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Enhancing the Index and Engineering Properties of Urban Fills by Stabilizing with Cement, Lime and Bagasse Ash

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Abstract

The experimental studies on urban fill stabilised using bagasse ash, lime and cement are presented in this paper. The studies were conducted by combining soil samples containing varied amounts of bagasse ash, cement, and lime, each was 4 percent, 8 percent, and 12 percent respectively. The goal of this research is to enhance the geotechnical qualities of urban fills by combining industrial waste bagasse ash with additives like lime and cement. Different percentages of cement, bagasse ash and lime were used in tests on geotechnical qualities and compaction of urban infill. The inclusion of bagasse ash, cement, and lime to a soil sample resulted in a considerable improvement in soil parameters. The addition of cement produces better outcomes than lime, according to the trial data. As an outcome of this research, Bagasse ash can be recommended as a stabilising ingredient for enhancing the urban fill's unconfined compressive strength.

Keywords: Geotechnical Properties, Industrial Waste, Mix Proportion.

Introduction

The state of the underlying soils determines the construction project's long-term performance. Structures can be seriously harmed by unstable soils. The long term, cost effective, chemical and physical manipulation of the soils to improve their physical qualities is known as soil stabilisation. Soil stabilisation improves the foundation's bearing capacity and strength, as well as its water tightness and washout resistance. The conventional approach of soil stabilisation can be used to replace inappropriate soils or soil fills with stronger material. Soil stabilisation refers to enhancing or changing the properties of soil in order to improve engineering performance. It is used in construction of air and road field pavement, where the primary goal is to improve soil strength or stability while lowering construction costs by utilising locally accessible resources. The huge quantities of ash become an industrial trash, posing disposal issues. Because they are burned under uncontrolled settings and at extremely high temperatures, the ashes collected directly from the mill on the other hand, are not reactive. The goal of this research is to enhance the Geotechnical qualities of the urban fills by combining industrial waste bagasse ash with additions like cement and lime. Bagasse, the fibrous material left behind after extracting the juice is incinerated to ash is referred to as ash. Researchers and scientists all over the world are working to meet the growing demand for consumption of cement by ways to manufacture environmental friendly binders that helps in long term management and as also contribute towards waste management. The utilization of bagasse ash in soil stabilization was studied by Amu et al., 2011; Akshaya Kumar 2012, Mohamed et al., 2007; Vinod et al., 2021, Dang et al., 2021; Landa-Ruiz et al., 2021; Singh et al., 2021; Hidalgo et al., 2020; Lal et al., 2020 and Ajay et al., 2013. The other industrial ashes such as fly ash was studied by several researchers (Havangi et al., 2004; Mishra and Mathur, 2004; Mtallib and Bankole, 2011). As part of this research work, the laboratory experiments were conducted on urban fills utilising 4 percent, 8 percent, and 12 percent bagasse ash, as well as lime and cement as additives.

Materials and Methods

Urban Fills

In this study, urban fills were exploited as a source of material. The samples were taken at the EWIT campus in Bangalore and were taken from a depth of 1.5 metres. The debris such as plastics, glass, and brick fragments among other things, are coarse-grained. The samples were oven dried after being kept in jute bags to achieve homogeneity before sieving with a 4.75mm sieve.

Figure 1: Urban fills

Table 1 Geotechnical properties of soil used

Properties	Urban fills
Color	Brown
Relative Density (G)	2.62
Grain Size Distribution	
Coarse to medium sand (%)	79
Fine Sand (%)	18
Silt (%)	2
Clay (%)	1
Atterberg's Limit	
Liquid Limit (%)	38
Plastic Limit (%)	23.22
Plasticity Index (%)	11.88
Shrinkage Limit (%)	16.92
Compaction	
Optimum moisture content (OMC) (%)	12
Maximum dry density (MDD) (g/cc)	1.79
Unconfined Compressive Strength(N/mm²)	63.29
CBR Unsoaked (%)	1.06
CBR Soaked (%)	1.15

Bagasse Ash (BA)

Bagasse ash is the cellulose fibre waste left over after sugarcane has been milled. The sugarcane fibres had been totally consumed by fire. In sugar factories, this material is generally an issue for disposal, especially in tropical regions. Bagasse (The fibrous residue from crushing sugarcane) is abundant in many tropical regions and is high in amorphous silica, indicating that it has pozzolanic qualities. For both economic and environmental concerns, research has focused on the use of industrial and agricultural waste materials in construction. Bagasse ash is collected in Mandya, Karnataka from a sugarcane mill and is used to stabilise urban infill.

Cement (C)

One of the most beneficial materials for minimising swelling qualities of soils is cement. The use of ordinary Portland cement (OPC) is to stabilise soils results in hardened materials which are able to withstand heavy loads for purpose of engineering. When the amount of cement applied to a soil is increased, the strength of the soil cement grows as well, and if this increase in strength does not occur, the soil is typically regarded unsuitable.

Lime (L)

The type of lime employed in this study is hydrated lime. Lime was purchased at a nearby market. Lime is an excellent choice for modifying soil qualities in the near term. Lime may improve practically all fine-grained soils, although clay soils with moderate to high flexibility benefit the most from it. Calcium oxide or calcium hydroxide is what lime is. In a variety of scenarios, lime can be applied to improve the workability and load-bearing qualities of soils

Experimental Programme

Primary laboratory tests were performed on urban fills to assess the basic parameters of soil samples according to IS 2720 (Attenberg's limit, compaction, CBR, and UCC).The Atterberg's limit is used to classify urban fills determined for basic qualities according to IS categorization. Bagasse ash is used to stabilise urban infill by combining the soil with various amounts of bagasse ash (4 percent, 8 percent, and 12 percent).Later the stabilisation with bagasse ash, urban fills is blended with bagasse ash, ordinary Portland cement and lime. Various combinations of percentage are used in the test. The results of the testing on various percentage combinations are listed in the table below. The outcomes are appropriately concluded.

Table 2: Percentage combinations for determining the Index properties

Sl. no	Mixture	With addition of cement	With addition of lime
		Soil +4% Bagasse Ash +4% cement	Soil +4% Bagasse Ash +4%Lime
1.	Soil+4% Bagasse Ash	Soil +4% Bagasse Ash +8% cement	Soil +4% Bagasse Ash +8%Lime
		Soil +4% Bagasse Ash +12% cement	Soil +4% Bagasse Ash +12%Lime
		Soil +8% Bagasse Ash +4% cement	Soil +8% Bagasse Ash +4% Lime
2.	Soil +8% Bagasse Ash	Soil +8% Bagasse Ash +8% cement	Soil +8% Bagasse Ash +8% Lime
		Soil+8% Bagasse Ash +12% cement	Soil+8% Bagasse Ash +12% Lime
		Soil +12% Bagasse Ash +4% cement	Soil+12% Bagasse Ash +4% Lime
3.	Soil +12% Bagasse Ash	Soil +12% Bagasse Ash +8% cement	Soil+12% Bagasse Ash +8% Lime
		Soil+12% Bagasse Ash +12% cement	Soil +12% Bagasse Ash +12% Lime

Preparation of Sample

The soil sample is dried in air or sun-dried after it is collected from the field. To speed up the drying process, the clods are shattered with a wooden hammer. The organic materials in the sample, such as tree roots and bark, was removed. After that, the sample is oven-dried at 110°C for 24 hours. The sample was air dried for testing such as liquid limit, plastic limit, and light compaction. Basic laboratory tests are performed on the sample as directed. In addition, the blend mix sample was made as following:

The soil was first dried for 24 hours at 110°C after being heated in an oven to remove moisture. The bagasse ash from agricultural waste is then placed in an oven to keep it dry. Bagasse ash composition was calculated according to particular percentages by soil weight for various blend mixtures, and it was blended with a dry form of soil. Similarly, for lime and cement blend, all components are consumed in dry form and mechanically mixed before test method is carried out.

Results and Discussion

Table 1 lists the basic properties of urban fills as determined by laboratory experiments in accordance with IS code specifications.

Results of urban fills stabilized with Bagasse Ash (BA)

After determining primary parameters, index properties such as LL, PL, and MDD were determined for urban infill stabilised using Bagasse ash. The following tables show the test results and graphs with waste addition (Bagasse Ash).

Figure 2: Graph depicting the change in Liquid Limit value as a result of the addition of Bagasse Ash.

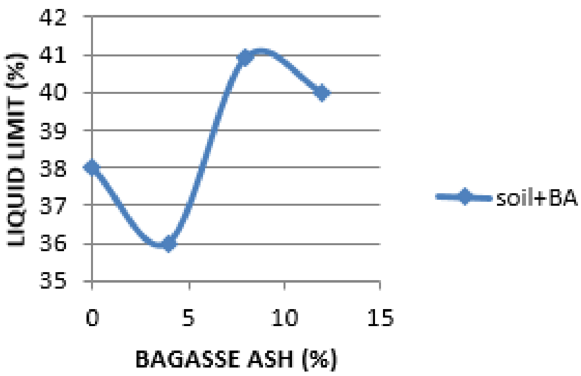


Figure 3: Graph depicting the variation of Plastic Limit value as a result of addition of Bagasse Ash.

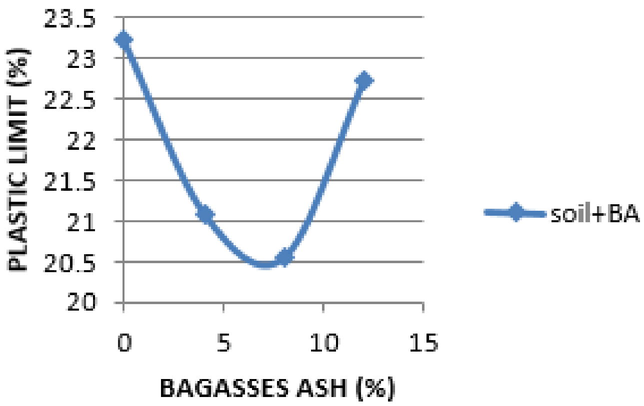
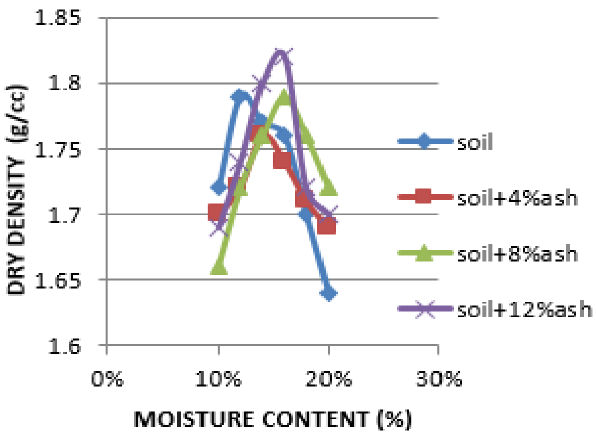


Figure 4: Graph depicting variation of Maximum Dry density value as a result of addition of Bagasse Ash



The outcomes of Bagasse ash (BA) and cement stabilised urban fills

The stabilisation is carried out using a combination of varying percentages of cement and bagasse ash (BA), and test findings are as follows:

Figure 5: Liquid limit variations in urban infill stabilised with cement and various ratios of bagasse ash.

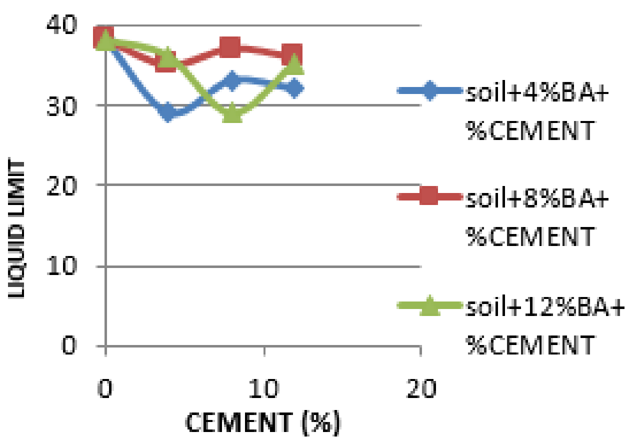


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Figure 6: Variations of Plastic limit of Urban fills stabilized with different percentages of Bagasse ash and Cement.

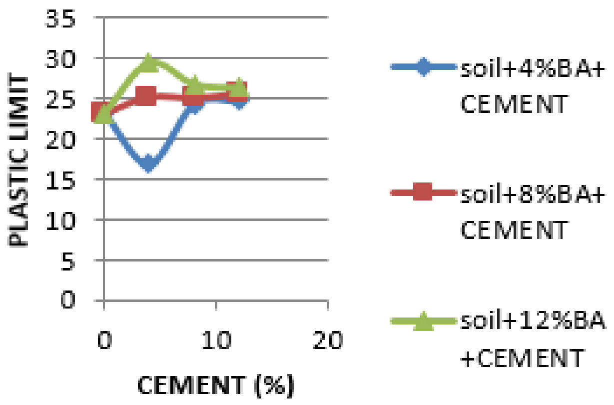


Figure 7: Curves of dry density versus moisture content for urban infill containing 4% bagasse ash and different percentages of cement.

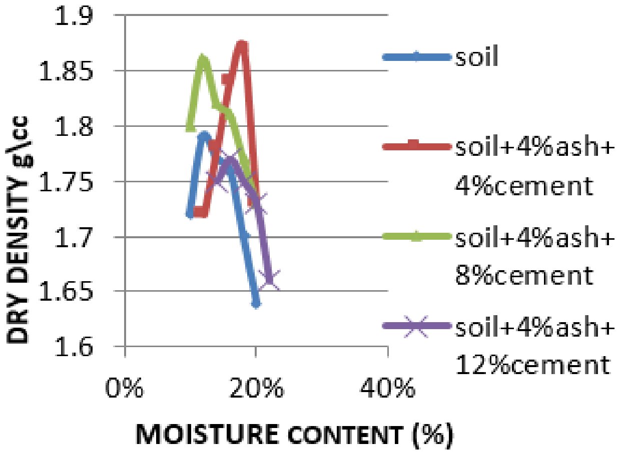


Figure 8: Curves comparing dry density versus moisture content for urban infill with different percentages of cement and 8% bagasse ash.

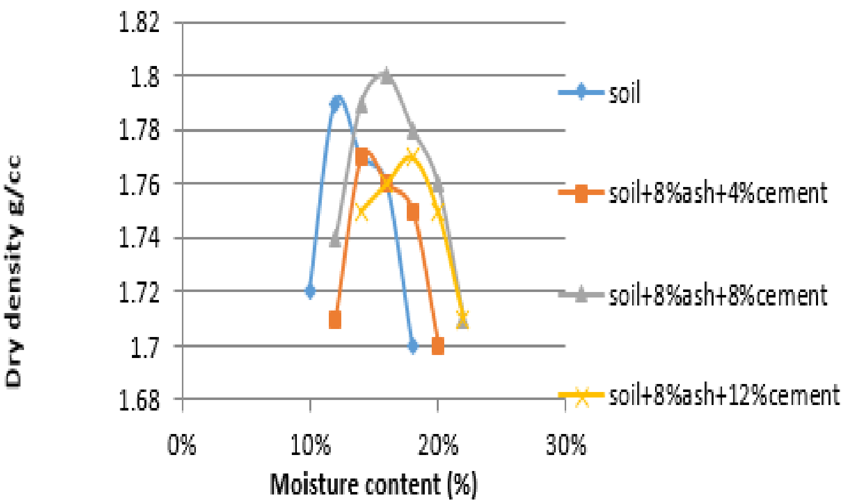
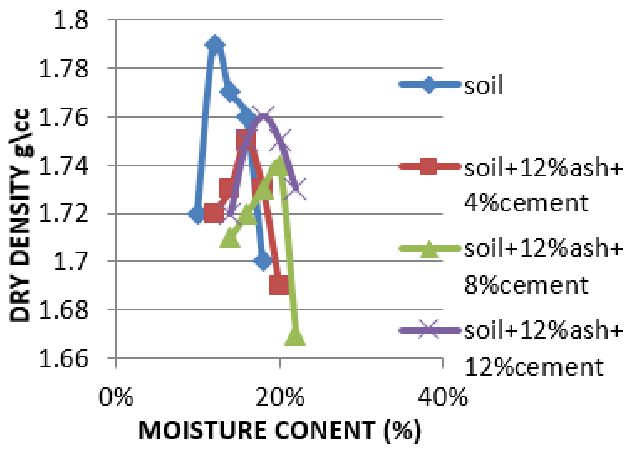


Figure 9: Curves showing dry density versus moisture content for urban infill containing different percentages of cement and 12 percent bagasse ash.



The outcomes of Bagasse Ash (BA) and Lime (L) stabilized urban fills.

The stabilisation is carried out using a mixture of varied percentages of Bagasse Ash (BA) and lime, with following results:

Figure 10: Liquid limit variations in urban infill stabilised with various ratios of bagasse ash and lime.

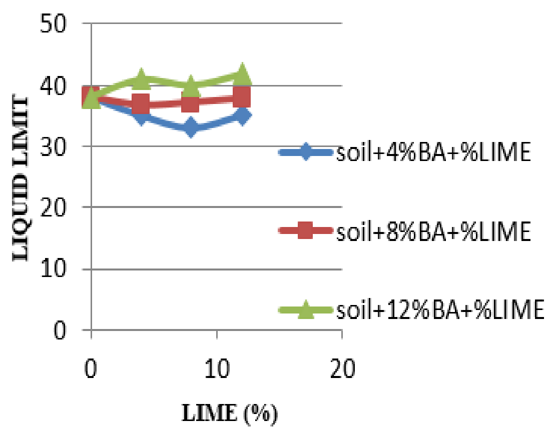


Figure 11: Variations in the plastic limit of the urban fills stabilised with various amounts of Bagasse Ash and lime.

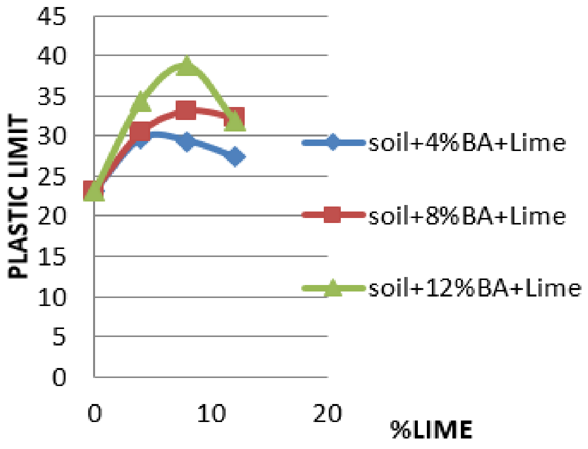


Figure 12: Curves of dry density versus moisture content curves for the urban fills varying percentage of lime with and 4% Bagasse Ash

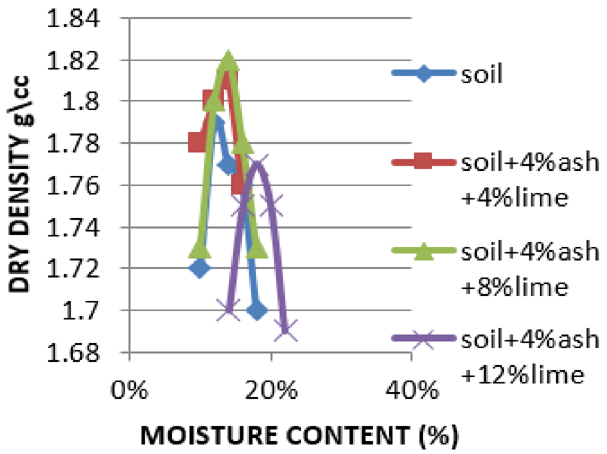


Figure 13. Dry density versus moisture content curves for the urban fills with 8% Bagasse Ash constant and varying percentage of lime

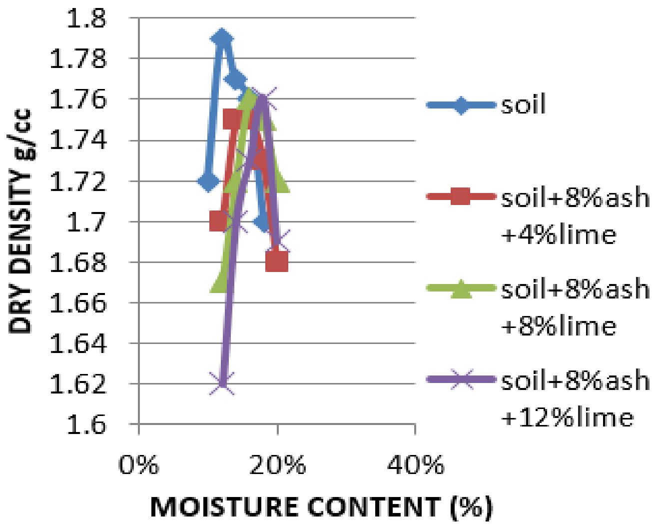


Figure 14: Curves of dry density versus moisture content for the urban fills containing varying percentages of lime and 4% Bagasse Ash.

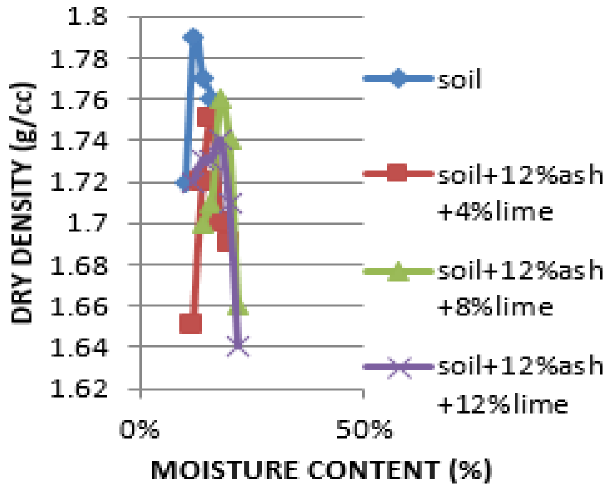


Figure 15: Stress versus Strain curves of the urban fills by varying Bagasse Ash percentage.

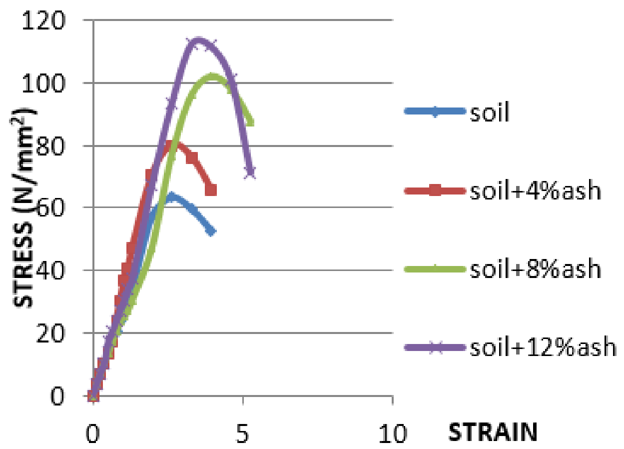


Figure 16: Stress versus Strain curves of the urban fills with 4% Bagasse Ash constant and varying percentages of cement

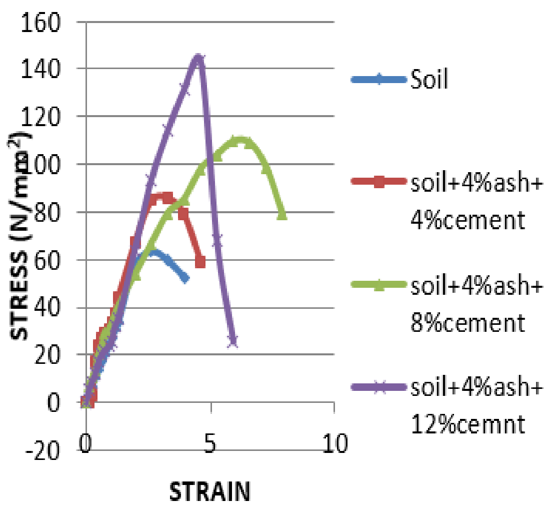


Figure 17: Stress versus Strain curves of the urban fills with 8% Bagasse Ash constant and varying percentages of cement

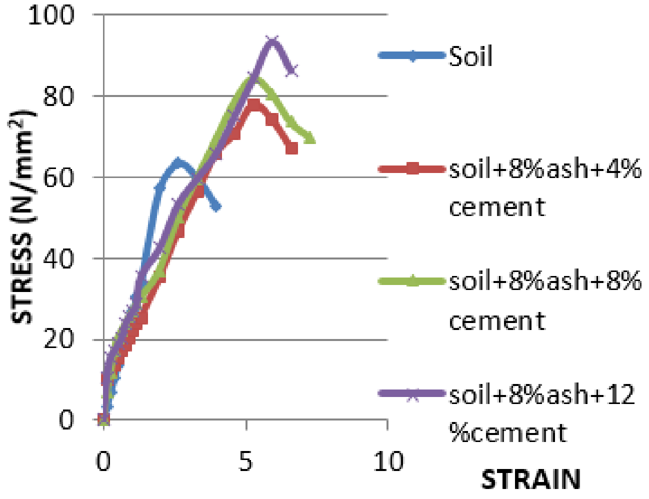


Figure 18: Stress versus Strain curves of urban fills with 12% Bagasse Ash constant and varying percentages of cement

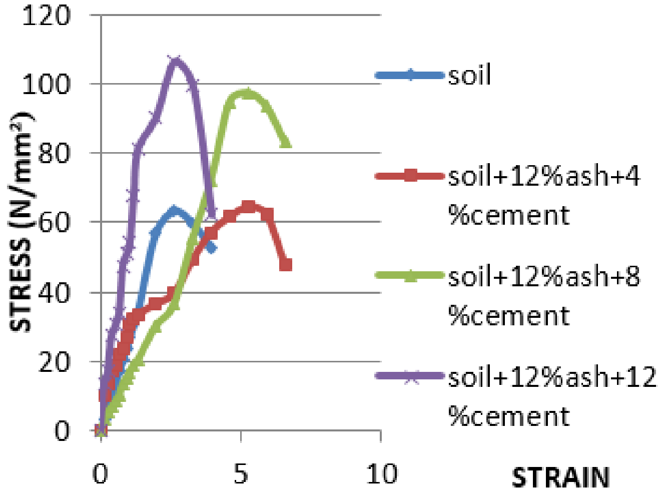


Figure 19: Stress versus Strain curves of the urban fills with 4% Bagasse Ash constant and varying percentages of lime

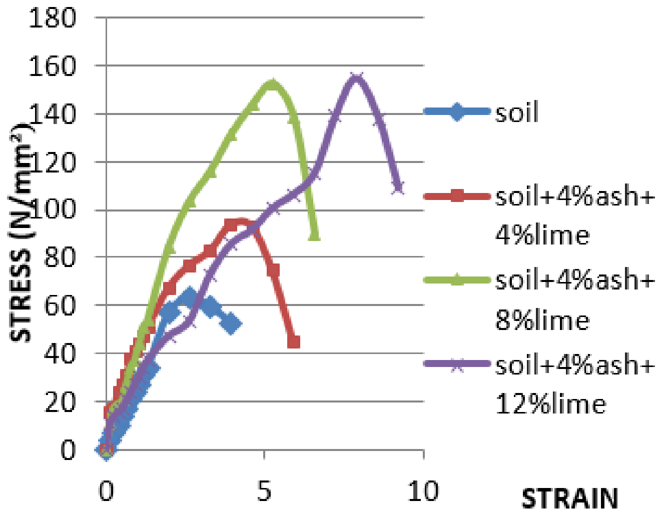


Figure 20: Stress versus Strain curves of the urban fills with 8% Bagasse Ash constant and varying percentages of lime

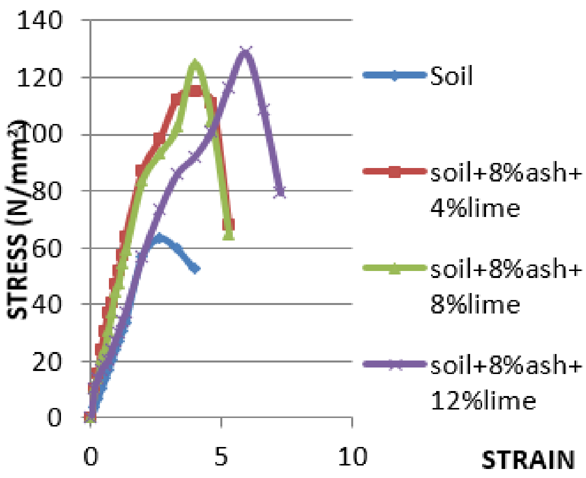
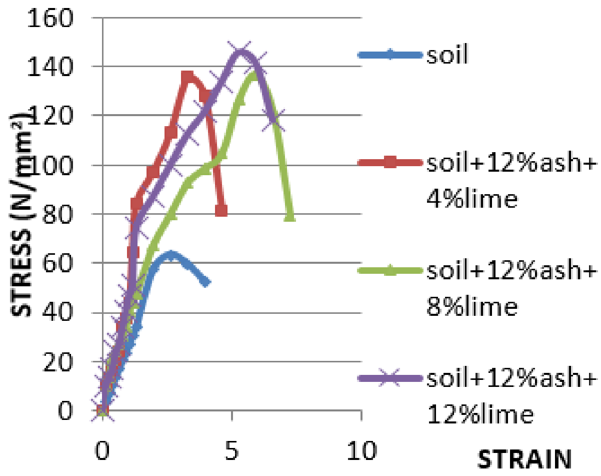


Figure 21: Stress versus Strain curves of the urban fills with 12% Bagasse Ash constant and varying percentages of lime



Conclusions

The outcomes of the experiment on urban fills stabilised with cement, BA and lime in various amounts led to the following conclusions.

Urban fills have a 38 percent liquid limit and the liquid limit is reduced to 36 percent when 4 percent BA is added. The liquid limit drops to 29 percent with the addition of 4 percent BA+ 4 percent cement and 12 percent BA+8 percent lime, and to 33 percent with the addition of 4 percent BA+8 percent lime. Urban fills have a plastic maximum of 23.22 percent. The plastic limit is reduced to 20.54 percent with the addition of 8% BA. The plastic limit is increased to 29.45 percent with the addition of 12 percent BA+4 percent cement, and to 38.73 percent with the addition of 12 percent BA+8 percent lime. The liquid and plastic limits improvement with cement mixtures is related to pozzalonic reactions and calcium hydroxide formations for lime combinations. Urban fills have a MDD of 1.79g/cc and an OMC of 12%, respectively. For a 12 percent BA, MDD and OMC rises 1.82g/cc and 16 percent, respectively. The maximum dry density and optimum moisture content increases 1.87g/cc and 18%, respectively, when 4 percent BA+4 percent cement was added, while the maximum dry density and optimum moisture content increased 1.81g/cc and 14 percent, respectively, when 4 percent BA+8 percent lime was added. The MDD improvement for BA combinations is attributable to binding action, pozzolanic reactions for BA with cement mixtures, and production of calcium hydroxide for BA with lime combinations. It was discovered that in other combinations, there was no improvement in dry density. For a 4 percent BA, MDD drops 1.76g/cc and optimum moisture content rises 14 percent. The MDD drops 1.74g/cc and the optimum moisture content rises 20% when 12 percent BA+8 percent cement is added, while the MDD drops to 1.74g/cc and the OMC rises to 18% when 12 percent BA+12 percent lime is added. The admixture's binding effect may be insufficient, resulting in a drop in soil MDD. Urban fills have an unconfined compression strength of 63.29N/mm^2. For a 12 percent BA, the urban fills unconfined compression strength increased to 112.49N/mm^2. The urban fills strength is increased to 143.59 N/mm^2 with the addition of 4 percent BA+12 percent cement, and to 154.41 N/mm^2 with the addition of 4 percent BA+12 percent lime. This process results in the synthesis of cementious compounds such as calcium silicate and calcium aluminates, which are responsible for the development of strength. As an outcome of this research, Bagasse ash can be recommended as a stabilising ingredient for enhancing the urban fill's unconfined compressive strength and decrease its plasticity.

References

Ajay Goyal, Hattori Kunio, OGATA Hidehiko, Mandula (2013) "Properties and Reactivity of Sugarcane Bagasse Ash". Conference: International Conference on Mechanical, Industrial and Materials Engineering 2013 (ICMIME2013).

Akshaya Kumar Sabat (2012): Associate Professor Department of Civil Engineering ITER, SOA University, Bhubaneswar "Utilization of Bagasse Ash and Lime Sludge for Construction of Flexible Pavements in Expansive Soil Areas"EJGE, Volume 17, page Number 1037-1046.

Amu. O, Ogunniyi S.A, and Oladeji, Department of Civil Engineering, Obafemi Awolowo University, Nigeria (2011): "Geotechnical properties of lateritic soil stabilized with sugarcane straw ash" American journal of scientific and industrial research. Pg 323 – 331.

Dang, L. C., Khabbaz, H., & Ni, B. J. (2021). Improving engineering characteristics of expansive soils using industry waste as a sustainable application for reuse of bagasse ash. *Transportation Geotechnics*, *31*, 100637.

Havangi, V.G., Prasad, P.S., Guruvittal, U.K., and Mathur, S. (2006) "Feasibility of utilization of copper slag –fly ash –soil mixes for road construction," Highway Research Bulletin, No.75, pp.59-75.

Hidalgo, F., Saavedra, J., Fernandez, C., & Duran, G. (2020, February). Stabilization of clayey soil for subgrade using rice husk ash (RHA) and sugarcane bagasse ash (SCBA). In *IOP Conference Series: Materials science and engineering* (Vol. 758, No. 1, p. 012041). IOP Publishing.

IS: 2720 (part 10)-1973, "Determination of Unconfined Compression Strength" The Bureau of Indian Standards, New Delhi.

IS: 2720 (part 16)-1979, "Laboratory determination of CBR" The Bureau of Indian Standards, New Delhi.

IS: 2720 (part 3)-1980, "Determination of Specific Gravity, Section-1 Fine grained soil." Bureau of Indian Standards, New Delhi.

IS: 2720 (part 5)-1985, "Determination of Liquid limit and Plastic limit." Bureau of Indian Standards, New Delhi.

IS: 2720 (part 6)-1974, "Determination of water content - Dry density using light compaction." Bureau of Indian Standards, New Delhi.

Lal, D., Kumar, M. J., Kumar, K. N., Sindhu, K., & Kumar, A. (2020). Soil Stabilization Using Bagasse Ash. In *Advances in Geotechnical and Transportation Engineering* (pp. 21-28). Springer, Singapore.

Landa-Ruiz, L., Márquez-Montero, S., Santiago-Hurtado, G., Moreno-Landeros, V., Mendoza-Rangel, J. M., & Baltazar-Zamora, M. A. (2021). Effect of the addition of sugar cane bagasse ash on the compaction properties of a granular material type hydraulic base. *European Journal of Engineering and Technology Research*, *6*(1), 76-79.

Mishra, A.K., Mathur, R. (2004) “Use of Phosphogypsum-An industrial byproduct in stabilization of black cotton soils,” Journal of Highway Research Bulletin, No. 70, pp. 65-75

Mohamed Abdullahi MU’AZU et al (2007): “Evaluation of Plasticity and Particle Size Distribution Characteristics of Bagasse Ash on Cement Treated Lateritic Soil” The Federal University of Technology, Civil Engineering Department, Minna, Nigeria, Leonardo Journal of Sciences, Issue 10, ISSN 1583-0233 pg 137-152.

Mtallib M.O.A and Bankole G.M, (2011): Department of Civil Engineering, Bayero University Kano, Nigeria “The Improvement of the Index Properties and Compaction Characteristics of Lime Stabilized Tropical Lateritic Clays with Rice Husk Ash (RHA) Admixtures. EJGE, Vol.16 Pg 986 – 996.

Singh, S., Chohan, J. S., Kumar, R., & Gupta, P. K. (2021). Stability of compressed earth blocks using sugarcane bagasse ash and wheat straw. *Materials Today: Proceedings*.

Vinod B R, Shobha R, Varun Purad, Anusha T G, Mansi S, Aditya Kumar Jha (2021) “Analysis of Engineering Properties of Expansive Soil Treated with Ferric Chloride and Bagasse Ash”, International Journal of Contemporary Architecture, Vol 8 No.2 (2021), ISSN:2198-7688.