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Paper Authors

Nelapudi Sonia, Dr. Ch.Bhavannarayana

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A STUDY ON STRENGTH PROPERTIES OF EXPANSIVE SOIL TREATED WITH WASTE PAPER SLUDGE ASH AND FERRIC CHLORIDE

Nelapudi Sonia*, Dr. Ch.Bhavannarayana **

*PG Scholar ,Kakinada Institute of Engineering and Technology - II, Korangi, Kakinada
** Professor & HOD, Kakinada Institute of Engineering and Technology - II, Korangi, Kakinada

ABSTRACT: *Expansive soils have problems to civil engineers in general and to geotechnical engineers in particular. In India, expansive soils popularly known as black cotton soils are highly problematic, as they swell on absorption of water and shrink on evaporation thereof. Because of this alternate swell and shrinkage, distress is caused to the foundations of structures laid on such soils. A methodical process, involving experimentation in the laboratory under controlled conditions is done. It is observed form the laboratory studies that maximum improvement in the properties of Expansive soils for Waste paper sludge ash treatment with Ferric Chloride tried in this investigation. A methodical process, involving experimentation on Atterberg limits(liquid limit, plastic limit), Differential free swell, Sieve analysis, specific gravity, Proctor compaction test, California Bearing Ratio(CBR), Unconfined Compressive Strength(UCS) tests were conducted by adding 0.5%, 1%, 1.5% & 2% of Ferric chloride to the expansive soil by dry weight under controlled conditions in the laboratory. It is observed from the laboratory studies that maximum reduction in properties is observed for stone dust treatment with Ferric Chloride. Waste paper sludge ash obtained from the paper mill in Rajahmundry in the stabilization of expansive soil. Different tests like DFS, Atterberg's limits, Dry Density, OMC and CBR are carried out with varying percentage of waste to check the effect on the basic properties of the soil. Based on the laboratory experimentation it is found that the addition of vitrified tiles waste to the sub grade expansive soils shows considerable improvement in the properties of the soil. Ferric chloride is an orange to brown-black solid. Ferric chloride is completely soluble in water. It is non-combustible and corrosive in nature.The percentages of Waste paper sludge ash by dry weight of soil was taken as 5%, 10%, 15% and 20%. The first series of compaction, CBR and UCS tests were conducted on the Expansive soil and the same tests were conducted in the second series on soil samples mixed with stone dust and similarly tests were conducted in the third series on soil samples mixed with waste paper sludge ash and ferric chloride. Laboratory experiments favorably suggest that mixing Waste paper sludge ash and ferric chloride with soil would be effective in improving soil properties.*

Key words: Waste paper sludge ash, ferric chloride,

1. INTRODUCTION

1.1 Expansive soils:

Expansive soil is one among the problematic soils that has a high potential for shrinking or swelling due to change of moisture content. Expansive soils can be found on almost all the continents on the Earth. Destructive results caused by this type of soils have been reported in many countries. In India, large tracts are covered by expansive soils known as black cotton soils. The major area of their occurrence is the south Vindhyachal range covering almost the entire Deccan Plateau. These soils cover an area of about 200,000 square miles and thus form about 20% of the total area of India. The primary problem that arises with regard to expansive soils is that deformations are significantly greater than the elastic deformations and they cannot be predicted by the classical elastic or plastic theory. Movement is usually in an uneven pattern and of such a magnitude to cause extensive damage to the structures resting on them.

In India, the area covered by expansive soil is nearly 20% of the total area. The expansive soils normally spread over a depth of 2 to 20m. In rainy season, they undergo heave and lose weight. In summer, they shrink and gain density and become hard. This alternate swelling and shrinkage damage the structures severely. This is more severe for the light structures.

During summer, polygonal cracks are appear at the surface, which may extend to a depth of about 2m indicating the active zone in which volume change occurs. The depth of active zone defined as the thickness of the soil below the ground surface

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within which moisture content variations and hence volume changes do take place. Sustained efforts are being made all over the world on highway research field to evolve more promising treatment methods for proper design and construction of pavements running over expansive soil sub grade.

1.2 Characterization of Expansive Soils

Field Identifications:

- Color: May be black, grey, yellow grey.
- During summers, side and deep map type cracking is observed.
- During heavy rains, when such soils get saturated, it would be very difficult to work through these soils because of high stickiness.
- Normally the slope of terrains very flat in the range of 0^0 to 2^0.
- Drainage is very poor.

In India, the vegetation in such area may consist of thorns, bushes, thorny trees (babul) cactus etc. Buildings constructed on such deposits exhibits heaving of floor lifting of columns and walls usually accompanied by cracking. Doors normally jammed during rainy season. In case of canals in embankments, partial cuts or in cutting, bed heaving accompanied by cracking of the bed concrete is observed. Heavy sliding accompanied by progressive failures is observed on the sides. Retaining structure show tilting and distress road get rutted.

2. SOIL STABILISATION

2.1 Definition

Soil stabilization is the process of altering some soil properties by different methods, mechanical or chemical in order to produce an improved soil material which has all the desired engineering properties.

Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field.

Soil is one of nature's most abundant construction materials. Almost all constructions is built with or upon soil. When unsuitable construction conditions are encountered, a contractor has 4 options.
(1) Find a new construction site.
(2) Redesign the structure so it can be constructed on the poor soil.
(3) Remove the poor soil and replace it with good soil.
(4) Improve the engineering properties of the site soils.

2.2 Principles of Soil Stabilization:

- Evaluating the soil properties of the area under consideration.
- Deciding the property of soil which needs to be altered to get the design value and choose the effective and economical method for stabilization.
- Designing the Stabilized soil mix sample and testing it in the lab for intended Stability and durability values.

2.3 Uses of Soil Stabilization

Traditionally, stable sub-grades, sub-bases and bases have been constructed by using selected, well-graded aggregates, making it fairly easy to predict the load-bearing capacity of the constructed layers. By using select material, the engineer knows that the foundation will be able to support the design loading.

Gradation is an important soil characteristic to understand. A soil is considered either "well-graded" or "uniformly-graded" (also referred to as "poorly-graded"). This is a reference to the sizes of the particles in the materials. Uniformly-graded materials are made up of individual particles of roughly the same size. Well-graded materials are made up of an optimal range of different sized particles. The addition of lime slurry is a form of chemical soil.

2.4 METHODS OF STABILIZATION

The basic methods of soil stabilization are

a. Mechanical stabilization
b. Cement stabilization
c. Lime stabilization
d. Bituminous stabilization
e. Chemical stabilization
f. Thermal stabilization
g. Electrical stabilization

2.5 USES OF STABILIZATION

- Stabilized soil functions as a working platform for the project.
- Stabilization waterproofs soil.
- Stabilization improves soil strength and durability.
- Stabilization helps reduce soil volume changes due to temperature or moisture.
- Stabilization improves soil workability.

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- Stabilization reduces dust in work environment.
- Stabilization conserves aggregate materials.
- Stabilization reduces cost and conserves energy

3. REVIEW LITERATURE

Dilip kumar Talukdar et al. (2015) examined the effect of waste paper sludge (Hypo-Sludge) in three different clay soil. The study includes Atterberg limits, the compaction, and swelling properties of three types of expansive soil. Compaction characteristics, strength characteristics and CBR values were analysis for soil treated with (0%,5%,10%,15%) of waste paper sludge and decrease in plasticity index, maximum dry density, and increase in OMC, CBR values were observed in soil treated with Lime sludge. It increases the CBR values with addition of lime mud in all types of soil sample. At 15% addition of lime sludge, the increase in CBR in 19.76% for Soil Sample1, Soil 2, and soil 3 the increases in 23.90% and 9.33% respectively.

Elias (2015) presented the effect of waste paper sludge on plasticity, free swell index, compaction, unconfined compressive strength and CBR in soft clayey soil. Compressive strength was increased by adding 5% WPSA (Hypo-Sludge) about 314 KN/m2 to 496 KN/m2 and 284 KN/m2 to 590 KN/m2 of 7 days, 28 days curing period respectively. Furthermore UCS values increased 107.9% by using 5% of WPSA (Hypo-Sludge) in 28 days curing

4. MATERIALS & METHODOLOGY

4.1 Materials

Soil:

The soil used was a typical black cotton soil collected from Allavaram mandalam near Amalapuram in East Godavari District, Andhra Pradesh State, India

Waste Paper Sludge Ash

The wastepaper sludge ash (WPSA) is a main additive to stabilize the soft soil was used in this study. This white WPSA was in a powder form is a waste product from 440 N. Khalid et al. the combustion of waste paper in paper recycling factories was obtained from Rajahmundry.

Fig :1Waste paper sludge ash

Ferric Chloride

Ferric chloride is white coloured sticky powder form which is highly reactive with water and clay particles of soil. It improves the index properties, dry density, and optimum moisture content of soil.

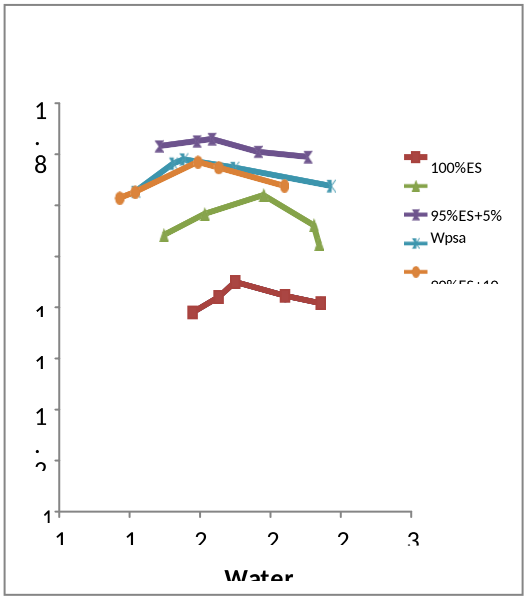
5. DISCUSSION ON TEST RESULTS

3 Laboratory Experimentation

Different tests were conducted in the laboratory on the expansive soil to study the behaviour of expansive soil, when it is treated with waste paper sludge ash along with ferric chloride

- Grain Size Analysis (Sieve Analysis)
- Water Content
- Free Swell Index (Fsi)
- Compaction Test
- 5strength Tests
- Specific Gravity Test
- Cyclic Plate Load Test.......e.t.c.

The OMC & MDD Values Of Expansive Soil Treated With % Variations Of WPSA



Graph 1 : Represents the OMC & MDD values of Expansive Soil Treated with % Variations of WPSA

The CBR values of Untreated and Treated Expansive soil with percentage variations of WPSA

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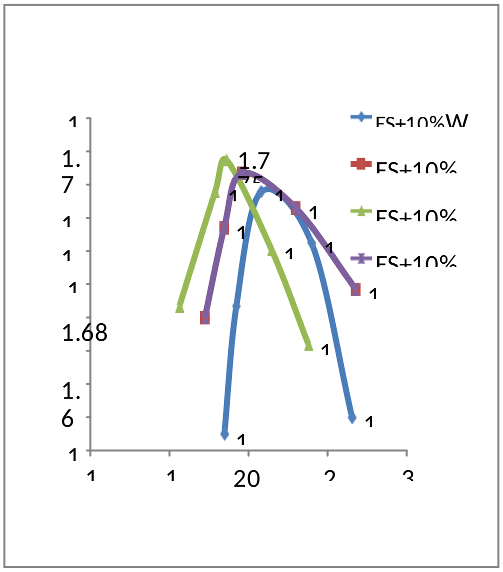
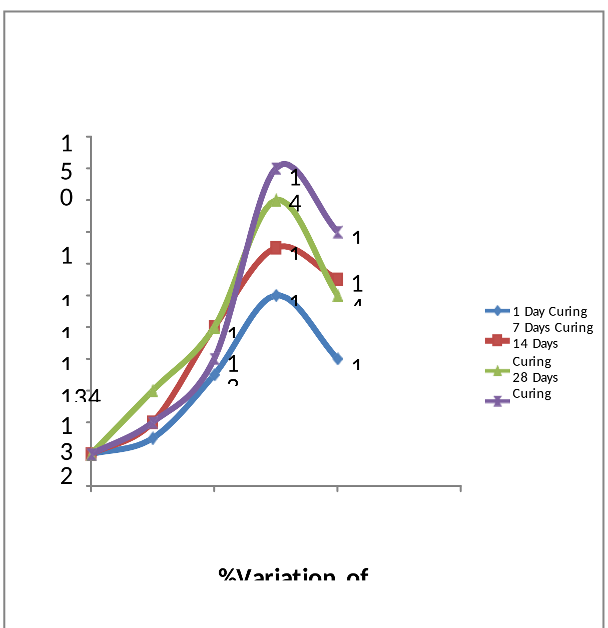
Graph 2 : Represents the CBR values of Untreated and Treated Expansive soil with percentage variations of WPSA

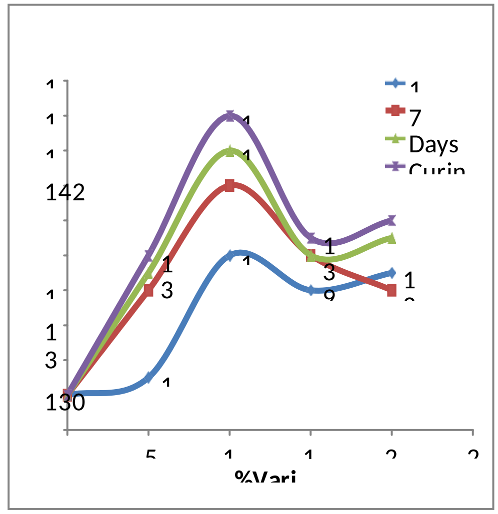


Optimum moisture Content and Maximum Dry Density of 10% Waste paper sludge ash Treated Expansive Soil with percentage Variation of Ferric Chloride



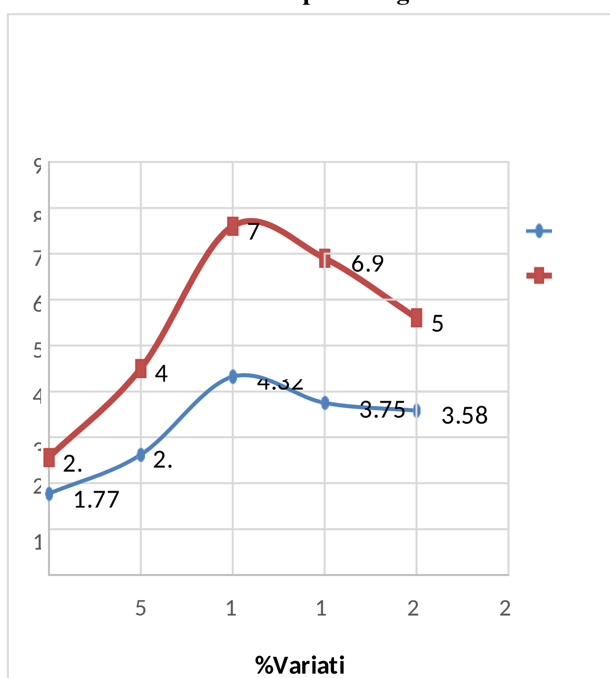
Graph 3: Optimum moisture Content and Maximum Dry Density of 10% Waste paper sludge ash Treated Expansive Soil with percentage Variation of Ferric Chloride

CBR values of treated expansive soil with 10 % WPSA with various percentages of Ferric chloride



Graph 4 :CBR values of treated expansive soil with 10 % WPSA with various percentages of Ferric chloride

UCS values of treated expansive soil with 10 % WPSA with various percentages of FeCl3



Graph 5 :UCS values of treated expansive soil with 10 % WPSA with various percentages of FeCl3

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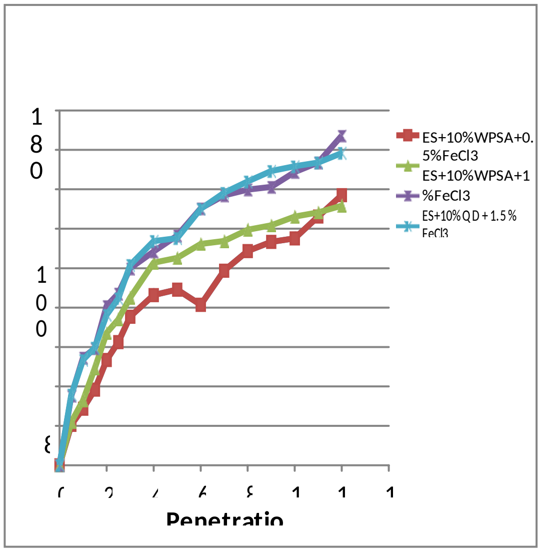
UCS values of treated expansive soil with 10 % WPSA with various percentages of Ferric chloride



Graph 6 :UCS values of treated expansive soil with 10 % WPSA with various percentages of Ferric **chloride**

6. CONCLUSIONS

The following conclusions were drawn based on the laboratory studies carried out on this study. Optimum percentage of chemical and quarry dust observed during the laboratory investigations are summarized and presented in the following table.

Table 6.1 Optimum percentage of quarry dust and ferric chloride observed during the laboratory investigations

Additives	**Optimum percentage addition**
WASTE PAPER SLUDGE ASH	15%
Ferric chloride	1.5%

- It is noticed from the laboratory investigations that the liquid limit of the expansive soil has been decreased by 6.06% on addition of 10% Vitrified Polish Waste and further the liquid limit of ferric chloride treated expansive soil has been decreased by 12.9% with the addition of 1.5 % ferric chloride as an optimum when compared with untreated expansive soil.
- It is observed from the laboratory investigations that the plastic limit of the expansive soil has been improved by 2.75% on addition of 10% Vitrified Polish Waste and further the plastic limit of ferric chloride treated with expansive soil has been improved by 13.29% with the addition of 1.5% ferric chloride as an optimum when compared with untreated expansive soil.
- It is observed from the laboratory investigations that the plasticity index of the expansive soil has been improved by 9.75 % on addition of 10% Vitrified Polish Waste and further the plasticity index of ferric chloride treated expansive soil has been improved by 12.49% with the addition of 1.5% ferric chloride as an optimum when compared with untreated expansive soil.
- It is found from the laboratory investigations that the optimum moisture content of the expansive soil has been decreased by 4.65% on addition of 10% Vitrified Polish Waste and further the optimum moisture content of ferric chloride treated expansive soil has been decreased by 20.96% with the addition of 1.5% ferric chloride as an optimum when compared with untreated expansive soil.
- It is is found from the laboratory investigations that the maximum dry density of the expansive soil has been improved by 18.9% on addition of 10% Vitrified Polish Waste and further the maximum dry density of ferric chloride treated expansive soil has been improved by 21.99% with the addition of 1.5% ferric chloride as an optimum when compared with untreated expansive soil.
- It is observed from the laboratory investigations that the C.B.R. value of the expansive soil has been improved by 111.86% on addition of 10% Vitrified Polish Waste as an optimum and further the C.B.R value of ferric chloride treated with expansive soil has been improved by 258.75% with the addition of 1.5% ferric chloride as an optimum when compared with untreated expansive soil.
- The soaked CBR values of expansive soil on stabilizing treated with ferric chloride is

found to be 4.58% and it is satisfying standard specifications. So finally it is concluded from the above results that the ferric chloride can potentially stabilize the expansive soil.

- The utilization of industrial wastes like Vitrified Polish Waste is an alternative to reduce the construction cost of roads particularly in the rural areas of developing countries.

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