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EFFECT OF WASTE ENGINE OIL ON LATERITE RHA/LoPEx STABILISED EARTH BRICKS FOR SUSTAINABLE BUILDING DEVELOPMENT.

by

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***ABSTRACT*.**

Waste engine oil (WEO), also called used or spent engine oil, has been an environmental menace, especially in Nigeria. Studies have shown that, it can be used as stabilizer in construction materials, with promising results. This study was conducted to ascertain the effect of waste engine oil on another promising type of brick; compressed RHA/LoPEx stabilized laterite brick. The parameters tested for were moisture absorbance and compressive strength. The results showed that, WEO enhanced, significantly, the water absorbance. The compressive strength, though also increased proportional to the WEO quantity, but decreased after adding it beyond about 15% by volume. The study confirmed the high potentials of WEO as additive in construction materials, and most importantly in non-cement laterite brick production. Hence, it is recommended that, further research be conducted in addition to disposing WEO as additive in construction materials.

Keywords. RHA, Locust bean pod, Waste engine oil, Bricks, WEO

1. Introduction

A lot of the materials used for concrete production are not environmentally and economically friendly. In the tropics, concrete elements like walls and roofs, transmit too much heat, and the process of sourcing its raw materials are often labor intensive. Moreover, cement as the most important part of concrete, has remained abominably costly. It is therefore, not much surprising that, from the last few decades, there has been a reemergence of interest around the world, in earth architecture generally, and in earth bricks particularly, obviously due to earth's environmental responsiveness. Consequent to the reemergence, old and new technologies and processes have been used to improve the durability of earth materials and products in many aspects. Some of these processes were adopted, for example, to make monolithic walls with earth, using machines to spray earth mixtures directly as in situ, and even extrusion processes to make earth blocks or plates.

Earth, or clayey soil, is hygroscopic in nature; in an event that, it comes in contact with water, it has high absorbance, and it also absorbs moisture from both the air and the ground(Polubarinova-Koch, 2015 and Mijinyawa et al., 2007). It is therefore pertinent to always find means of reducing movement of moisture in construction materials, especially in where earth is used as a construction material, in order to remain dry. Since earth, on its own, is susceptible to effect of water, sometimes even crumbling from the effect, several methods of stabilization have been employed to improve its behaviour against moisture or other factors. Some of the stabilizers are of animal source such as, animal fats and blood (Losini et al., 2021) (Medvey & Dobszay, 2020) egg whites (Ouedraogoa et al., 2021), excrement (Bamogo et al., 2020) urine, (Larsen et al., 2021). Some were of vegetable source, like flour (Sanga et al., 2022), cactus (Murugappan & Muthadhi, 2022), ashes (Ige & Danso, 2022), while some were even of geological source, like engine oil (Kolawole et al., 2020).

Compressed earth brick, on its own, has been among the most sustainable and environmentally friendly construction materials, possessing requisite mechanical properties. However, compressed earth brick, incorporated or stabilized with appropriate sustainable stabilizers such as rice husk ash (RHA) and locust bean pod extract

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(LoPEx), has been proven to be highly improved in its properties, especially with regards to greater durability against water actions (Ochola et al., 2021; Muhammad et al., 2017; Eires et al., 2015).

Another sustainability related issue is the regular subsistence of waste engine oil (WEO), also called used engine oil (UEO) or spent engine oil (SEO), which is an environmental menace, especially in places where environmental laws are not enforced (Ikhajiagbe et al., 2013) (Uchendu & Ogwo, 2014). For example, in Nigeria, an estimated 55% of WEO is mostly thrown directly onto the soil (Shafiq et al., 2018), and this has continued to be done (Azorji et al., 2022), where it contaminates even ground water (R. G. Muhammad et al., 2022). Being a highly visible form of pollution due to its immiscibility, even a small spillage of WEO can result in serious pollution (Gaur et al., 2022) (García-Hernández et al., 2022) (Udebuani et al., 2011). To appreciate WEO environmental dangers, (Chin et al., 2012) reported that, a single quart of WEO can pollute over 3,700 m2 of soil or 250,000 gallons of drinking water, rendering them useless for either farming or plant growth for many decades. It is therefore pertinent to find a safer disposal means for WEO, which is highly promising in construction materials, as additive, such as in brick production (Weir et al., 2022) (Cheng et al., 2019) (Fernandes et al., 2018) (Aziz et al., 2015). This promise is typically seen in mechanic workshops where WEO is constantly spilt or directly poured on the concrete floor or even ground, for the place to show water-repelling characteristics over time.

Moreover, WEO has been used as an admixture in concrete with impressive results; parameters such as slump value, air content, and hardened concrete properties, showed WEO as a plasticizer, improving the concrete's workability (Alsadey, 2018). It is however worthy to note that, a slight loss of compressive strength (Hussen, 2016) as well as flexural strength (Hamad et al., 2003), perhaps negligible, was recorded in some studies. It is also worthy of note that, in another study which analyzed slump value variation, air content, total porosity of concrete, compressive strength, and oxygen permeability (Shafiq et al., 2018), there was not much difference between the effects of WEO and those of new engine oil. However, it has been reported that, as WEO was increased as admixture, the compressive and tensile strengths could decrease (Moelich et al., 2019) (Khamehchiyan et al., 2007). Yet in another study, WEO admixture showed that, it decreases concrete's initial setting time, proportionally increases its porosity and moisture absorption. The WEO also slightly reduced the concrete's degree of hydration (Ajagbe et al., 2012) compressive strength (Shafiq et al., 2018), homogeneity (Abdelaziz, 2011), and density (Abdelaziz, 2011).

As most of researches were on concrete or compressed earth bricks, this study was conducted to ascertain the effect of waste engine oil (WEO) on laterite RHA/LoPEx stabilised earth bricks, with respect to parameters of moisture absorption and compressive strength.

2. Materials and Methods

2.1 RHA/LoPEx stabilised earth bricks

Sample RHA/LoPEx stabilised earth bricks were prepared in accordance with Muhammad et al. (2017), and used as the control samples or control group. The adoption of their research parameters was based on their favourable results. Their results submitted that, both RHA and LoPEx, being pozzolans, increased the compressive strength of stabilized earth bricks by about 30%. They further showed that, the strength is directly proportional to the quantity of LoPEx added to the earth mix. It therefore served as an appropriate control sample.
Specifically, laterite soil for the bricks was acquired from naturally occurring deposit in Gandu area of Lafia L.G.A. because of its iron richness and hard ferruginous surface expression, added to some degree of chemical and mineralogical differentiation below (Saynor & Harford, 2010) (Eggleton, 2001).

2.2 Waste Engine Oil

The waste engine oil was obtained from car service station oil change shop.

2.3 Mixing of the Batches

The laterite soil collected had large clods which were broken down for easy drying, and was sundried for about twelve days. The dried broken laterite soil was then sieved using a 0.6-micron sieve in order to remove roots and other unwanted items, and also to get graded soil. The sieving was done on a clean concrete slab. Mixing of the batches of samples was adopted based on the mixing ratios in Table 1

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Table 1: Mixing ratios for brick samples production

S	Label	Mixing ratio by volume (Laterite:RHA:LoPEx)	WEO Addition by volume (headpan)	Number of Samples
1	X	11:4:8	0	6
2	A1	11:4:8	1	3
3	B1	11:4:8	2	3
4	C1	11:4:8	4	3
5	D1	11:4:8	6	3

After the sieving, the soil was then spread thin and the RHA was added to it. After being thoroughly dry-mixed using shovels, to achieve an even mix, the mix was again spread thin to add the required quantities of LoPEx, poured slowly so as to ensure proper soaking. Still the mixes of all the batches had to be left to soak and reduce plasticity for up to 4 days; dryig up to some extent, to be moldable. That was as a result of the LoPEx quantity of 8 headpans. On the 4th day, the lumps that formed, were broken down by use of shovels again, and underwent additional thorugh mixing with shovels to become even enough.

For the Control sample mix, there was one batch, ‘X’, prepared without WEO addition; i.e., 11 head pans of laterite soil, 4 head pans of rice husk ash (RHA), and 8 head pans of locust bean pod extract (LoPEx). For the Test sample mixes, there were ‘A’, ‘B’, ‘C’, and ‘D’, prepared with each batch having WEO added in its varying quantity of 1, 2, 4, and 6 head pans respectively. For example, Test sample ‘A’ mix was prepared by mixing 11 head pans of laterite soil, 4 head pans of rice husk ash (RHA), 8 head pans of locust bean pod extract (LoPEx) and 1 head pan of WEO. Same process was used to prepare rest of the sample mixes. All the materials were measured by volume, using head pans, and measured level with the rim of the head pans.

2.4 Production of the Bricks

For the Test sample mixes of batches ‘A’, ‘B’ and ‘C’, the mixes were plastic enough to be molded immediately, while for batch ‘D’, with 6 headpans of WEO added, it had to stay for about 5 days to reduce the high plasticity, and become less plastic, enough to be conveniently moldable. Production of all the bricks was done using a locally fabricated, manually operated machine press, which was fabricated by SOLBATEC in Nigeria. The research adopted sizes of bricks as shown in Table 2. The machine press has a mold of 210x100x100 size.

Size of the brick samples molded

Length (mm)	Width (mm)	Height (mm)
210	100	100

For the Control Batch ‘X’ samples, there were nine bricks produced without WEO addition, while for the Test Batches ‘A’, ‘B’, ‘C’, and ‘D’ samples, there were 9 bricks each produced. The samples were then left to sun-dry for a period of 21 days to acquire natural condition. After then, and for purpose of preparing the test brick samples for experimentation, a locally fabricated ice block making chamber was modified to serve as a humidity chamber, equipped with a humidifier; it was used to simulate a constant relative humidity of 80% (Figure 1). The test brick samples were all weighed before being placed in the humidity chamber, and were placed and enclosed inside, on racks of steel wire mesh. The samples spent 15 days in the chamber, a period during which they were weighed after every 3 days, at the end of which they were found to be stable enough to carry out the experimentation.

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Figure 1: Local ice-making machine used as humidity chamber

2.5 Experimentation

The two parameters of moisture absorption and compressive strength were then measured as follows

2.5.1 Moisture Absorption

The sun-dried test bricks sample were weighted before being put in the humidity chamber, where they remained in the chamber for 15 days. At the end of the period, no more gain in weight was recorded in the samples due to humidity. Hence, the moisture absorption was assessed using the formula

Moisture absorption (kg) = γo — γi
where *γo* represents final mass of test bricks samples after 14 days in the humidity chamber,
and *γi* represents initial mass of test bricks samples.

2.5.2 Compressive strength

Compressive strength of the test bricks samples was also measured after the humidity stability chamber simulation. The strenghts were tested using a bench top UTM
(Universal Testing Machine) DTM 50-100 KN Table Top 100kN. The failure loads for all test bricks samples were appropriately recorded and the compressive strengths calculated using the formular

Compressive strength =
$$\frac{maximum\ load\ at\ failure}{cross\text{-}sectiona\ \ area\ of\ brick}\quad N/mm2$$

3. Results And Discussion

3.1 Effect of WEO on Moisture Absorption of RHA/LoPEx brick samples

The results showed that, for all the batches of test RHA/LoPEx compressed laterite bricks samples prepared with WEO, 'A', 'B', 'C' and 'D', their moisture absorption decreased as the WEO quantity was increased. The trend was also found to be statistically significant at $p < 0.05$ (Figure 2). Therefore, it can be conveniently deduced that whenever WEO is added to RHA/LoPEx compressed laterite bricks, it creates properties in the bricks which inhibits moisture absorption.

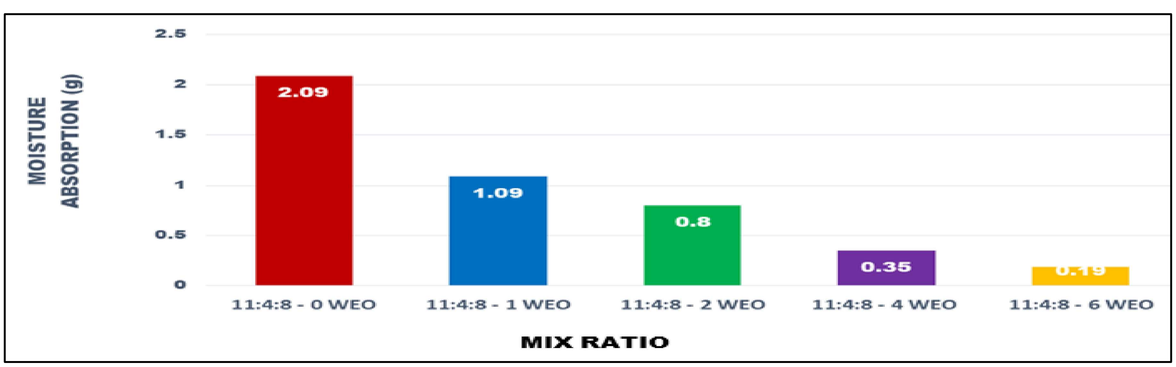

Fig. 2: Moisture absorption of RHA/LoPEx compressed laterite bricks samples with different WEO Quantities

3.1 Effect of WEO on Compressive Strength of RHA/LoPEx brick samples

3.1.1 Compressive Strength of RHA/LoPEx brick samples Without WEO

The first compressive strength to be tested were those of the control brick samples with mix ratios of 11:4:8:0 (laterite:RHA:LoPEx:WEO). Since there were 6 bricks produced, the compressive strenghts were as in Table 3.The average compressive strength of the control bricks was 1.26 N/mm^2.

Table 3: Compressive Strengths of Control Batch X at Ages after Humidity Chamber

Sample Label	Exit Chamber Date	Testing Date	Age for testing (days)	Structure	Weight of bricks (g)	Density of bricks (kg/m3)	Maximum Crushing load (KN)	Brick ross section Area (mm2)	Crushing strength (N/mm2)	Ave strength (N/mm2)
Batch X 11:4:8:0 At 7 days	17/12/2021	24/12/2021	7	Brick X1	8065	1484	61	48000	1.3	1.26
	”	”	”	Brick X2	7954	1317	59	”	1.2	
	”	”	”	Brick X3	8314	1501	58	”	1.2	
Batch X 11:4:8:0 At 14 days	17/12/2021	31/12/2021	14	Brick X4	8125	1387	60	”	1.3	
	”	”	”	Brick X5	8365	1584	61	”	1.3	
	”	”	”	Brick X6	8165	1284	60	”	1.3	

3.1.1 Compressive Strength of RHA/LoPEx brick samples Stabilised with WEO

At 7 days after removal from the humidity chamber, results for compressive strenghts of the four test batches of brick samples, ‘A’, ‘B’, ‘C’, and ‘D’ are presented in Table 4. As it shows, the compressive strenghts at 7 days, of samples ‘A’, ‘B’, and ‘C’, increased gradually as the Wsate Engine Oil (WEO) was increased at mixing ratios; 11:4:8:1, 11:4:8:2, and 11:4:8:4 respectively. Samples ‘A’ had average strenght of 1.3 N/mm^2, ‘B’ had 1.4 N/mm^2, and ‘C’ had 1.5 N/mm^2. For samples ‘D’ however, which had the highest quantity of WEO, the average compressive strenght decreased to 1.3 N/mm^2. It showed that, compressive strength was significantly affected negatively when WEO was increased to mixing ratios 11:4:8:6 (($p < 0.05$).

Table 4: Compressive Strengths of Samples A, B, C, D, at 7 days After Humidity Chamber

Sample Label	Casting Date	Testing Date	Age for testing (days)	Structure	Weight of bricks (g)	Density of bricks (kg/m3)	Maximum Crushing load (KN)	Brick ross section Area (mm2)	Crushing strength (N/mm2)	Ave strength (N/mm2)
Batch A 11:4:8:1	17/12/2021	24/12/2021	7	Brick A1	8072	1486	64	48000	1.3	1.3
	”	”	”	Brick A2	8051	1417	63	”	1.3	
	”	”	”	Brick A3	8071	1301	64	”	1.3	

Batch B 11:4:8: 2	"	"	"	Brick B1	8093	1466	66	48000	1.4	1.4
	"	"	"	Brick B2	8100	1376	65	"	1.4	
	"	"	"	Brick B3	8079	1466	66	"	1.4	
Batch C 11:4:8: 4 **15% WEO**	17/12/2 021	24/12/2 021	7	Brick C1	8080	1466	70	48000	1.5	1.5
	"	"	"	Brick C2	8157	1376	71	"	1.5	
	"	"	"	Brick C3	8103	1466	68	"	1.4	
Batch D 11:4:8: 6	"	"	"	Brick D1	8210	1305	65	48000	1.4	1.3
	"	"	"	Brick D2	8196	1294	64	"	1.3	
	"	"	"	Brick D3	8093	1375	60	"	1.3	

At 14 days after removal from the humidity chamber, compressive strenght test results of the four batches of brick samples (Table 5) were similar to those at 7 days. For samples ‘A’, ‘B’, and ‘C’, the strenght increased directly proportionally to the WEO. Samples ‘A’ had average strenght of 1.4 N/mm^2, ‘B’ had 1.5 N/mm^2, and ‘C’ had 1.6 N/mm^2, while samples ‘D’, having highest quantity of WEO, had 1.3 N/mm^2. Results still showed that, increasing WEO beyond that in samples ‘C’ significantly (($p < 0.05$) decreased the compressive strength of the bricks.

Table 5: Compressive Strengths of Samples A, B, C, D, at 14 days After Humidity Chamber

Sample Label	**Casting Date**	**Testing Date**	**Age for testing (days)**	**Structure**	**Weight of bricks (g)**	**Density of bricks (kg/m3)**	**Maximum Crushing load (KN)**	**Brick ross section Area (mm2)**	**Crushing strength (N/mm2)**	**Ave strength (N/mm2)**
Batc h A 11:4: 8:1	17/12/ 2021	31/12/202 1	7	Brick A1	8019	1575	67	48000	1.4	1.4
	"	"	"	Brick A2	7941	1309	68	"	1.4	
	"	"	"	Brick A3	7270	1467	67	"	1.4	
Batc h B 11:4: 8:2	"	"	"	Brick B1	8132	1456	71	48000	1.5	1.5
	"	"	"	Brick B2	8109	1576	73	"	1.5	

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	”	”	”	Brick B3	8077	1468	70	”	1.5	
Batch C 11:4:8:4 **15% WEO**	17/12/2021	24/12/2021	7	Brick C1	8179	1469	73	48000	1.5	1.6
	”	”	”	Brick C2	8089	1468	75	”	1.6	
	”	”	”	Brick C3	8133	1576	75	”	1.6	
Batch D 11:4:8:6	”	”	”	Brick D1	8095	1325	67	48000	1.4	1.4
	”	”	”	Brick D2	8199	1384	68	”	1.4	
	”	”	”	Brick D3	8300	1386	67	”	1.4	

The results generally showed that, increasing quantity of WEO in laterite RHA/LoPEx bricks, upto a ratio of 11:4:8:4 enhances the compressive strenght of the bricks; but beyond that, it does not. It is worthy of note that, some researchers, like (Nadeem et al., 2017) submitted 5% as the maximum engine oil addition for uptimum compressive strenght and water absorption. Notwithstanding, they also showed that, adding cement can still boost the strenght beyond that percentage. Moreover, the 15% level of WEO addition observed in this study may be attributed to the fact that, RHA and LoPEx are both pozzolans, which cementous characteristics (Muhammad et al., 2017 and Pushpakumara & De Silva, 2012) which had helped in the higher percentage in WEO addition.

4. Conclusion And Recommendations

Results of this study showed that waste engine oil has significant positive effect on the moisture inhibition properties of laterite RHA/LoPEx bricks, as well as their compressive strenghts to a large extent. The positive effect can be linked to the pozzolanic/cementitious effects of RHA and LoPEx, and also the age of bricks.

Based on the results, the following recommendations would be in line

1. Waste engine oil should be disposed as additive in brick production.
2. Waste engine oil can be used as additive in laterite RHA/LoPEx bricks up to a maximum of 10% by volume in a mix proportion of 11:4:8:4 (laterite:RHA:LoPEx:WEO).
3. Further studies need to be conducted on effect of WEO on laterite RHA/LoPEx bricks stabilized with cement.

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