International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
Vol. 7 Issue 8, August - 2023, Pages: 39-44

Evaluation of Modulus of Elasticity of Lateritic Soil Stabilized With Cement Types

Salihu Usman[1], Samir Isah Yahaya[2], Salihu Abdulrasheed[3]

[1]Department of Civil Engineering, Kogi State Polytechnic, Lokoja.

[2]Department of Urban and Regional Planning, Nasarawa State University Keffi.

[3]Department of Architectural Technology, Kogi State Polytechnic, Lokoja.

E-mail: usmansalihu87@yahoo.com, isasameer20@gmailcom, binsalih10@yahoo.com

Tel: 08065393798, 07030354031, 08036637202

Abstract: *The modulus of elasticity of lateritic soil stabilized with cement types has been evaluated in this work. The aim of this study was to determine the modulus of elasticity of the lateritic soil before and after treated with cement types. The natural lateritic soil and lateritic soil with varying percentages (0, 3, 6, 9 and 12%) of the three types of cement namely CEMENT I, CEMENT II and CEMENT III were used in this work. Specimens for the modulus of elasticity were compacted with British Standard Light (BSL) effort and cured for 1, 7, 14, 21 and 28 days. The two types of modulus of elasticity were examined in this study, namely tangent modulus of elasticity (E_T) and secant modulus of elasticity (E_S). CEMENT I recorded the highest values of modulus of elasticity followed by CEMENT II and then CEMENT III on both tangent and secant. On all the cement types used the values of elasticity increased with increase in cement content and the increments in curing days. The tangent modulus of elasticity tends to be higher than secant modulus of elasticity on every specimen and CEMENT I produced the highest modulus of elasticity. Therefore, this research work proved that the improved samples are adequate for engineering use.*

Keywords: modulus, elasticity, lateritic- soil, cement types

1.0 INTRODUCTION

Laterite is a group of highly weathered soils formed by the concentration of hydrated oxides of iron and aluminium (Gidigasu, 2012; Thagesen, 1996). It contains significant amounts of iron and aluminium oxides and is frequently utilized in construction due to its robust and durable properties (Todingrara *et al.,* 2017).The soil name "laterite" was coined by Buchanan in 1807 in India, from a Latin word "later" meaning brick. This first reference is from India, where this soft, moist soil was cut into blocks of brick sizes and then dried in the sun. The blocks became irreversibly hard by drying and were used as building bricks. Makasa, (2004) observed that soils under this classification (laterites) are characterized by forming hard, impenetrable and reversible pans when dried. Cement, in the general sense of the word can be described as a material with adhesive and cohesive properties which make it capable of bonding mineral fragments into a solid mass of adequate strength and durability (Sinha and Roy 2011). Gartner and Sui (2018) expressed that, Portland cement, which is reference in this study is been manufactured conventionally and is a finely powdered substance, usually grey or brownish grey composed largely of artificial crystalline materials. The most important of the crystalline materials are calcium and aluminium silicates. Cement is usually manufactured from a mixture of approximately two parts of calcium carbonate such as lime stone and one part of silica or alumina such as clay or shale. A great variety of limestone and clays can be used for the making of cement (Sinha and Roy, 2011). Different standards are used for classification of Portland cement. The two major standards are the ASTM C150, used primarily in the USA and EN 197-1 Standards. Cement type according to ASTM C150, has type I, II, III, IV and V, while EN 197-1, cement types are CEMENT I, CEMENT II CEMENT III, CEMENT IV and CEMENT V, which do not correspond to the similarly named cement types in ASTM C150 (Robert, 2004).

Cement stabilization primarily results in cementation, with a secondary reaction related to the calcium hydroxide generated during hydration. The end product is a cemented material consisting of the original soil, in which most clay minerals are partially or completely destroyed or altered, resulting in reduced plasticity. Various chemical reactions take place during cement stabilization, but in essence, crystals of hydrated calcium and alumina silicates generated during these reactions join together and bind the individual soil particles, usually providing significantly increased compressive and tensile strengths (Jones *et al.*, 2012).

Table 1.1: Typical chemical composition of clinker and Portland cement

Oxide Formula	Shorthand Notation	Percentage by Mass in clinker	Percentage by mass in cement
CaO	C	65	63.4
SiO_2	S	22	20.9
Al_2O_3	A	6	5.7
Fe_2O_3	F	3	2.9

MgO	M	2	1.9
K_2O+Na_2O	K+N	0.6	0.6
Other (include SO_3)	(-S)	1.4	3.6
H_2O	H	Nill	1.0
	Total	100	100

Source: Van OSS (2005)

Table 1.2: Typical mineralogical composition of modern Portland cement

Chemical Formular	Oxide Formula	Shorthand Notation	Description	Typical Percentage
Ca_3SiO_5	$(CaO)_3SiO_2$	C_3S	Tricalciumsilicate ('alite')	50-70
Ca_2SiO_4	$(CaO)_3SiO_2$	C_2S	Dicalciumsilicate ('belite')	10-30
$Ca_3Al_2O_6$	$(CaO)_3AlO_3$	C_3A	Tricalcium aluminate	3-13
$Ca_4Al_2Fe_2O_{10}$	$(CaO)_4Al2O_3FeO_3$	C_4AF	Tetracalciumaluminoferrite	5-15
$CaSo_4.2H_2O$	$(CaO)(SO_3)(H_2O)$	C_5H_2	Calcium sulfate dihydrate (gypsum)	3-7

Source: Van OSS (2005)

2.0 MATERIALS AND METHODS

2.1 Materials

The materials used for this study include; lateritic soil cement and water. Lateritic soil used in this work was obtained by the method of disturbed sample collection from an existing borrow pit at an average depth of 1.5m - 2.0m from Gidan Kwano in Niger State, Nigeria. The soil collected was reddish-brown in colour, and air dried in an open area before usage. The cement used are CEMENT I, CEMENT II and CEMENT III as specified in EN (197-1) standard. They were obtained from Dangote Cement Company, Obajana, Kogi State. Clean Portable and drinkable water was sourced from Gidan Kwano campus of Federal University of Technology, Minna, Niger State.

2.2 Adopted Methods of Study

This research was conducted in accordance to British Standard BS 1377 (1990) and BS 1924 (1990). They were carried out at the Federal University of Technology, Minna (FUT-MINNA) Civil Engineering Laboratory. Lateritic soil-cement mixes were produced from varied percentages proportions of (0.0%, 3.0%, 6.0%, 9.0% and 12.0%) of different types of cement.

3.0 RESULTS AND DISCUSSION

3.1 Modulus of Elasticity

The modulus of elasticity is defines as the ratio of the stress to the strain without influencing the cross sectional deformation of the test body. Two type of modulus of elasticity were calculated in this work, namely tangent modulus of elasticity (E_T) and secant modulus of elasticity (E_S).

3.1.1 Tangent Modulus of Elasticity (E_T)

Table 1.3 shows the results of tangent modulus of elasticity (E_T) for untreated and treated lateritic soil with cement types. The tangent modulus of elasticity for untreated lateritic soil ranges from 2333kN/m^2, 4239kN/m^2, 5250kN/m^2, 6286kN/m^2 and 7750kN/m^2 for 1, 7, 14, 21 and 28 days curing period respectively. The values increases as the number of days cured increases. This is because increases in fine content causes increases in the cohesion and gives rise to increases in bonding of soil particles, which translate to the overall increment in modulus of elasticity (Alao, 1983)..

However, for three (3) different types of cement used in this research work at various cement content have recorded measurable improvement in tangent modulus of elasticity for the treated lateritic soil with cement types. For CEMENT I, the values of E_T at 28 days ranges from 60000kN/m^2, 70000kN/m^2, 71429kN/m^2 to 81632kN/m^2 at cement content of 3%, 6%, 9%, and 12% respectively. Therefore, the addition of cement binder content had shown a significant increment in tangent modulus of elasticity.

For CEMENT II, the values of tangent modulus of elasticity at 28 days ranges from 44118kN/m^2, 66250kN/m^2, 68000kN/m^2, to 69149kN/m^2 for cement content of 3%, 6%, 9% and 12% respectively. The cement content added at the different percentages indicated positive improvement in the tangent modulus of elasticity, but are however, less than those obtained from CEMENT I.

For CEMENT III, the values of E_T at 28 days ranges from 56410kN/m^2, 63200kN/m^2, 66923kN/m^2 to 67547kN/m^2, for 3%, 6%, 9% and 12% respectively. The cement content added at various percentages also shows a measurable increment in the results, but they were less than those obtained from CEMENT 1 and CEMENT II.

International Journal of Academic Multidisciplinary Research (IJAMR)
ISSN: 2643-9670
Vol. 7 Issue 8, August - 2023, Pages: 39-44

Table 1.3: Results of Tangent Modulus of Elasticity (E_T) for Lateritic soil with Cement types

Samples	Cement Content (%)	E_T (kN/m^2) For 1 day curing	E_T (kN/m^2) For 7 days curing	E_T (kN/m^2) For 14 days curing	E_T (kN/m^2) For 21 days curing	E_T (kN/m^2) For 28 days curing
Lateritic Soil	0	2333	4239	5250	6286	7750
Lateritic Soil/	3	10000	26000	40000	50000	60000
CEMENT I	6	10333	32500	51000	58500	70000
	9	12000	33333	56667	58537	71429
	12	17000	55000	71429	76250	81632
Lateritic Soil/	3	11333	5699	8290	35714	44118
CEMENT II	6	8500	23727	42553	52500	66250
	9	11833	35000	52500	53571	68000
	12	12195	41250	62142	64583	69149
Lateritic Soil/	3	5063	21167	26667	31147	56410
CEMENT III	6	6667	23333	39583	50000	63200
	9	9759	34000	57143	61000	66923
	12	15000	35714	60000	64500	67547

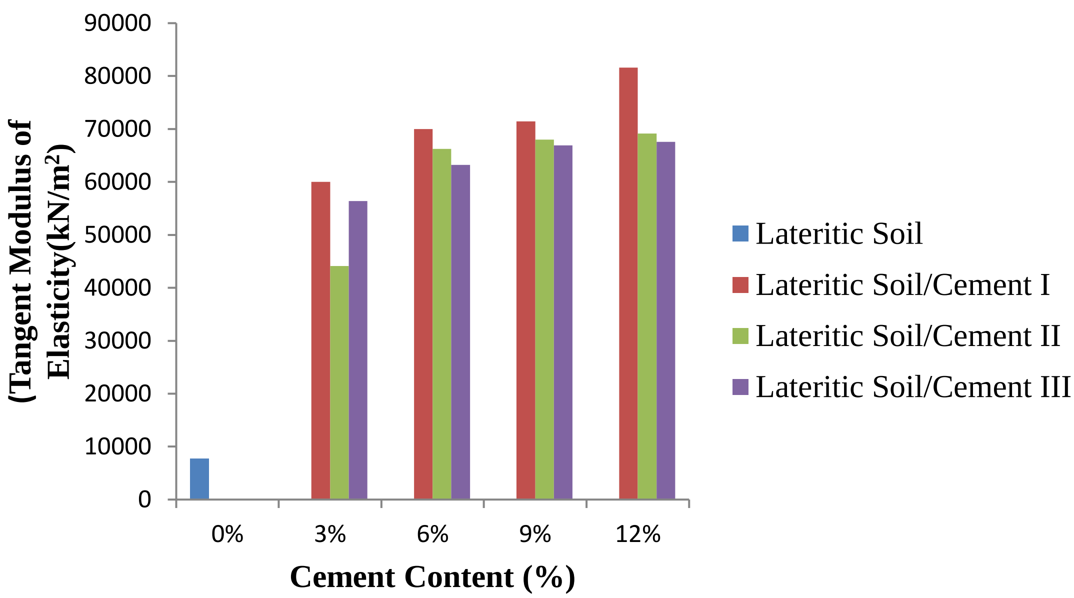

Figure 1.1: Relationship between Cement Content (%) and Tangent Modulus of Elasticity (kN/m^2) for cement types at 28 days.

3.1.2 Secant Modulus of Elasticity

Table 1.4 shows the results of secant modulus of elasticity (E_s) for untreated and treated lateritic soil with cement types. The secant modulus of elasticity for untreated lateritic soil ranges from 2054kN/m^2, 2348kN/m^2, 2719kN/m^2, 3355kN/m^{2}to 3634 k/m^2, for 1, 7, 14, 21 and 28 days curing period respectively. The values also increases as number of curing days increases. This is also in line with the increment in UCS as a result of fine content increases that gives rise to cohesion and bonding of lateritic soil particles.
Furthermore, for the three different cement types used in this research at various cement content employed have shown significant improvement in secant modulus of elasticity of treated lateritic soil with cement types. For CEMENT I, the values of the secant modulus of elasticity ranges from 10811kN/m^2, 11450kN/m^2, 11502kN/m^{2}to 17354kN/m^2 at cement content of 3%, 6%, 9% and 12% respectively. The increase in cement content showed a significant improvement in the secant modulus of elasticity, as observed.

For CEMENT II, the values of secant modulus of elasticity (E_S) ranges from 9719kN/m^2, 11379kN/m^2, 14778kN/m^{2}to 14924kN/m^2 at cement content of 3%, 6%, 9% and 12% respectively. The increase in cement content also shows significant positive improvement. These values were all less than those obtained in CEMENT I, except the value recorded at 9% binder, in which CEMENT II was higher than CEMENT I.

For CEMENT III, the values of the secant modulus of elasticity (E_S) ranges from 56410kN/m^2, 63200kN/m^2, 66923kN/m^2 to 67547kN/m^2 at cement content of 3%, 6%, 9% and 12% respectively. The increase in cement content showed a gradual increment 9in the observed values result, however, they were all less than those obtained for CEMENT I and CEMENT II. Therefore, from the discussion above, the values of tangents modulus of elasticity are higher than the secants modulus of elasticity on every test conducted for both untreated and treated lateritic soil with cement types.

Table 1.2: Results of Secant Modulus of Elasticity (E_S) for Lateritic Soil with Cement types

Sample	Cement Content (%)	E_S (kN/m^2) For 1 day curing	E_S (kN/m^2) For 7 days curing	E_S (kN/m^2) For 14 days curing	E_S (kN/m^2) For 21 days curing	E_S (kN/m^2) For 28 days curing
Lateritic Soil	0	2054	2348	2719	3355	3634
Lateritic Soil/	3	2274	5739	9772	8253	10811
CEMENT I	6	3051	6640	9862	10066	11450
	9	7255	8534	12328	13793	11502
	12	6102	8318	11490	12029	17354
Lateritic Soil/	3	1864	5699	8290	7920	9719
CEMENT II	6	3757	4963	7337	8566	11379
	9	2449	6334	8240	14184	14778
	12	6633	8148	9870	11166	14924
Lateritic Soil/	3	1829	4309	5925	6684	9845
CEMENT III	6	2159	4488	9190	7683	10941
	9	3063	6218	10917	1223	14249
	12	4741	7241	11703	10184	14656

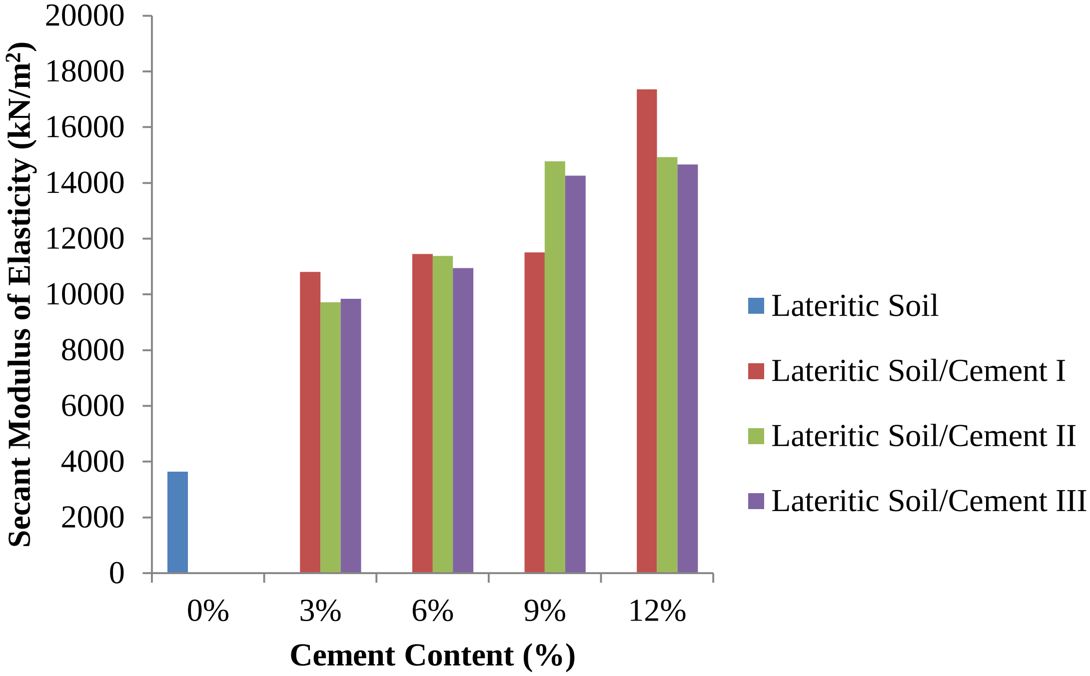

Figure 1.2: Relationship between Cement Content (%) and Secant Modulus of Elasticity (kN/m^2) for cement types at 28 days.

4.0 CONCLUSION AND RECOMMENDATIONS

4.1 Conclusion

The cement content on lateritic soil using cement types CEMENT I, CEMENT II and CEMENT III, have major effect on the strength and the modulus properties of lateritic soils. Out of the three cement types used, CEMENT I produced excellent result of unconfined compressive strength and modulus of elasticity of lateritic soil.

Modulus of elasticity, the maximum tangent and secant modulus of elasticity were determined to be 81632kN/m^2 and 17354KN/m^2 respectively, for CEMENT I at 12% cement content in 28 days. This finding reveals that the modulus of elasticity increases with days of curing. Then, the addition of 3%, 6%, 9% and 12% cement content for CEMENT I, CEMENT II and CEMENT III respectively shows significant improvement. The values of tangent modulus of elasticity are higher than secant modulus of elasticity on every test.

4.2 Recommendations

It is however, recommended that further research be carried out on CEMENT IV and CEMENT V in order to evaluate their effects on lateritic soils.

REFERENCES

Alao, D.A. (1983). Geology and Engineering Properties of Laterite from Ilorin Nigeria.*Engineering geology.*19, 111-118.

B.S. 1924, (1990). Method of Testing for stabilized soils, British standard Institution London.

B.S. 1377, (1990).Methods of Test for soils for civil Engineering Purposes, British Standards Institution London.

Gartner, E and Sui, T. (2018). Alternative cement clinkers. *Cement and concrete research 114, 27-39, 2018.*

Gidigasu, M. (2012). Laterite soil engineering: pedogenesis and engineering principles. Elsevier, 2012. Obtained from https://www.books.google.com on 23rd July, 2023.

Fredlund, D.G. (1999). The Implementation of Unsaturated Soil Mechanics into Geotechnical Engineering, the 1999 R.M. Hardy lecture, 55th Canadian Geotechnical Conference, Redina, Saskatchewan, Canada.

Jones, D., Rahim, A., Sadeh, S. & Harvey, J. T. (2012).Guidelines for the Stabilization of Sub-grade Soils in California.California: Partnered Pavement Research Centre.

Makasa, B. (2004). Utilization and Improvement of Lateritic Gravel in Road Bases. *International Institute for Aerospace Survey and Earth Sciences*, 15-22.

Robert, G.B. (2004). The history of calcareous cement and concrete.(4th Ed.). Amsterdam: Elsevier, Butterwort – Heinemann, 1-24.

Sinha, N. C. & Roy, S. K. (2011). Fundamentals of Reinforced Concrete, (2nded.). New Delhi India: S. Chand and Company Limited.

Todingrara, Y.T., Tjaronge, M.W., Harianto, T. and Ramli, M. (2017). Performance of laterite soil stabilized with lime and cement as a road foundation. *International Journal of Applied Engineering Research 12 (14), 4699-4707, 2017.*

Thagesen, B. (1996). Tropical Rocks and Soils in Highways and Traffic Engineering in Developing Countries.London: Ed Chapman and Hall publishers.

Van Oss, H.G.(2005). Background Facts and Issues Concerning Cement data. Virginia: United States Geological Survey 986 National Centre Reston.