DOI: 10.36297/vw.jei.v4i3.67

VW Engineering International, Volume: 4, Issue: 3, 88-95

Study of the performance of lime and flyash as soil subgrade stabilizing agents

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Received: Nov. 9, 2022
Accepted: Nov. 19, 2022
Published online: Nov. 26, 2022

Abstract: Inefficient soil characteristics are a major problem in engineering projects today. Sometimes the first stage in building is to change the characteristics of inappropriate soil. Early signs of degradation in pavement structures on low soil subgrades include pavement that fails too soon. The potential for clayey soil to exhibit unfavourable engineering features, such as low bearing capacity, high shrinkage and swell characteristics, and high moisture susceptibility, is typically present. It is common practise to stabilize these soils to increase their strength. In order to enhance the engineering performance of soil, a technique called soil stabilization is used to add a binder to the soil. This study details how the addition of both lime and fly ash increased the cohesive soil's strength in the surrounding area. Fly ash has been used to bind non-cohesive soil, granular soil, or soil that is poorly cohesive in place of the typical usage of lime alone in soil that contains clay and is highly cohesive. Fly ash is mostly utilised to support the base course or sub base.

Keywords: California Bearing Ratio , Liquid Limit, Plastic Limit, Dry Density, Moisture Content, Specific Gravity.

1. Introduction

A developing nation like India, which has a sizable population and geographic area, needs an extensive infrastructure, such as a network of highways and structures. The land is being used all over the place for a variety of buildings, from simple homes to skyscrapers, bridges to airports, and from country roads to expressways. Nearly every civil engineering structure is built on a different soil stratum.

Rock fragments, sand, silt, and clay are all components of soil, according to one definition. It is created by the progressive disintegration or breakdown of rocks as a result of natural processes, such as the disintegration of rocks caused by stresses from temperature-related expansion or contraction. Sand, silt, and clay are being formed as a result of weathering and decomposition, which are chemical reactions caused when water, oxygen, and carbon dioxide gradually combine with the minerals within the rock formation. Different soil formations, such as those found in river deltas, sand dunes, and glacial deposits, are created as a result of the transportation of soil components by wind, water, and ice. In the various climatic zones, factors such as temperature, precipitation, and drainage are crucial in the formation of soils. Different soils will develop from the same original rock formation under various drainage regimes.

Alluvial soil, marine soil, laterite and lateritic deposits, expansive soils, sand dunes, and boulder deposits are the six categories into which soils in India are divided. The soil strata at the site must be accepted as they are because man has no control over the process of soil formation; instead, construction must be done in a way that takes into account the subsoil conditions. Because the soil's safe bearing capacity might not be sufficient to maintain the specified load, the current soil at the given location might not be suitable for supporting the needed infrastructure, such as buildings, bridges, dams, and so forth. The Engineers may frequently come across circumstances where the chosen site is deemed unsuitable to support the weight of the intended construction. In these situations, many soil stabilization techniques are used to enhance the ground's qualities. Enhancing the site's soil properties is the primary goal of the soil stabilization. Because there are less and fewer suitable locations for construction, the field of soil stabilization is expanding quickly. Shallow foundations like footings and rafts are typically the most cost-effective option when the soil is good at a shallow depth below the surface of the earth. However, if there is a robust stratum present at a great depth but poor soil near the ground's top, deep foundations like. There is a need for caissons, wells, and piles. Deep foundations are highly expensive and only financially viable when supporting a very large and heavy structure. Even at deeper depths, the soil quality might be quite poor, making it impractical to build even deep foundations. Different soil improvement (stabilization) strategies are used in these situations. The goal is to raise the soil's bearing capacity and reduce settling of the buildings placed on it by improving site qualities that make the soil load-bearing, increasing shear strength, and decreasing compressibility. Sometimes the goal is to lessen the soil's permeability.

The process of enhancing the soil's engineering qualities in order to increase its stability is known as soil stabilization. It is necessary when the construction-ready soil is unfit for the intended use. In its broadest sense, stabilization encompasses a variety of techniques that change the soil material itself in order to enhance its qualities, including compaction, pre-consolidation, drainage, and many more. The natural soil is stabilised by the addition of a cementing substance or chemical.

In order to raise the soil mass's shear strength and decrease its permeability and compressibility in structures, soil stabilization is applied. To strengthen the foundation soils' bearing capability, soil stabilization is necessary. However, the primary function of stabilization is to enhance the natural soils for the development of airfields and roadways. The bases and sub-bases of highways and airports are built using the concepts of soil stabilization. Additionally, soil stabilization is utilised for military and other emergency applications to quickly make a location passable. In order to increase the sound absorption of city and suburban streets, soil stabilization is occasionally used. Although the resources for soil stabilization are practically endless because the entire earth's crust can be used in some capacity, this course of action is not feasible due to other limitations that call for immediate action.

A coal combustion product called fly ash or flue ash, also known as pulverised fuel ash in the UK, is made up of the particulates of boiler of coal plants. Fly ash is typically collected by electrostatic precipitators or other particle filtration equipment in modern coal-fired power plants before the flue gases reach the chimneys. It is referred to as coal ash along with bottom ash taken out of the boiler. However, all fly ash contains sizeable amounts of silicon dioxide (SiO2), both amorphous and crystalline, aluminium oxide (Al2O3), and calcium oxide (CaO), the main mineral compounds in coal-bearing rock strata. The components of fly ash vary significantly depending on the source and composition of the coal being burned.

2. Materials and Methods

The experimental work strategy used to investigate the behaviour of soils stabilised with fly ash and lime is described in depth in this chapter. Through CBR and Unconfined tests, the effects of these parameters on the soil's degree of compaction and shear strength have been assessed. Included in this document are the characteristics of the tested material, a description of the testing apparatus, and the test technique.

Materials:

Lime :

Oxides and hydroxides, frequently calcium oxides and hydroxides, are the major components of lime, a calcium-containing mineral. Lime is a useful tool for enhancing the soil's properties, including its workability and bearing capacity. Additionally, it increases the soil's stability and impartibility, resulting in less downtime and more workspace.

Flyash:

Class C fly ash can be used as a standalone material due to its self-cementitious properties. It is possible to use Class F fly ash in soil stabilisation applications by combining it with a cementitious component (lime, lime kiln dust, CKD, and cement). The self-cementitious activity of fly ashes is measured by ASTM D 5239. In this test, a common method is used to estimate the compressive strength of cubes made of fly ash and water (the water/fly ash weight ratio is 0.35), measured after seven days of usual moist curing. The following is a rating of the self-cementitious characteristics: The results from ASTM D 5239 should be emphasised because they merely describe the cementitious qualities of the fly ash-water blends and do not, by themselves, provide a basis for evaluating the potential interactions between the fly ash and soil or aggregate. Regional environmental rules for leaching and potential interactions with neighbouring streams and ground water may apply to fly ash use for soil stabilisation and alteration.

Soil:

On the boundaries of Baba Ghulam Shah Badshah University jammu India, we took soil samples. In the Geotechnical Engineering lab at the College of Engineering and Technology BGSBU Rajouri, soil prototypes were developed. The numerous preliminary assessments of the strength and index attributes were completed. Every sample was subjected to sieve analysis. By performing a conventional proctors test in line with IS-2720-1980, the soil's characteristics regarding compaction have been identified (IS light compaction). The samples for CBR testing were created with the highest possible dry density and the ideal moisture content (OMC), which was determined using the traditional Proctor test.

Methods:

Standard Proctor Test (IS 2720)

the measurement of the relationship between the density and moisture content of soils compacted with a 2.5 kg rammer dropped from a height of 30 cm. The findings of this test will be useful in improving slope stability, decreasing unwanted volume changes, decreasing undesirable settlement of structures, boosting foundation bearing capacity, and reducing hydraulic conductivity.

California Ratio Test (CBR) (IS 2720-16)

A penetration test called the California Bearing Ratio Test (CBR Test) is used to assess the subgrade toughness of pavements and roadways. The results of these tests are combined with empirical curves to determine the pavement's layer thickness. This method of constructing flexible pavement is the most common.

Direct Shear Test:

Three or four samples from a generally undisturbed soil sample are subjected to the test. A specimen is placed in a shear box with two stacked rings that keep the sample in place; the contact between the two rings is about at the sample's midpoint. The upper ring is drawn laterally while a confining tension is given vertically to the specimen, pulling it until the sample fails or reaches a predetermined strain. Frequent measurements of the load applied and the strain caused are made in order to create a stress-strain curve for each confining stress. To calculate the shear strength parameters, soil cohesion (c), and the angle of internal friction, often known as the friction angle several specimens are examined at various confining loads

3. Results

3.1 Standard Proctor Test

The maximum dry density is at 2.5% fly ash by mass of soil. The dry density decreases to 1.135%, 1.44% at 5% and 7.5% fly ash by mass of soil.

Table 1. Standard Proctor Test for simple soil

STANDARD PROCTOR TEST OF SIMPLE SOIL As per IS-2720(Part-5)				
VOL. OF MOULD (V) = 3418 cc				
Determination	1	2	3	4
Weight of Empty mould (W1) kg	6.352	6.352	6.352	6.352
Weight of mould + compacted soil (W2) kg	10.65	10.83	10.67	10.68
Weight of compacted soil = (W2 - W1) kg	4.298	4.482	4.318	4.336
Bulk Density, = M/V = (W2-W1)/ V	1.25	1.311	1.263	1.268
Water Content (w%)	8	11	14	17
Dry density = ρ/(1+w)	1.15	1.18	1.107	1.08
RESULTS				
Optimum water Content (%) =	11			
Maimum. Dry density (g/cc) =	1.18			

The variation in dry density with percentage in fly ash (keeping lime constant at 5%) is shown in Figure 1 below.

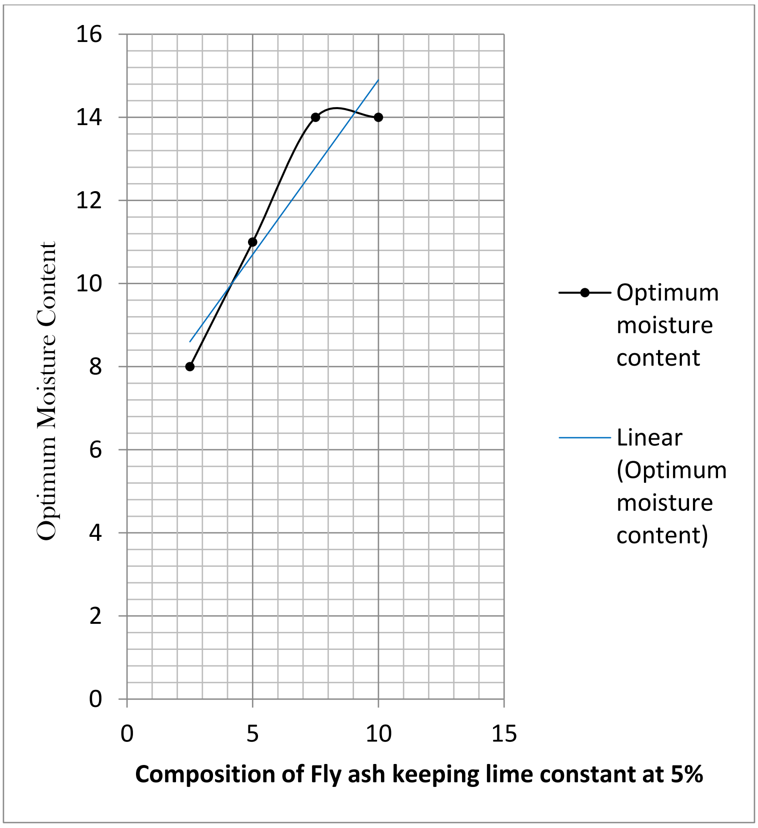

Figure 1. Variation of Fly ash keeping lime constant at 5 % vs Optimum moisture content

3.2. The maximum value of California Ratio is at 2. 5% of Fly ash keeping Lime constant at 5% by Mass of soil. The California Bearing Ratio decreases with variation in Fly ash from 2.5-10%. The maximum value 460 is observed at 2.5 % of Fly ash by weight.

C. BEARING RATIO TEST OF SIMPLE SOIL(Un-soaked condition) As per IS-2720(Part-16)		
PENETRATION (mm)	PROVING RING READING	LOAD (Kgf)
0.5	1.1	70.4
1.0	1.8	236.88
1.5	2.3	459.08
2.0	2.8	747.6
2.5	3.1	1035.09
3.0	3.3	1323.96
3.5	3.6	1689.12
4.0	3.9	2094.3
4.5	4	2424.8
5.0	4.1	2762.17
RESULTS		
CBearing at 2.5 (%) : 75.5		
C Bearingat 5 mm (%) :130.03		
Reported CBR (%) : 130.03		

Table 2 : CBR Test for Simple Soil (Unsoaked Condition)

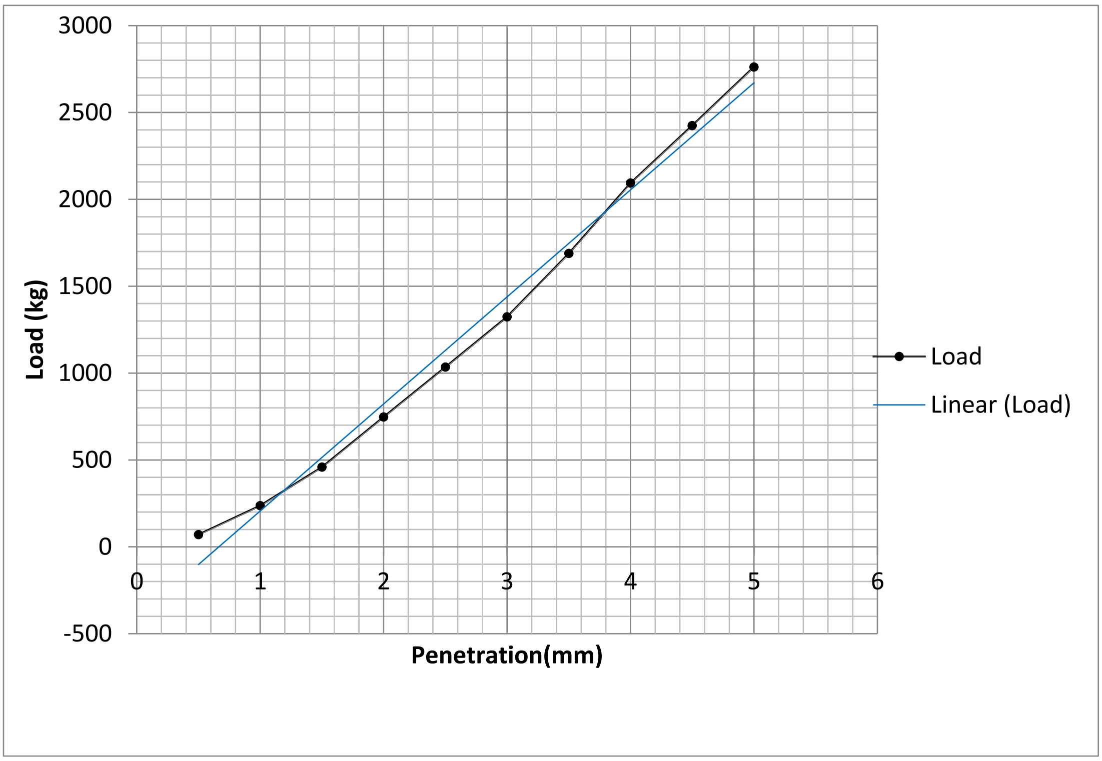

Fig 2: Load Penetration Curve for CBR (Unsoaked Condition)

Table 3: CBR Test for Simple Soil (Soaked Condition)

CALIFORNIA BEARING RATIO TEST OF SIMPLE SOAKED SOIL As per IS-2720(Part-16)		
PENETRATION (mm)	PROVING RING READING	LOAD (Kgf)
0.5	0	0
1.0	0.1	13.16
1.5	0.15	29.94
2.0	0.17	45.407
2.5	0.2	66.76
3.0	0.22	88.264
3.5	0.24	112.60
4.0	0.29	115.93
4.5	0.3	181.86
5.0	0.3	202.11
RESULTS		
CBearing at 2.5 (%) : 4.8		
CBearing at 5 (%) : 9.8		
Reported CBR (%) : 9.8		

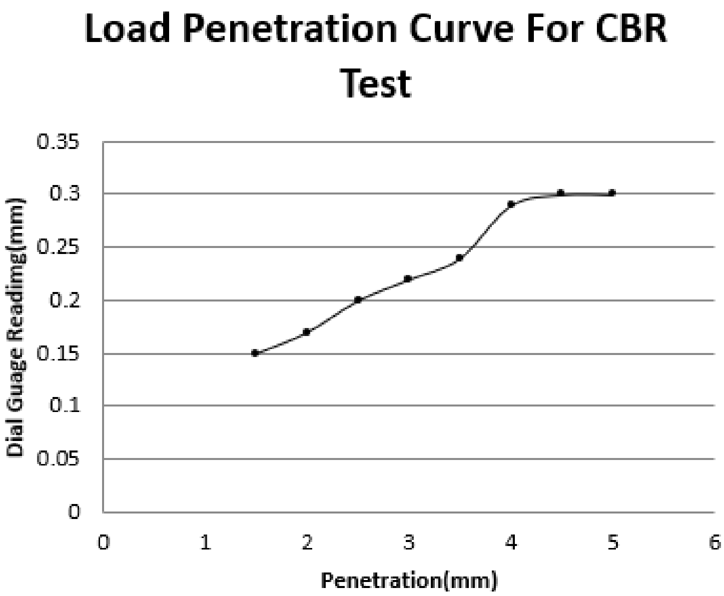

Fig 3 : Load Penetration Curve For CBR Test (UnSoaked)

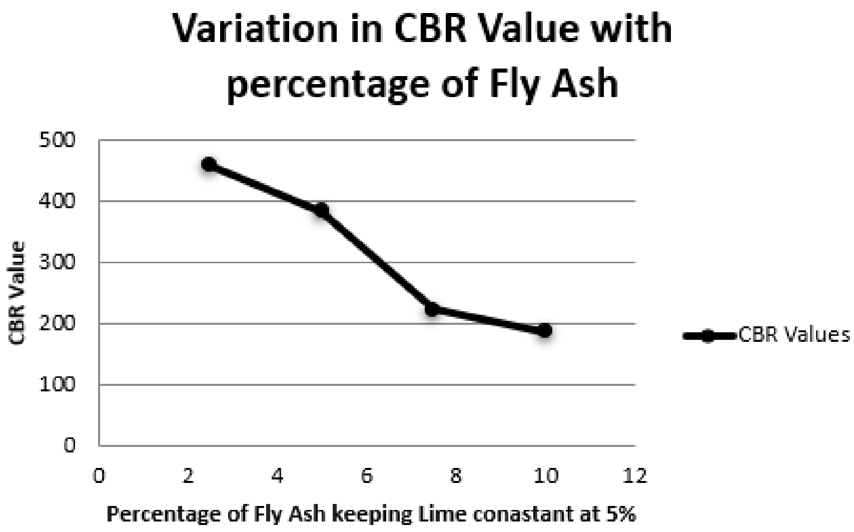

Fig 4: Variation of CBR value with Fly ash in %age

3.3 Direct Shear Test:

The maximum value of Direct Shear test is at 5% Fly Ash by weight of soil keeping lime constant at 5%. The shear stress varies from 3-18 Kg/cm^2 at 0.5 kg maximum at 5% Fly ash. The maximum value will be 18 Kg/cm^2. 1 kg varies with 45-70 Kg/cm^2 with a maximum value of 70.Hence the maximum value of shear stress is at 5% lime and 5% Fly ash

4. Conclusion

The current study can be expanded to take into account different lime and flyash quantities as well as other admixtures. Field tests can be conducted to obtain more useful results. In order to establish the effectiveness of lime and flyash as a general or all-purpose soil stabilizer, it is important to examine their effects on various types of soils as well. It is observed that the maximum dry. density decreased from 1.18 g/cc to 1.85g/cc on Addition of 2.5% FlyAsh &5% Lime. The California Bearing value increased from 130.03 to 458 on addition of 2.5% FlyAsh &5% Lime. The maximum value of Direct Shear test is at 5% Fly Ash by weight of soil keeping lime constant at 5%. Thus the Local Materials Lime and Flyash is a satisfactory stabilizing agent for clayey soils

5. References

1. N.Krithiga, D.Pujitha. Palayam, and A. Revathy (2017) "Soil Stabilization Using Lime and Fly Ash "ICRTCETM 2017.

2. Neeraj Kumar Sharma, S.K Swain, Umesh C. Sahoo, "Stabilization of soil using Lime and Fly Ash: A Micro Level Investigation", Received: 17 November 2011 / Accepted: 11 June 2012 © Springer Science+Business Media B.V. 2012.

3. Sai Harshita "Soil stabilization using lime", IJRASET, June 2018.

4. Pratik Somaiya, Yashwant Zala, Rushikesh Dangar, "Stabilization Of Expansive Soil Using Fly Ash" Researchgate (2013).

5. Jawad, I. T., Taha, M. R., Majeed, Z. H., & Khan, T. A. (2014). Soil stabilization using lime: Advantages, disadvantages and proposing a potential alternative. Research Journal of Applied Sciences, Engineering and Technology, 8(4), 510-520.

6. Jaleel,Z.T.(2011), Effect of Soaking on the CBR-Value of Sub base

7. Arasan S (2005) Investigation of the effect of cement, lime, silica fume and fly ash on swelling pressure and cation exchange capacity of fine grained soils, MS Thesis, Ataturk University, Erzurum, Turkey

8. Bell FG (1976) The influence of the mineral content of clays on their stabilization by cement. Bull Assoc Eng Geol 13(4): 267–278

9. Bhatty JI, Miller FM (2004) Application of thermal analysis in cement manufacturing. Innov Portl Cem Manuf 8(4): 1037–1067

10. Bhuvaneshwari S, Robinson RG, Gandhi SR (2005) Stabiliza- tion of expansive soils using fly ash. Fly Ash Utilization Programme, (FAUP), Technology Information Forecasting & Assessment Council (TIFAC), Department of Science and Technology (DST), New Delhi, India

11. Brooks MR (2009) Soil stabilization with fly ash and rice husk ash. Int J Res Rev Appl Sci 1(3):209–21

12. Chen FH (1975) Foundations on expansive soils. Elsevier Scientific Publishing Company, New York, p 280

13. Christopher BR, Schwartz C, Boudreau R (2006) Geotechnical aspects of pavements. U.S. Department of Transportation Publication No. FHWA NHI-05-037

14. Geiman, C.M., 2005. Stabilization of soft clay subgrades in Virginia phase I laboratory study. M.A. Thesis, Virginia Polytechnic Institute and State University.

15. George, S., D. Ponniah and J. Little, 1992. Effect of temperature on lime-soil stabilization. Constr. Build. Mater., 6(4): 247-252.

16. Hampton, M.B. and T.B. Edil, 1998. Strength Gain of Organic Ground with Cement-type Binders. Geotechnical Special Technical Publication No. 81, Soil lmprovement for Big Digs, pp: 135-148.

17. Harrison, A.J.W., 2008. Reactive magnesium oxide cements. Patent US 7347896 B2. Hilt, G.H. and D. Davidson, 1960. Lime fixation in clayey soils. Highway Res. Board Bull., 262: 20-32. Holtz, W., 1969. Volume change in expansive clay soils and control by lime treatment. Proceeding of 2nd International Research and Engineering Conference on Expansive Clay Soils, pp: 157-174