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Appraisal of Strength Characteristics of Bituminous additive Lateritic Soil as Pavement Material in construction industry

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ABSTRACT

This research investigated the bituminous additive prerequisite of some lateritic soil samples as pavement materials. Both chemical and geotechnical experiment were carried out on untreated (raw) and improved laterite. Bituminous material was utilized in the present research as admixture. The California bearing ratio (CBR), Atterberg limit (Liquid and plastic limit), specific gravity, moisture content, and compaction experiments of the samples were performed with varying percentages or proportions of bitumen; 3, 6, 9 and 12%. The soil categorization test reveals that the lateritic soil is between A-2-7 and A-2-4 which is silty or clayed clayey gravel and sand based on AASHTO soil categorization.The C.B.R values are 9.87, 4.35% and 7.28% for samples A, B and C correspondently at 0% additivecontent, while for 12% additives, the result showed maximum C.B.R values for sample A and Bas 41.21% andSample C as 40.04%. Thus, bitumen has beenverified to be a good admixture on the enhancement of the propertiesof lateritic soil as pavement materials.

Keywords: Strength Characteristics, Bitumen, Lateritic Soil, pavement materials.

1.0 INTRODUCTION

Majority of available soils are deficient in some vital engineering properties to carry the anticipated superimposed loads, thus enhancements have to be performed to make these soils better by means of soil stabilization or /enhancement (Oluwatuyi et al. 2018; Shalabi et al. 2017). Lateritic soils can be defined as groups of soils that have a broad variety of yellow, red, and brown, fine-grained soils of light or weightless texture plus cemented soils, and nodular gravels(Adeyanju and Okeke 2019a). Abundance or copiousness of these soils and their promising structural and geotechnicalproperties make them valuable as a construction foundation or pavements material forlow- cost building or housing, highways or express roads, airfields,and compacted fill in earth embankments (Adeyanju and Okeke 2019b; Ogbiye et al. 2018; Yoobanpot et al. 2017; Hassan et al. 2016). Akinje (2015) illustrate soil stabilization or improvement as the treatment of raw soil to enhance its engineering properties. Stabilization aimed at adding inert materials and enhancing the soil density so as to increase the ostensible cohesion and small friction resistance materials (Mengue et al. 2017; Akinwumi, 2014). Chemical soil enhancement using Portland cement to stabilize the soil through replacement and compactiontechnique with rolling equipment revealed the cured outcomeas a low-grade concrete (Al-Homidy et al. 2017; Akinwumi et al., 2012). Similarly, bitumen is a genetic or chromosomal namefor numerous mixtures of semisolid or solid (Osinubi and Amadi 2010), hydrocarbons gaseous, liquidin nature, as well astotally soluble in carbon disulphide (Adeyanju and Okeke 2019b; Latifi et al. 2013). The most popular materials within genus of bitumen are asphalts, tars, and pitches. They have tendency to remainat solid surface and it adhesiveness is subject tothe surface scenario and the state of the bitumen (Adeyanju and Okeke 2019b).

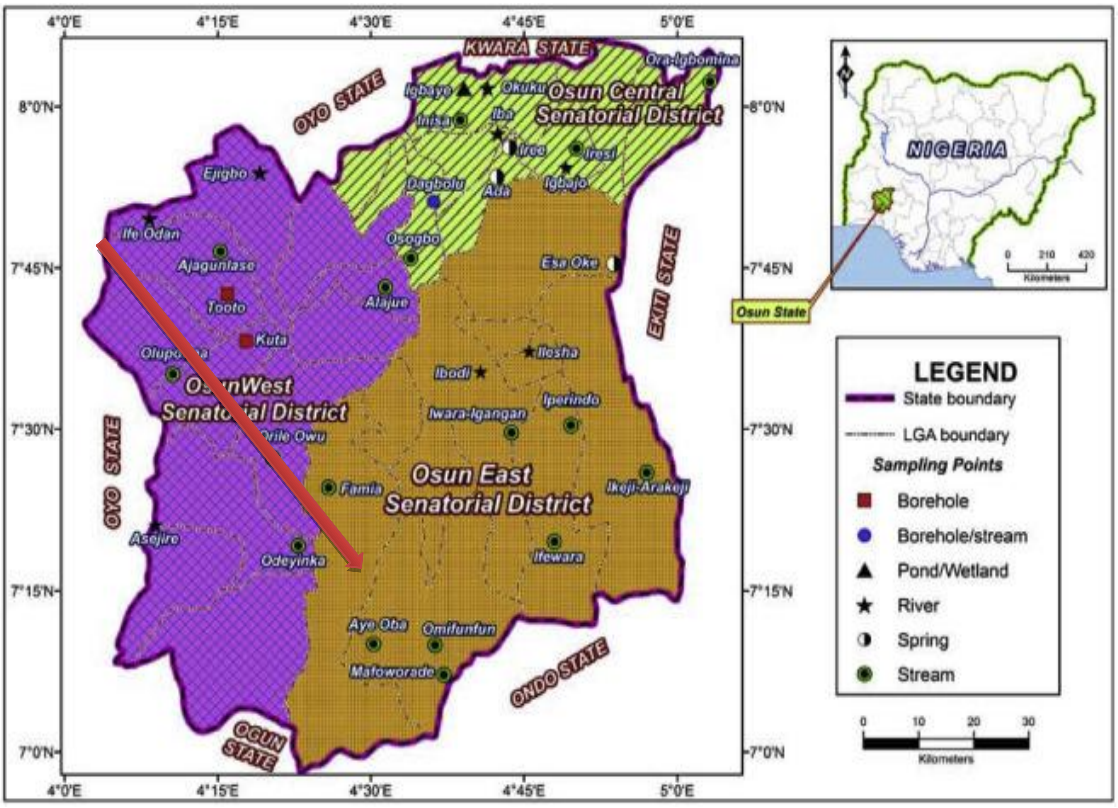


Fig. 1: Map of study area, Osogbo Osun state (Google 2021).

2.0 MATERIALS AND METHODS

The Lateritic soil was obtained from three distinct site located at KM 10 Osogbo – Ibadan Highway, Osun State, Nigeria as displayed in Figure 1.Ongoing highway construction works exposed the soil layers and the samples were taken at 2m depths from the natural ground surface via Trial Pit techniques.The sampling was air dried so as to tackle theaggregating capabilities of lateritic soils upon exposure to airas asserted by Abe (2019). The Portland cement used for this experimentwas purchased fromthe Osogbo market,whereas S 125 bitumen utilized was obtained from Dekit Construction Company inOsogbo,Osun StateNigeria (Coordinates 7.7827°N, 4.5418°E). Experimental Engineering strength tests on treated and untreated samples were performed in the laboratory of Civil Engineering Department, Federal Polytechnic Ado-Ekiti, Ekiti State Nigeria in accordance with AASHTO (American Association of State andTransportation Officials), 2007recommendation for 0, 3, 6, 9 and 12% additive.

Table 1: Outcomes of Preliminary experiments

Features	**Soil Samples Description**		
	A	B	C
Particle Size Distibution			
Fine (%)	90.86	93.46	93.91
Coarse (%)	09.16	06.56	06.11
Bulk density (KN/m^3)	14.63-29.75	12.24-22.23	14.63-22.77
Consistency Test (%)			
Liquid Limit (LL)	43.02	43.51	21.51
Plastic Limit (PL)	19.08	25.66	16.34
Plasticity Index (PI)	23.92	17.86	5.18
Specific Gravity	2.70	2.71	2.69
Group index	19.01	19.02	18.88
Optimum moisture content (%)	9.16	9.91	9.16
Maximum Dry Density (Mg/m^3) 1.325	1.866	1.663	1.481
CBR (%)	9.89	7.28	4.37
AASHTO Classification	A-2-7	A-2-7	A-2-4
Soil Category	Silty or clayed clayey gravel and sand		

3.0 RESULTS AND DISCUSSION

A. Outcomes of Preliminary Experiments

Results of preliminary experiments on the three lateritic soil aredisplayed in Table 1. It demonstrated that the soil is categorized as A-2-7 and A-2-4 based on AASHTO classification method. This infersthat it below the suggested standard for pavement construction work, thus it requireenhancement.

B Outcomes of Oxide Composition of Cement and Bitumen

Results of the oxide composition of cement and S125 bitumen are demonstrated in Table 2. The result displays the main chemical constituents of cement which areCaO, SiO2, Al2O3, MgO etc.

This illustrates that cement isa good pozzolana that mayassist further stimulation of theformation of otherhydration reaction products such as lime, rice husk ash and/or fly ash. Though bitumen shows lessen water penetration and adding cohesion strength in appearance because bitumen stabilization comprises of cementation and water proofing deeds.

Table 2: Results of Oxide Composition of Portland cement

Cement		**Bitumen**		
Features	**Composition (%)**	**Features**	**Values (%)**	**Test Standard**
CaO	66.32	Form	Thick viscose liquid	Obvious
SO_3	1.13	Colour density g/m^3	Dark Brown	Obvious
SiO_2	20.04	Solid content %		
MgO	1.06	Penetration @25.2^{0}C	40+- 5	ASTM D5
Fe_2O_3	3.74	Service Temperature C^0	1.04+-0.01	ASTM D2939
Na_2O	0.28	Setting time (hours)		
Insoluble residue	0.13		6.01 – 47.01	ASTM D2939
Al_2O_3	5.93			
K_2O	0.64		8 touch dry – 24 x firm set	ASTM D2939
LOI	0.07			

C. Outcomes of Atterberg Characteristics

The test results are displayed in Figures 2- 5. It reveal that thecement additive (3%) Liquid limit and plastic limit value is greater than bitumen additive, while bitumen additive (3%) plasticity index (PI) higher than cement additive.Meanwhile at 12% bitumen additive, plasticity index higher than cement additive.This decline in liquid limit for the mixing proportions of Portland cement,and S125 bitumen, canbe as a result of the pores in the lateritic soil, thatfilled up by the particles of the two stabilizers or improvers andsominimize vulnerable with rising water content which is in agreement with Grazi et al. 2017.

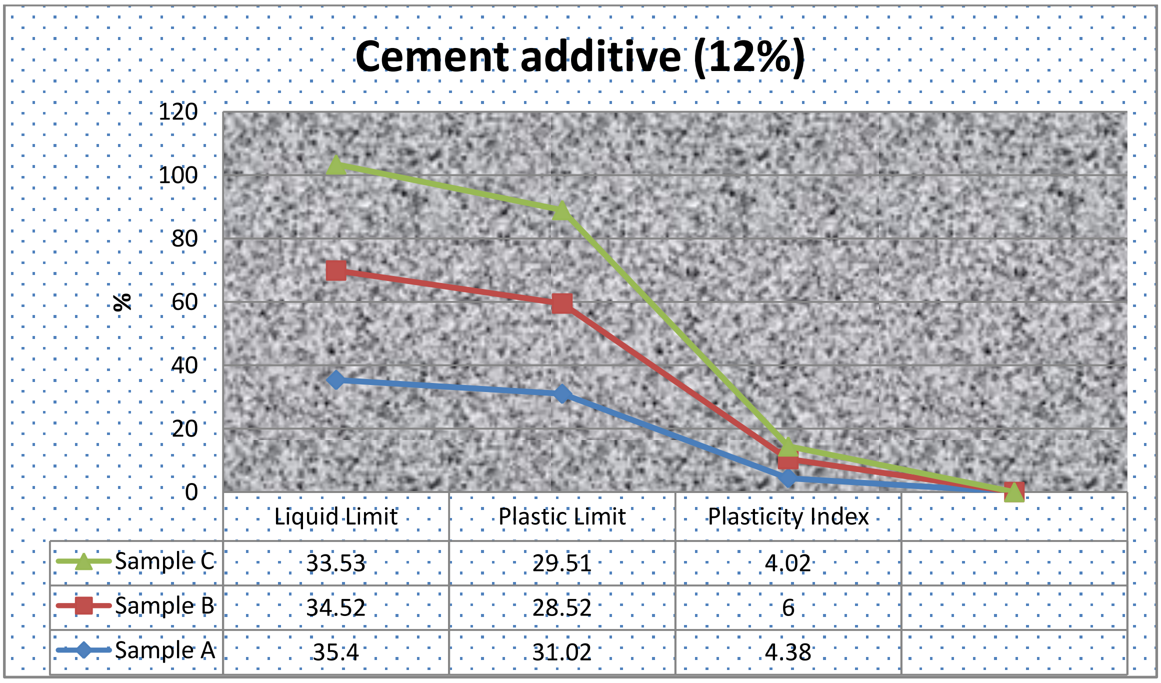
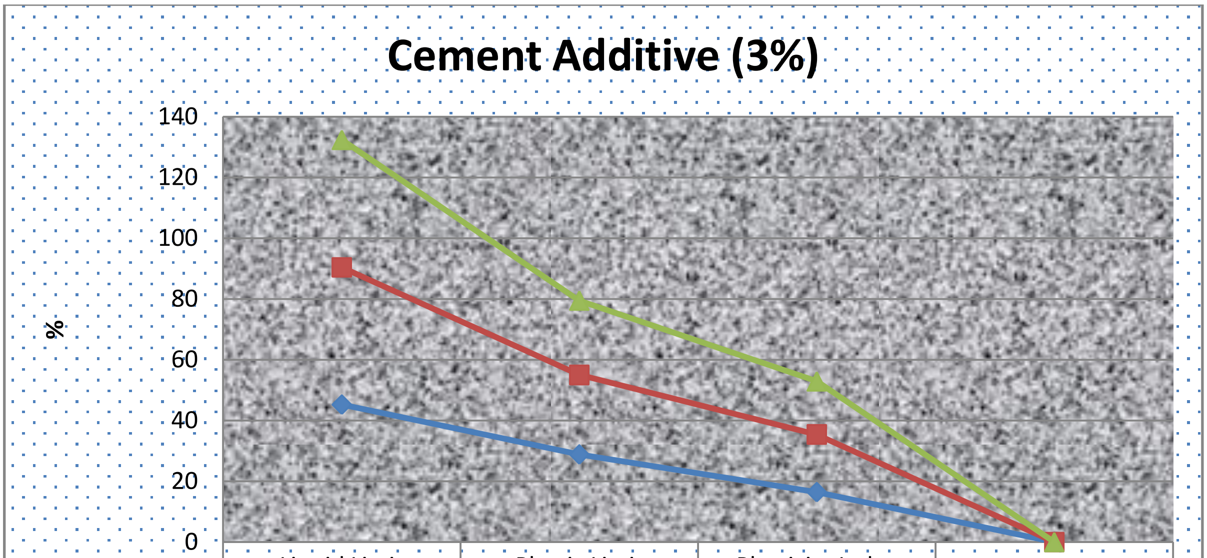
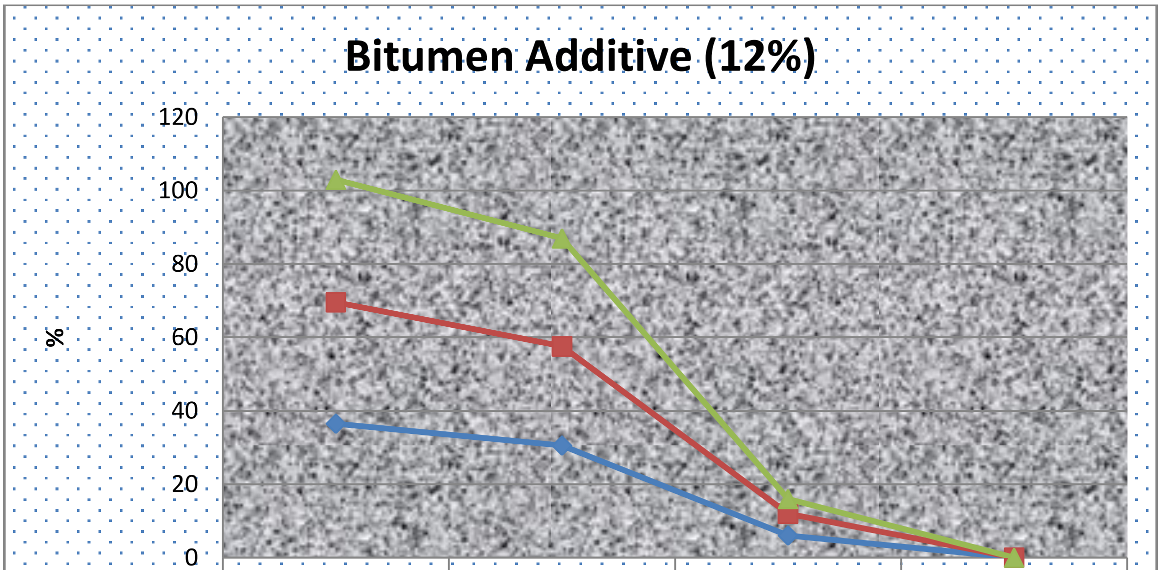


Fig. 2: Atterberg Limit test for cement additive at 12%



	Liquid Limit	Plastic Limit	Plasticity Index	
Sample C	42.01	24.51	17.5	
Sample B	45.2	26.2	19	
Sample A	45.2	28.8	16.4	

Fig. 3: Atterberg Limit test for cement additive at 3%.



	Liquid Limit	Plastic Limit	Plasticity Index	
Sample C	33.43	29.43	4	
Sample B	33.02	27.02	6	
Sample A	36.48	30.51	5.99	

Fig. 4: Atterberg Limit test for bitumen additive at 12%

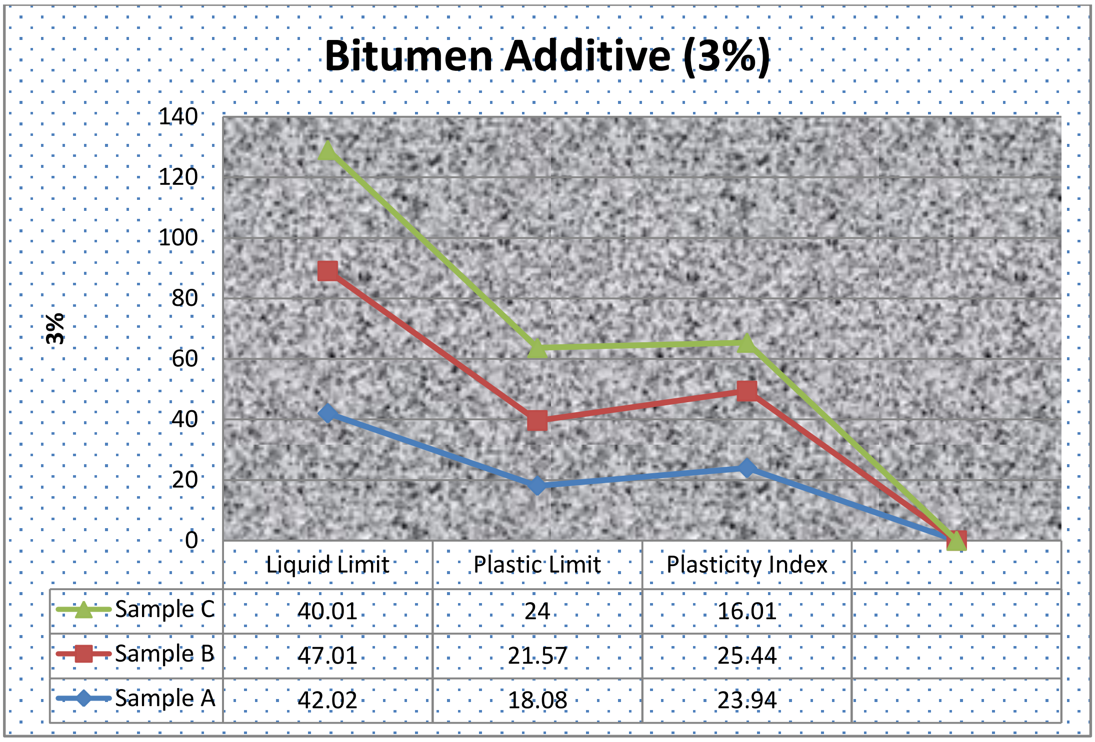


Fig. 5: Atterberg Limit test for bitumen additive at 3%.

D. Outcomes of Compaction Characteristics

Figures 6-9demonstrated the variations between OMC (Optimum Moisture Content), MDD (Maximum Dry Density) with S125 bitumen addition. The MDD improved with increase in S125 bitumen content. The values range from 1.866mg/m^3 at 0% to 2.003mg/m^3 at 10% S125 bitumen content. Similarly, OMC diminishes from 9.91% at 0% to 7.04% at 12% S125 bitumen.The increasing of mixing ratios might cause by flocculation andaccumulation of fine-grained soil particles whichfilled up the available larger space before improvement and consequently resulted toa corresponding fallin dry density. Grazi et al. (2017) and Adeyanju and Okeke(2019b)reported similar results.

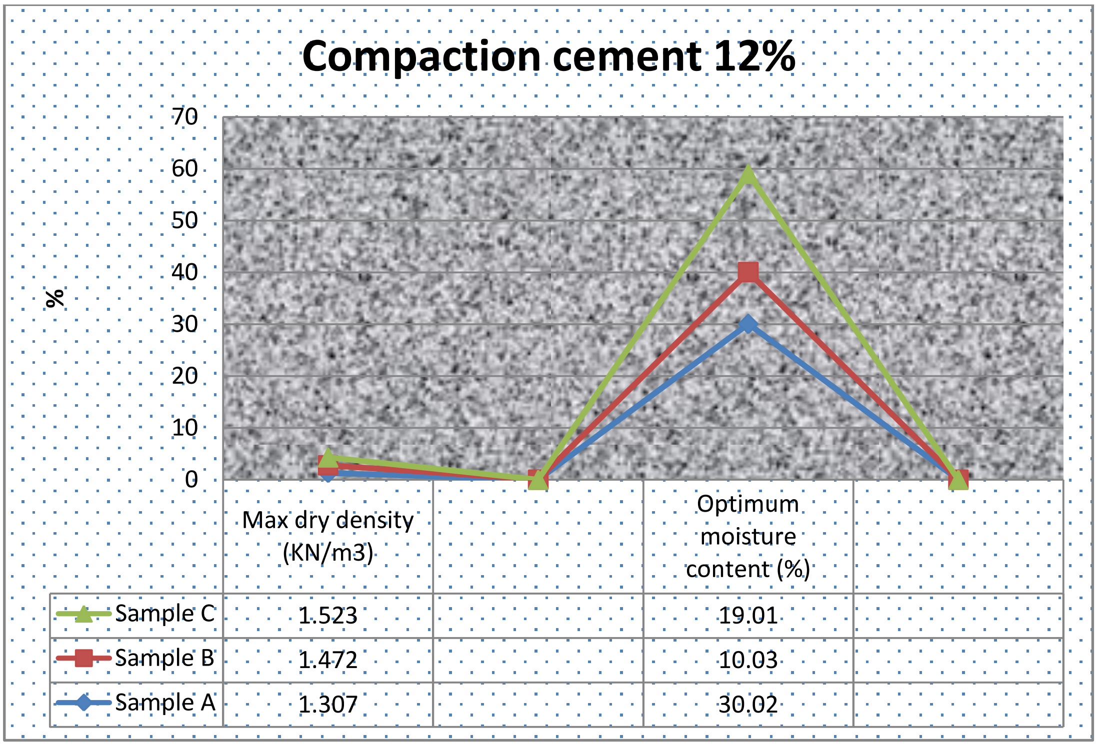


Fig. 6: Compaction characteristic for cement additive at 12%.

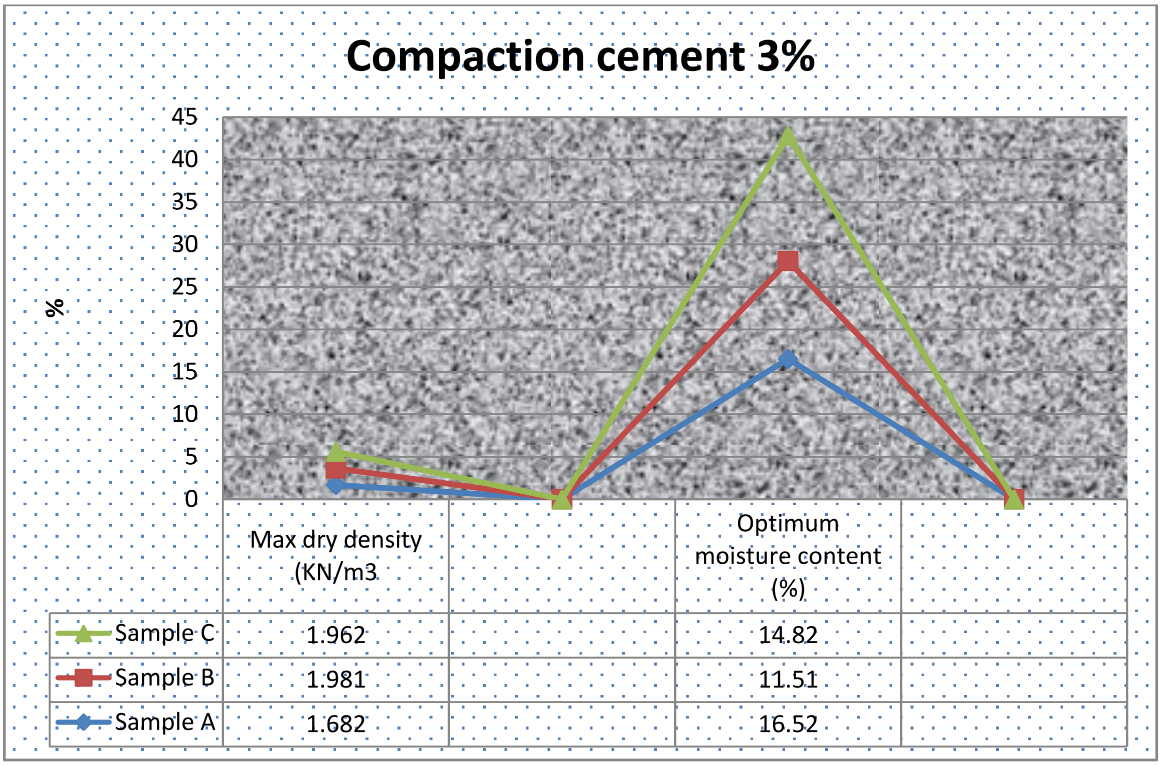


Fig. 7: Compaction characteristic for cement additive at 3%.

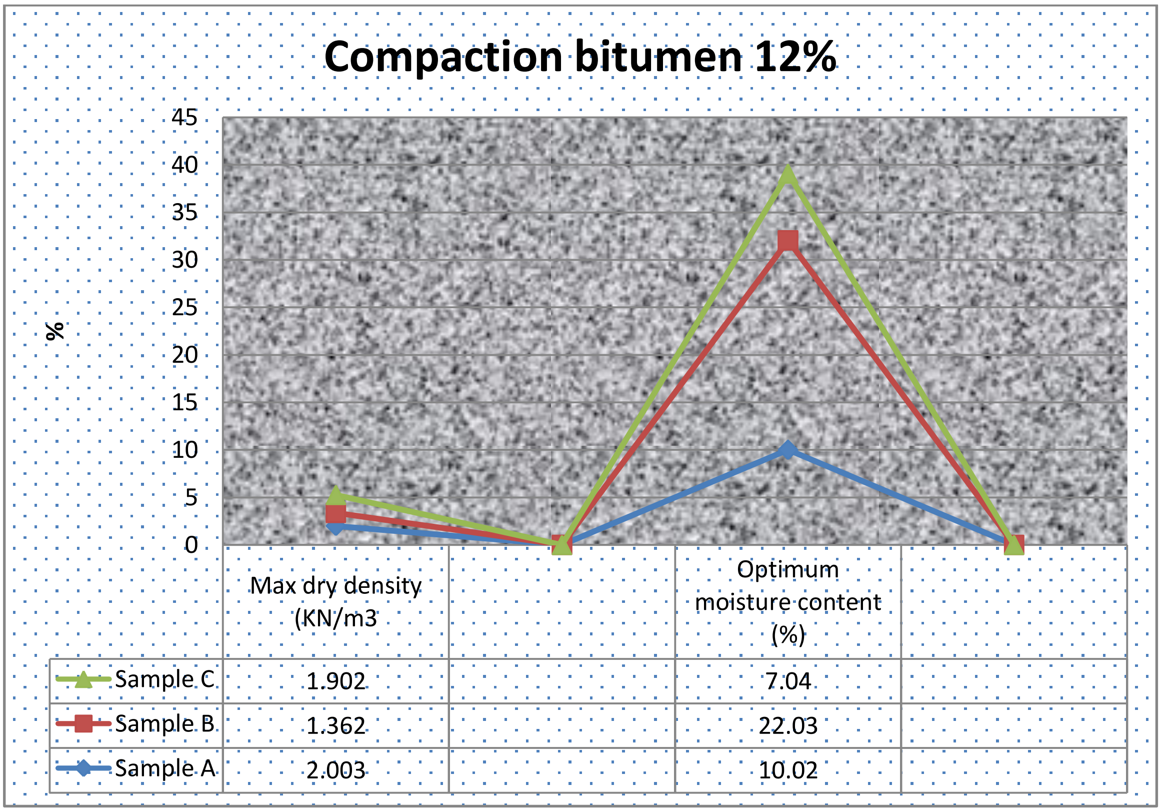


Fig. 8: Compaction characteristic for bitumen additive at 12%.

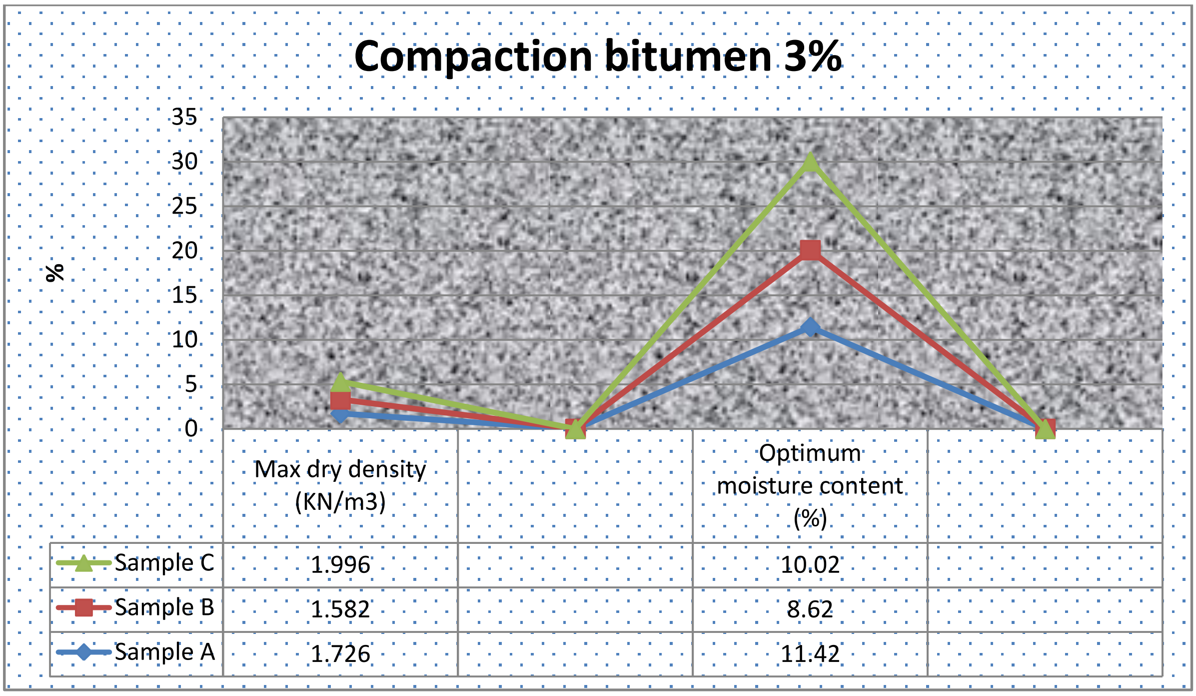


Fig. 9: Compaction characteristic for bitumen additive at 3%.

E. Outcomes of California Bearing Ratio (CBR)

From Table 1AASHTO 2007 characterized the threesamples as bad pavement materials due to their lowdry densities and strength, thus improvement is required. Outcomes of CBR test is displayed in Figures 10 & 11. The results revealed that CBR values amplified from 9.89% at natural (raw) soil level to 41.02% at 12% bitumen content, which is below cement additive of 55.02% at 12%.

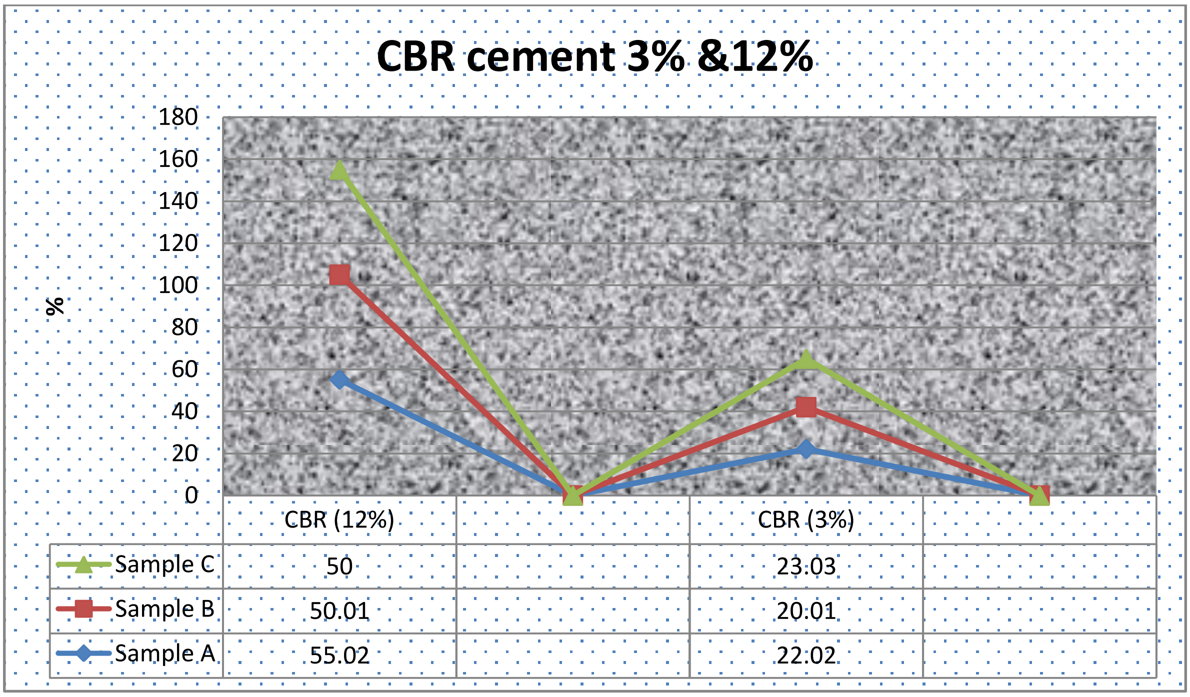


Fig. \10: CBR characteristic for cement additive at 3% and 12%

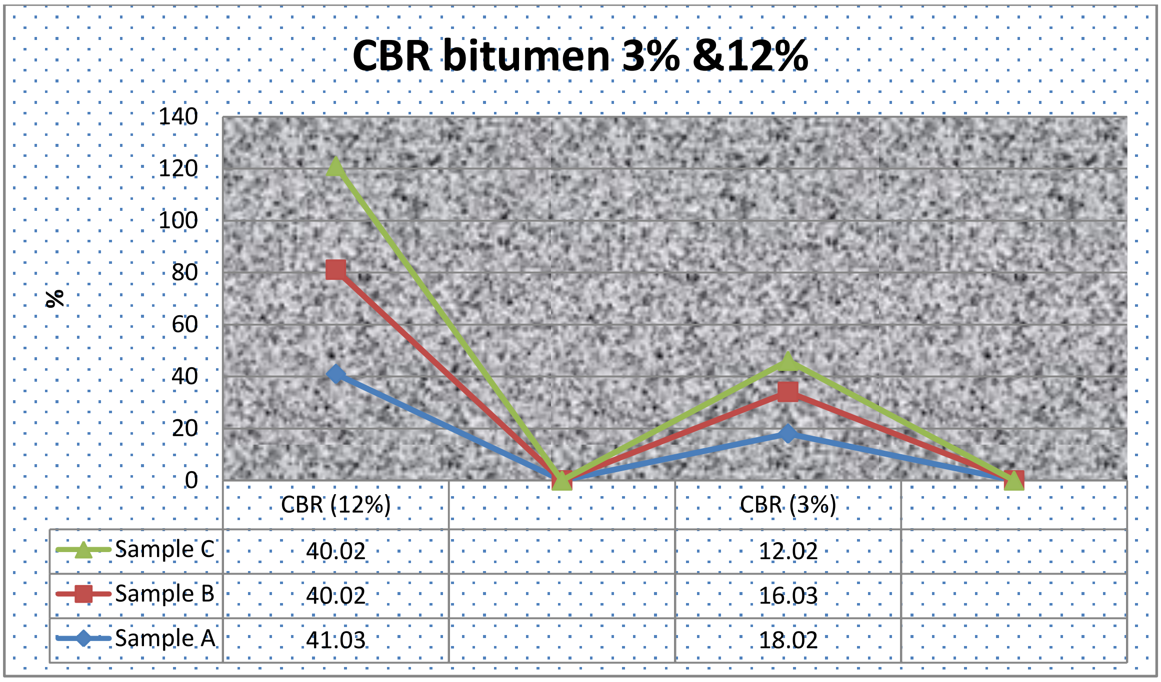


Fig. 11: CBR characteristic for bitumen additive at 3% and 12%

CONCLUSION

The following conclusions were made on the basis of theinvestigations:

- Categorization test shown that the lateritic soilwas grouped as A-2-7 and A-2-4 soil, that is Silty or clayed clayey gravel and sand.
- At 6% Portland cement content (PCC), the experimentdisplayed a general improvement in MDD with 3% S125 bitument content. Whereas, OMC also diminished with increase in S125 bitumen content.
- It was identified that CBR increased with 3% bitumen content for the 6%cement content.
- Thus, bitumen is confirmed or inveterate to be a beneficialadmixture in lateritic soil enhancement using 6%cement and 3% bitumen.

REFERENCES

1. AASHTO, (2007). Standard Specification for Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, AASHTO M 145.
2. E.A. Adeyanju, C.A. Okeke. (2019a) Clay soil stabilization using cement kiln dust, in: IOP Conf. Ser. Mater. Sci. Eng. pp. 1–10.
3. N. Yoobanpot, P. Jamsawang, S. Horpibulsuk, Strength behavior and microstructural characteristics of soft clay stabilized with cement kiln dust and fly ash residue, Appl. Clay Sci. 141 (2017) 146–156. https://doi.org/10.1016/j.clay.2017.02.028.
4. E. Adeyanju, C. Okeke. (2019b). Exposure effect to cement dust pollution : a mini review , SN Appl. Sci. 1. 1–17. https://doi.org/10.1007/s42452-019-1583-0.
5. Ogbiye Adebanji, Busari Ayobami and Adeyanju Emmanuel. (2018). Pavement interlayer material improvement using industrial waste: Review of literatures, Int. J. Civ. Eng. Technol. 9 1114–1122. https://www.scopus.com/inward/record.uri?eid=2-s2.0-85049572285&partnerID=40&md5=bca16f769b74b0b03272297a78dbf409.
6. Hasan H, L. Dang, H. Khabbaz, B. Fatahi, S. Terzaghi. (2016). Remediation of Expansive Soils Using Agricultural Waste Bagasse Ash, Procedia Eng. 143, 1368–1375. https://doi.org/10.1016/j.proeng.2016.06.161.
7. O.E. Oluwatuyi, B.O. Adeola, E.A. Alhassan, E.S. Nnochiri, A.E. Modupe, O.O. Elemile, T. Obayanju, G. Akerele, Ameliorating effect of milled eggshell on cement stabilized lateritic soil for highway construction, Case Stud. Constr. Mater. 9 (2018) e00191. https://doi.org/10.1016/J.CSCM.2018.E00191.
8. F.I. Shalabi, I.M. Asi, H.Y. Qasrawi, Effect of by-product steel slag on the engineering properties of clay soils, J. King Saud Univ. - Eng. Sci. 29 (2017) 394–399. https://doi.org/10.1016/J.JKSUES.2016.07.004.
9. A.A. Al-Homidy, M.H. Dahim, A.K.A. El Aal, Improvement of geotechnical properties of sabkha soil utilizing cement kiln dust, J. Rock Mech. Geotech. Eng. 9 (2017) 749–760. https://doi.org/10.1016/j.jrmge.2016.11.012.

10. Mengue Emmanuel ; Hussein Mroueh; Laurent Lancelot; and Robert Medjo Eko (2017). Mechanical Improvement of a Fine-Grained Lateritic Soil Treated with Cement for Use in Road Construction, Journal of Materials in Civil Engineering /Volume 29 Issue 11.
11. Akinje I. (2015). Comparison Characterization of A-6(10) laterite soil stabilized with powermax cement and hydrated Lime separately. International journal of Engineering and technology, 5(No 7), 392 - 401.
12. Akinwumi I. (2014). Plasticity, Strength and Permeability of Reclaimed Asphalt and Lateritic Soil Blends. International Journal of Scientific and Enginnering Reseach, 5(6), 631-636.
13. Akinwumi I, Adeyeri J and Ejohwomu A. (2012). Effects of steel slag Addition on the plasticity, strength and permeability of Lateritic soil. Proceedings of the Second International Conference of Suitanable Design, Engineering and Construction. Texas.
14. Latifi N, Marto A and Eisazadeh A. (2013). Structural characteristics of Lateritic soil treated SH 85 and TX - 85/ Non- traditional stabilizers. The Electrronic Journal of Geotechnical Engineering, 1707 - 1718.
15. Ghazi M. Mutter, Abdul-Sahib T. Al-Madhhachi and Raghad R. Rashed. Influence of soil stabilizing materials on lead polluted soils using Jet Erosion. International Journal of Integrated Engineering, Vol. 9 No. 1 (2017) p. 28-38.
16. Osinubi J and Amadi A (2010). Evaluation of Strength of Compacted Lateritic Soil - Bentonite mixture for use as landfill linear and cover. Journal of Engineering Research, No 3, 13.