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Effects of Synthetic Foam on the Properties of Stabilized Lateritic Bricks

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Abstract: Managing the production costs of construction projects is crucial especially in the aspect of material management. The use of lightweight materials reduces the dead load in structures, thus the reduction in the use of reinforcement and concrete in the foundation. To this end, this study examined the effect of synthetic foam on the properties of stabilized lateritic brick with a view to producing lightweight stabilized laterite brick for use on weak soils with low bearing capacity. Laboratory tests were conducted on the bricks produced to determine the density, compressive strength, and water absorption properties at 7, 14, 21, and 28 days. Preformed foam using synthetic foaming agent was used at 0%, 25%, 50%, 75% and 100% to replace the water in the experiment. One hundred twenty samples of stabilized foamed lateritic bricks were produced at a mixed ratio of 1:4 (cement: laterite) using a 0.6 water/cement ratio. The result showed that the bricks at all percentages of foam content meet up with the minimum requirement of compressive strength of 1.6N/mm^2, 2.0N/mm^2 and 3.5N/mm^2 recommended by the Nigerian Building code, Nigerian Building and Road Research Institute, and the third class brick of the BS 3921:1985 respectively. The water absorption is within the limits of bricks specified in standards as 15%. The highest compressive strength was recorded at 25% foam inclusion (4.839N/mm^2) on 28th day hence concluding that foaming agent stabilizes the characteristics strength of laterite bricks and also reduces its density.

Keywords: Lightweight stabilized lateritic bricks, synthetic foaming agent, compressive strength, water absorption, density.

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1. Introduction

Proper management of construction projects is crucial especially in terms of saving the costs of the projects. Savings in the cost of construction projects in order to meet housing needs has led to the use of lateritic bricks; produced with locally available materials (laterite) and stabilized with the use of various additives to improve its properties and characteristics. Laterite is some soil obtained from the weathering and percolation of large varieties of rock found in the tropical and sub-tropical humid environment. It is composed of iron oxide, aluminum oxide, silica, which are disintegrated into clay components of kaolite and illite formed from the weathering of rocks and other minute minerals (Lemongna et al., 2011; Olutoge et al., 2018). Keel 1963 as cited by Olowu et al. (2014) discovered that different types of clays deposited at various geological periods ranging from soft to hard shale are used for the production of bricks, which are either sun-dried, also referred to as adobe or burnt. The production of burnt clay bricks leads to the emission of gases into the atmosphere and greater consumption of fuel for burning. These necessitate the use of alternative materials for the production of bricks in the form of lateritic soil whose chemical compositions are determined by the forming rock.

Aguwa (2010) asserted that lateritic cement blocks have densities that are greater than that of sandcrete blocks aside from the provision of more solid and durable walls in buildings. Raheem et al. (2012) also concluded that the absence of hollow in solid lateritic bricks has contributed immensely to its density being about three times greater as compared to hollow sandcrete blocks. This has compounded the use of lateritic bricks for taller buildings due to an increase in dead load which invariably will have a ripple effect on the foundation structure design and also negating the use of lateritic bricks in weaker soils. The introduction of air voids in concrete through the addition of foaming agents control the density of the concrete mix. These air voids are encompassed in the concrete mix (Amran et al., 2015). The commonest means of foam generation is through the use of "synthetic or protein based" agents, with the synthetic foaming generator producing reduced density through larger expansion of air in the concrete making it lightweight (Amran et al., 2015; Afifuddin et al., 2020). The production of lightweight lateritic bricks will help to reduce the structural dead load i.e. lower density for low bearing soils, foundation size, labour, transportation, and operational cost as compared to the normal laterite bricks. The introduction of foam in the production process to make the lateritic bricks lightweight also induces the resistance of fire, thermal and sound insulation properties as a result of the presence of voids and voidable surface appearance of the bricks (Amran et al., 2015).

Previous studies (Rahman, 1988; Aguwa, 2010; Ismail and Yaacob, 2011; Oyelami and Van, 2016; Adogla et al., 2016; Fadele and Ata, 2018; Ndububa, 2018; Phadatare et al., 2018) employed the use of rice husk ash, oil palm empty fruit bunch fibres, cement, fly ash, eggshells, bamboo leaf ash, lignum additives from both softwood and hardwood, bitumen, and lime in the stabilization of lateritic bricks. So much work has not been done with the use of foaming agents to reduce density, improve sound and thermal insulation, and also to compare the strength of cement stabilized brick with the inclusion of foam. It seems there is a dearth of research on the use of synthetic foam in stabilizing lateritic brick. Hence, this study aims at determining the effects of synthetic foam on the properties of stabilized lateritic bricks. Specifically, the study examines the effect of synthetic foam on the strength, density, and water absorption properties of lateritic bricks. This is to make lateritic bricks useful for all types of soil and also increase its quantity thereby reducing the cost of production. Owing to the need for both sustainable and cost-effective building on an increase, this will also promote the use of locally available construction materials to encourage economic growth, cost effectiveness, and make structures eco-friendlier.

2. Literature

According to Ravi Shankar et al. (2018) obtaining predetermined targets for the use of soil as a material for construction is by soil stabilization which is a procedure for enhancing the physical and engineering characteristics of the soil. The improvement in the properties of lateritic bricks by stabilization include compressive strength, stiffness, durability, reduction in swelling potentials or dispersity of wet soils. Various researches have been carried out by stabilizing lateritic bricks with cement, fly ash, eggshells, compaction parameters, bamboo leaf ash, lignum additives from both softwood and hardwood, bitumen, lime, etc. Oyelami and Van (2016) opined that a 5% cement addition may be suitable to achieve the required compressive strength in compressed earth brick; Phadatare et al. (2018) recommended the use of fly ash mixed with laterite cement brick for load-bearing walls, 30% addition of eggshell by weight of laterite to the production of lateritic bricks gave significant improvements in density, compressive strength, and durability (Adogla et al., 2016). Aguwa (2010) discovered that cement stabilized lateritic bricks have densities and compressive strength greater than sandcrete blocks; replacing cement with bamboo leaf ash at 25% replacement for the production of stabilized lateritic bricks can be used for load-bearing walls (Adewuyi and Umoh, 2016); lignum additives from both softwood and hardwood sawdust contributed to the increase in compressive strength of stabilized lateritic bricks (Fadele and Ata 2018). Ndububa (2018) in comparison to stabilizing lateritic bricks with lime, bitumen, and cement discovered that cement proved to be the best characteristic performer with the exception of water absorption property where bitumen stabilized lateritic brick absorbed the least water. Rahman (1988) introduced rice husk ash (RHA) into the production of lateritic bricks thereby reducing the density linearly with an increase in the RHA to a maximum of 20%. These decreases in density indicate that lightweight lateritic bricks can be produced. Ismail and Yaacob (2011) produced lightweight lateritic bricks with the addition of oil palm empty fruit bunch fibres but discovered that such bricks are permeable to water due to the absorption of water by the cellulose fibre influenced by the void and the amount of cellulose material present affecting density, though, maximum compressive strength was gained at 3% fibre content. Pahroraji et al., (2020) while using hydrated lime, blastfurnace slag, fly ash and bottom ash as binders in place of portland cement discovered that optimum density and compressive strength was achieved at 75% foam inclusion in the mix for producing coal ash foamed brick stabilized with hydrated lime (HL) – activated ground granulated blastfurnace slag (GGBS). A further increase in foam content led to a decrease in density but was accompanied by extremely low strength of compression. It was also discovered that both curing days and binder ratio have an effect on the compressive strength whereby an increase in HL coupled with a decrease in GGBS led to a decrease in compressive strength hence recommends a binder ratio of (10:20) in HL: GGBS with 10% bottom ash and 60% fly ash constituents. The challenge of capital outlay has made sustaining housing development to the medium and low income earners of society a major issue. Hence, the use of compressed stabilized lateritic brick though its acceptability has been characterized by various apathy due to lack of knowledge of its advantageous physical properties and availability in the open market. Amongst such properties are its excellent insulating properties, non-toxic material, sound resistance, insect resistance, environmental friendliness, non-requirement of specialty skill in production, and laying (Alagbe, 2010). Laterite soil absorbs moisture, gets soft and low in compressive strength necessitating the need for stabilization to increase its performance as materials for building construction (Inim et al., 2018). Some properties of laterite bricks are improved using different methods of stabilization. Oyelami and Van (2016) suggested the inclusion of 5% cement for Compressed Earth Bricks (CEB) to achieve the recommended compressive strength and also the use of compaction methods in respect of optimum moisture content and maximum dry density to suggest the volume of water needed in acquiring the optimum density, porosity and permeability of the bricks. Inim et al. (2018) also opined that dampness of the soil aids particle interlocking yielding a greater proportion of bondness. This bondness is also determined by the particle size distribution and clay content of the laterite soil. Lemongna et al. (2011) also suggested that pulverizing the particles of lateritic soil and heating up to a certain temperature will aid the bondness of the particles together due to the natural components of the materials. Agbede and Joel (2008) opined that lateritic bricks are easier to lay and economical as compared with sandcrete blocks and fired clay bricks. Sampling that 30%-47% saving with a price index of 0.53 to 0.69 and 19% with a price index of 0.81 were achieved in the use of lateritic bricks as compared with the use of sandcrete blocks and fired clay bricks respectively. Burning of clay bricks aside leading to the production of porous bricks with the percentage of porosity depending on the amount of exposed heat also causes impairment on the physical properties of the bricks (Olowu et al., 2014). Joshua et al. (2016), found the compressive strength of sandcrete to be adequate at 20% partial replacement of sand with lateritic soil. Aguwa (2010) asserted the strength of compression of lateritic brick is usually greater than that of sandcrete blocks at below 10% cement content and a minimum of 6% cement is required for load bearing walls. Moreover, laterite cement blocks are more economical than sandcrete blocks yielding a 30% savings in cost per square metre of wall. A saving of 30% to 47% was discovered when the use of lateritic brick was compared with sandcrete blocks while a saving of 19% was achieved when fired clay bricks were compared to sandcrete blocks for the erection of a square metre wall. Also discovered was that, lateritic bricks produced by adding 45% and 5% sand and cement respectively achieved 1.8N/mm^2 above the 1.65N/mm^2 specified strength of compression in standard (Agbede and Joel, 2008).

Lateritic bricks when stabilized with Bamboo Leaf Ash (BLA) - which is highly pozzolanic when blended with cement with up to 25% bamboo leaf ash (BLA) replacing cement, attained compressive strength above 2.8N/mm^2 minimum strength required at 28 days for load bearing walls (Adewuyi and Umoh, 2016). Stabilized lateritic bricks with lignin additives from both softwood and hardwood contributed to compressive strength gain. Softwood lignin additives satisfied the 7 days' minimum compressive strength of 1.60MPa specified by the Nigeria Building and Road Research Institute (NIBRRI) except at 4% addition while the 28 days' strength specified by the National Building code was satisfied at all levels. The hardwood additives satisfied both the 7 days and 28 days' strength at all levels but showed a reduction in strength at 12% lignin additive content (Fadele and Ata, 2018). According to Adogla et al. (2016), powdered eggshells having a substantial amount of calcium compounds of 64.8% when used to stabilize laterite bricks has significant improvement in density, compressive strength, and durability when compared with conventional laterite bricks. This is attained at an optimum addition of 30% powdered eggshell by weight of laterite. Fly ash mixed laterite cement brick can be used for load bearing walls internally and externally. The compressive strength of fly ash mixed laterite cement brick was found to be 4.5N/mm^2, which is 28.5% more than standard clay brick (Phadatare et al., 2018). Clay bricks powder (CBP) generated from construction waste was also discovered to be useful in the production of foamed concrete by Yang et al. (2020) with a recommendation of 15% inclusion of CBP in foamed concrete production to improve such properties as compressive strength, hydration and shrinkage level thereby yielding positive effects of waste to wealth in economic and environmental friendliness.

Foamed concrete is recommended for its high flowability, low cement content, low aggregate usage, and excellent thermal insulation. Tarameshloo et al. (2017) observed that the development of lightweight products and insulators have been challenged by the use of materials having the least reduction in mechanical properties of air insulation and high porosity. There are two types of foaming agents used in concrete production, which are, the protein based agent and the synthetic otherwise called surfactant foaming agent (Panesar, 2013).

The synthetic foaming agents produce more expansion hence having density while the protein foaming agents produce more closely formed bubbles resulting in a stronger, stable, and larger amount of air inclusion (Amran 2015; Afifuddin et al., 2020). Sun et al. (2018) noted that the structure and properties of foamed concrete were greatly influenced by the type of foaming agent used. Synthetic Surfactants (SS) produce foam that is stronger and more stable than those made with Animal glue/blood based Surfactants (AS) and Plant Surfactants (PS). This is attributed to the higher density and viscosity of the Synthetic Surfactant foam. The compressive strength of SS is higher than that of AS and PS by 11% and 43% respectively. It was also discovered that the shrinkage level of foamed concrete made with SS is lower than that of AS and PS by 13% and 21% respectively. This is as a result of the narrower pore size distribution and fewer connected pores of SS than that of AS and PS. This was also supported by the assertion of Tarameshloo et al. (2017) that Sodium Lauryl Surfactant generated foam is cheaper in reducing density as compared with protein based and peroxide of hydrogen foam. This was attributed to the pore size and pore population which affect the compressive strength: the larger the pore size, the lower the compressive strength. Panesar (2013) also concluded that the network of air voids present in concrete produced with synthetic foam is well connected than those produced with a protein based foaming agent. Indicating that protein based foaming agents have spherical remote air voids which affect the thermal conductivity property of the concrete though stable due to the mechanism of the formation of the bubbles; by the breaking down of molecules of the protein leading to the bonding of hydrogen between the molecular group thereby producing hydrophobic molecules. Temperature and pH also affect the efficacy of protein based foam. Foamed concrete produced with synthetic foaming agents has more thermal insulation properties as compared with protein based agents. The stability of foam in concrete may further be accomplished through the inclusion of flourinated surfactants; a foam stabilizer. The attainment of early strength gain is achieved through the use of Fluorosurfactant (FSI), a common plasticizer used to remarkably influence the compatibility and workability of the foamed concrete by reducing the quantity of mixing water (Amran et al., 2015).

3. Materials

Various researches have proven the need for the stabilization of lateritic bricks as a result of the high moisture absorbent property of the laterite soil leading to the brick becoming weak in compression and dense excessively. This study aims to compare the compressive strength of lightweight lateritic bricks using a foaming agent to solid lateritic brick with a view to making recommendations on percentage content of foaming agent from the result of the test in producing lightweight laterite brick to meet up with the standard compressive strength. This is achieved by the production of lightweight lateritic bricks using a foaming agent and lateritic bricks stabilized with cement. Relevant tests and analyses were carried out to determine the weight, the density, the compressive strength, and water absorption of the lightweight lateritic bricks. This was done in order to address the improvement of the density of bricks using a lightweight agent, providing an economical and environmentally friendly brick to ensure its use in weak soil with low bearing capacity. It focuses on the use of a synthetic foaming agent to reduce the density of laterite bricks so produced.

3.1 Laterite

Lateritic soil is majorly considered for the production of compressed earth bricks (CEB) used in the construction of both load bearing and non-load bearing walls. This serves as an alternative and cost effective means of the production of walling material in place of the conventional sandcrete blocks. Laterite crusts were originally widely used for the construction of monuments and dwellings. Soil stabilization is one of the cheapest, trusted, and practicable ways of improving the resistance of the lateritic soil to water absorption, strength enhancement, opposition to distortion and permeability.

3.2 Foaming Agents

Foaming agents generate voids by creating a mechanical and chemical reaction between the constituents of the materials it is made of. It generates voids filled with air bubbles aside decreasing the surface tension of the solution but also adding stability to the bubbles so formed in concrete production. The use of a synthetic foaming agent has gained recognition in the construction industry worldwide where lightweight blocks, bricks, and cellular concrete are required in large quantities at the reduced effort. They are chemicals that produce foam by reducing "the surface tension of liquids" (Rai and Kumar, 2017).

The laterite soil used for this study was free from impurities and sourced from an Alimosho Local Government Area of Lagos state in Nigeria. Prior to the use, the laterite soil collected was sun dried, crushed to break all lumps, and sieved to remove impurities. The dried laterites were passed through a 4.75mm sieve to remove dirt and particles present in the laterite.

The synthetic foaming agent used for this study was obtained from a chemical store in the local market for chemicals at Ojota, the Mainland Local Government area of Lagos. The materials include texpon, solphonic acid, sodium laureate sulphate and foam booster. The foaming agents were batched in appropriate proportions of 1 part of water to 0.5 parts of foam generator, stirred in water and agitated to generate foam. Each material that makes up the foaming agent was weighed to 0.21kg each. The percentage of foaming agent used include 0% foaming agent, 25% foaming agent, 50% foaming agent, 75% foaming agent and 100% foaming agent. The preformed foam used for the experiment is as shown in figure 1.

CEM II/B-L 42.5N grade limestone Portland cement produced to NIS 444-1:2014 specification was used for the study. Portable water-free impurities, clean, colorless, and odorless was also used for mixing the foaming agent. The use of the expression x=water/cement ratio was employed to arrive at the optimum water/cement ratio for the experimental study. This gave a water/cement ratio of 0.62, hence for every 1kg of cement equivalent to $0.6944 \times 10^{-3} m^3$(0.69litres), 4kg of laterite soil was employed and 0.043 liters of water was used (6.2% of the cement used).

Fig. 1. Preformed foam

4. Procedure

The wooden mould of standard size 201.5mm x 100mm x 65mm was cleaned of dust and debris, then oiled properly so as to properly enable demoulding the bricks with ease. Batching by weight was adopted for the study. A mixed ratio of 1:4 (cement: laterite soil) was employed, this was mixed manually thoroughly to achieve a consistent and uniformed paste using a water cement ratio of 0.62. Filling of the mould was done systematically by initially making the mould half-filled with the laterite mix, tampered using the tampering rod then fully filled and compacted accordingly. The compaction was necessary to eliminate voids inside the mixed materials. Not only does the compaction process improve the quality but also its durability and properties such as the strength of the soil and compressive strength, shrink-swell action, and wettability (Inim et al. 2018). The compacted bricks are removed from the moulds onto a flat surface the second day after casting. Samples of the demoulded bricks are shown in figure 2. Curing of the bricks was carried out by putting the bricks in sealed plastic bags. Sealing the plastic bags was done to prevent moisture loss by evaporation as suggested by Agbede and Joel (2008).

Fig. 2. Samples of bricks produced

The samples were tested for compressive strength at 7, 14, 21, and 28 days. The test was carried out through the use of a mechanically operated crushing machine as described by the British Standard (BS) for the specification of clay bricks as shown in figure 3. Water absorption test on the laterite brick samples after the 28 days curing was conducted according to the requirements of BS 3921: 1985 by weighing the samples in the air after being dried in a ventilated oven at a temperature of 105°C to 115°C, cooled to room temperature, weighed and when fully immersed in water for 24 hours to determine the durability properties of the bricks such as the degree of burning, quality and behavior of the bricks in weathering. The values obtained from the average of 6 samples produced were used to compute water absorption capacity which is expressed as a percentage using the expression in Eq. 1. Eq. 2 depicts the calculation of the compressive strength of the specimens using the formula while Eq. 3 describes the method adopted for the determination of the density of the samples (BS 3921:1985).

$$Water\ Absorption = \frac{Wet\ Weight - Dr\ \ Weigh}{Volume\ of\ Brick} \tag{1}$$

$$Compressive\ Strength = \frac{Maximum\ Crush\ Load}{Cross\ Sectional\ Area} \tag{2}$$

$$Density\ of\ brick\ sample = \frac{Weight\ of\ sample}{Volume\ of\ sample} \tag{3}$$

Fig. 3. Performing compression test on the brick samples

5. Result and Discussion

The analysis of data obtained from the various experiments carried out on the samples was presented and evaluated to determine the compressive strength and durability properties. The tabular presentation of the result of the comparison of the compressive strength of lateritic brick without the addition of foam and with the addition of foam at 25%, 50%, 75%, and 100% water replacement at various curing days was as shown in Table 1. The result showed that there was a decrease in the compressive strength of the brick at 28 days with a continuous increase in the percentage of foam. The highest strength was attained at 25% foam inclusion (4.839N/mm^2) which is far and above 3.5N/mm^2 the minimum stipulated by the BS 3921:1985 for third-class bricks giving a 38.23% increase in minimum compressive strength required by the BS 3921:1985. At 50% foam addition, the compressive strength decreased to 4.798N/mm^2 i.e. 37.09% more than the minimum requirement of the British Standard for a third class brick, at 75%, compressive strength was 4.591N/mm^2 while at 100% foam addition the compressive strength was recorded as (4.177N/mm^2). It is noted that the decrease in compressive strength after the 25% foam inclusion at 21 and 28 days curing is linear with a further increase in the percentage of foam addition as evident in figure 4. This decrease can be attributed to the increase in the amount of pores per area as well as an increase in the pore average size. This is supported by the works of Tarameshloo et al. (2017) and Pahroraji et al. (2020) where it was discovered that the population of pores and the sizes of the pores influence the compressive strength reduction in concrete; the larger the pore sizes, the lesser the strength of compression. Although the compressive strength of the brick at no inclusion of foam is 4.098N/mm^2 which is above that recommended by the Nigerian Building code, the BS 3921:1985 and Nigerian Building and Road Research Institute as 1.60MPa (1.6N/mm^2), 3.5N/mm^2 and 2.0 MPa (2.0N/mm^2) leading to 17.09% increase of the British Standard. Upon comparison of the compressive strength of the lightweight bricks produced with the control sample of brick with no foam, at 25% foam, the compressive strength is 18.20% higher, at 50% (17.20%), at 75% (12.14%) while at 100%, it was 2.03% higher. The percentage increase in the strength of compression of the foamed bricks when compared with the strength increment of lightweight brick obtained by using oil palm empty fruit bunch (OPEFB) by Ismail and Yaacob (2011) is higher, where the maximum increment in strength was obtained at 3% fibre content giving an increased strength of 4.2%.

The density of the samples ranges from 1168.16kg/m^3 to 1481.20kg/m^3 at 100% foam; 7 days curing and 0% foam; 21 days curing respectively. At 28 days curing, the lowest density was attained at 100% foam content (1320 kg/m^3) while the maximum density was at 0% foam (1389.58 kg/m^3). The higher the percentage foam content, the lesser the density as observed in the results, this occurred as a result of an increase in pore sizes and pore numbers with the percentage increase in foam which is filled with void hence reducing the weight of the lateritic brick and at the same time increasing the number of bricks produced thereby resulting in a saving in the cost of production. On comparing the densities of the control sample with those of foam addition, there was a linear reduction of density with a continuous increase in foam constituent at 28 days curing age. At 25% foam, density reduction is 3.85%; at 50%, reduction is 3.30% and at 100% foam, density reduction is at 4.95%. Rahman (1998) discovered that the addition of 20% rice husk ash (RHA) to lateritic production yields a reduction in density from 1640kg/m^3 to 1520kg/m^3 giving a 7.32% reduction in density. Ismail and Yaacob (2011) also discovered a reduction of density in lateritic bricks produced with the addition of oil palm empty fruit bunch from 2086.29kg/m3 to 2037.36kg/m3 yielding a 2.3% reduction in density at 1% fibre content. This reduction increases linearly with an increase in fibre content to 7% reduction at 5% fibre content. Pahroraji et al. (2020) also observed a continuous decrease in density with a percentage increase in the quantity of foam in foamed HL – activated GGBS brick.

Table 1. Compressive strength and density of lateritic bricks at the varying percentage of foam and curing age

Curing age (days)	Foam (%)	Weight of brick (Kg)	Density (Kg/m^3)	Maximum Load (N)	Compressive strength (N/mm^2)
7	0	1.84	1404.85	90833	4.508
	25	1.64	1252.15	90000	4.467
	50	1.64	1252.15	94167	4.673
	75	1.57	1198.70	93333	4.631
	100	1.53	1168.16	89167	4.425
14	0	1.91	1458.29	91667	4.550
	25	1.85	1412.48	92500	4.591
	50	1.82	1389.58	96667	4.797
	75	1.83	1397.21	95000	4.715
	100	1.70	1272.51	90000	4.467
21	0	1.94	1481.20	84167	4.177
	25	1.74	1328.50	96667	4.797
	50	1.81	1381.94	94850	4.707
	75	1.84	1404.85	99167	4.921
	100	1.76	1343.77	77500	3.846
28	0	1.82	1389.58	82500	4.094
	25	1.75	1336.13	97500	4.839
	50	1.76	1343.77	96670	4.798
	75	1.81	1381.94	92500	4.591
	100	1.73	1320.86	84170	4.177

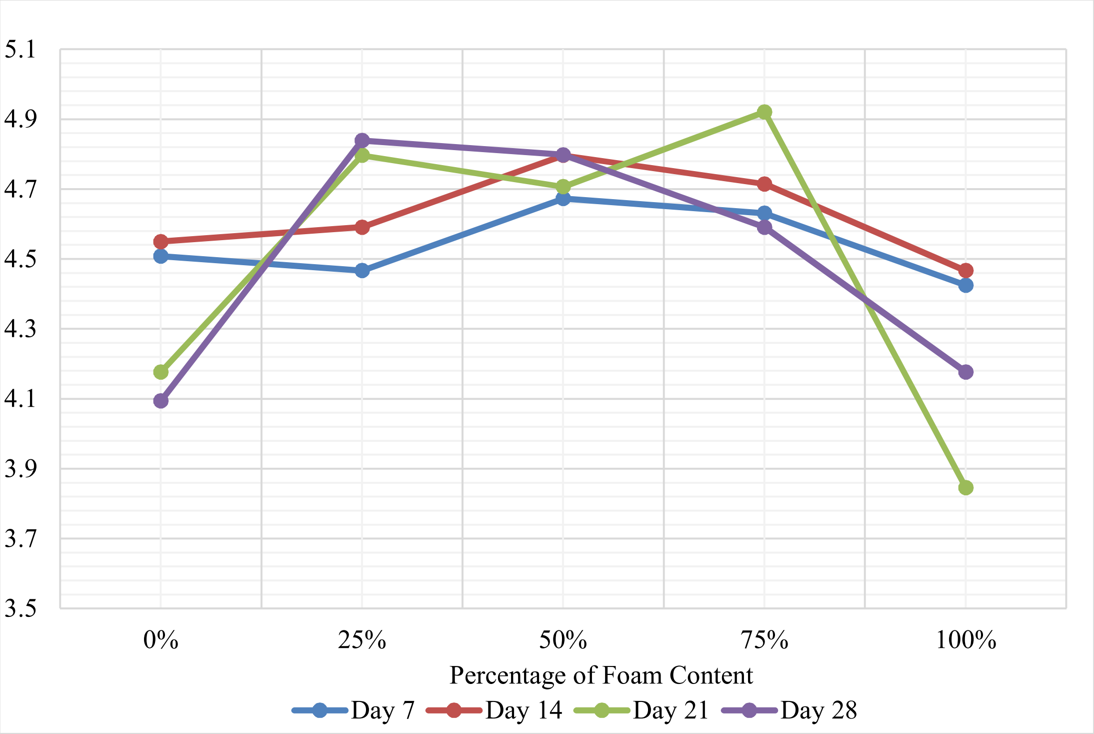

Fig. 4. Compressive strength graph of lightweight lateritic bricks

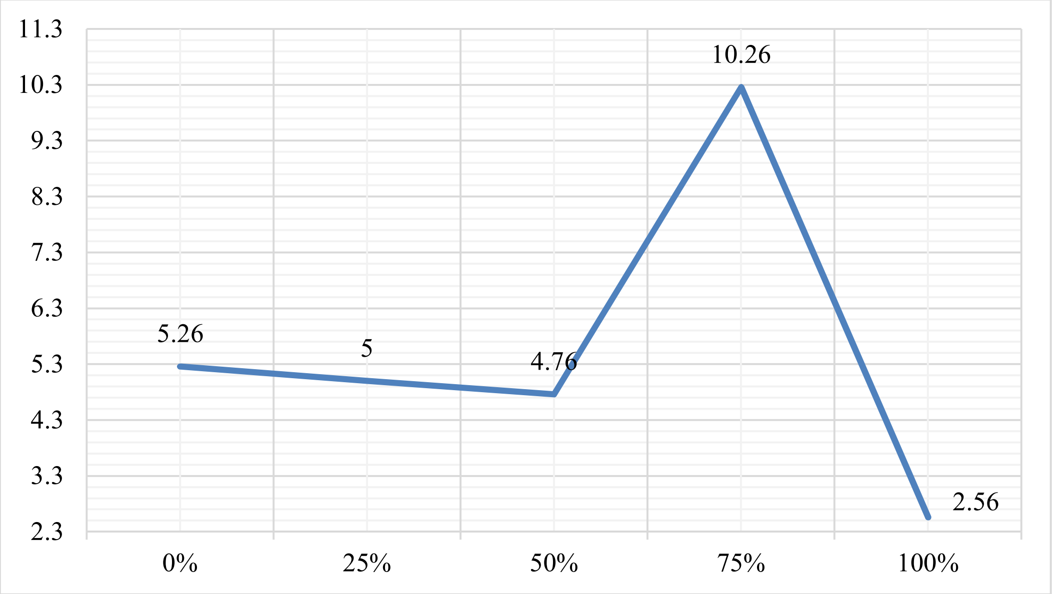

Fig. 5. Percentage of water absorption at 28 days curing

Table 2 presents the results of the water absorption test carried out on the lightweight lateritic brick at 28 days curing age under the varying percentage foam content after soaking in water for 24 hours. The water absorption rate ranges between 2.56% to 10.26%. The lowest rate was at 100% foam inclusion while the highest was at 75% foam inclusion. This can be attributed to the lightweight brick achieving complete saturation point at the 75% foam inclusion due to the presence of a higher number of pores and an increase in pore sizes due to the larger foam content. At 75% foam content, the water absorption was at its peak reaching 10.26%, highest absorption. At 25% and 50% foam content, the water absorption rate was 5.00% and 4.76% respectively. The water absorption rate in all the percentage foam content was found out to be lower than the recommended 15% limit of allowable water absorption (BS 3921:1985)

Table 2. Analysis of the water absorption rate of lightweight laterite bricks

Foam content (%)	Final weight (kg)	Initial weight (kg)	Water content (kg)	Percentage of water absorption (%)
0	2.00	1.90	0.1	5.26
25	2.10	2.00	0.1	5.00
50	2.20	2.10	0.1	4.76
75	2.15	1.95	0.2	10.26
100	2.00	1.95	0.05	2.56

6. Conclusion

Producing cost-effective materials such as laterite bricks is necessary for the management of construction projects. Thus, the study sought to investigate the effects of synthetic foam on the properties of stabilized lateritic bricks. The results of the experiment show that the strength of compression of lateritic bricks at different inclusion percentage of foam is within the standard of Nigerian Building code, the BS 3921:1985 and Nigerian Building and Road Research Institute. Furthermore, the result shows that an increase in the percentage of a foaming agent in laterite bricks led to a decrease in the density of bricks.

The study contributes to knowledge by discovering that the highest strength of lightweight lateritic bricks can be attained at 25% foam inclusion (4.839N/mm^2) while water replacement with 100% foam gives the least strength as 4.177N/mm^2. It is therefore recommended that lightweight lateritic bricks can be produced with the addition of foam produced from synthetic foaming just as it is used in the production of lightweight concrete. This is suitable for use in places where there is a need to reduce the structural dead load of the structure. It can also be used for construction projects where cost management is essential during the construction process. Furthermore, for a factor of safety, the foam can be used at 25-75% water replacement in the manufacture of stabilized lateritic bricks. From the findings, the study concludes that synthetic foam has effects on the strength, density, and water absorption properties of laterite bricks. In addition, since laterite bricks made with synthetic foam have the standard strength and density required for bricks, they can be used on weak soil with low bearing capacity due to high strength and low density. The lightweight lateritic bricks can also be used in places of severe weather conditions where there is persistent rainfall as an external and internal load bearing walls areas as it has less water absorption rate.

The research is limited to the use of cement and synthetic foaming agents as foam generators with tests carried out on strength of compression, water absorption, and determination of density. Further research can be carried out on the use of synthetic foam with other forms of lateritic brick stabilizers, such as bamboo leaf ash, eggshell, and fly ash.

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