EXPANSIVE SOIL STABILIZATION USING GLASS FIBER AND EPOXYRESIN

Anju Manoj[1], Hailna PH[2], Selma James[3]

[1]B.Tech Student, Department of Civil Engineering, Toms College Of Engineering, Kerala, India
[2]B.Tech Student, Department of Civil Engineering, Toms College Of Engineering, Kerala, India
[3]Assistant Professor, Department of Civil Engineering, Toms College Of Engineering, Kerala, India

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Abstract - *In India, a major portion of total land area is covered by clayey soil and is of expansive soil. Soil Stabilization is one of the promising techniques used to improve the geotechnical properties of soil and has become major practice in construction engineering. This project aims to conduct a study to check the improvements in properties of expansive soil by adding glass fiber and epoxy resin. By varying percentage of resin and fiber the soil parameters such as liquid limit, plastic limit, maximum dry density and CBR may be studied. Finally it can be said that stabilization of expansive soil using fiber and resin is an effective method.*

Key Words: Soil stabilization, Epoxy resin, glass fiber, Maximum Dry Density, Reinforcement.

1.INTRODUCTION

Engineering properties of soils play vital role in civil engineering construction works in road work, foundations, embankments and dams, to mention but a few. In such situations the practice is to modify the soil properties by blending with different foreign materials, and it is generally known as Soil Stabilization. Therefore, it is imperative to carry out tests on soil upon which foundation or superstructure is to be erected, prior to construction. Invariably, the outcome will determine soil suitability as construction material. Marginal and weak soils, including soft clays, black cotton soil, organic deposits, and loose sand, are often unsuitable for construction due to their poor engineering properties.

Expansive soil experiences volume change due to alteration in moisture content. In monsoon seasons, soils absorb water, swells, become soft and capacity to bear water is reduced. In drier seasons, these soils shrink or reduce in volume due to evaporation of water and they become harder. Due to its peculiar characteristic of high plasticity, excessive swelling, shrinkage and low strength when wet, the soil is regarded unsuitable for construction. Kumarakom soils are soft highly organic clay or silt deposits with higher compressibility and lower strength characteristics found in Kottayam district in Kerala, India.

Here we study the effect of glass fiber and Epoxy resin inclusion on Engineering properties of clayey soil. The mixing of randomly oriented glass fiber and Epoxy to soil sample may be considered same as other admixtures used to stabilize soil. Glass fiber is one such fiber having a durable, inert nature possessing high tensile and compressive strength. It is extremely strong and robust material. Glass fibers are among the most versatile industrial materials known today. Epoxy is now used globally as a construction material. The aim of the research was to ascertain glass fiber and Epoxy performance as a stabilizer by measuring its effects on expansive soil and determine appropriate quantities of the glass fiber and Epoxy required for adequate stabilization of the expansive soil.

2. LITERATURE REVIEW

Mohamed Ezzat Al-Atroush [2021] This paper introduced a novel application of the closed- cell, one-component epoxy resin (HPUF) to be used as a swelling soil stabilizer. Based on the results of the experimental study it was concluded that HPUF could competently reduce both the swelling potential and the shrinkage cracking of the reactive expansive soil, even after several wet-shrink cycles.

Ahmed S. Abdulrasoo [2021] This paper has presented an alternative novel material for improving the collapsible soil behavior. According to the obtained results, filling the collapsible soil's pores with PF resin improves its behaviour under saturation and loading. The results of the direct shear tests indicate that the PF liquid affects the shear strength parameters of the gypseous soil by increasing the apparent cohesion and the angle of internal friction relatively decreased.

E. R. Sujatha [2020] Glass fiber reinforcement has beneficially modified the geotechnical properties of the soil, particularly its UCS and CBR values that reflects its suitability for use as subgrade reinforcement. The type of glass fiber and the glass fiber content, both influence the properties of the reinforced soil. The liquid limit of the reinforced soil increased by 16% in case of ARGFRS (Alkali Resistant Glass Fiber Reinforced Subgrade) and 26.3% for E-GFRS (E- Glass Fiber Reinforced Subgrade) at the maximum investigated percentage of fiber addition (i.e) 1%. UCS of the soil improved by 60% and 48% for ARGFRS and E-GFRS respectively at a fiber content of 0.75%. CBR value of glass fiber reinforced soil increased by nearly 52% at 0.2% AR glass fiber addition and 48% at 0.5% E glass fiber addition.

Samer Rabab'ah [2020] The data and results obtained in this research work show that the addition of Glass fiber to expansive soil has a considerable effect on their UCS (Unconfined Compressive Strength), indirect tensile strength, and free swell. This increase in the strength of the soil and the reduction in the swelling tendency was proportionally dependent on the percent of used fiber. . By improving the strength and stiffness of subgrade soil, the use of glass fiber in expansive subgrade reinforcement can result in a significant reduction in the design thickness of pavement.

Gbenga Matthew Ayininuola [2018] The study revealed that addition of glass fiber into the two lateritic soils led to increase in soil California bearing ratio and maximum dry density. Performance of Glass Fiber as a stabilizer was evaluated by measuring its effect on soil through a comparison of the properties of the soil with and without the addition of the glass fiber. The CBRvalue of soil sample AJ without the addition of glass fiber was 51.0%. The glass fibers had optimum effect on the soils between 1.2% and 1.6% of soil samples. When optimum value of glass fiber was exceeded, the excess formed spongy spot in the soil matrices that constituted a weak portion.

SUMMARY OF REVIEW

Above literature reviews indicate that the addition of various percentage of glass fiber and epoxy resin increasing the strength of the soil. However the combined effect of both epoxy resin and glassfiber on the soil sample was not explored in any of the literatures. So our present study is to find a working ratio for both the epoxy resin and glass fiber for our soil sample, with the aim of improvingsoil characteristics.

3. MATERIALS USED

3.1 CLAY SAMPLE

Soil is collected from Kumarakom, Kerala ,India. Kumarakom is part of Kottayam, (10km). The composition of Kumarakom clay reveals a unique combination of various minerals with considerable organic content. The annual normal rainfall over Kumarakom region is 1100 mm. It is identified as clayey soil. Thetopsoil was removed manually to a depth of about 1.5 m before subsoil samples were collected. The subsoil samples is then air-dried, stock piled separately and covered with polythene materials to prevent moisture ingression. Properties of clay samples are given in Table:1

3.2 GLASS FIBER

Glass fiber are manufactured in various compositions by changing the amount of raw materials like sand for silica, clay for alumina, calcite for calcium oxide, and colemanite for boron oxide. Glass fiber is made by blending raw materials, melting them in a three-stage furnace extruding the molten glass through a bushing in the bottom of the forehearth, cooling the filaments with water and then applying a chemical size. The filaments then are gathered and wound into a package. Properties are given in Table:2.

3.3 EPOXY RESIN

Epoxy resins are liquid compound that when cured, forms a hard, composite material. It is strongadhesive with high compatibility with other materials. It is resistant to heat and doesn't react with other chemicals. Araldite LY 556 epoxy and Aradur HY 951 hardner were used. Araldite LY 556 is medium viscosity, unmodified liquid epoxy resin based on Bisphenol-A, Aradur HY 951 is a low viscosity, unmodified, aliphatic polyamine. Properties are given in Table:3.

Table -1: Properties of collected clay sample.

Properties	Values
Specific gravity	2.3
Percentage of clay	52
Percentage of sand	38
Percentage of silt	10
Liquid limit	64%
Plastic limit	47%
Shrinkage limit	6%
Plasticity index	17%
Toughness index	11%
Maximum dry density	1.45g/cc
Optimum moisture content	30%
California Bearing Ratio	2.01%

Table -2: Properties of collected glass fiber

Fiber	Properties
Size	12 mm
Toxic content	Nil
Strength & stiffness	High
Brittleness	Less
Material	Alkali resistant
Shape	Straight
Chemical resistance	High

Table -3: Properties of collected epoxy resin

Resin	Properties
Adhesion property	Good
Compressive strength	High
Compatibility	High
Tensile strength	High
Corrosion resistance	High
Heat resistance	High
Shrinkage	Low

4. METHODOLOGY

4.1 STANDARD PROCTOR COMPACTION TEST

Standard Proctor test was performed to determine the moisture content-dry unit weight relationship according to ASTM D- 698-91. In the proctor test, the soil was compacted in the mold that has a volume of 944 cm3. The diameter of the mold is 101.6 mm. The soil was mixed with varying amounts of water and then compacted in three equal layers by a hammer that delivers 25 blows to each layer using an automatic dynamic compacter with a hammer is dropping from a height that produce a compactive effort. The compaction test has been performed on soils with different fiber contents (0.5,0.6,0.7,0.8 %), resin contents(0.5,0.6,0.7,0.8 %), both fiber and resin (0.6%) of dry mass.

Fig -1: Standard proctor apparatus

4.2 CALIFORNIA BEARING RATIO

The CBR is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. The test is performed on a disturbed soil or undisturbed soil of soaked and unsoaked soil. It is measured by the pressure required to penetrate as oil sample with a plunger of standard area which is then divided by the pressure required to achieve an equal amount of penetration on a standard crushed rock material. For the test, mix proportions used for the compaction test were used again, dry soil was mixed thoroughly with calculated quantity of water to obtain moist soil as per the required moisture percentage obtained from the compaction test. The soil was compacted in a CBR moulds, each in 3layers and of 56 blows at each layer using the standard rammer. The top surface was scraped and levelled after compacting the third layer. The loading was applied at the rate of 1.25 mm/min. 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5. The CBR test has been performed on soils with different fiber contents (0.5,0.6,0.7,0.8 %), resin contents(0.5,0.6,0.7,0.8 %), both fiber and resin (0.6%) of dry mass.

Fig -2: CBR apparatus

5. RESULT AND DISCUSSIONS

During the test specimen the consistency limits, strength characteristics, CBR value of clay soil by adding varying contents of resin and fiber.

5.1 PROPERTIES OF CLAY WITH FIBER

5.1.1 ATTERBERG'S LIMITS

Table -4: Atterberg's limit of clay with fiber

Percentage of fiber (%)	Liquid limit (%)	Plastic limit (%)
0.5	52	43
0.6	58	48
0.7	56	45
0.8	55	44

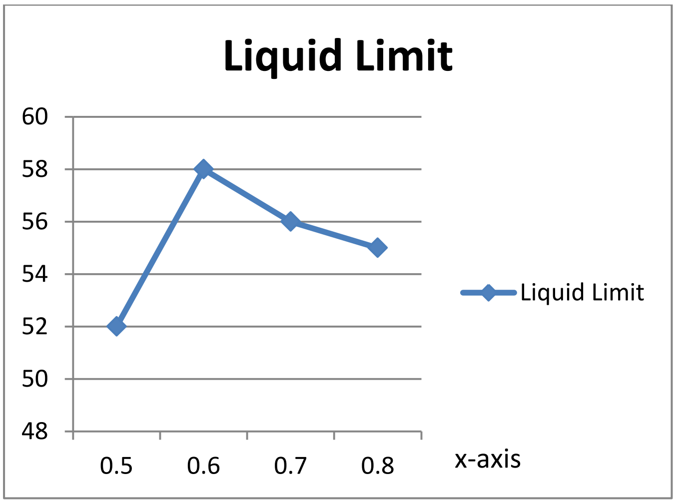

Chart -1: Variation of liquid limit value by adding varying percentage of fiber

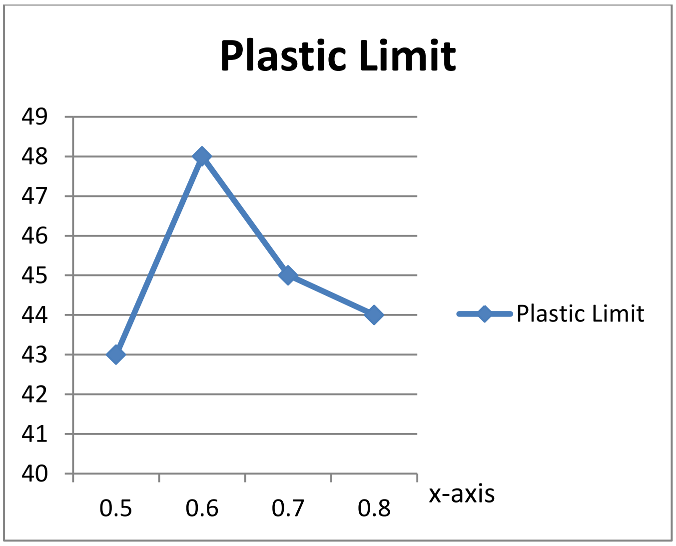

Chart -2: Variation of plastic limit value by adding varying percentage of fiber

5.1.2 STRENGTH CHARACTERISTICS

Table -5: Dry density of clay with fiber

Percentage of fiber (%)	Dry density (g/cc)
0.5	1.66
0.6	1.67
0.7	1.66
0.8	1.64

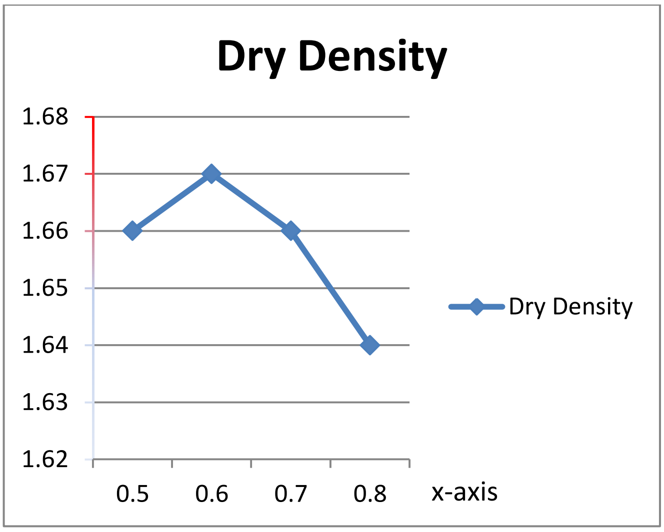

Chart -3: Variation of dry density value by adding varying percentage of fiber

5.1.3 CBR VALUE

Table-6: CBR value of clay with fiber

Percentage of fiber (%)	CBR value (%)
0.5	4.8
0.6	5.9
0.7	5.6
0.8	5.2

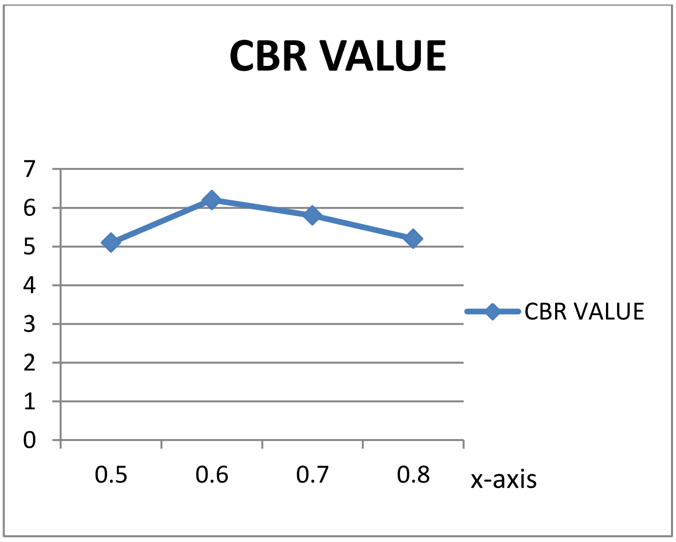

Chart -4: Variation of CBR value by adding varying percentage of fiber

5.2 PROPERTIES OF CLAY WITH RESIN

5.2.1 ATTERBERG'S LIMITS

Table -6: Atterberg's limits of clay with resin

Percentage of fiber (%)	Liquid limit (%)	Plastic limit (%)
0.5	58	45
0.6	63	49
0.7	54	47
0.8	50	45

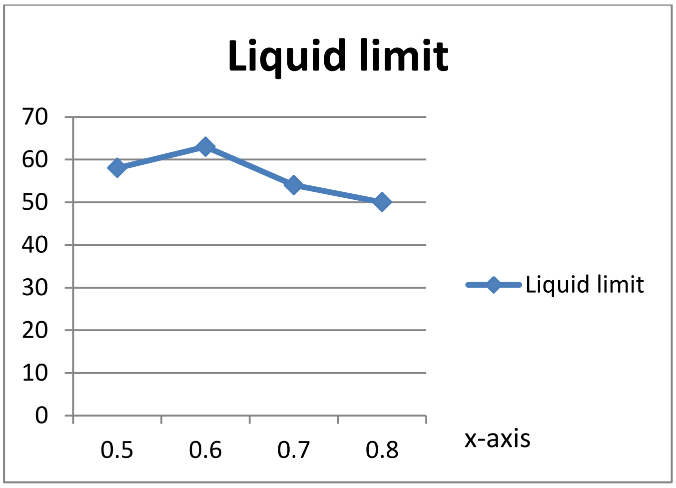

Chart -5: Variation of liquid limit value by adding varying percentage of resin

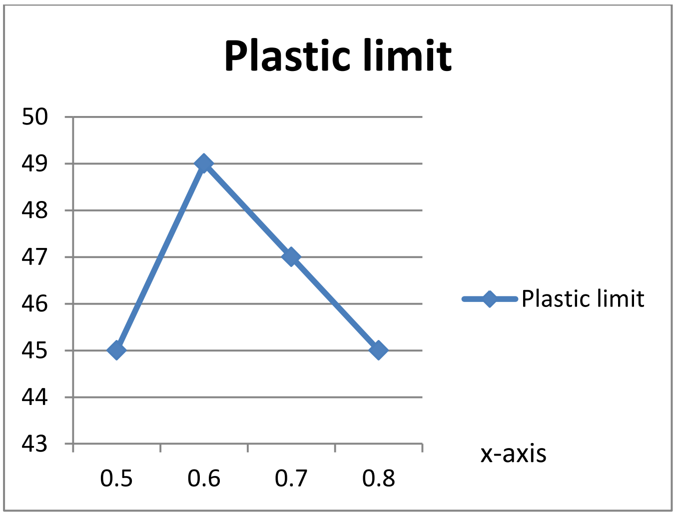

Chart -6: Variation of plastic limit value by adding varying percentage of resin

5.2.2 STRENGTH CHARACTERISTICS

Table -7: Dry density value of clay with resin

Percentage of resin (%)	Dry density (g/cc)
0.5	1.609
0.6	1.64
0.7	1.44
0.8	1.367

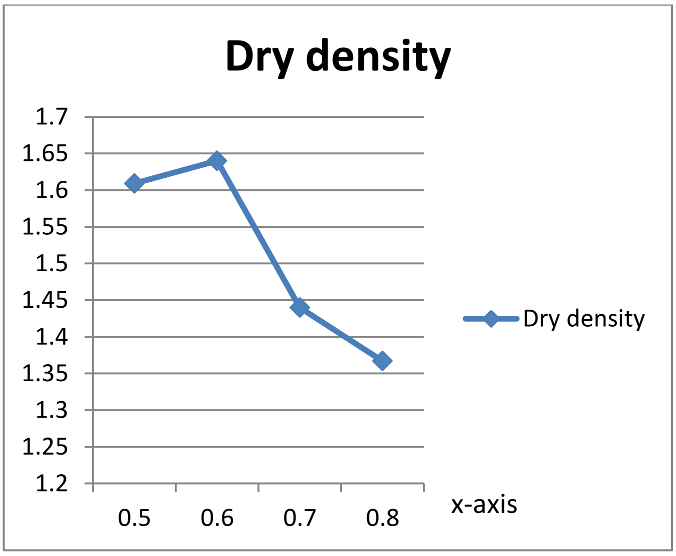

Chart -7: Variation of dry density value by adding varying percentage of resin

5.2.3 CBR VALUE

Table -8: CBR value of clay with resin

Percentage of resin (%)	CBR value (%)
0.5	5.1
0.6	6.2
0.7	5.8
0.8	5.2

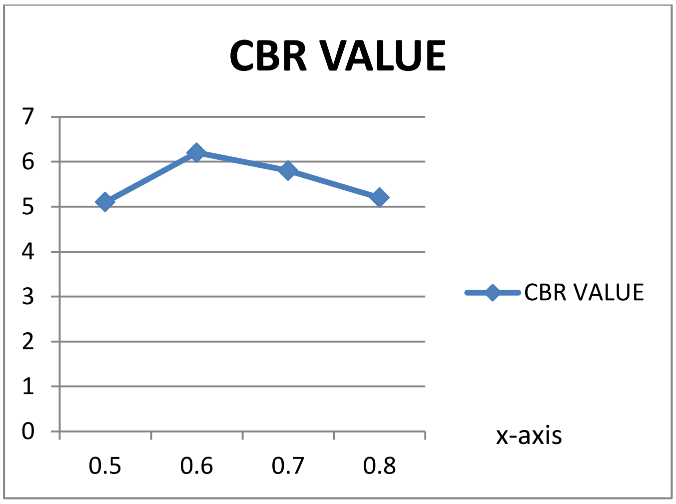

Chart -8: Variation of CBR value by adding varying percentage of resin

5.3 PROPERTIES OF CLAY WITH BOTH RESIN & FIBER

Since the optimum ratio of both glass fiber and epoxy resin was found to be 0.6% for the clay sample, so here used that ratio and the result given in the Table-7.

Table -7: Properties of clay with 0.6% both fiber and resin

Properties	Value
Plastic limit	50%
Liquid limit	64%
Compaction characteristics	1.717g/cc
CBR value	6.9%

6. CONCLUSIONS

This study results that the effect of adding epoxy resin and glass fiber on behavior of clayey soil. Based on result presented in this paper the following conclusions are drawn:

- Liquid limit of clayey soil increases with resin and fiber (0.6%).
- Plastic limit of clayey soil increases with resin and fiber content (0.6%).
- Maximum dry density of clayey soil with resin and fiber content (0.6%).
- California bearing ratio values with resin and fiber content (0.6%).

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