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Analysis of The Effect of PolypropylenePolymer(Crushed Plastic Waste)On Oven DriedLateriteBricks.

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***Abstract**: The sandcrete blocks have been a major material for the construction of structures inNigeria. This material has provided a means of constructing walls and partition.However, the sandcrete blocks also have the disadvantage of cost and unavailability ofmaterials such as granite, cement and other combining aggregates. Laterite, a readily available material can be efficiently used to produce Laterite brickswhich can be fired to improve its structural properties. The incorporationof wastes such as polymer into the production of bricks can contribute to a more stable constructional material. The main advantage which is the reduction of nonbiodegradable materials dominating dumpsites and landfills. The main idea of this research is to focus on the possibility of creating lateritebricks with properties improved through the addition of waste plastic. Study was carried out on the effect of the plastic wastes on the compressive strength, flexural strength, loss of weight and shrinkage due to heating. The results showed that properties such as compressive and flexural strength decreased upon increasing the polymer content but remained within the acceptable limits. Based on the results of this study, the use of waste plastic in bricks is recommended but to a limit of 5%.*

***Keywords**: laterite bricks, polypropylene polymer bricks, crushed plastic laterite bricks.*

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I. Introduction

Before the discovery of limestone and the advent of cement, mankind has relied on simple earth made bricks for the construction of various structures and artifacts some of which still stands today. These bricks were mostly made of well graded Laterite soils without additives which were mixed with a proportion of water to obtain a paste and were cast or moulded into different shapes. Although these bricks had the advantage of being solid and had a very good resistance to shear forces, they still were brittle and deteriorated in the presence of water. These made them very unsuitable for construction in marshy areas, lands prone to intense flooding and for certain other constructions such as dams and bridges.

In modern times, it is now known that these bricks can be baked in temperature regulated kilns to improve some of their properties some of which include their tensile strength and water resistance. Compressed soil masonry blocks formed using moist soil compacted mechanically have now gained popularity. Benefits of earth blocks in this manner include improved strength and durability as compared to adobe while maintaining significantly low embodied energy levels than alternative materials. However, problems arise still from the material's low tensile strength, brittle behaviour and deterioration in the presence of water. Stabilization by a hydraulic binder such as cement, lime or combination of the two can significantly improve water resistance and strength to some extent [36].

Solid waste management especially the huge quantity of waste plastics is one of the major environmental concerns nowadays. Their employability in brick making in form offibres (plastic fibre-Laterite bricks) as one of the methods of waste management can be investigated through a fundamental research.

Also, previously carried out researches have shown that most studies on natural fibresare focused on cellulose basedfibres obtained from renewable plant resources exceptinthe case of animal fibre and in another case of plastic fibre and polystyrene fabric. Inthis context, for the plastic fibre-Laterite bricks to be more widely applicable, asystematic quantification of the relevant physical and mechanical properties is crucial; to enable an objective evaluation of the material's response to actual field conditions. This research project aims at highlighting the salient observations from theinvestigation of a systematic study on the effect of embedded plastic fibre on theperformance of stabilized bricks[23].

II. Materials and Methods

Polypropylene

Polypropylene is a polymer that belongs to the group of polyolefins which are partially crystalline and non-polar having properties similar to polyethylene but is slightly harder and more resistant to heat. is the second most widely produced commodity plastic used in a variety of applications including packaging and labelling,textiles (e.g ropes,thermal wear, andcarpets), stationery, plastic parts and reusable containers of various types,laboratoryequipment, loudspeakers, automotive components, and polymer banknotes. An addition polymer made from the monomer propylene, it is rugged and usually resistant to any chemical solvent, bases and acid [17].

The plastic wastes are to be derived from disposed or damaged plastic chairs. These materials were obtained from Shagamu Ogun state.They were collected and transported to the crushing factory at Ijebu Ode where they were first fed into the crusher which pulverized them into granules. They were further passed into water which removed contaminants and deleterious materials.

Soil

The laterite soil used for this research was obtained at a laterite deposit in Institute of Food Security, Environmental Resources and Agricultural Research (IFSARER), Federal University of Agriculture, Abeokuta (FUNAAB), Ogun State, Nigeria.

Figure 1: Sample of crushed plastic polymer.

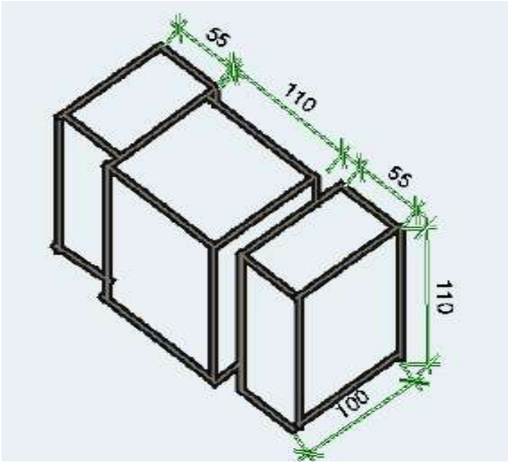
Figure 2: Sample of laterite obtained

Water

The well water was obtained near the casting site which was used in mixing andpreparation of brick cubes. Thewater was clear, free from physically settleable andsuspended particles,potable and satisfied the requirements for water according to thestandards stated in Methods of test for water for making concrete, BS 3148, BritishStandard Institution, 1980.

Mix Details and Proportions

The brick used for this study consists of composites of Laterite and water. The designmix ratio was 1:25 and the water-laterite ratio was 0.5. The brick samples used forevaluating compressive strength (T_A) had a dimension 10 x 22 x 11cm while those for flexural tests (T_B)had dimensions 22 x 22 x 11cm.



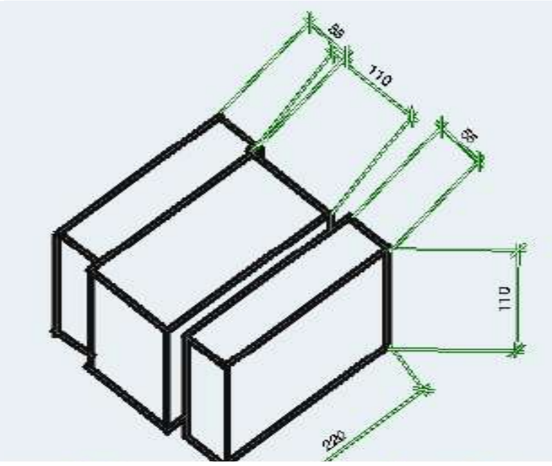


Diagram 1: Dimension of Clay Brick (T_A) **Diagram2:**Dimension of Clay Brick (T_B)

Procedure for Casting of Bricks

Batching the constituents by weight: Batching by weight eliminates error due to variations contained in a specific volume. Regular inspection and calibration of the equipment must be done in order to provide a consistent batch of aggregate between mixes. The production of bricks began with the control samples followed by the mixture contents, varying the percentage replacement of laterite aggregates by the polypropylene plastic fiber. The percentage replacements considered are 0%, 5%, 10% and 15% of the laterite aggregate with crushed plastic.

Percentage replacement (%)	Total number of bricks	Number of bricks (T_A)	Number of bricks (T_B)	Mass of soil (T_A)	Mass of soil (T_B)	Total mass of soil	Total mass of polymer
0	9	6	3	30.0	30.0	60	0
5	9	6	3	28.5	28.5	57	3
10	9	6	3	27.0	27.0	54	6
15	9	6	3	25.5	25.5	51	9

Table 1: Mix details

Mechanized Forming Process

The Hydraform brick making machine MODEL M8DE MFD 2014 was used for making brick samples used for this research. After the laterite has been mixed with plastic at the required percentage and water added to the aggregate, the upper arm of the machine is raised with the aid of a hydraulic gear revealing the form chamber, the mixture is batched by weight and carefully poured into the chamber. Compression is carried out by both of the lower and upper arm with a pressure of 2200Psi (150bar) after which the upper arm is again lifted and the lower arm raised to lift the moulded brick out of the chamber. Brick mixture with three levels of polystyrene granules were investigated to determine their compressive and flexural strength.

Drying

The wet brick from the moulding machine contain 5%-15% moisture. Before the commencement of oven drying, the samples were first dried in the open air for 14 days to reduce its water content.

Oven Drying

The drying of Laterite bricks in oven is adopted to further reduce the water content of Laterite bricks or other ceramic products. Drying in an oven or kiln controls many important properties of the finished ware. Some of these properties include Mechanical strength, Abrasion resistance, dimensional stability, resistance to water, fire and chemical.

Drying Process

The brick was dried in an oven for 48 hours. The oven was charged by electricity to a temperature of 105°C. The oven drying of plastic bricks intends to improve durability through sintering which can be seen as the bonding mechanism of laterite particles. The key to oven drying is to strictly ensure that the temperature of the oven ismaintained at the required temperature for the period of time through which fusion is improved and partial vitrification occurs but viscous fusion is avoided. Similar to kilns, the oven had a temperature sensor equipped to monitor and control the heating temperature. Near the end of the heating process, the oven was turned off to accomplish the flashing process. Flashing means the drying temperature was reduced[17].After the heating in the oven for the required time period. the bricks were cooled for 24hours in open air before any test was carried out on them. Cooling is an important stage in brick manufacturing as it has a significant effect on the colour of the Laterite material.

Tests Performed on Laterite Bricks

Compressive Strength Test: this is an utmost important test which gives an idea about all the characteristics strength of the brick. The compression test was carried out on the specimens at the end of 7 days and 28 days ofcuring.

Compressive strength = P/A

Where, P=Failure load (N)

A=Cross sectional area (mm^2)

Three trial tests were carried out average of which was used for determining the strength of the bricks.

Flexural Strength Test: It is loaded unlike compression or tensile test; flexuraltest does not measure fundamental properties of materials. When a test specimen isplaced under flexural loading, all the fundamental stresses arepresent.

$$\text{Modulus of Rupture} = \frac{3Pa}{bd^2} \qquad \text{……….1}$$

Where

b = measured width of in cm of the beam,

d = measured depth in cm of the beam at the point of failure,

L = Length in cm of the supported beam

P = maximum load in KN applied to the beam.

Water Absorption Test: The purpose of this test method is to provide a meansfor comparing relative water absorption tendencies between bricks of different mixproportions. The brick after casting was air dried for 14 days and furthermore ovendried for 2days. This weight was then noted as the dry weight (W_1) of the block. Afterwhich the specimen is to be submerged in water for 24hours. Then the weight would then be noted and water absorption would be thus calculated.

$$\text{water absorption (\%)} = \frac{W_2 - W_1}{W_1} \times 100 \qquad \text{………... 2}$$

Where,

W_1 = Oven dried weight of brick in grams.

W_2 = weight of block afterimmersion in water for 24hours. [5].

Linear Shrinkage: was obtained by measuring the length of the sample before and afteroven drying using a caliper with a precision of ±0.01mm, according to the standardASTM C326 [4]. The firing linear shrinkage (before and afterfiring) expressed as a percentage and calculated according to the following formula presented as the results were more readily available.

$$\text{Firing shrinkage (\%)} = \frac{L_{dried} - L_{fired}}{L_{dried}} \qquad \text{……….. 3}$$

Where,

L_{dried} is the length of the oven dried sample (mm)

L_{fired} is the length of thefired sample (mm).

Firing shrinkage was determined by measuring the physical dimensions of thespecimens before and after firing.

III. Results and Discussion

Compressive strength:this greatly depends on the amount ofplastic waste in the fired brick specimens and the firing temperature. In addition,compressive strength of specimens decreased upon increasing the proportions of plastic polymers. The decrease was caused by the following;

- Differences in grain size of laterite and polymer granules.
- Weak bond between the laterite grains and polymer granules.

The test results showed that the highest compressive strength was 2.05N/mm2 for 0%waste plastic additive. The result in indicated that the compressive strength of ovendried Laterite bricks is inversely proportional to the containing amount of plasticpolymer. The value decreases progressively up to a minimum of 0.6N/mm2 for 15%plastic polymer replacement.

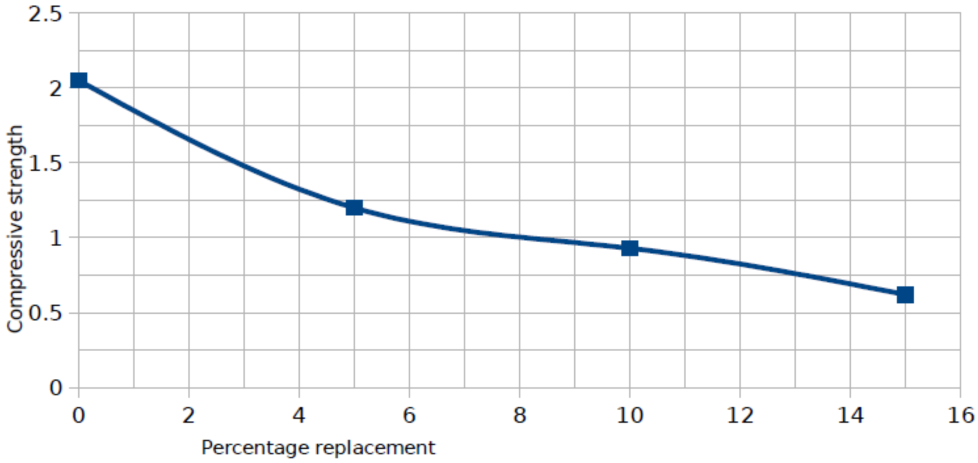


Diagram3: Graph showing the compressive strength of laterite brick samples

Shrinkage: this is related to loss of water among Laterite particles resulting in the closerpacking of granules and resulting shrinkage. During heating, ceramic particles fusetogether leading to greater proximity and thus enhancing linear shrinkage. It is considered that the reduction in firing shrinkage of brick material had a positive impact on its load bearing. Large shrinkage could result in cracks and dimensional effects. Results showed that thefiringshrinkage increased with an increase in proportion of plastic polymer with the highest proportion (15%) developing visible cracks. Shrinkage is normally an important factor to determine the degree of densification during firing. Bricks must have a firing linear shrinkage lower than 8% in order to retain good mechanical performance [37].. The results showed that the lowest linear shrinkage occurred in the control Laterite bricks having no
addition of plastic polymer while the highest value of 4.25% occurred in 15% polymer replacement. The linear shrinkage for all brick samples is within the safe limits for industrial production as indicated in ASTM C326 however the cracks developing in higher percentage replacements. It can be seen in figure 4.2 below that for all the
additives tested, linear shrinkages are below 8%. In addition, the lower these results, thebetter the final product's properties.

$$\text{Firing shrinkage (\%)} = \frac{L_{dried} - L_{fired}}{L_{dried}} \quad \ldots\ldots\ldots.. \quad 3$$

Where
L_{dried} = Length of brick sample before oven drying,
L_{fired} = Length of brick sample after oven drying.

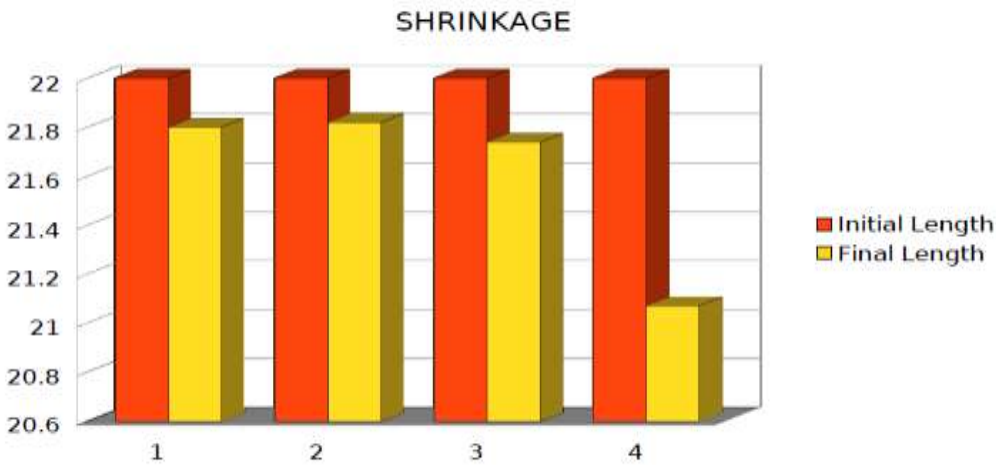


Diagram4: Chart Showing the Average Shrinkage of bricks having varying proportionsof polypropylene.

Weight loss: the oven dried Laterite bricks was dependent on the quantity of polymercontained. The greatest weight loss was observed to be that of 0% polymerreplacement. This was caused by dehydroxylication and also organic or carbonaceousmatter burnt off during the heating process. From Figure 4.3, it was observed that the weight loss of oven dried Laterite bricks decreased upon increasing the quantity of polymer additives.

$$\text{weight loss (\%)} = \frac{W_1 - W_2}{W_1}$$

Where
W_1 = open air-dried weight of bricks in grams.
W_2 = Oven dried weight of bricks in grams

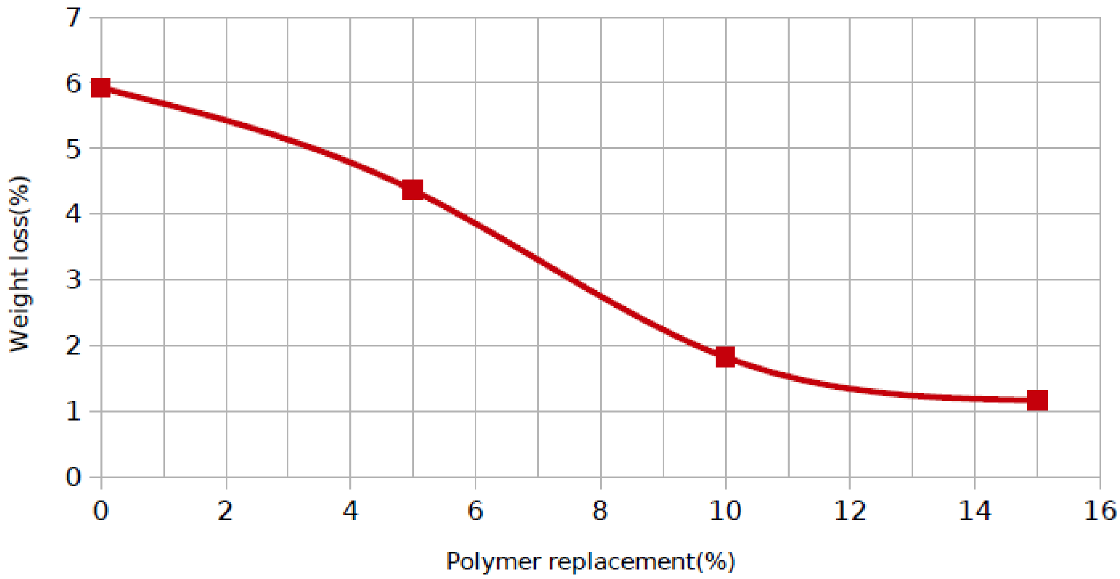


Diagram5: Graph Showing Weight Loss of various Laterite bricks

Flexural Strength: noticeable decrease was observed in flexural strength as the polymer content was increased. Modulus of rupture of the oven dried bricks similarly increased with an **i**ncrease in polymer content. The explanation for this is, due to the reactions that occurred within the samples during the heating process. The brick samples having a higher quantity of plastic polymer had visible cracks after heating for 48 hours which greatly served as a weak point within the body of the brick samples. The test results showed that the highest flexural strength was 4.23N/mm^2 for 0% polymer additives and the lowest, 2.02N/mm^2 for 15% polymer additives. The results showed that the flexural strength of oven dried Laterite bricks is dependent greatly on the amount of waste plastic addition. The values of which decreased progressively from 4.23N/mm^2 to 2.02N/mm^2,

Figure 3: Flexural Strength Test Set Up

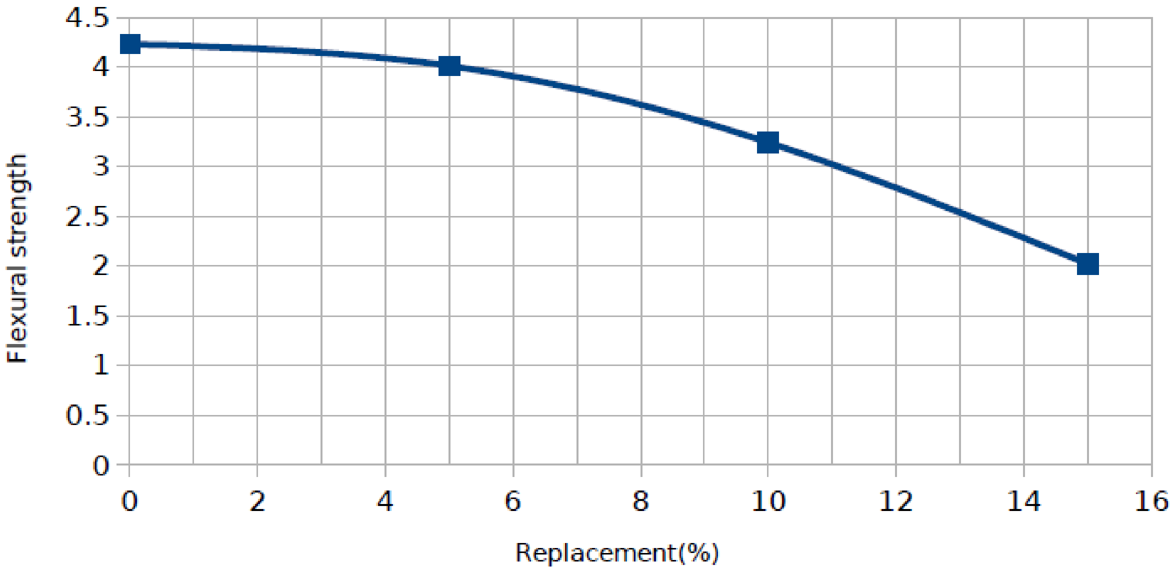


Diagram6: Graph showing flexural strength of brick samples

Collapse of oven dried bricks

Mainly due to the absence of a binder in the mixture used in moulding, the Lateritebricks collapsed into pieces after a few hours of immersion in water. Although, brickshaving no or very little quantity of plastic polymer took longer before getting soaked with water, they still were very permeable due to weak forces that held together the

grains of the laterite soil. Also, the permeability of the bricks was greatly enhanced upon increasing the amount of plastic polymer additives, the polymer grains having an approximate size of 1-2mm in diameter banded poorly with the laterite grains bonds of which could easily be broken by the absorption of water. Factors resulting in the collapse of Laterite bricks are;

- Absence of binder in the mixture
- Presence pores caused by organic matter burnt off during the heating process.
- Poor bonding between the laterite grains and polymer granules.
- Presence of cracks in bricks having a higher percentage of polymer

The bricks having a higher percentage of plastic polymer were observed to soak up and crumble after few minutes of immersion in water. The properties of the laterite soil used in the production of the bricks also influenced the permeability the bricks. These properties include engineering properties like sieve analysis, liquid limit and plastic limit.

IV. Conclusion

The brick samples used for this research were oven dried for 24 hours at a temperature of 105°C. The conclusions from the aforementioned experiments are as follows. The Compressive Strength tests carried out showed that the compressive strength of oven dried Laterite brick is inversely proportional to the containing quantity ofpolypropylene fiber. It was also observed from the experiments conducted that the strength of Laterite bricks is affected greatly by the amount of polymer fiber it contains.

Results from this research also showed that in order to maintain the structural capacity of oven dried Laterite bricks, the maximum amount of replacement with polymers should not exceed 5% of its total weight. Also, to maintain good engineering and mechanical qualities, the particle size of polymer granules or other similar additives should not exceed 1mm.Experiments tests gave a maximum compressive strength of 2.01N/mm2 and according to BS3921, the compressive strength for a single storey building should be within the range of 1 to 5N/mm2 which is also recommended by building authorities. The compressive strength of the oven dried Laterite bricks was observed to seriously decline when the amount of polymer additives exceeds 5%.These results show the inability of oven dried Laterite bricks to be used for high strength applications. However, the overall dead load of the building is greatly reduced due to the relatively low density and weight of the bricks. Thus, the bricks can be used for interior purposes, wall partitions and decorations the maximum flexural strength of 4.23N/mm^2 was recorded for the oven driedLateritebricks. Similar to the compressive strength, the flexural strength of oven dried Lateritebricks is inversely proportional to the containing amount of polymer.

Tomaintain the flexural capacity of oven dried Laterite bricks, the used ratio of plastic in the brick material should not exceed 5% of the material weight.

The collapse of oven dried Laterite bricks and entire shrinking was observed to increase upon increasing the quantity of polymer additive. The greatest shrinkage of4.25% for 15% polymer replacement was recorded during this research. The shrinkage of oven dried Laterite bricks showed a slight decrease as the amount was increased from 0% to 5% and begin to increase as the amount of containing polymer exceeded5% of the total weight. Thus, the acceptable limit of shrinkage due to oven drying can be ensured by limiting the quantity of polymer or other similar materials to 5% of the material weight.

The weight loss by the oven dried Laterite bricks decreased upon a significant increase in the quantity of polymer additive. Although bricks of 15% polymer replacement had the least weight loss (1.16%), all brick samples satisfied the recommended maximum weight loss of 15% as stated in the British Standard BS5628.

This research shows that oven dried Laterite bricks failed totally when undergoing the test of water absorbing quality. As a result, oven dried Laterite bricks are not suitable for use in external purposes or in water logged areas or conditions but can be used for internal walls, partitions and for other internal structural purposes.

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