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Investigation of the Potentials of the Use of Termite Mould In Brick Production

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ABSTRACT

The article discloses the results of the research, which was made on the resources of the termite mould as the building material, and compares its characteristics and application to the traditional ones (sand, and cement). The main materials that were used in the experiment were sand, termite mould, cement and water. The termite mould was used to make three sample mixtures with different proportions (termite mould only, 1:4 termite mould to sand and 4:1 termite mould). Findings indicated that the sample prepared using termite mould (sample 1) had the least water content (6.25 percent), reduced absorption rate (four voids after drying) and the specific gravity of 2.5. Conversely, the sample (3) that had termite mould and cement had the highest water content (15.63%). The sample composed of termite mould and cement (sample 3) demonstrated the highest compressive strength, reaching 24.42 MPa after 28 days of curing. The research has presented practical implications that the research of termite mould soil as a construction material showed that it could be used to produce environmentally friendly and thermally efficient bricks with average compressive strength. Meanwhile, to be practical in the contemporary construction, it requires either the refinement of the consistency of the brick production process and a better material enrichment (addition of more cement or sand).

Keywords: Bricks; Cement; Recycling; Sustainability; Termite mould

Introduction

Bricks are one of the most common and traditional materials of building all over the world. Their power, durability, and ability to provide thermal insulation have seen them remain the staple of the construction sector through the years. Adeniyi and Olugbenga (2016) indicate that bricks are used in the construction of wall, pavements, foundations and other buildings. Efficient and sustainable building materials are gaining more relevance in the construction sector with the increase in construction demand in the world and the growing concerns about the environment. The conventional building materials such as sandcrete and concrete blocks emit some level of obnoxious carbon contents into the atmosphere, posing a major problem (Bhat & Shukla, 2018). Nonetheless, naturally occurring termite mould that is generated by termites is rich in organic compounds and clay, which could enhance adhesion properties of materials. It is an attractive option in construction projects since it is heavily available and has an environmental friendly nature (Olufemi and Adeyemo, 2020). Also, cement usage can be reduced by the addition of termite moulds to further reduce the ecological impact of cement production (Kumar & Kumar, 2019).

To minimize wastages, carbon emission and costs and encourage eco-friendly building methods, this research paper will explore the substitution of traditional cement with clay, sand and termite mould. The main goals of the research are the following: to determine the mechanical and physical properties of soil located in termite moulds; to test the possibility

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Table 1: Physical Properties of the principal materials

Properties	Termite mould	Sand
Water content	15.15%	0.53%
Specific gravity	2.5	2.6
Volumetric Shrinkage	10%	2%

of using glass and termite mould as partial substitutes of cement in the production of bricks; to evaluate the capacity of concrete to be strong, to absorb water, and to be durable at different replacement rates; to observe how the composite materials will perform under various environments. This research is important as it attempts to establish if glass powder and termite mould could be proposed as viable and sustainable solutions in the use of conventional cement as this would enhance the durability and sustainability of building structures. In addition, it will reduce over dependence on cement and minimize on construction costs through an improvement of thermal and structural properties of the manufactured bricks.

Materials and Methods

The following are the materials used for the practical experiment: The termite mould is a waste product of the termite harvesting that is a partial cement substitute. Water was used to combine and moisturize the cement. The sand, which is the fine aggregate is used in the production of the bricks. For the cement, the Portland Limestone Cement (PLC) was used as the binding agent. The Table 1 reveals the physical properties of the major materials (termite mould and sand). In terms of the equipments used, the British Standard BS EN 771 - 3 was adhered to in the production of the bricks.

Regarding the collection of the materials as well as their preparation, the termite mould was sourced from a natural termite hill in a rural area located in Akure, Ondo State, Nigeria. The soil in question after collection was sieved using the 0.425mm sieve to remove large particles, stones and rubbish and retained only uniformly fine particles, which are used for the brick mix. The termite mould moisture content was adjusted by air-drying for a period of 48 hours. For the mixing, the different materials (cement, sand and termite mould) are batched by weight as shown in Table 2.

Water Content

Water content test is carried out to ascertain the level of moisture content level in the bricks. The outcomes of the test are used to determine the strength and sustainability of the bricks. Water content can be calculated by:

$$Water\ Content\ (\%) = \frac{W2 - W1}{W1} \times 100$$

W1 - initial weight; W2 - wet weight

Water Absorption Test

This is a test created to determine the capacity of the bricks to absorb water given that increased water absorption would be an indicator of structural instability and sensitivity to weathering. The results of the test were determined by tallying the number of void bobbles as they were soaked in water.

Moulding and Shaping

A hand press machine was used to press the mixed termite mould soil into normal sizes of bricks. The bricks were left to dry after 24 hours to attain the initial hardness and then the firing process was done. There were no visible cracks in the moulding process

Table 2: Mix combinations for the different samples

Samples	Termite mould (%)	Sand (%)	Cement (%)	Proportion
1	100	0	0	16 kg Termite Mould
2	20	80	0	Weight of termite mould 20 kg, 80 kg Sand (1:4).
3	80	0	20	Cement 20 kg, Termite Mould 80 kg (1:4)

and the newly moulded bricks were smooth. This was an implication of the fact that there were high binding properties in termite mould soil that would be applicable in large scale production.

Firing Process

The bricks were calcined in a kiln at temperatures ranging between 900 - 1000 ^{o}C over a period of approximately 12 hours. The fire process did have some shrinkage, but these were tolerable. Termite mould soil responds well to extreme temperatures and retains its form as observed by the absence of observable warping or distortions by the bricks when they are fired. After the burning, there was a noticeable change in the colour, the bricks being changed to darker, reddish-brown. This showed the extent of hardening of the material by high temperature making it more resistant to external forces such as mechanical stress and water uptake.

Visual and Surface Quality

The dirt bricks produced by the termite moulds were smooth with a minor number of surface flaws following the burning. The lack of major cracks or deformities was a good sign of good binding qualities. A slight occurrence of efflorescence, characterized by a white, powdery substance, was noticed on the surface of some bricks, likely resulting from the soil's salt content. The uniform reddish-brown color and texture of the burnt bricks make them aesthetically appealing and suiTable for eco-friendly architectural projects.

Compressive Strength

Compressive test is followed to find out the load that each brick can sustain before deformation. The compressive strength is a significant variable in the structural integrity of a building, and for this study, the British Standard BS EN 771 - 3 was adhered to. The test assists in evaluating the appropriateness of the bricks to be used in the process of loading and the bricks also help to check the safety and stability of the structures to be built using the bricks.
It is determined by:

$$Compressive\ strength = \frac{Load}{Cross - sectional\ area}$$

Results and Discussions

Water Content Test

As indicated in Table 3, Sample 1 brick absorbed 6.25 percent of its initial weight in water in 7 minutes of immersion. This implies a relatively low content rate of water. When sand and cement are included in the mixture, the rate of water content intensifies in the bricks sample two (12.50%) and three (15.63%). This implies that those factors are inclined towards accelerating the uptake of water in bricks. This is unlike Limbachiya and Roberts (2016), which found out that when termite mould was added to sand and cement, a slight decrease in water content was realized. However, the addition of termite mould reduces this rate that makes the bricks resistant

Table 3: Water Absorption and Water Contents of the Samples

	Initial weight (kg)	Final weight (kg)	Water absorption (No of voids)	Duration (minutes)	Water content (%)
Brick 1 (termite mould only) (100:0)	3.2	3.4	4	7	6.25
Brick 2 (termite mould:sand) (20:80)	3.2	3.6	4	7	12.50
Brick 3 (termite mould:cement) (80:20)	3.2	3.7	8	7	15.63

Table 4: Compressive Strength Results of the Samples

Sample	Brick area (mm2)	Load (kN)	Compressive strength (MPa)
Brick 1 (termite mould only) (100:0)	2247	32.97	14.67
Brick 2 (termite mould:sand) (20:80)	2247	45.0	20.02
Brick 3 (termite mould:cement) (80:20)	2247	54.86	24.42

to excessive moisture. The water content of brick samples 3 could be attributed to the presence of more termite mould in the mixture, which might have made the bricks porous and contain water more as compared to the sample 1. This is in line with the findings of Ogubode and Ogunkaya (2018) which stated that the increased water level led to low binding and affected the final shape and the strength of the bricks.

Absorption test

After 7 minutes submersion of sample 1 brick, there were four voids that were observed on the surface as is indicated in Table 3. The porosity of brick production could be the cause of the holes. Vapours can affect the general architecture of the brick, its capacity to absorb water, and its lifetime. This is in line with a research by Founouni and Nguimbi (2017) which discovered that bricks lose structural integrity due to the added moisture filling them with holes. Also 8 distinct voids were observed on the surface of sample 3 brick after 7 minutes of submersion. The high part of the sample bricks could be due to the interior grain structure of the sand added to the mix. The fact that there are several holes implies that the brick could enjoy a porous structure which could be why the brick absorbs water faster. The research by Duan and Wang (2019) claims that the presence of voids could affect the ability of the brick to resist the deterioration caused by moisture as well as its ability to bear the load and its insulating properties.

Compressive Test

In order to determine the ability of cement-termite mould bricks to carry the weight, compressive test was performed on them. Following 28 days of bricks curing, they were put into test. After being placed in the compression testing machine, the bricks were put under a constant load till they broke down. The compressive strength was measured in megapascals (MPa) and presented in Table 4.

The compressive strength was directly proportional to the period of curing. Sample 3 (termite mould: cement) was the strongest with the highest 28-day strength of 24.42 MPa and sample 1 (termite mould only) was the weakest with 14.67 MPa. This means that the compressive strength of the material is increased with the addition of cement as compared to other materials. The findings are in line with the results of Kabir and Alam (2018), which posits that cement possesses some binding qualities hence tends to give concrete some compressive resistance. Also, the results varies slightly with that of Olufemi and Adeyemi (2020), which had a compressive strength of 30.23 MPa, which might be attributed to possible discrepancies in production processes.

Conclusion

The replacement of cement with sand and termite mould to construct bricks is a giant leap to the top of more green building practices. These bricks have improved thermal characteristics, use waste materials and lessen environmental effects of cement production. The study conducted several tests on different formulations such as compressive and water absorption test and the research gave useful information regarding the viability of such substitute materials in the building industry. Initial compressive tests had indicated that the strength development of cement-termite mould bricks is highly dependent on the time of curing. Compressive strength also increased following the period of curing (28 days) that demonstrated the importance of adequate curing to the functionality of composite bricks. Additionally, maximisation of the proportions of the materials and methods of curing needs to be undertaken so that the bricks can qualify according to the industry standards with regard to water-resistance and compressive strength.

To sum up, the experiment shows that termite mould can be used as successful partial replacements to cement and this offers good chances to reduce environmental footprint of construction operations. Nevertheless, more studies can be encouraged to maximize the ratio of materials, enhance their durability, innovate industry standards, and increase the adoption of these eco-friendly building materials to minimize the emission of greenhouse gases in the construction industry.

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