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Research paper

Experimental investigation of soil blended with lime and lignosulphonate

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Abstract

The deterioration of the structures which are built on the expansive soils is due to its volume change behavior, due to the presence of Mont-morillonite minerals in soil. Hence this soil requires adequate stabilization before commencement of any construction activities. The stabili-zation phenomenon in which addition suitable additives completely alters the behavior of the soil by changing the basic prop-erties and there-by increasing the bearing strength of soil. The choice of the additives depends on the ease and permanence of the stabiliz-ing characteristics achieved for the expansive soil. In this paper, an attempt is done to evaluate the behavior of soil when blended with additives like saw dust ash, lime and lignosulphonate at varying blending ratio. The objective of the research work is to focus on the change in the plasticity charac-teristics by utilizing the industrial waste as additive due to its cementitious value, making it eco-friendly and reduction in cost. Lignosulpho-nate is a by-product of paper pulp industry, generated during the sulphite process. From the literature, the optimum percentage for stabilizing works for lime and lignosulphonate was found to be two to eight percent and one to three percent respectively. Basic Index properties and compaction characteristics test were determined for both virgin and treated soil. The additives decreased the plasticity index, causing ag-glomeration of clay particles involving pozzolanic reaction.

Keywords: *Expansive Soil; Lignosulphonate; Lime; Montmorillonite; Pozzolanic.*

1. Introduction

An expansive soil which expands when it comes in contact with water becomes more problematic in the construction sites. The presence of tree adjacent to a foundation located in clay soil subjects the foundation to undue stresses due absorption of subsoil moisture, resulting in shrinkage of the soil underneath the foundation. Cracking of a wall is caused by uplift of the expanding clay. It poses major foundation problems, causing damage to the super structure if proper precautions are not taken. A type of damage common to light weight buildings on shallow foundation is caused by tilting of footings and walls.

Due to the expanding lattice structure of soil, loss of strength and settlement cracks are encountered in the structure. The expansive nature depends upon the type, amount of clay minerals and exchangeable bases. Presence of Montmorillonite mineral in the soil exhibits more swell-shrink behavior. Hence these soils are to be stabilized in order to eliminate the problems concerned with strength loss and volume change.

Soil stabilization techniques by the addition of suitable additives are usually adopted for modifying the index and engineering properties of the soil for the intended use. The industrial waste such as saw dust, tannery waste, quarry dust, fly ash, rice husk ash and chemical products like Xanthum gum, lime, MgOH, Ground granulated blast furnace slag, cement are some of the additives which are at research level and practical usage as well. These products create changes in structure of soil and induce the pozzolanic reaction resulting in increased strength.

Various tests can be conducted to study the changes of expansive soil on addition of additives such as Atterberg limit, swell potential, swell pressure, shear strength, permeability test, standard proctor test, and CBR test. In this study an attempt is made to counter the problems related to expansive soil by addition of binders such as lime and lignosulphonate. The basic properties of the soil have been studied and soils with additives were tested for Atterberg limit, and compaction test.

The objectives of this study are to compare the behavior of lime and lignosulphonate amended expansive soil based on the changes in the plasticity and compaction characteristics.

2. Testing program and methods

Two additives namely Lime of 2%, 4% and 8% and Lignosulphonate of 1%, 2%, 3 % by weight are added to the virgin soil. Atterberg's limits and Mini compaction test are carried out on the treated and untreated soil.

2.1. Study area

The virgin soil used for the testing was taken from Siruseri, Chennai, Tamil Nadu (12.835^{0}N, 80.20^{0}E).For the experimental study, the soil was air dried, pulverized and crushed and sieved through 1 mm IS sieve. Free swell test has been carried to ascertain whether the soil belongs to expansive soil group.The basic index properties based on the Atterberg's limits were determined as per IS 2720: Part 5-1985. The index properties of the soil are given in Table 1. Grain size analysis was carried out by hydrometer analysis as per IS 2720: Part 4-1985. Based on these physical properties, the soil is classified as CH as per Indian Standard classification system.

Table 1: Index Properties of Virgin Soil

Soil Properties	Values
Atterberg limit	77
a) Liquid Limit (%)	25
b) Plastic Limit (%)	9
c) Shrinkage Limit (%)	
Grain distribution	
Clay (%)	66
Silt (%)	33
Sand (%)	0
Compaction test characteristics	14.1
Maximum dry unit weight (kN/m^3)	28
Optimum moisture content (%)	
Differential free swell (%)	100

2.2. Lime and lignosulphonate

Different forms of Lime available are quicklime, hydrated lime or lime slurry is used to treat the soil. Lime is collected from the local market which has high calcium lime with MgO not more than 5% is choosen as an additive. Commercially available calcium lignosulphonate is used for the present study. Fig.1 shows the physical form of lime and lignosulphonate. Table. 2 gives the properties of calcium lignosulphonate

(A) (B)

Fig. 1: (A) Lime and (B) Lignosulphonate.

2.3. Free swell test

Free swell test as per IS:2720 (Part 40) -1977 is recommended to identify the potential of a soil to swell. 10 g of 425 micron sieved soil was taken in glass graduated cylinders in which one was filled with kerosene (non-polar liquid) and other was filled with distilled water upto 100ml (Fig.2). By stirring, air voids were removed and allowed to be in equilibrium position for 24 hours. The final volumes of soils in each of the cylinder were noted.

Table 2: Composition of Calcium Lignosulphonate

Name	Description
Appearance	Yellow brown powder
P_H value	5 to 7
Dry matters	95% min
Water insoluble	2.50%
Sulphate	2% min
Total Calcium magnesium (sulfate)	5% - 6%
Lignosulphonate	50% min
Sugar	10 - 12%
Reducing sugar	7% around
Ash	18% - 21%
Bulk Density (kg/m$^{3)}$	205
Moisture	7%

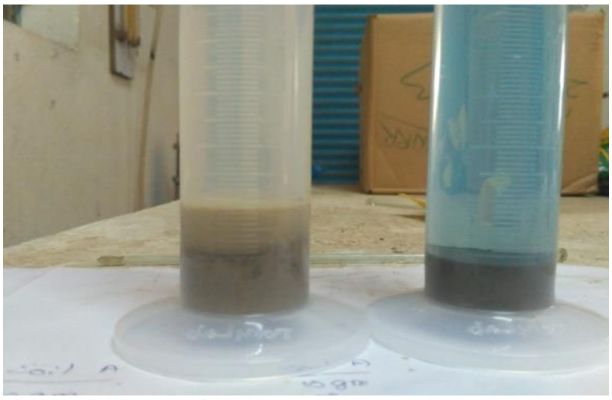

Fig. 2: Free Swell Test of Siruseri Soil with Distilled Water and Kerosene

2.4. Atterberg limits

2.4.1. Liquid limit

120 g of 425- micron sieved soil is mixed with water to form a paste with good consistency. Clayey soil was left with water for 24 hours for uniform mix (Fig.3). Casagrande Apparatus is used to determine the Liquid limit

2.4.2. Plastic limit

The soil specimen passing through 425-micron sieve is mixed with water such that the soil mass becomes plastic enough to be moulded with fingers of 3mm diameter (Fig.3). The thread formed is kept in oven for 24 hours to find the plastic limit.

2.4.3. Shrinkage limit

The saturated soil is allowed to dry up gradually, its volume goes on reducing. The dried specimen is subjected to mercury displacement method and the readings were taken in form of weight and volume (Fig.3). Table.2Composition of Calcium Lignosulphonate

Fig. 3: Atterberg's Limit Determination.

2.5. Mini compaction test

To obtain the OMC-γ_{dmax}, Sridharan (2005) has carried out mini compaction test as per the procedure. A brass mould of 3.8 cm diameter and 9 cm height was compacted with soil in three layers with 36 blows each. The hammer weight of 2.5 kg and free fall of 19.1 cm were used. 200 g of raw soil and blended soil was taken for the test to be conducted.

Fig. 4: Mini Compaction Apparatus for the Compaction Characteristics.

3. Results and discussion

3.1. Free swell test

The test is done as per IS: 2720 (Part 40) -1977. It was found that raw soil from Siruseri has FSI of 100%. Lime treated soil reduces the swell percentage of the soil form 100% to 70 % for 4%lime. However, the effect of lignosulphonate is not much pronounced. The various percentage of swell capacity of soil blended with additives were shown in Table 3.

Table 3: Free Swell Percentage of Soil Blended with Additives

Soil type	Free swell Percentage (Swelling capacity (%))
Raw soil	109
Soil + 2% Lime	80
Soil + 4% Lime	70
Soil + 8% Lime	65
Soil+1% lignosulphonate	90
Soil+1.5% Lignosulpho-nate	90
Soil+3% Lignosulphonate	85

3.2. Atterberg's Limit

IS 2720 (Part-5) (Part-6) is used to determine the Liquid, Plastic and Shrinkage limit. The oven dried soil sieved on 425 micron sieve is taken for testing. Table.4 gives the liquid, plastic and shrinkage limits of various blended soil and raw soil. As expected the lime treated soil shows considerable reduction in liquid limit compared to lignosulphonate treated soils. Both the additives show reduction in LL but lime treated soils shows more promising results, (Fig.5). Similarly, the plastic limit and shrinkage limit values given in Table. 4, shows considerable increase in the values due to the formation of cementation bonds in lime treated soil compared to lignosulphonate treated soil. The additives reduce the plasticity of the soil as indicated by the reduction in plasticity index of the soil (Table. 4).

Table 4: LL, PL and SL of Soil Blended with Additives

SAMPLE DESIGNATION	LL	PL	SL
Raw Soil	77	25	9.5
Soil + 2% Lime	55	35	10.5
Soil + 4% Lime	46	40	36
Soil + 8% Lime	44	NA	6
Soil + 1% Lignosulphonate	60	25	-
Soil + 1.5 % Lignosulphonate	58	20	35
Soil + 3 %Lignosulphonate	59	23	38

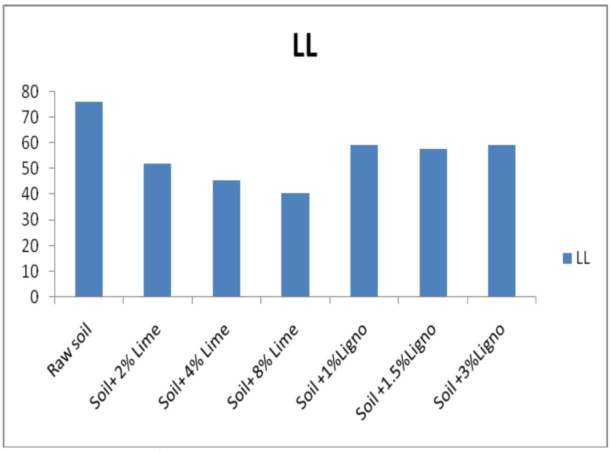

Fig. 5: Variation of Liquid limit with lime and lignosulphonate Treated Soils.

3.3. Mini compaction test

The maximum dry density and optimum moisture content was arrived using mini compaction test. Higher the percentage of additives, lesser the maximum dry density and higher the optimum moisture content. Increase in plasticity increases maximum dry unit weight. The optimum moisture content for virgin soil is 21% and $\gamma_{dmax}$is 15 kN/m^3. Lime addition reduces the maximum dry density and increases the optimum water content. The lignosulphonate treatment do not cause much changes. The details of the Omc and $\gamma_{dmax}$is given in Table.5

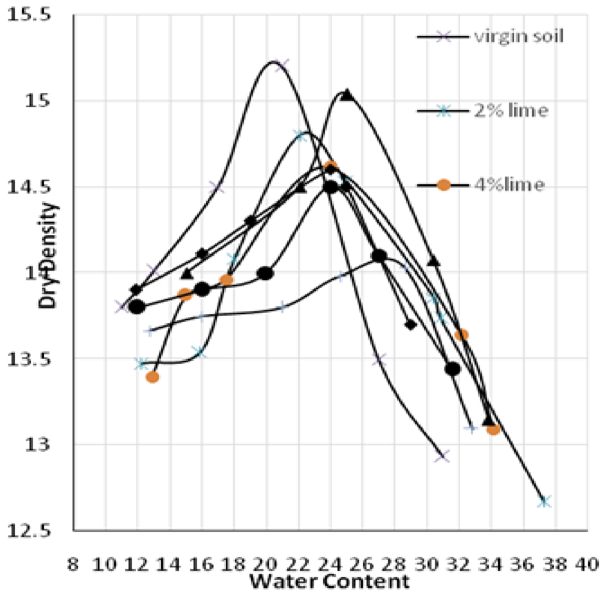

Table.5: Details of OMC and γDMAX for Treated and Untreated Soil

Soil Type	γdmax(kN/m^3)	OMC(optimum moisture content)
Virgin soil	15.2	21
Soil + 2% Lime	14.79	22
Soil + 4% Lime	14.6	24
Soil + 8% Lime	14	29
Soil+1% Lignosulpho-nate	15	25
Soil + 1.5 % Lignosul-phonate	14.6	24
Soil + 3 % Lignosulpho-nate	14.5	24

4. Conclusion

As per the tests conducted based on IS 2720, the results are concluded as,

1) Lime and lignosulphonate treated soils reduces the plasticity of the virgin soils. Lime treated soil shows results that are more promising compared to lignosulphonate.
2) The lime treatment alters the compaction characteristics of the expansive soil, the OMC of the soil is increased and γdmaxis decreased comparatively.

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