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Original Article

Experimental Study of Lateritic Soil Stabilized with Diospyros Malabarica

J. D. Akshatha[1], Ramakrishna Hegde[2], K. E. Prakash[3]

[1,2]*Civil Department, Srinivas University, Institute of Engineering and Technology, Karnataka, India*
[3] *Principal, Shreedevi Institute of Technology, Karnataka, India.*

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Abstract *- Using locally accessible resources as stabilising agents to develop a better soil material with engineering capabilities. In this investigation, we used the locally available fruit Diospyros Malabarica. Testing in the lab determines how effective organic resin is and how much organic resin is used while evaluating efficacy. Once the effectiveness of the organic resin improves the strength characteristics of locally available lateritic soil, the best percentage of organic resin is then acquired for maximum strength enhancement. By replacing OMC with additions in percentages of 33, 66, and 100 percent, the soil's compressive strength is raised, and the CBR value of the soil also greatly rises. To study the effect of organic resin on increasing the bearing capacity of the soil and the effect on decreasing the permeability of the soil. Sustainable construction development is aided by efficiently using locally accessible soils and other relevant stabilising agents.*

Keywords *- Bearing capacity, California Bearing Ratio, Maximum Dry Density, Optimum Moisture Content, Organic resin, Unconfined Compressive Strength.*

1. Introduction

Cost-effective building supplies are essential for any nation's economy to flourish. In order to reduce construction costs, it is vital to find new materials and enhance construction methods. The rapid depletion of commonly used materials has increased the price of construction. As a result, there is more motivation to find new materials and better ways to process local materials for greater performance. Since the nature and characteristics of natural soil vary greatly, a suitable stabilising approach must be implemented for a specific situation after considering the soil characteristics. It is common to practice enhancing soil using mechanical or chemical methods. Numerous inorganic and organic chemical additions have also been employed to stabilise soils and improve strength and durability. Natural soil is stabilised by adding a chemical or cementing ingredient. Engineers must think of more cost-effective ways to construct roads due to the diminishing supply, rising costs, and uncertain economic conditions. Using materials that are easily accessible locally is a clear solution. Biological and photochemical stabilizers Diospyros Malabarica are used for medicinal purposes and other parts of folklore medicines[1]. To replace the expensive stabilizers, we can use locally available and cheap materials for the stabilization. Waste ashes such as saw dust ash, coconut husk ash, millet husk ash, corn cob ash, rice husk ash, and bagasse ash promote e-management and reduce air or land pollution [2].Adding coconut coir at different percentages with soil, cement and aggregate gives tremendous results in basic tests on soil.[3].Granulated Blast furnace Slag(GBFS) was used as a replacement material in marginal lateritic soil. Class c fly ash was used for geo polymerization to develop a low-carbon pavement base material.The study has enabled the 10% GBFS recommended at high NS: NH ratios (80:20)[4].Periwinkle shell ash possessed an appreciable amount of calcium oxide, which supports the pavement materials' cohesiveness with some cement as a binding agent for road pavement construction.[5]. CBR and USCS tests met the 80% requirements for coarse base materials with environment-friendly palm oil mill waste.[6]. ceramic waste dust for the stabilization of lateritic soil has increased the soil properties, and a study recommended that ceramic dust can be used up to 30% for soil improvement.[7].Xanthum gum for effective stabilization of lateritic soil was found to be 1.5% .microstructural analysis indicated that the xanthum gum is an eco-friendly and sustainable soil improvement additive.[8], [9].Laterite soil stabilized using calcium-based additive prepared from biomass silica as an alternative traditional stabilizer for residual tropical soil construction.[34]. Regarding CBR values, stabilizing lateritic soil using bamboo leaf ash has produced positive results. OMC decreased, and MDD increased depending on the BLA %[11]. For CBR's soaked and unsoaked conditions, laterite is best treated with an 8 percent oil palm empty fruit. Additionally, the UCS strength improved at 7, 14, 28, and 8 percent EFBA content. Lateritic Soil stabilization was evaluated using Cassava peels Ash by looking at how CPA affects Lateritic Soil [12]. Due to its high affinity for water, lateritic soil can absorb water. As a result, as water content rises, soil strength decreases. [13]. RHA reduced the MDD of the soil but increased OMC [14]. The contamination of crude oil will alter the index properties of lateritic clay. The soil needs to be stabilized before being used for building.[15]. Non-traditional additions include an acid solution, an enzymatic solution, and calcium lignosulfonate to treat the soil. They assessed the soil's distinctive properties due to the additions, and the microstructural investigation was carried out for characterization using SEM and MIP tests [16].Lack of knowledge of the exact qualitative and quantitative distribution of adhesive components in the natural adhesives prohibits their use in the adhesive field[31].The behaviour of earth materials is essential for mining, energy resource development and recovery, and scientific studies in virtually all geosciences[18]. the UCS results indicated that the degree of improvement for TX-85-stabilized laterite soil was approximately four times greater than the natural soil in a 7-day curing time period[19]. the UCS results showed that the degree of improvement for SH-85-stabilized laterite soil was roughly five times stronger than the untreated soil at the early stages of curing (7-day period). Also, a significant increase in the compressibility resistance of treated samples with curing time was observed[20]. performance of laterite soil with lime stabilization is better than sediment soil with cement stabilization and approaching common soil. It is concluded that laterite soil with lime stabilization has potential as a road foundation [21]. stabilization of lateritic soil with SNSA, in addition to being affordable and environmentally friendly, improved the physical properties of the soil for use in construction works[32]. laterite is suitable for subgrade and sub-base type but not as a base material in road construction and author recommends stabilization also equally important. Encouraging the use of industrial wastages in building low-cost construction of roads, a liquid natural chemical product is actively incorporated for stabilizing soils and improvement within the test ranges covered in the program. There is further need to make use of this inexpensive fruit extract. sugarcane molasses has been found to improve the physical properties of metakaolin-based geopolymer stabilized soil. large scale stabilization with industrial waste should be embarked by various construction companies and agencies involved in road construction[23]. It was also observed from the results that the workability of laterite concrete increases with increase in the replacement level of sand by laterite[24]. potential of using bagasse ash as admixture in lime stabilized expansive soil[25]. experimental studies on four latente soils and one intrazonal non-laterite soil, with special attention to their susceptibility to stabilization [26].The focus of this research is to stabilise lateritic soil by the action of organic resin, increase soil bearing capacity, and reduce soil permeability. We may examine the strength parameters of soil, such as UCS, CBR, versus dose of organic resin by modifying the geotechnical properties of lateritic soil using organic resin.

2. Materials and Methods

2.1. Diospyros Malabarica

The genus Diospyros Malabarica (Ebenaceace) is distributed throughout the tropics. The fruit, especially when unripe, as shown in figure 2, contains a viscid pulp rich in tannins and is the source of gum and adhesive in bookbinding. The chemical properties of Diospyros malabarica are flavonoids, tannins, alkaloids, and saponins. The quantity of organic resin is an important parameter; different quantities of organic resin (fruit extract) give a different effect for the same samples. Insufficient additives may lead to less stabilization or decrease the soil sample's strength. Hence, determine the strength and bearing capacity of blended soil by varying the percentages of organic resin.

2.2. Lateritic Soil

Laterite soils in India are found in the Eastern Ghats of Orissa, the Southern parts of Western Ghats, Malabar Coastal plains, Ratnagiri of Maharashtra, and some of Andhra Pradesh, Tamil Nadu, Karnataka, Meghalaya, the western part of West Bengal. They are formed by decomposing rock, removing the bases and silica, and forming iron and aluminum oxides at the top of the soil profile. For this study, lateritic soil was procured from pavenje near mukka, Dakshina Kannada District, India. The geotechnical properties of lateritic soil tests were conducted per Indian standard procedures. The results are tabulated in Table 1.

2.3. Material Preparation and Processing

The soil samples were prepared for Unconfined Compression Strength (UCS) and California Bearing Ratio (CBR) tests in the laboratory according to the Indian standard procedure using unripe diospyros malabarica fruit extract with water. Here we considered the dosage of organic resin as shown in Table 2. Firstly, the fruit is smashed into pieces and soaked in water for 4 days. After 4 days, the fruit extract, as shown in the figure, is taken using a filter. To prepare the soil mixture, the organic resin was added at different percentages to the weight of the soil. For each mixture specimen, different percentages of organic resin, such as 33%,66%, and 100%, were added, and corresponding Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) were maintained. Samples were cured for 4 days to determine the CBR test**.**

Table 1. Geotechnical Properties of Lateritic Soil

Property	Value
Consistency Limits (%)	
Plastic Limit	42
Liquid Limit	53
Plasticity Index	11
Compaction Properties	
Max Dry Density (g/cc)	1.55
Optimum Moisture Content (%)	18
Unconfined compression test (Kg/cm^2)	2.9
California Bearing Ratio Test Value	
Optimum Moisture Condition (%)	10.387
Soaked condition (%)	9.03
Specific Gravity	2.47
Grain Distribution Analysis	
Co-Efficient of Curvature	1.27
Co-Efficient of Uniformity	9.02
Grade	Well Graded

Table 2. Dosage of Organic resin

Dosage	**% By weight of soil**	**Weight per Kg of soil (ml)**
1	33	330
2	66	660
3	100	1000

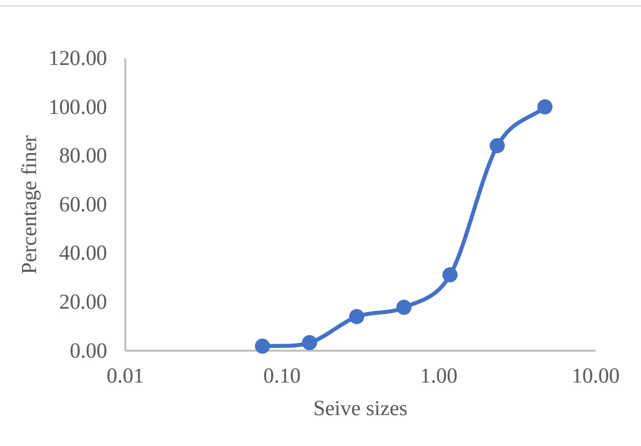

Fig. 1 Grain size distribution curve of laterite soil

Fig. 2 Unripe Diospyros Malabarica Fruit

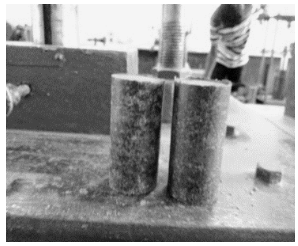

Fig. 3 UCS test samples

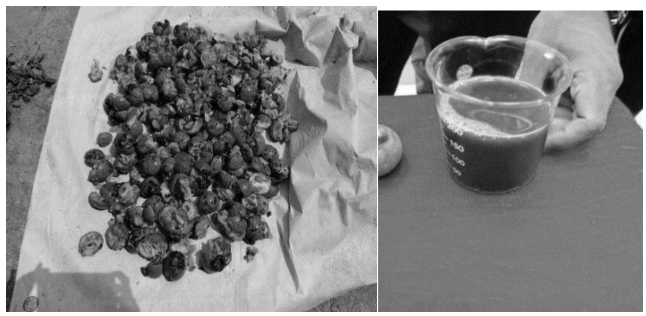

Fig. 4 Extracted Organic resin from unripe Diospyros Malabarica fruit.

2.4. Experimental Testing and Procedure

2.4.1. Compaction Test

The standard and modified compaction tests were performed on the untreated soil as per IS code[33]. Water content and dry density values are tabulated, and from the graph, optimum Moisture Content and Maximum Dry Density values are derived.

2.4.2. Unconfined Compression Strength Test

In this experiment, standard UCS test equipment and procedures (IS: 2720 part 17)-1986,) were applied[28]. Figure 3 shows the samples prepared using the static compaction method at the optimum water content and the required maximum dry density. The steel tube's volume was determined to be the same as the sample's volume. The weight of the sample for mixes, whose combination percentages were chosen, is determined using the volume and density requirements, and the water content corresponding to the optimum moisture content is added.

2.4.3. California Bearing Ratio Test

The present investigation applied IS 2720 (part 16) existing standard test apparatus and methodology[29]. The optimal dosage was considered to determine the variation in CBR values.CBR was performed for both soaked and unsoaked conditions.

2.4.4. Permeability Test

In the present study, standard permeability test procedures (IS 2720 (part 17)-1986) are followed[30]. The permeameter's internal dimensions are measured, its internal volume is determined, and its weight is recorded.

3. Results and Discussion

3.1. Sub Effect of Organic resin on Unconfined Compression Strength Test

The test was conducted for both standard and modified compaction cases. The test results of the unconfined compression strength test are shown in figure 6. As we can see from the graph for 0% of organic resin, the UCS value of soil is less than other resin percentages. As the percentage of glue increased, the UCS value also increased. This is due to the biological activity of constituents in the fruit can easily convert to the black polymeric material. The graph shows that replacing 100 % water with glue significantly increases soil strength.

3.2. Effect of Organic Resin on CBR

There was an increase in the CBR values as the percentage of glue increased, as in figure 7 and figure 8 for soaked and unsoaked conditions, respectively. It is due to the organic resin offering better resistance to plunger penetration. The resistance is due to the strong bonding between soil particles and the organic resin. There is a good improvement in CBR values as the curing period increases. To evaluate soil's bearing capacity, these CBR values play an important role and show the good packing of diffraction fraction of the soil.

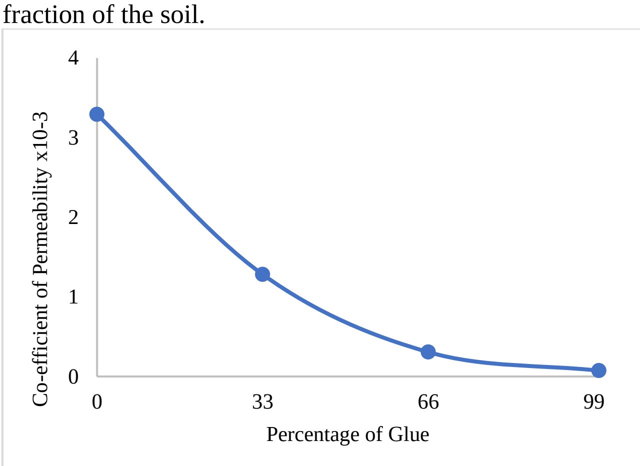

Fig. 5 Permeability test graph of Lateritic soil

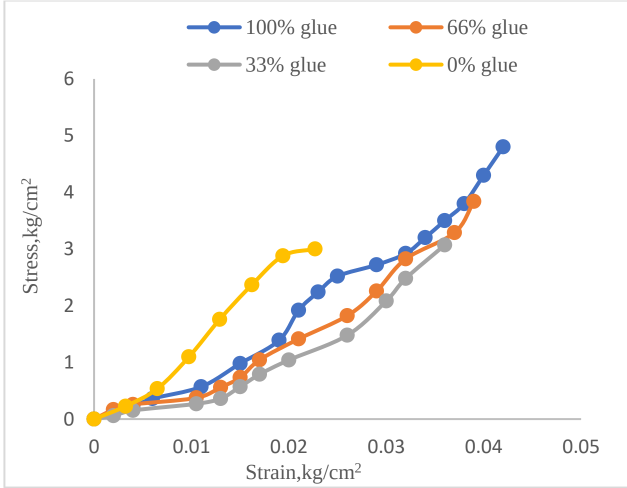

Fig. 6 UCS values for organic resin treated soil.

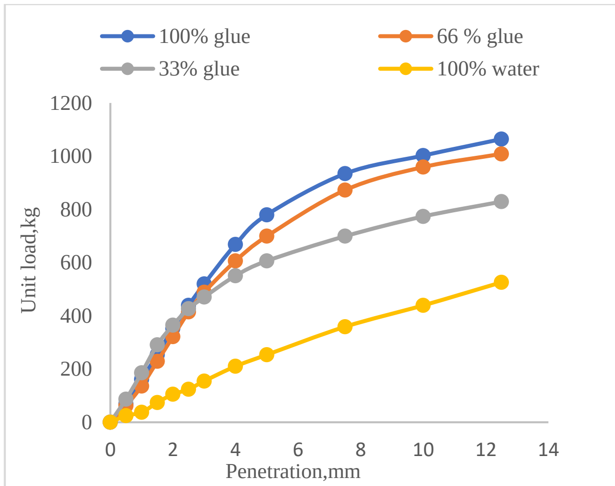

Fig. 7 CBR values at the soaked condition for organic resin-treated soil

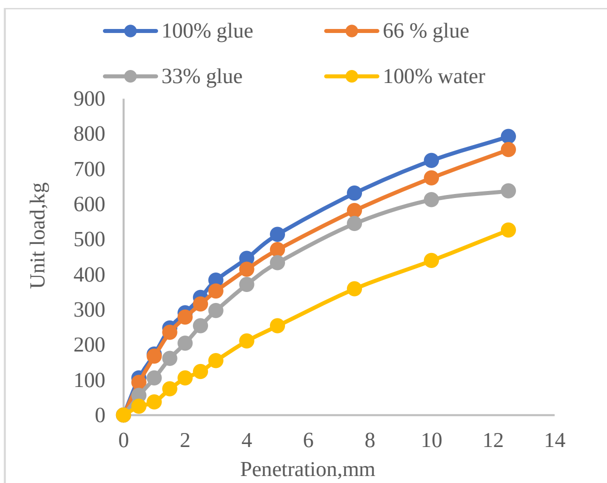

Fig. 8 CBR values at the unsoaked condition for organic resin-treated soil

4. Conclusion

1. Based on the tests conducted in the laboratory, the following conclusions can be drawn.
2. The characteristics of the lateritic soil significantly improved after adding organic resin. Positive outcomes include an increase in the compressive strength of soil for each percentage of soil and the replacement of OMC. When organic resin was used as a 100 percent substitute for water in terms of OMC, the soil's CBR value increased.
3. Due to the filling of pore spaces during the compaction process, soil permeability reduced as glue percentage increased.
4. We can conclude that the soil was stabilized, and its shear strength was enhanced due to the addition of organic resin.
5. It is inexpensive and environmentally friendly to stabilize lateritic soil using Diospyros malabarica fruit. Because it is a plant that is naturally available, as a result, we can use this as a substitute for more traditional techniques to build village roads.

References

[1] Vichitra Kaushik, Vipin Saini, et al., "A Review of Phytochemical and Biological Studies of Diospyros Malabarica," *International Journal of Pharmaceutical Sciences Letters*, vol. 2, no. 6, pp. 167-169, 2013.

[2] S. I. Adedokun, and J. R. Oluremi, "A Review of the Stabilization of Lateritic Soils with Some Agricultural Waste Products," *Annals of Faculty Engineering Hunedoara*, vol. 17, pp. 63–74, 2019.

[3] A. U. Ravi Shankar, B. A. Priyanka, and Avinash, "Experimental Studies on Laterite Soil Stabilized with Coconut Coir, Cement and Aggregate," *Lecture Notes in Civil Engineering,* vol. 88, pp. 751-763, 2021. *Crossref,* https://doi.org/10.1007/978-981-15-6237-2_61

[4] Itthikorn Phummiphan, Suksun Horpibulsuk, et al., "High Calcium Fly Ash Geopolymer Stabilized Lateritic Soil and Granulated Blast Furnace Slag Blends as a Pavement Base Material," *Journal of Hazardous Materials*, vol. 341, pp. 257–267, 2018. *Crossref,* https://doi.org/10.1016/j.jhazmat.2017.07.067

[5] A. O. Adeboje, S. O. Bankole, et al., "Modification of Lateritic Soil with Selected Agricultural Waste Materials for Sustainable Road Pavement Construction," *International Journal of Pavement Research and Technology*, vol. 15, pp. 1327-1339, 2022. *Crossref,* https://doi.org/10.1007/s42947-021-00091-5

[6] O. O. Komolafe, and K. J. Osinubi, "Stabilization of Lateritic Soil with Cement - Oil Palm Empty Fruit Bunch Ash Blend for California Bearing Ratio Base Course Requirement," *In Iop Conference Series: Materials Science and Engineering*, vol. 640, no. 1, 2019. *Crossref*, https://doi.org/10.1088/1757-899x/640/1/012085

[7] Olumuyiwa Onakunle, David O. Omole, and Adebanji S. Ogbiye, "Stabilization of Lateritic Soil from Agbara Nigeria with Ceramic Waste Dust," *Cogent Engineering*, vol. 6, no. 1, 2019. *Crossref,* https://doi.org/10.1080/23311916.2019.1710087

[8] Nima Latifi, Suksun Horpibulsuk, et al., "Xanthan Gum Biopolymer: An Eco-Friendly Additive for Stabilization of Tropical Organic Peat," *Environmental Earth Sciences*, vol. 75, no. 9, 2016. *Crossref,* https://doi.org/10.1007/S12665-016-5643-0

[9] Ahmad Safuan A. Rashid, Nima Latifi, Christopher L. Meehan, and Kalehiwot N. Manahiloh, "Sustainable Improvement of Tropical Residual Soil using an Environmentally Friendly Additive," *Geotechnical and Geological Engineering*, vol. 35, no. 6, pp. 2613–2623, 2017. *Crossref,* https://doi.org/10.1007/S10706-017-0265-1

[10] Majoie Ronelyam Mbakbaye, Erick Kiplangat Ronoh, and Isaac Fundi Sanewu, "Effects of Shea Nutshell Ash on Physical Properties of Lateritic Soil," *SSRG International Journal of Civil Engineering*, vol. 8, no. 11, pp. 1-6, 2021. *Crossref,* https://doi.org/10.14445/23488352/IJCE-V8I11P101

[11] Olugbenga O. Amu, and Akinwole A. Adetuberu, "Characteristics of Bamboo Leaf Ash Stabilization on Lateritic Soil in Highway Construction," *International Journal of Engineering & Technology,* vol. 2, no. 4, pp. 212–219, 2010.

[12] Afeez Adefemi Bello, Joseph Adebayo Ige, and Hammed Ayodele, "Stabilization of Lateritic Soil with Cassava Peels Ash," *British Journal of Applied Science & Technology,* vol. 7, no. 6, pp. 642–650, 2015. *Crossref,* https://doi.org/10.9734/BJAST/2015/16120

[13] F. Alayaki, "Water Absorption Properties of Laterite Soil in Road Pavement: A Case Study Ife-Ilesha Highway, South Western Nigeria," *International Journal of Emerging Technology and Advanced Engineering,* vol. 2, no. 11, pp. 51–57, 2012.

[14] F. O. Okafor, and U. N. Okonkwo, "Effects of Rice Husk Ash on Some Geotechnical Properties of Lateritic Soil," *Leonardo Electronic Journal of Practices and Technologies,* vol. 8, no. 15, pp. 67–74, 2009.

[15] I. I. Akinwumi, D. Diwa, and N. Obianigwe, "Effects of Crude Oil Contamination on the index Properties, Strength and Permeability of Lateritic Clay," *International Journal of Applied Science and Engineering,* vol. 3, no. 4, pp. 816–824, 2014. *Crossref,* https://doi.org/10.6088/ijaser.030400007

[16] Gaëtan Blanck, Olivier Cuisinier, and Farimah Masrouri, "Soil Treatment with Organic Non-Traditional Additives for the Improvement of Earthworks, Waste and Biomass Valorization," *Waste and Biomass Valorization,* vol. 9, no. 6, pp. 1111-1122, 2014. *Crossref,* https://doi.org/10.1007/S11440-013-0251-6.

[17] Blaise Dabou, Christopher Kanali, and Zachary Abiero-Gariy, "Structural Performance of Laterite Soil Stabilised with Cement and Blue Gum (Eucalyptus Globulus) Wood Ash for Use as a Road Base Material," *International Journal of Engineering Trends and Technology*, vol. 69, no. 9, pp. 257-264, 2021. *Crossref*, https://doi.org/10.14445/22315381/IJETT-V69I9P231

[18] J. K. Mitchell, Behavior Jk Mitchell Amp K Soga, "Fundamentals of Soil Behavior," *Geotechnical Engineering*, vol. 3, no. 4. 2005.

[19] Nima Latifi, Aminaton Marto, and Amin Eisazadeh, "Analysis of Strength Development in Non-Traditional Liquid Additive-Stabilized Laterite Soil from Macro- and Micro-Structural Considerations," *Environmental Earth Sciences,* vol. 73, no. 3, pp. 1133–1141, 2015. *Crossref*, https://doi.org/10.1007/S12665-014-3468-2

[20] Nima Latifi, Aminaton Marto, and Amin Eisazadeh, "Physicochemical Behavior of Tropical Laterite Soil Stabilized with Non-Traditional Additive," *Acta Geotechnica,* vol. 11, no. 2, pp. 433–443, 2016. *Crossref,* https://doi.org/10.1007/S11440-015-0370-3

[21] Zubair Saing1, Lawalenna Samang, et al., "Study on Characteristic of Laterite Soil with Lime Stabilization as a Road Foundation," *International Journal of Applied Engineering Research,* vol. 12, no. 14, pp. 4687–4693, 2017.

[22] Aswar D. S., et al., "Performance of Terra Zyme for Soil Stabilization of Various Soil Groups," *International Journal of Engineering Trends and Technology,* vol. 70, no. 4, pp. 258-271, 2022. *Crossref,* https://doi.org/10.14445/22315381/IJETT-V70I4P222

[23] E. Emeka, "Stabilization of Laterites with Industrial Wastes: A Recent and Comprehensive Review," *International Journal of Advanced Research and Technology,* vol. 4, no. 11, pp. 69–87, 2015.

[24] F. F. Udoeyo, U. H. Iron, and O. O. Odim, "Strength Performance of Laterized Concrete," *Construction and Building Materials,* vol. 20, no. 10, pp. 1057–1062, 2006. *Crossref,* https://doi.org/10.1016/J.Conbuildmat.2005.03.002

[25] Meron Wubshet, and Samuel Tadesse, "Stabilization of Expansive Soil Using Bagasse Ash & Lime," *Zede Journal*, 2014.

[26] Hans F. Winterkorn, and E. C. Chandrasekharan, "Laterite Soils and Their Stabilization."

[27] Timothy Danjuma, Mbimda Ali Mbishida, et al., "Soil investigation of a Collapsed Building Site in Jos, Nigeria," *International Journal of Recent Engineering Science*, vol. 8, no. 5, pp. 1-5, 2021. *Crossref,* https://doi.org/10.14445/23497157/IJRES-V8I5P101

[28] IS: 2720 (Part 10):1991, "Indian Standard: Methods of Test for Soils, Part 10: Determination of Unconfined Compressive Strength," *Bureau of Indian Standards, New Delhi*, no. Reaffirmed 2006, pp. 1–6, 1991.

[29] BIS: 2720 (Part-16), "Methods of Test for Soils-Laboratory Determination of CBR," *Bureau of Indian Standards, New Delhi India*, 1987.

[30] "IS: 272o (Part17)-1986methods of IS: 272o(Part17)-1986 Standard Test for Soils," *ASDC Journal of Dentistry for Children,* vol. 54, no. 4, pp. 273–276, 1987.

[31] S. Parija, M. Misra, and A. K. Mohanty, "Studies of Natural Gum Adhesive Extracts: An Overview," *Journal of Macromolecular Science. Reviews in Macromolecular Chemistry and Physics,* vol. 41, no. 3, pp. 175–197, 2001. *Crossref,* https://doi.org/10.1081/Mc-100107775

[32] Bureau of Indian Standards, "Methods of Test for Soils, Determination of Water Content Dry Density Relation Using Light Compaction," 2720 Part VII-1980, pp. 1–16, 2011.

[33] N. Latifi, A. Eisazadeh, et al., "Tropical Residual Soil Stabilization: A Powder Form Material for increasing Soil Strength," *Construction and Building Materials*, vol. 147, pp. 827–836, 2017. *Crossref,* https://doi.org/10.1016/J.Conbuildmat.2017.04.115