3, Showed that, water absorption value increased from 1.91 % and 2.00 % at 35ºC (room temperature) to 21.72 % and 17.44 %, respectively when bricks were subjected to a temperature of 500ºC.

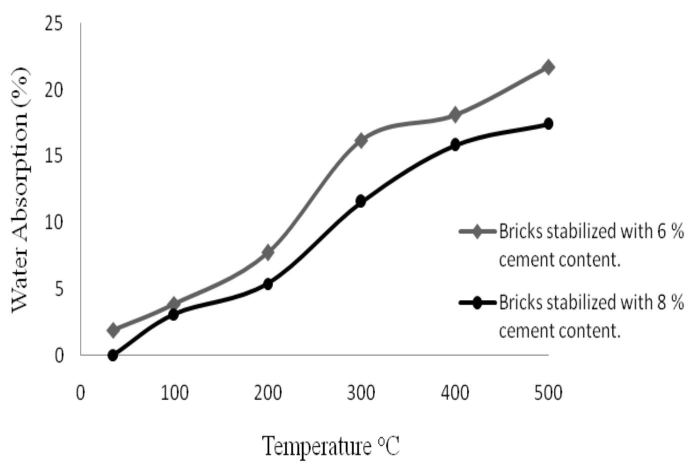

Fig.3: Varitation of Water Absorption with Temperature.

Water absorption of bricks stabilized with 6 % and 8 % cement content increased with temperature, this can be attributed to voids in the bricks. Voids are created as result of the destruction of cement gel form during the hydration of cement and the expansion of the clay fraction which create pores within the stabilized bricks. Results showed that bricks stabilized with 8 % cement content satisfy maximum allowable water absorption value of 12 % recommended by Nigerian Industrial Standard (2004), if bricks are not subjected to temperature greater than 300ºC, bricks stabilized with 6 % cement, will satisfy the maximum water absorption value if subjected to temperature less than 200 ºC. Results clearly showed that temperature rise has effect on water absorption values of lateritic interlocking bricks.

VIII. CONCLUSION

Based on the findings from this study, it can be concluded that:

I. Temperature variation has effect of the compressive strength of interlocking bricks made produced from laterite stabilized with 6 % and 8 % cement content.
II. Within the temperature range of room temperature (35ºC) to 500 ºC the use of water based fire extinguisher is not recommended for use in putting off fire associated with walls built with interlocking bricks as it will affect the strength of the bricks, after heating. This recommendation is based on low compressive strength of bricks when immersed in water for 24 hours after heating.
III. Temperature variation has effect on the water absorption value of lateritic interlocking bricks stabilized with 6 % and 8 % cement content.

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