SSRG International Journal of Material Science and Engineering
ISSN: 2394 – 8884 /doi:10.14445/23948884/IJMSE-V7I2P102

Volume 7 Issue 2, 7-12, May-Aug 2021

Moisture Absorption, Shrinkage Ratio and Compressive Strength of Cement Stabilized Laterite Bricks Mixed with Spent Engine Oil

Mobolaji Oluyimika Omobowale

Senior Lecturer, Department of Agricultural and Environmental Engineering, Faculty of Technology, University of Ibadan, Oyo State, Nigeria

Received Date: 08 June 2021
Revised Date: 10 July 2021
Accepted Date: 22 July 2021

Abstract - *Spent engine oil is one of the waste products that create environmental problems due to improper disposal methods. Oils are known to reduce moisture diffusivity, however, and sufficient experimental data is required to prove this. Moisture diffusion, which causes moisture movement into storage facilities, is a known problem in the bulk storage of dried products. This study investigated the effect of spent engine oil (SEO) on cement stabilized laterite bricks with respect to moisture absorption, volumetric shrinkage, and compressive strength for possible use in constructing storage structures. SEO addition was varied at 0.0, 0.2, and 0.4 kg by the weight of cement. Likewise, samples were produced at varied mix ratios of 0:5, 1:5, and 2:5 of cement and laterite, respectively. Water quantity was also varied at 0.35, 0.4, and 0.45. Moisture absorption decreased with an increase in spent engine oil addition, and shrinkage ratio decreased gradually with an increase in cement quantity. Except for a few instances, spent oil addition resulted in compressive strength degradation of the bricks. Shrinkage in samples at spent oil addition of 0.2 and 0.4 kg was minimal. It was concluded that the addition of 0.2 kg spent engine oil at the mixing ratio of 2:5:0.4 (cement:laterite: water) is most suitable for structural purposes if moisture inhibition is a desirable property in brick production because of reduced level of degradation in brick strength.*

Keywords: *Compressive strength, laterite, moisture absorption, spent engine oil, volumetric shrinkage*

I. INTRODUCTION

Soil, an unconsolidated inorganic material on the earth's crust, is considered loose and formed by the mechanical and chemical weathering of solid rocks [1], [2]. For structural purposes, the soil refers to a material that is used in any kind of civil engineering purposes, either as foundation material which is used to support the load exerted by structures or as construction material, either for earth fills, buildings, or for highway construction [3], [4], [5]. Clay is slightly hygroscopic, absorbing moisture from the environment, and when it comes in contact with water, it can easily absorb moisture [6]. A means of reducing moisture movement in clay is necessary, especially in situations where clay is used as a construction material for storage structures and stored produce ought to remain dry.

Indiscriminate disposal of spent engine oil (SEO) has become an environmental menace, especially in countries where environmental laws are not enforced [7], [8]. It has been estimated that about 45% of SEO is collected for reuse (e.g., as an insect repellent for wood against termites) while the remaining 55% is thrown away, most time directly onto the soil [9]. Likewise, just about 40% of the total re-used oil is properly disposed of [10], [11], [12].

Different forms of hazards related to spent engine oil have resulted from various additives used in its manufacture and from the heavy metals contaminants picked up from the internal combustion engine [13], [14], [15]. SEO is one of the most common and highly visible forms of pollution as it is immiscible, and even a small spillage can result in serious pollution [16], [17]. This is because SEO poured in household drains or directly onto the ground can contaminate waterways and groundwater [18]. It has been reported that one quart of oil can pollute 250,000 gallons of drinking water or over 3,700 m^2 of soil, making it non-productive for farming or plant growth for many decades [11].

The addition of spent engine oil into construction materials like concrete and bricks may serve as a means of achieving safe disposal [19], [20], [21]. For instance, [22] reported the possibility of using SEO as a concrete admixture based on the observation that oil leakage into concrete resulted in concrete with greater resistance to freezing and thawing. A visit to the vehicle maintenance site also shows that points, where spent engine oil are splashed or directly poured showed water-repelling characteristics over time. [23] also used discarded engine oil as an admixture in concrete. Parameters compared includes slump value, air content, and hardened concrete properties. SEO was found to act as a plasticizer in concrete which improves its workability. It also showed a negligible loss of about 10% of compressive strength and about 8-30% loss in the value of flexural strength.

In a study, different parameters of concrete were compared based on the addition of SEO, new engine oil, and superplasticizer as admixture [9]. Parameters considered include slump value variation, air content, total porosity of concrete, compressive strength, and oxygen permeability. The result shows that the effects of new engine oil and spent engine oil were more or less similar. A dosage of 0.15% of spent oil reduced the total porosity of concrete between 14-27%. The above dosage also had the lowest value of the coefficient of oxygen permeability. [24] used spent engine oil to extend the initial setting time and workability of concrete. This is because the admixture used is for exceptional cases like offshore structures, there it will require more time for placing concrete because of deep foundation aspects. The tests carried out helped concluded that workability was enhanced, the compressive and tensile strength of the concrete was decreased with an increase in spent oil content. It was concluded that in order to increase the workability of concrete, waste engine oil is a good admixture.

A comparison of different properties of concrete with variation in spent oil as an admixture in the range of 0, 0.15, 0.3, and 0.6% of cement value was carried out by [18]. The initial setting time, air content, rate of slump loss, homogeneity and density, moisture absorption, compressive strength, and hardness of concrete were attained in various admixtures. Results showed that SEO decreases the initial setting time of the concrete, and an increase in dosage of SEO is an increase in porosity and moisture absorption, as well as a slight reduction in the degree of hydration. Compressive strength, homogeneity, and density were said to be slightly degraded due to the presence of SEO. There is a dearth of information on the effect of SEO on cement stabilized laterite bricks. Therefore, the main objective of this study is to evaluate the effect of spent engine oil on cement stabilized laterite specimens with respect to moisture absorption, volumetric shrinkage, and compressive strength.

II. METHODOLOGY

Laterite was collected from a naturally occurring deposit along the Lagos–Ibadan expressway, Nigeria, after which large clods were broken down for easy drying. These were sundried for five days. The dried laterite was sieved using a 0.6-micron sieve. Spent engine oil was collected from a mechanic workshop while ordinary portland cement was procured from local retailers. Brick production started with the weighing of materials based on mixing proportions presented in Table 1, using an electronic balance (Accuris Instruments, Model W3300, USA), with a capacity of 10kg at 1 decimal place.

Table 1 shows the mixing ratios adopted for this experiment and the corresponding labels. For samples prepared without cement stabilization and SEO addition, e.g., sample A1, 5 kg of laterite was weighed and mixed with 0.35 kg water. Furthermore, for samples prepared with cement stabilization and SEO addition, e.g., sample B9, 2 kg of cement was mixed with 5 kg of laterite, after which 0.45 and 0.2 kg of water and SEO were added simultaneously and mixed thoroughly. The same process was repeated for all other samples. Cube molds of 50 mm^3 were used in casting specimens for testing. The samples were left to sun-dry for a period of 14-days.

Table 1: Mixing ratios for specimen preparation

S/N	Label	Mixing ratio (Cement: Laterite: Water)	SEO Addition by weight of cement (kg)
1	A1	0: 5: 0.35	0
2	A2	0: 5: 0.4	0
3	A3	0: 5: 0.45	0
4	A4	1: 5: 0.35	0
5	A5	1: 5: 0.4	0
6	A6	1: 5: 0.45	0
7	A7	2: 5: 0.35	0
8	A8	2: 5: 0.4	0
9	A9	2: 5: 0.45	0
10	B1	0: 5: 0.35	0.2
11	B2	0: 5: 0.4	0.2
12	B3	0: 5: 0.45	0.2
13	B4	1: 5: 0.35	0.2
14	B5	1: 5: 0.4	0.2
15	B6	1: 5: 0.45	0.2
16	B7	2: 5: 0.35	0.2
17	B8	2: 5: 0.4	0.2
18	B9	2: 5: 0.45	0.2
19	C1	0: 5: 0.35	0.4
20	C2	0: 5: 0.4	0.4
21	C3	0: 5: 0.45	0.4
22	C4	1: 5: 0.35	0.4
23	C5	1: 5: 0.4	0.4
24	C6	1: 5: 0.45	0.4
25	C7	2: 5: 0.35	0.4
26	C8	2: 5: 0.4	0.4
27	C9	2: 5: 0.45	0.4

An environmental chamber was designed, fabricated, and equipped with a humidifier (Model: Hunter 33257, Cordova, Tennessee, USA), which enclosed the samples as shown in Figure 1. The loading rack for the samples was fabricated from galvanized steel wire mesh. The evaporative humidifier was set to maintain a constant relative humidity of 80%. The samples were weighed before being placed in the environmental chamber, after which they were weighed once a week. The experiment lasted for 30 days after it was obvious that the masses of the sample were stable. Moisture absorption, volumetric shrinkage, and compressive strength were then determined.

Fig. 1: Samples in the Environmental Chamber

A. Experimentation

Moisture absorption, volumetric shrinkage, and compressive strength were determined using the following procedures:

a) Moisture Absorption

The initial weight of the sun-dried bricks and the date was recorded. The samples remained in the chamber for another twelve days, after which no gain in weight was observed in the samples. Moisture absorption in kg was expressed as follows:

$$\text{Moisture absorption} = \gamma_o - \gamma_i$$

Where γ_o represents the final mass of samples after spending twelve days in the environmental chamber and γ_i, the initial mass of samples.

b) Volumetric shrinkage

This was measured after the maximum moisture had been attained, using an electronic digital caliper (Carrfan Waterproof Stainless Steel Vernier Caliper, Model IP54, China) to measure the length, breadth, and height, thereby measuring the volume of each sample. Volumetric shrinkage was calculated as:

$$\text{Volumetric shrinkage} = \frac{\text{Initial volume} - \text{Final volume}}{\text{Final volume}} \times 100\%$$

c) Compressive strength

After the maximum moisture had been reached, the compressive strength of the brick samples was tested using a table-top Universal Testing Machine (10-ton capacity Okhard SJX-10KV, Okhard Machine Tools, China). The maximum load at which the samples failed were recorded, and compressive strength was calculated as:

$$\text{Compressive strength} = \frac{\text{maximum load at failure}}{\text{the cross} - \text{sectional area of brick}} N/mm^2$$

III. RESULTS AND DISCUSSION

A. Effect of Spent Engine Oil on Moisture Absorption of Samples

As shown in Figure 2, it was observed that for each batch of samples prepared without cement stabilization, moisture absorption of the samples decreased with an increase in spent oil addition, and this trend was statistically significant at $P < 0.05$. For samples produced with one portion of cement stabilization, a similar trend was observed, in that moisture absorption of the bricks decreased with increased spent oil, and this pattern was also statistically significant at $P < 0.05$, as shown in Figure 3. Similarly, the mean moisture absorption of bricks stabilized with two portions of cement, and results showed that moisture absorption of the bricks decreased with an increase in spent oil addition, and this was statistically significant at $P < 0.05$ (Figure 4). It can therefore be deduced that SEO addition confers moisture absorption inhibiting properties on the laterite clay.

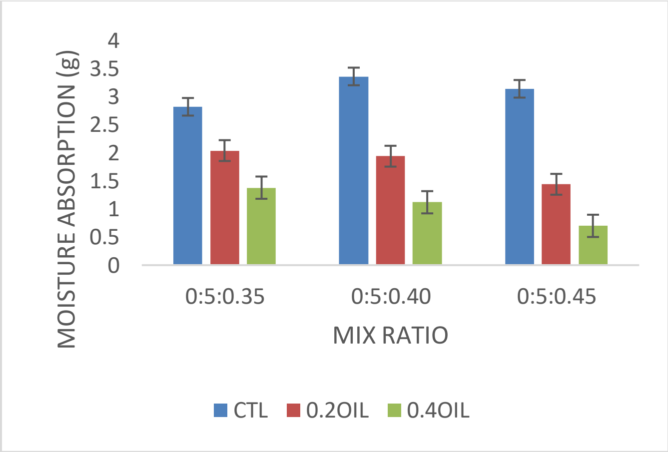

Fig. 2: Moisture absorption of samples at different SEO and zero cement addition (*CTL = Control)

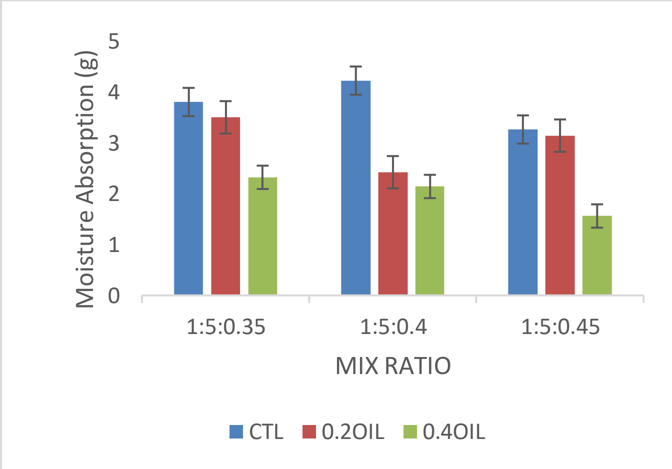

Fig. 3: Moisture absorption of samples at different SEO content and 1 kg cement stabilization

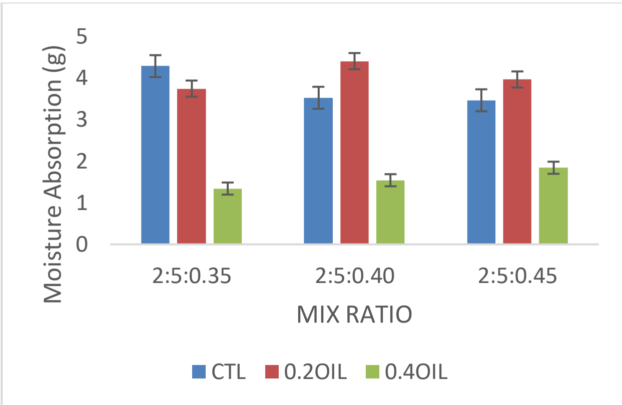

Fig. 4: Moisture absorption of samples at different SEO content and 2 kg cement stabilization

B. Effect of Spent Oil on Volumetric Shrinkage of Bricks

For samples without cement stabilization, mean volumetric shrinkage obtained at mixing ratios of 0:5:0.35, 0:5:0.40 and 0:5:0.45 (cement: laterite: water) for 0.0, 0.2 and 0.4 kg of spent oil were 0.16, 0.07, 0.039; 0.31, 0.14, 0.04, and 0.33, 0.94 and 0.043 respectively. It was observed that the shrinkage ratio decreases gradually with an increase in spent oil addition, as shown in Figure 5. Furthermore, statistical analysis showed that spent oil addition has a significant effect ($P<0.05$) on the shrinkage ratio of the bricks.

As for samples stabilized with one portion of cement, shrinkage was not statistically significant, which may be due to reduced void spaces between the molecules of cement and other materials in the sample. As shown in Figure 6, samples with 0.2 SEO content have a constant shrinkage ratio irrespective of the difference in water content, while that of control samples decreased with an increase in water and spent oil content at 0.4 kg. Furthermore, as shown in Figure 7, the shrinkage ratio of the bricks tends towards zero as spent oil and water are added, and their effect on the shrinkage ratio of the bricks was not statistically significant ($P > 0.05$).

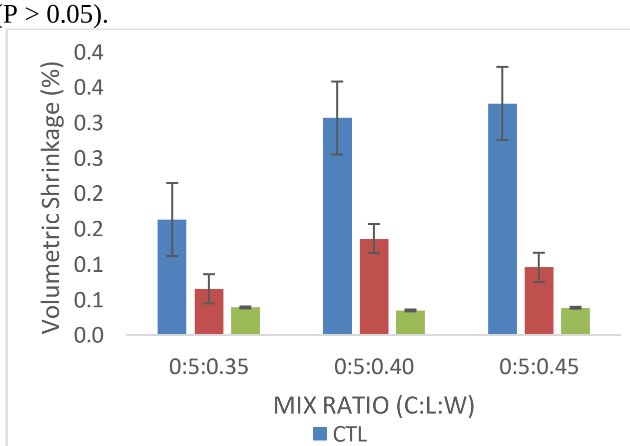

Fig. 5: Volumetric Shrinkage of non-stabilized samples with increasing SEO addition

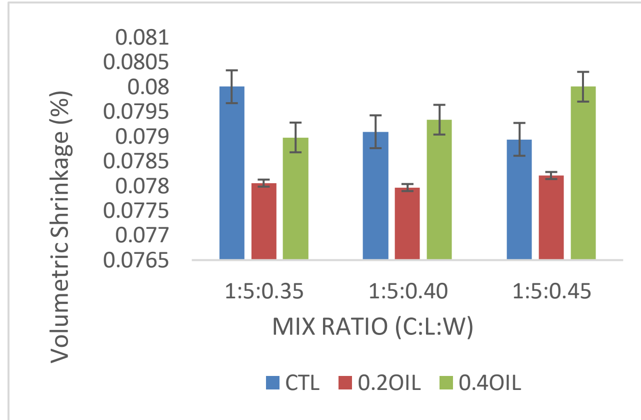

Fig. 6: Volumetric shrinkage of samples stabilized with 1 kg of cement with increasing SEO addition

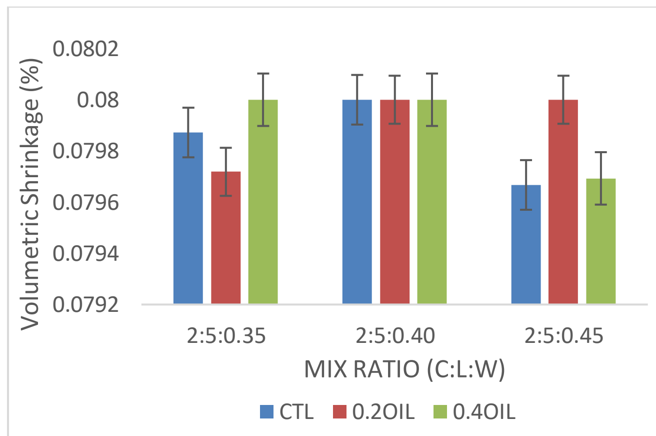

Fig. 7: Volumetric shrinkage of samples stabilized with 2 kg of cement with increasing SEO addition

C. Effect of Spent Engine Oil on Compressive Strength of Bricks without Cement Stabilization

Mean compressive strength of control samples at mixing ratios of 0:5:0.35, 0:5:0.40 and 0:5:0.45 (cement: laterite: water) for 0.0, 0.2 and 0.4 kg of spent oil were 0.60, 0.54, 0.14 N/mm^2; 0.97, 0.29, 0.11 N/mm^2; and 0.89, 0.25, 0.05, respectively as shown in Fig. 8. Compressive strength increased from 0.60 to 0.97 N/mm^2 as the quantity of water in the mixture increased from 0.35 to 0.4 kg and then slightly decreased at 0.45 kg. This can be attributed to the increased availability of water which makes it possible for the clay particles to bond together. Compressive strength was found to be significantly affected, as evidenced by a sharp decrease as the percentage of spent oil in the mixture increased. Furthermore, it was observed that the addition of spent engine oil has a significant effect ($P <0.05$) on the compressive strength of the bricks.

Moreover, mean compressive strength obtained at mixing ratios 1:5:0.35, 1:5:0.40 and 1:5:0.45 (cement: laterite: water) for 0.0, 0.2 and 0.4 kg spent oil addition were 1.59, 1.15, 0.78 N/mm^2; 1.07, 1.00, 0.71 N/mm^2; and 0.98, 0.77, 0.66 N/mm^2 respectively. Compressive strength decreased gradually with an increase in spent oil addition. The addition of cement boosted the compressive strength in comparison with the values of compressive strength obtained in Fig 1. As shown in Fig. 9, compressive strength reduced as the percentage spent oil content increased. Spent oil addition and water content had a significant effect ($P < 0.05$) on the compressive strength of the bricks.

Similarly, compressive strength of bricks obtained at mixing ratios of 2:5:0.35, 2:5:0.40, 2:5:0.45 (cement: laterite: water) for 0.0, 0.2 and 0.4 kg of spent oil were 2.79, 1.29, 0.83 N/mm^2; 1.98, 1.93, 0.78 N/mm^2; and 1.93, 0.49, 0.70 N/mm^2 respectively. Just as in previous samples, compressive strength decreased gradually as spent oil addition increased (Fig. 10). Furthermore, spent oil addition had a significant effect ($P < 0.05$) on the compressive strength of the bricks. However, the addition of cement boosted the compressive strength in comparison with those obtained for non-stabilized samples. This is similar to the findings of [25], who reported that samples constituting 5% by weight of used engine oil show acceptable results for flexural stress, compressive strength, and water absorption, and they have a negligible effect on strength properties.

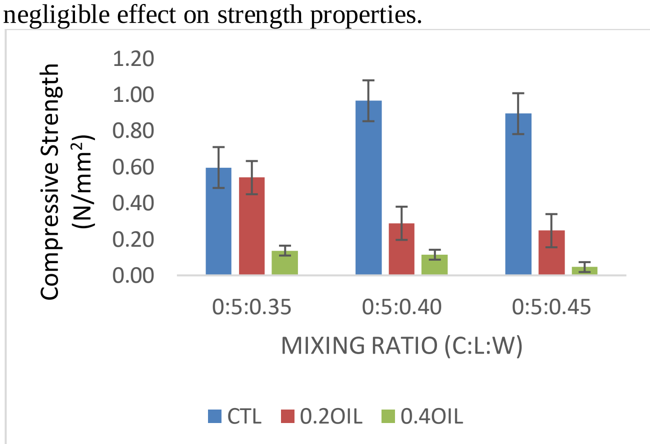

Fig. 8: Compressive strength of samples without cement stabilization

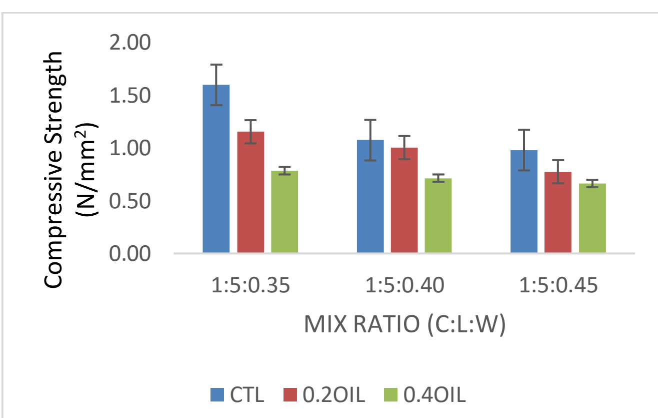

Fig 9: Compressive strength of samples stabilized with one portion of cement

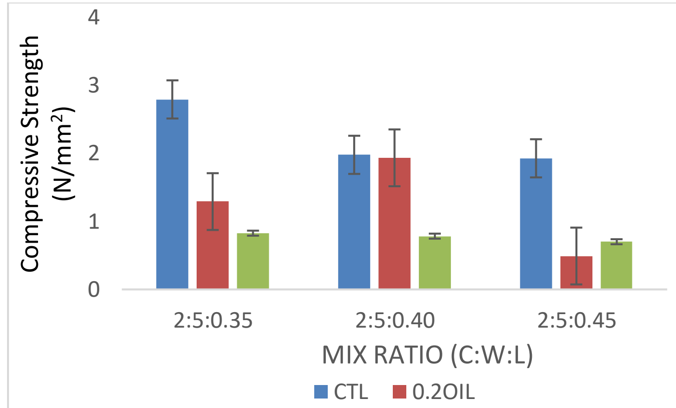

Fig. 10: Compressive strength of samples stabilized with two portions of cement

IV. CONCLUSION AND RECOMMENDATIONS

A. Conclusion

This study showed that the effect of spent engine oil on bricks compressive strength was significantly negative when the control samples without spent oil are compared with the other samples as compressive strength decreased with increased oil content across all mix ratios. However, cement stabilization helped to improve the compressive strength considerably. Moisture absorption decreased with an increase in spent engine oil content, and it can be concluded that spent engine oil has a reasonable influence on inhibiting moisture movement. Similarly, volumetric shrinkage decreased gradually with an increase in spent engine oil. Volumetric shrinkage tends towards zero with the increase in cement stabilization; e.g., with the addition of 2 portions of cement, there was little or no shrinkage. The addition of spent engine oil was also observed to have affected the rate of hardening of the non-stabilized samples, as well as a decrease in the plasticity of brick. Bricks with 0.4 kg spent oil content by weight of cement had a very slow drying rate compared to other mix samples, coupled with a significant compromise on the brick strength.

B. Recommendations

From the results obtained from this research, the following recommendation is suggested:

1. It is recommended that spent engine oil can be added to cement stabilized laterite clay bricks at a maximum of 0.2 kg to 5kg of laterite and, with best results obtained at 2 kg cement stabilization. By weight, this corresponds to 4% of the quantity of laterite to be used. This replacement will have a minute/insignificant compromise of the brick's strength quality.
2. Further studies should be carried out on spent engine oil's effect on the fire resistivity of the brick. Also, there should be further studies on the effect of firing on similar samples.

REFERENCES

[1] Biplab T. and Subhechya R., Formation of Soil, Thematics Journal of Geography, 8(8) (2019) 144-150.

[2] Clinton A. and Chinago A., Environmental impact of weathering and soil formation in geomorphological research, World Journal of Research and Review, 8(3) (2020) 47-51.

[3] Danso H., Suitability of Soil for Earth Construction as Building Material, Advance in Civil Engineering Technology, 2(3) (2018) 1-13.

[4] Bruno A.W., Scott B., and D'Offay-Mancienne I. and Perlot C., Recyclability, durability, and water vapour adsorption of unstabilized and stabilized compressed earth bricks, Materials and Structures, 53(149) (2020) 1-15.

[5] Kasinikota P. and Tripura D., Evaluation of Compressed Stabilized Earth Block Properties using Crushed Brick Waste, Construction, and Building Materials, 280 (12520) (2021) 1-19.

[6] Mijinyawa, Y; E.B. Lucas and F.O. Adegunloye. Termite Mound Clay as Material for Grain Silo Construction". Agricultural Engineering International: the CIGR Ejournal. Manuscript BC 07 002. IX (2007).

[7] Ikhajiagbe B., Anoliefo G.O., Jolaoso M.A. and E.O. Oshomoh Phytoassessment of a Waste Engine Oil-polluted Soil Exposed to Two Different Intervals of Monitored Natural Attenuation Using African Yam Bean (*Sphenostylis stenocardia*). Pakistan Journal of Biological Sciences, 16 (2013) 680-685.

[8] Uchendu U.I. and Ogwo P.A., The Effect of Spent Engine Oil Discharge on Soil Properties in an Automobile Mechanic Village in Nekede, Imo State, Nigeria; IOSR Journal of Environmental Science, Toxicology and Food Technology, 8(11) (2014) 28-32.

[9] Shafiq N., Chin, S.C. and Isa M.H., Effects of used engine oil on the slump, compressive strength and oxygen permeability of normal and blended cement concrete, Journal of Construction and Building Materials, 187 (2018) 178-184.

[10] Ali, F. A ., Contamination of environment with heavy metals emitted from automotive Ecotoxicology and Environmental Safety, 8(2) (1984) 152-161.

[11] Chin S.C., Shafiq N., and Nuruddin, M.F., Effects of Used Engine in Reinforced Concrete Beams: The Structural Behavior, Journal of Civil and Environmental Engineering, 6 (2012) 254-260.

[12] Okashah A.M., Abdulkareem M., Ahmad Z. M. Ali A.Z.M., Ayeronfe F, and Majid M.Z.A., Application of Automobile Used Engine Oils and Silica Fume to Improve Concrete Properties for Eco- Friendly Construction, Environmental and Climate Technologies, 24(1) (2020) 123–142.

[13] Akintunde W.O., Olugbenga O.A., and Olufemi O.O., Some Adverse Effects of Used Engine Oil (Common Waste Pollutant) On Reproduction of Male Sprague Dawley Rats; Journal of Medical Science, 3(1) (2015) 46–51.

[14] Enorense O.F. and Chukwunonso A.K., Level of Awareness and Perceptions about the Health Hazards of Spent-Engine Oil on Exposed Auto-Mechanics around Benin-City Metropolis, Southern Nigeria, Journal of Medical Laboratory Science 2(4) (2017) 15 – 27.

[15] Pelitli V, Dogan O, and Koroglu HJ ., Waste oil management: Analyses of waste oils from vehicle crankcases and gearboxes, Global Journal of Environmental Science and Management, 3(1) (2017) 11-20.

[16] Okonokhua B.O., Ikhajiagbe B., Anoliefo G.O., and Emede T.O., The Effects of Spent Engine Oil on Soil Properties and Growth of Maize (Zea mays L.), J. Appl. Sci. Environ., 11(3) (2007) 147 – 152

[17] Udebuani AC, Okoli CI, Nwigwe H, and Ozoh PTE., Effects of spent engine oil pollution on arable soil of Nekede Mechanic Village Owerri, Nigeria; International Journal of Natural and Applied Sciences, 7(3) (2011) 257 – 260

[18] Abdelaziz G. E., Utilization of Used-Engine Oil Concrete as a Chemical Admixture, Housing and Building Research Center, HBRC, 3(3) (2009) 1-12.

[19] Hamad S. B., Rteil A. A., Effect of Used Engine Oil on Structural Behavior of Reinforced Concrete Elements, Construction, and Building Materials, 17 (2003) 203–211.

[20] Akinwumi I, Maiyaki U, Adubi S., Daramola S. and Ekanem B. Effects of Waste Engine Oil Contamination on the Plasticity, Strength, and Permeability of Lateritic Clay, International Journal of Scientific and Technology Research, 3 (2014) 331-335.

[21] Alsadey S., Effects of Used Engine Oil as Chemical Admixture in Concrete, International Journal of Energy and Sustainable Development, 3(2) (2018) 38-43.

[22] Beddu, S., Shafiq N., Nuruddin, M. F., Kamal N. L. M. and Sadon, S. N., Effects of Used Engine Oil as an Admixture in Concrete Durability, Current Journal of Applied Science and Technology, 15(6) (2016) 1-10.

[23] Deepti, S. and Rajeev, K., Experimental study of the usage of discharged engine oil as an admixture in concrete, International Research Journal of Engineering and Technology, 3(6) (2016) 2739-2734.

[24] Giridhar, V., Impact of Waste Engine Oil in Concrete Composition, Technical Research Organization of India Bulletin, 4(10) (2017) 12-19.

[25] Nadeem H, Habib BE, Aun NC, Zoorob SE, Mustaffa Z, Mesney R, Suubitaa BE., Engine oil as the alternate binder for buildings – a comparative study; Waste and Resource Management, 170(2) (2017) 57-65.