STABILIZATION OF EXPANSIVE SOIL BY USING LIME AND REINFORCEMENT WITH GEO-TEXTILE

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Abstract. Expansive soils are those soil which have high rate of swelling. Hence the improvement of the soil properties has to be done. In this study, we are using of lime and geo synthetic material for stabilization of soil. Lime is an efficacious product to be mixed with fine grained soils with high plasticity and it improves certain properties of soil due to its chemical action. Stabilization of expansive soil with geo-textile will increase the stiffness and load bearing capacity of the soil through frictional interaction between the soil and geo-textile material. The lime is mixed in different percentages and reinforced with geo-textile by placing at certain depth with in sample height of four layers. In conclusion it shows an improvement of strength is in terms of CBR and peak load.

1. Introduction

Soil has been using as the construction material for roads, buildings, irrigation structures, etc. due to some of the weakness in its strength and mechanical properties it has to be improved (according to the requirement). In Andhra Pradesh, black cotton soil (BC soil) is covered in large area. BC soil is very hard in dry condition and lose its strength in wet condition. It has the properties to absorb more water and high in swelling. The BC soil is not suitable for the construction works because of its volumetric changes when they get in contact with water. Therefore, the BC soil stabilization is been done in the paper by using lime and geo-textile.

Soil stabilization is a method used to improve the engineering properties of a soil to make it useful for the intended purpose. It is done by blending and mixing material into soil to achieve a desired gradation or the mixing of commercially available additives that may alter the gradation, texture or plasticity, or act as a binder for cementation of the soil. The commonly used soil stabilizations are,

a) Cement stabilization
b) Lime stabilization
c) Bituminous stabilization
d) Chemical stabilization

Lime stabilization is performed by mixing lime to the soil and useful the clayey soils. The basic types of lime are

a) High calcium, quick lime, CaO
b) Hydrated, high calcium lime, Ca(OH)2
c) Dolomitic lime (CaO + MgO)

d) Normal, hydrated dolomitic lime \{\text{Ca(OH)}_2 + \text{MgO}\}

e) Pressure, hydrated dolomitic lime \{\text{Ca(OH)}_2 + \text{MgO2}\}

The main benefits of using lime stabilization is it improves the workability, strength, and stability. Workability is improved due to the flocculation makes the clay more friable, this assists combination for effective mixing and compaction. Lime increases the optimum water content for compaction, which is an advantage when dealing with wet soil. The compaction curve for lime treated clay is generally flatter, which makes moisture control less critical and reduces the variability of the density produced.

The geosynthetics are geo-textiles(woven & nonwoven), geogrids, geomembranes, erosion control blankets and materials, geosynthetic clay liners, geo-composite drainage materials and geonets. The major functions of geosynthetic materials are separation, filtration, reinforcement, drainage, and acting as a liquid barrier. The effectiveness of use of nonwoven geo-textiles as reinforcement material for stabilization of soil for different engineering works. Nonwoven Geo-textiles are planar polymeric materials that have been extensively used for separation, filtration, drainage and reinforcement. The effect of Lime and geo-textile on the properties of the soil. Their main objectives was to determine the properties of the soil before and after the addition of lime and geo-textile to it. The different tests they conducted were natural moisture content determination, specific gravity, Atterberg’s limits, Compaction test, unconfined Compressive Strength test and CBR test. After studying and conducting the entire above test, the optimum lime content was found and they concluded that there was a substantial increase in the CBR and peak load.

2. Materials and Experimental Work

Soil: The disturbed expansive soil was collected from mandhadam near velagapudi region at a depth of 1.5m. The collected soil is dried and pulverized for conducting physical properties tests as per the required sieve sizes of a test. These tests are conducted as per the ASTM; Physical properties are shown in table 1

| S.no | properties                         | observations |
|------|-----------------------------------|--------------|
| 1    | IS classification                 | CH           |
| 2    | Free Swell index (%)              | 60           |
| 3    | pH                                | 7.5          |
| 4    | Liquid limit (%)                  | 69           |
| 5    | Plastic limit (%)                 | 43           |
| 6    | Plasticity index (%)              | 26           |
| 7    | Optimum moisture content (%)      | 28           |
| 8    | Dry unit weight(gm/cc)            | 1.42         |
| 9    | Specific gravity                  | 2.56         |
**Lime**: Lime is from saraswathi chemicals Ltd. Guntur. It is manufactured by heating lime stone, sea shella etc. Which are mainly using in the method of soil stabilization. It is mainly increase strength and reduces the swell or shrink property. But further additions may decreases the plasticity of soil and excessive lime treatment contributes to brittle failure characteristic of soils that lead to rapid and great loss in strength when failure occurs.

![Fig. 1 Lime](image1)

Properties of lime are listed in table 2.

*Table 2: Basic properties of lime*

| S.no | Properties       | Observations |
|------|------------------|--------------|
| 1    | Physical appearance | Dry powder   |
| 2    | color            | white        |
| 3    | Specific gravity | 2.44         |

**Geo-textile**

The geo-textile used in this study was a medium-weight, nonwoven, spun-bond, and needle punched geotextile. The nonwoven geo-textile was procured from a local market and is available in form of rolls as shown in fig 2. The properties of geo-textile were evaluated in a laboratory and are presented in table 3.

![Fig: 2 nonwoven geo-textile](image2)

*Table 3: Properties of geo-textile*

| S.no | properties       | observation |
|------|------------------|-------------|
| 1    | Type             | Nonwoven    |
| 2    | Color            | white       |
| 3    | Thickness(mm)    | 1.6         |
Influence of lime on the geotechnical characteristics of expansive soil was investigating standard proctor tests, California bearing ratio test and unconfined compression tests. In this study evaluate the effectiveness of different percentages of lime. The results are presented as graphical plots and tables.

Table 4. compaction, CBR and UCS values at different percentages of lime

| Soil sample % + lime % | OMC (%) | MDD (%) | CBR (%) | UCS (%) |
|------------------------|---------|---------|---------|---------|
| 100% soil sample       | 28      | 1.415   | 2.02    | 129.55  |
| 96% soil sample + 4% lime | 27.5   | 1.445   | 7.278   | 301.13  |
| 94% soil sample + 6% lime | 19.54  | 1.50    | 12.5    | 602.43  |
| 92% soil sample + 8% lime | 21.42  | 1.44    | 20.2    | 740.07  |
| 90% soil sample + 10% lime | 23.809 | 1.449   | 9.30    | 418.18  |

Compaction characteristics: The tests were performed as per Indian standard specifications for standard proctor compaction tests. Light compaction tests were carried out on the soil-lime mixtures. The compaction tests were performed for various combinations of lime. OMC is decreases and maximum dry density increases with increasing of percentage of lime content in soil. Variation of OMC and MDD shown in graph 1&2

Graph: I varying of optimum moisture content with various percentage of lime
2.3: California bearing ratio test

CBR test conducted as per the IS2720 part16, for lime blended soil specimens with different percentages. Test specimen is prepared by mixing of lime in different percentages by the dry weight of soil and lime was mixed thoroughly with equivalent dry unit weight and optimum moisture content which is obtained from proctor test. Mixed soil sample is placed in five layers in CBR mould having dimensions of 150mm diameter and 175mm height and compacted each layer with a hammer of weight 25.5N in weight falling from a height of 310mm in 56 blows. The prepared soil sample is soaked for four days. After soaking condition conducting CBR test. Variation of CBR values at different percentages of lime as shown in fig 3
**Fig. 3.** Experimental set up for conducting California bearing ratio test

**Graph: 4 Comparison of load penetration curves for lime blended soil specimen.**

**CBR test conducting on single and multiple layer reinforcement**

CBR test conducted with 8% lime blended soil specimens then by placing geo-textile at single and multiple layers. In single layer reinforcement placed at 3cm depth from top of the mould. The load influence is up to 3cm only. In multiple layer reinforcement four layers (each 3cm) of geo-textile will be placed up to 12cm in the mould.

**California Bearing Ratio (CBR) on Black cotton soil with 8% Lime and Geotextile @ single layer**
Table 5: CBR values at single layer reinforcement

| S.NO | Soil sample + lime (%) | Depth (cm) | CBR(%) |
|------|-------------------------|------------|--------|
| 1    | 92% soil sample + 8% lime | 0          | 20.2   |
| 2    | 92% soil sample + 8% lime | 2.5        | 16.175 |
| 3    | 92% soil sample + 8% lime | 3          | 22.645 |
| 4    | 92% soil sample + 8% lime | 6          | 17.38  |

Grap.: 5 Comparison of load penetration curves for 8% lime and geo-textile placed at single layer

California Bearing Ratio (CBR) on Black cotton soil with 8% Lime and Geotextile @ multiple layer.

Table 6: CBR values at multiple layer reinforcement

| S.NO | NO. OF LAYERS OF GEOTEX TILE | % SOIL SAMPLE+ % LIME | DEPTH (cm) | CBR(%) |
|------|------------------------------|------------------------|------------|--------|
| 1    | 0                            | 92% soil sample+8% lime | 0          | 20.2   |
| 2    | 1                            | 92% soil sample+8% lime | 3          | 22.645 |
| 3    | 2                            | 92% soil sample+8% lime | 3 & 6      | 25.475 |
| 4    | 3                            | 92% soil sample+8% lime | 3, 6 & 9   | 30.32  |
| 5    | 4                            | 92% soil sample+8% lime | 3, 6, 9 & 12 | 32.35 |
Graph: Comparison of load penetration curves for 8% lime and geo-textile placed at multiple layers

**Peak load values at various depths in multiple layers:** CBR test conducted with 8% lime blended soil specimens then by placing geo-textile at multiple layers. In multiple layer reinforcement four layers (each 3cm) of geo-textile will be placed up to 12cm in the mould. Peak load will be calculated by using CBR test.

**Table.7 Peak load values at multiple layer reinforcement**

| s.no | No. of layers of geotextile | % soil sample+% lime | depth (cm) | peak load (kpa) |
|------|-----------------------------|----------------------|------------|-----------------|
| 1    | 0                           | 92% soil sample+8% lime | 0          | 129.55          |
| 2    | 1                           | 92% soil sample+8% lime | 3          | 5531.87         |
| 3    | 2                           | 92% soil sample+8% lime | 3, 6       | 6499.94         |
| 4    | 3                           | 92% soil sample+8% lime | 3, 6 & 9  | 6555.26         |
| 5    | 4                           | 92% soil sample+8% lime | 3, 6, 9 & 12 | 6776.54  |
2.4 Unconfined compression strength test

Unconfined compression tests is performed the comparison of soil improvement by adding of different percentages of lime. As per the IS code 2720 part 6 unconfined compression strength test have been conducted. At maximum dry density and optimum moisture content soil specimens were prepared with dimensions of 36mm diameter, 76mm height and the specimens those are prepared by soil-lime samples for curing period 3days in a tightly covered plastic bags then testing is conducted.

Graph: 7 Comparison of stress-strain curves for 8% lime and geo-textile placed at multiple layers

3. Results and Discussions

CBR values increased 2.02% to 20.2% and unconfined compression strength values increased 129.55kpa to 740.07kpa with only lime up to 8%. At 10% lime CBR and UCS value decreases. But with lime and reinforced nonwoven geo-textile specimens results in much greater improvement in soil strength. In 8% lime content, non-woven geo-textile placed as single and multiple layers. Single layer...
reinforcement at 3cm depth from top of the mould gives highest CBR value 22.645%. Four layers of 3, 6, 9 & 12cm depth gives the highest CBR value 32.35% and peak load value 6776.54%.

Graph: 9 CBR values at different percentages of lime

Graph: 10 UCS values at different percentages of lime

Graph: 11 CBR values at various depths in single layer
Conclusions and Future Scope:
In this project work, it has been found that
1. The amount of lime increases there is apparent increase in maximum dry density and in optimum moisture content.
2. The optimum lime content is 8%.
3. There is significant increase in UCS values.
4. At 8% lime, number of layers of geotextile increased to increase the CBR value and peak load. There is substantial scope for carrying our further work in this area as the various types of geo-synthetic materials use.

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