A Study on Stabilization of Expansive Soil using Tile Waste and Recron-3S Fibres

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Abstract

Expansive soils are so widespread that it becomes impossible to avoid them for highway construction. Many highway agencies, private organizations and researches are doing extensive studies on waste materials and research projects concerning their feasibility and environmental suitability. Utilization of industrial waste materials in the improvement of soils is a cost efficient and environmental friendly method. The properties of the black cotton soils can be altered in many ways viz. mechanical, thermal and chemical means. Therefore, soil stabilization techniques are necessary to ensure the good stability of soil so that it can successfully sustain the load of the superstructure especially in case of soil which is highly active; also, it saves a lot of time. This paper describes the attempts made to investigate the stabilization process by blending different percentages of Tile Waste and Recron-3S Fibres in expansive soil and conducted various laboratory tests like Atterberg;s Limits, Compaction and Soaked CBR with a view to determine the effect on strength properties of expansive soil. Test results shows that stabilizing expansive soil with Tile Waste and Recron-3S Fibres enhance the strength.

Keyword — *Expansive Soil, Tile Waste, Compaction, Soaked CBR, Recron-3S Fibres.*

I. INTRODUCTION

Expansive soils are so widespread that it becomes impossible to avoid them for highway construction. Many highway agencies, private organizations and researches are doing extensive studies on waste materials and research projects concerning their feasibility and environmental suitability. Swelling of expansive soils causes serious problems and produces harm to many structures. Many research organizations are doing extensive work on waste materials concerning the viability and environmental suitability. Expansive clays are the most problematic soils due to their unique alternate swell-shrink behavior with fluctuations in moisture content. World over, many case studies [1-2] of failed structures built on expansive soils have been reported. The situation in India is also no different with extensive coverage of expansive soils that occupy almost one fifth of the geographical land area [3]. The raw materials to form tile consist of clay minerals mined from the earth"s crust, natural minerals such as feldspar that are used to lower the firing temperature, and chemical additives for the shaping process. A lot of ceramic tiles wastage is produced during formation, transportation and placing of ceramic tiles. This wastage or scrap material is inorganic material and hazardous. Vitrified tiles are the latest and largest growing industry alternate for many tiling requirements across the globe with far superior properties compared to natural stones and other man made tiles. Hence its disposal is a problem which can be removed with the idea of utilizing it as an admixture to Stabilization. Effect of Recron-3S fibres on expansive soil blending with different percentages and concluded that MDD of the reinforced soil decreases as compared to OMC with the fiber content Increase, moisture content of the reinforced soil increments with the rise of length of the fiber and MDD decrease, CBR of the reinforced soil for the aspect ratio 6 mm and 12 mm increases to 76.37%, 106.30% as compared to the unreinforced soil. The percentage of unsoaked CBR value increases with the increase in the fiber content and also with increase of length of the fiber. Soaked CBR of the reinforced soil for the aspect ratios 6 mm and 12 mm increase to 58.47% and 98.30% as compared to the unreinforced soil. Unsoaked CBR of the reinforced soil is higher as compared to the soaked CBR of the reinforced soil [4]. Laboratory experiments and concluded that , addition of tiles waste and NaOH decreases the liquid limit and plastic limit of the soil up to 35% and it increases beyond this limit.MDD increase with increase in 1% of tile waste and NaOH. In direct shear test, the shear stress increases with in 5 of tiles waste and NaOH. Up to 35% of tile waste and 7.5% of NaOH and tend to decrease beyond this limit. The CBR value increase with increase in addition of tile waste and NaOH. From the above results, it can conclude that addition of tile waste up to 35% and NaOH up to 17.5% is recommended. Sugarcane straw ash and polypropylene fibres blending in expansive soil at varying percentages to stabilize the soil. Various geotechnical laboratory tests like compaction, Unconfined Compression Test and California Bearing Test were carried by varying the percentage of sugarcane straw ash (10%, 15%, 20% and 25%) and polypropylene fibres (0.5%, 1.0% and 1.5%) respectively. It is found that 20 % increase in the percentage of sugarcane straw ash and 1% polypropylene fibres increases the UCS and CBR values. Hence 20% of sugarcane straw ash and 1% of fibres had shown promising influence on the strength characteristics of soil, thereby giving a two-fold advantage in improving poor soil and also solving a problem of waste disposal [5]. The shear test were performed for mix compositions of fine sand of different dry densities 1.50 gm/cc, 1.55 gm/cc and 1.58 gm/cc with ceramic tile waste of varying percentage 2%, 4%, 8% and 12%. The angle of internal friction (shearing resistance) ϕ increases with increase in dry density of fine sand and quantity of the ceramic tile waste. As the ϕ is increasing, the required section for embankment is reduced. Permeability Tests were performed for mix composition of 2%, 4%, 8% and 12% of ceramic tile waste and fine sand of 1.58 gm/cc dry density. The coefficient of Permeability k (cm/sec) increases with increase in the percentage of ceramic tile waste mixed to fine sand. Greater the percentage of ceramic tile waste more was the mix composition permeable. Hence, the impermeable material should be used in the mix composition to reduce the permeability [6]. Addition of ceramic waste liquid limit, plastic limit and plasticity index of the clayey soil decreases. Optimum moisture content of the clayey soil decreases as the percentage of ceramic waste increases and maximum dry density obtained at certain optimum content of ceramic waste and decreases beyond this optimum content of ceramic waste. California bearing ratio and unconfined compressive strength of the clayey soil increases with the increase in the percentage of ceramic waste. The differential free swell of clayey soil decreases as the percentage of ceramic waste increases [7]. Stabilisation of expansive soil with different percentages of tile waste by conducting different laboratory experiments and concluded that, California Bearing Ratio test was done and its value is 3.406%. Addition of tile waste up to 30% decreases the values of liquid limit, plastic limit and optimum moisture content. And increases the values of shrinkage limit, maximum dry density, unconfined compressive strength and California bearing ratio (CBR). After 30% addition of tile waste the values are opposing the corresponding values and lose the soil properties [8]. A series of laboratory tests were conducted to study the effects of tile waste on the, liquid limit, plastic limit, MDD, OMC, soaked CBR and swelling pressure of an expansive soil, • The liquid limit and plastic limit decreasing irrespective of the percentage of addition of tile waste. The Maximum Dry Density attained at 20% tile waste and OMC goes on decreasing with increase in percentage of tile waste. The soaked CBR goes on increasing with increase in percentage of addition of tile waste. There is 105% increase in soaked CBR value as compared to untreated soil, when 20% tile waste was added[9].Experimental program carried out in the laboratory to evaluate the effectiveness of using foundry sand and flyash with tile waste for soil stabilization by studying the compaction and strength characteristics for use as a subgrade material. The highest value of maximum dry density is achieved for clay-foundry sand-fly ash-tile waste mix of 54:36:10:2.25 followed by other proportions. The California bearing ratio value of clayey soil improved significantly i.e. from 2.43% to 7.35% with addition of foundry sand, flyash and tile waste in appropriate proportion. Thus, clayey soil stabilized with foundry sand, fly ash and tile waste can be used as a sub-grade material for construction of flexible pavements in rural roads with low traffic volume [10]. Stabilization of Dune- Sand with Ceramic Tiles Wastage as admixture by conducting California Bearing Ratio, Standard Proctor Tests and Direct shear tests. From the test results M.D.D.increases on increasing the quantity of admixture (increment from 10% to 30%), increase in CBR values in both unsoaked and soaked conditions. Direct Shear Test, angle of internal friction increases with increase in size of ceramic tiles wastage and also increases with the quantity of the ceramic tiles wastage [11]. In the present work, an attempt has been made to calculate the variations in Index properties, Compaction parameters and CBR of treated expansive soil with different percentages of tile waste and Recron-3SFibres and its effect on strength charesteristics.From the test results it is observed there is an improvement in engineering properties and the optimum percentages were arrived accordingly.

II. MATERIALS USED

Details of various materials used during the laboratory experimentation are reported in the following section.

A. Expansive Soil

Natural black cotton soil was obtained from Godilanka, Amalapuram, East Godavari district, Andhra Pradesh. The soil is dark grey to black in color with light clay content. The obtained soil was air dried, pulverized manually and soil passing through 4.75 mm IS sieve was used as shown in the Fig. 1. The physical properties of black cotton soil are furnished in Table.1.

Table.1: Physical Properties of Expansive Soil

Property	Value
Liquid Limit (%) W_L	88
Plastic Limit (%) W_P	38
Plasticity Index (%) I_P	50
Gravel (%)	0.0
Sand (%)	5.0
Silt (%)	12.0
Clay (%)	83.0
Soil Classification	CH
Specific Gravity G	2.69

Differential Free Swell (%) DFS	130
Optimum Moisture Content (%)OMC	27.68
Maximum Dry Density(g/cc)	1.451
Natural Moisture Content (%)	11

Fig.1 Expansive Soil

B.Tile Waste

A ceramic tile is an inorganic, non-metallic solid prepared by the action of heat and subsequent cooling. Ceramic materials may have crystalline or partly crystalline structure, or may be amorphous. The tile waste mainly consisting of Cao and Silica. The raw materials to form tile consists of clay mineral mined from earth crust, natural mineral such as feldspar. A lot of tile waste is produced during formation, transportation and placing of ceramic tiles. The disposal of tile waste is a major problem so it is used effectively used for soil stabilization. tile waste is made into powder form by hand ramming and tile waste powder passing 90 micron sieve is replaced with soil. Tiles waste was collected from a local industry. Ceramic tile wastes are cheap and non-reusable material, it is shown in all construction area and easy to collect. By the using of ceramic tile waste to reduce the waste materials in earth and economical.

C. Recron-3S Fibres

Recron 3s fiber used in this study is the most commonly used synthetic material fiber due to its low cost and hydrophobic and chemically inert nature which does not allow the absorption or reaction with soil moisture or leachate and it is a polypropylene fiber which is a stabilizer to improve CBR and UCS values. Recron -3S fibre used in the experiment is of 12mm length and it was manufacture by Reliance industries shown in Fig.2. Fibers are randomly mixed in soil due to the fact for making a homogeneous mass and maintaining the isotropy in strength. The Properties of Recron 3S- fibers are Colour = White, Specific gravity = 1.334, Cut length = 12mm, Equivalent diameter (*um*) = 32-55, Water absorption (%) = 85.22, Tensile strength (MPa) = 600, Acid resistance = Excellent, Melting Point (°C) = >250 and Alkali resistance is Good (*courtesy Reliance industries*).

Fig. 2 Recron-3S Fibres

III. LABORATORY EXPRIMENTATION

Various tests were carried out in the laboratory for finding the index and other important properties of the expansive soil used during the study. Index Properties, Compaction and CBR tests were conducted by using different percentages of Tile Waste and Recron-3S Fibres mixed with black cotton soil materials for finding optimum percentages.

A. Index Properties

Standard procedures recommended in the respective I.S. Codes of practice [IS:2720 (Part-5)-1985; IS:2720 (Part-6)-1972], were followed while finding the Index properties viz. Liquid Limit and Plastic Limit of the samples tried in this investigation.

B. Compaction Properties

Optimum Moisture Content and Maximum Dry Density of black cotton soil with different percentages of Tile Waste and Recron-3S Fibres mixes were determined according to IS Heavy compaction test IS: 2720(Part VIII).

C. California Bearing Ratio (CBR) Tests

Different samples were prepared for CBR test using expansive soil material mixing with different percentages of Tile Waste and Recron-3S Fibres with a view to determine optimum percentages. The CBR tests were conducted in the laboratory for all the samples as per IS Code (IS: 2720 (Part-16)-1979) as shown in the Fig.3.

Fig. 3. California Bearing Ratio Test Apparatus

IV. RESULTS AND DISCUSSIONS

Various tests were conducted in the laboratory as per IS Code provisions and the test results are furnished below with a view to determine the optimum percentages and the effect on strength characteristics.

A. Effect of Till Waste on Index Properties

The results of liquid limit tests on expansive soil treated with different percentage of tile waste can be seen that with increase in percentage of tile waste the liquid limit of soil goes on decreasing from 87% to 56% and the plastic limit of soil goes on decreases from 37.5% to 29.05 % when tile waste is increased from 0 to 25% respectively as shown in Fig.4.

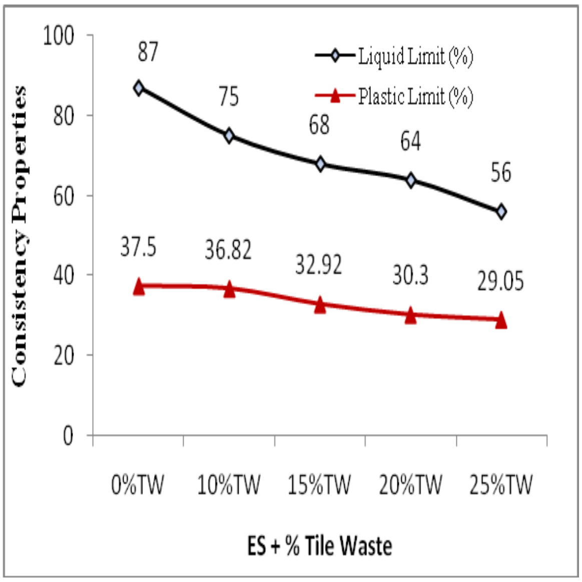

Fig.4 Variation of Liquid &Plastic Limit Values of Expansive Soil Treated with Different Percentages of Till Waste

B. Effect of Tile Waste and Recron-3S Fibres on Compaction

The Optimum Moisture Content and Maximum Dry Density values are calculated from the test results and are presented below form Figs. 5 &6.

All the expansive soil samples were mixed with varying percentages of tile waste material by weight. From the test results maximum dry density increases from 14.19 kN/m^3 to 15.38 kN/m^3 at 15 % of tile waste, beyond which it decreases as shown in Fig.5. However water content continuously decreases.From the above test results the optimum percentage of tile waste is 15% at the maximum dry density is maximum is considered as base mix and different percentages of Recron-3S Fibres the maximum dry density increases up to 1.5% addition fibres and further addition of fibres decreases the MDD and OMC continuously increases irrespective of % fibres as shown in the Fig. 6 . From the above results 15% of tile waste and 1.5% recron fibres attains maximum density compared to other samples tried this investigation.

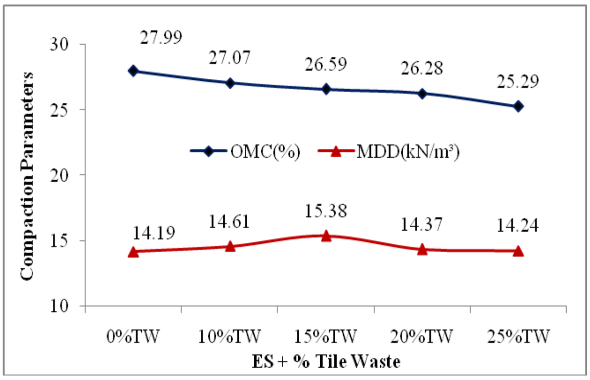

Fig 5: Variation of Compaction Parameters of Expansive Soil and Different Percentages of Tile Waste

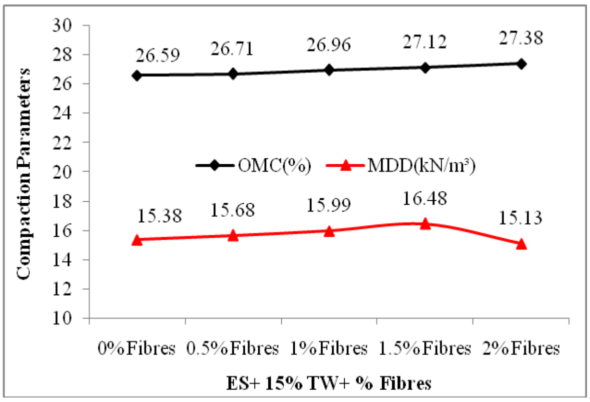

Fig 6: Variation of Compaction Parameters of Expansive Soil and 15% Tile Waste with Different Percentages of Recron-3S Fibres

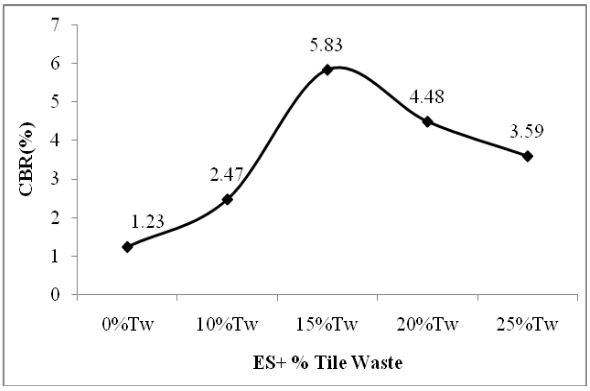

Fig 7: Variation of Soaked CBR Values of Expansive Soil with Different Percentages of Tile Waste

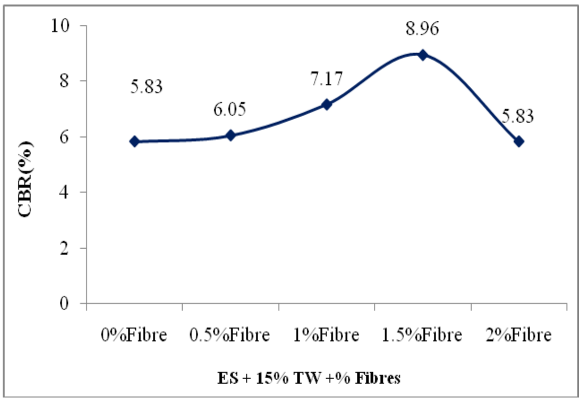

Fig 8: Variation of Soaked CBR Values of Expansive Soil and 15% Tile Waste with Different Percentages of Recron-3S Fibres

C. Effect of Tile Waste and Recron-3S Fibres on California Bearing Ratio (CBR)

Soaked CBR tests were conducted for expansive soil mixed with different percentages of Tile Waste and Recron-3S Fibres and the results are shown in Fig. 7 & 8. From the results it can be seen that with increase in percentage of tile waste, the soaked CBR of soil goes on increasing from 1.23 to 5.83 when tile waste is increased from 0 to 15% and further addition decreases the CBR value as shown in the Fig.7.Further Recron-3S Fibres are added with different % to soil with 15% tile waste mix the soaked CBR values are increasing from 5.83 to 8.96 up to 1.5% addition of fibres and beyond it decreases as shown in the Fig.8.From the above Figures the optimum percentage of Tile Waste and Recron-3S Fibres are 15% and 1.5% respectively.

V. CONCLUSIONS

A series of laboratory tests were conducted to study the effects of tile waste and Recron-3S Fibres on the, liquid limit, plastic limit, MDD, OMC and soaked CBR an expansive soil .Based on the observations, following conclusions are drawn from this study.

The liquid limit and plastic limit decreasing irrespective of the percentage of addition of tile waste.

The Maximum Dry Density attained at 15 % tile waste and OMC goes on decreasing with increase in percentage of tile waste and at 1.5% Recron-3S Fibres attains maximum dry density.

The soaked CBR goes on increasing with increase in percentage of addition of tile waste. There is 3.8 times increase in soaked CBR value as compared to untreated soil, when 15% tile waste was added.

The soaked CBR goes on increasing with increase in percentage of addition of 15% tile waste and 1.5% fibres,there is 6.3 times increase in soaked CBR value as compared to untreated soil, when 15% tile waste was added.

From the above analysis it is found that tile waste up to 15 % and 1.5% Recron-3S Fibres can be utilized for strengthening the expansive soil with a substantial save in cost of construction.

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