STUDY OF BEHAVIOUR OF EXPANSIVE SOIL USING GYPSUM AND SHREDDED (PET) PLASTIC

Ezhilarasi.R[1], Reya George K[2]

[1,2]Assistant Professor, Dept. of Civil Engineering, Velammal Engineering College, Chennai (TN) India.

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Abstract - *This paper deals with the effect of stabilization of the expansive soil using gypsum and shredded Poly Ethylene Terephthalate plastic. The expansive soil tends to shrink in drained season due to evaporation of the water and starts swelling in wet season due to these effects the soil undergoes greater voluminous changes and also the expansive soil will have low bearing capacity. Therefore in order to address the shrinkage and swelling effect an optimum percentage of gypsum is identified using free swell index test and in order to address the bearing capacity of the soil shredded PET plastics of size 2mm width and 5cm length are used and its optimum percentage is identified using standard proctor test. The effect of both gypsum and shredded PET plastic is identified by conducting California bearing ratio test.*

Key Words: Expansive soil, Swelling, Shrinkage, Gypsum, Low bearing capacity, Plastic, Stabilization

1. INTRODUCTION

Many areas of India consist of soils with high silt content, more strength and poor bearing capacity. Due to rapid growth in population and development activities suitable ground for constructions are depleting day by day. The poor engineering performance of such soils has forced engineers to attempt to improve the engineering properties of poor quality of soil. The poor quality soils such as expansive soils are not good for construction of civil engineering structures. Expansive soil contains minerals that are capable of absorbing water. They undergo severe volume changes corresponding to changes in moisture content. They swell or increase in their volume when they imbibe water and shrink or reduce in their volume on evaporation of water. Because of their alternate swelling and shrinkage, they result in detrimental cracking of lightly loaded civil engineering structures such as foundations, retaining wall, pavements, airports, side-walks, canal beds and linings. Due to these reasons, expansive soils are generally poor material for construction. With the rapid industrialization, bursting population and decrease of available land, transportation sector has to expand out on available black cotton soils pose challenges in selecting suitable soils modifications techniques. The quality of a pavement depends on the strength of its sub-grade. Soil stabilization is one of the best methods to improve the properties of the soil. The objectives of any stabilization technique used are to increase the strength, durability, erosion control, improve workability and constructability of soil.

2. METHODOLOGY

There are different materials in utilization for the stabilization of expansive soils .Depending on the internal factor which describes the bonding between the soil and the stabilizer utilized; the methods are broadly classified into two types. Inclusion of plastic waste strips comes in the category of mechanical stabilization of soil. Addition of gypsum comes under chemical stabilization of soils. Plastic solves the problem of low bearing capacity of expansive soil. But the other major issue of expansive soil is its shrinkage and swelling characteristics, which leads to formation of cracks, which has not been addressed by the use of mechanical stabilization. So, to address this issue, we have chemical stabilization as the solution. Addition of gypsum was chosen over lime because of reasons: Ca ion of gypsum replaces Na/K/Mg ions which results in flocculation and calcium silicate/aluminates formed helps in bonding. Gypsum is a naturally occurring mineral that is made up of calcium sulphate and water (CaSO4+2H2O) that is sometimes called hydrous calcium sulphate. It is the mineral calcium sulphate with two water molecules attached. By weight it is 79% calcium sulphate and 21% water. Gypsum is mined and made into many products like drained wall used in construction, agriculture and industry. It is also a by-product of many industrial processes

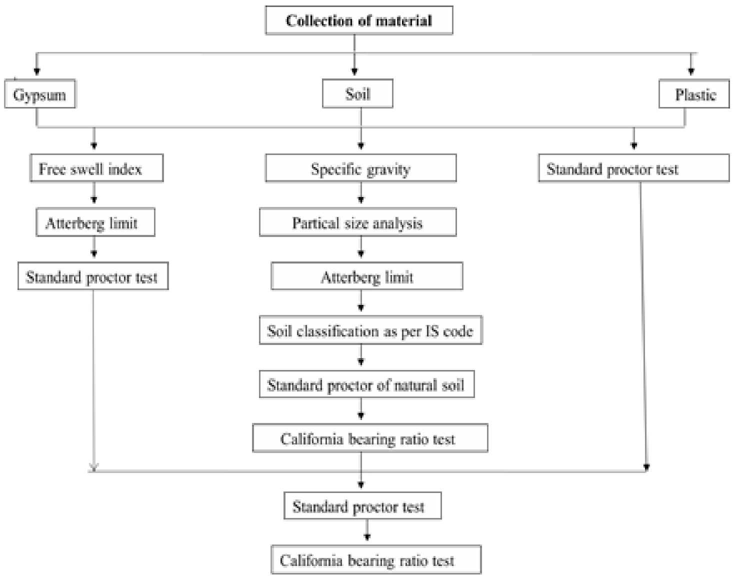

Fig.1: Flow chart

3. PROPERTIES OF NATURAL CLAY

Expansive soils were collected 1.4m below earth surface from the western outskirts of Puzhal, Chennai, India. Approximately 10kgs of soil was collected and all the basic tests were carried out.

3.1 Particle size distribution

The particle size distribution of a powder, or granular material, or particle dispersed in fluid, is a list of values or a mathematical function that defines the relative amount, typically by mass, of particles present according to size. Significant energy is usually required to disintegrate soil, etc. The PSD of a material can be important in understanding its physical and chemical properties. It affects the strength and load bearing properties of the rocks and soils

Weight of soil taken for the test = 200 g
Weight retained in 0.075 mm sieve after washing (g)=36.52g = 36.52 g
Weight of soil passing through 2.36 mm sieve taken =100 g

Table -1 Particle size distribution

Sieve Size (mm)	Wt retained (g)	Total wt retained (g)	Total Wt (g)	Passing %
4.75	0	0	100	100
2.36	0	0	100	100
1.18	6.24	6.24	93.76	93.76
0.425	8.48	14.72	85.28	85.28
0.15	9.66	24.38	75.62	75.62
0.075	12.14	36.52	63.48	63.48

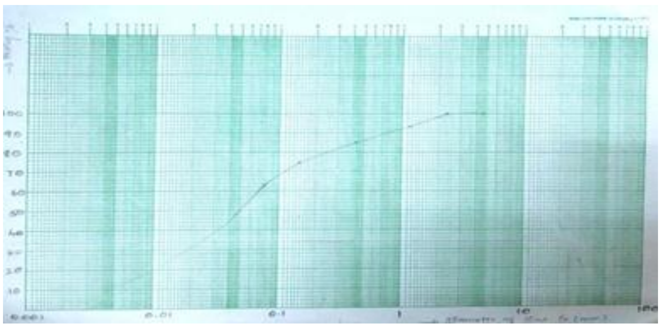

Fig. 2: Grading of soil

Table -2 Properties of expansive soil

S.NO.	Properties	Values
1.	Specific gravity	2.607
2.	Liquid Limit	45%
3.	Plastic Limit	20.55%
4.	Plasticity Index	24.45%
5.	Shrinkage limit	15.2%
6.	Drained Density	17.04kN/m³
7.	OMC	16.36%

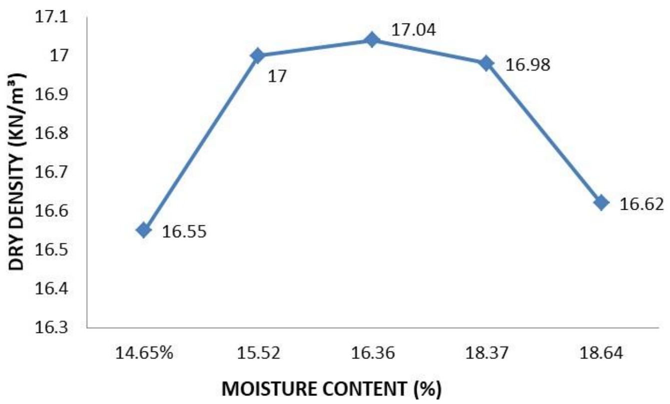

Fig. 3 OMC & MDD of clay sample

3.1 California Bearing Ratio

A sample of 6kg passing 4.75 mm IS sieve was taken. It was thoroughly mixed by adding water equal to optimum moisture content of the sample. The moist soil was compacted in three layers with each layer being compacted by 60 blows from a standard hammer of 50 mm diameter. After compacting the three layers, the collar was removed and the excess soil was struck off to the top of the mould by means of straight edge. The mould was placed in the soaking tank for 4 days (this step was ignored in case of drained condition). After 4 days, the mould was taken and the surface was dried with a cloth. The surcharge weight was placed on the top of the specimen in the mould and the assembly was placed under the plunger of the loading frame. Load was applied on the sample by a standard plunger at the rate of 1.25mm/min. a load penetration curve was drawn.

Surcharge weight = 2.5 kg
Proving ring capacity = 774 divisions
Load for 2.5mm penetration = 6.214 kg
CBR for 2.5mm penetration = 8.9%
Load for 5mm penetration = 8.756 kg
Surcharge weight = 2.5 kg
Proving ring capacity = 774 divisions
CBR for 5 mm penetration = 8.3%
CBR for clay at drained condition = 12.5%

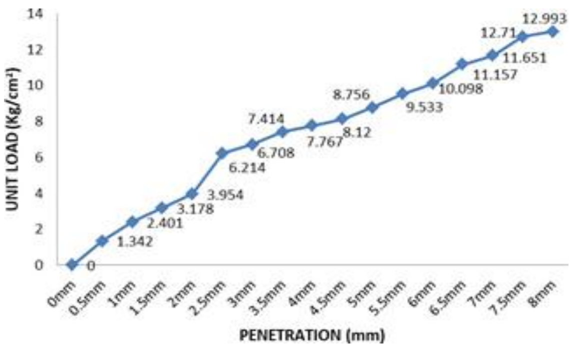

Fig.4 CBR results for clay sample in drained condition

Load for 2.5mm penetration = 4.519 kg
CBR for 2.5mm penetration = 6.5%
Load for 5mm penetration = 6.638kg
CBR for 5 mm penetration =6.3%
CBR of the clay in soaked condition:
6.5%

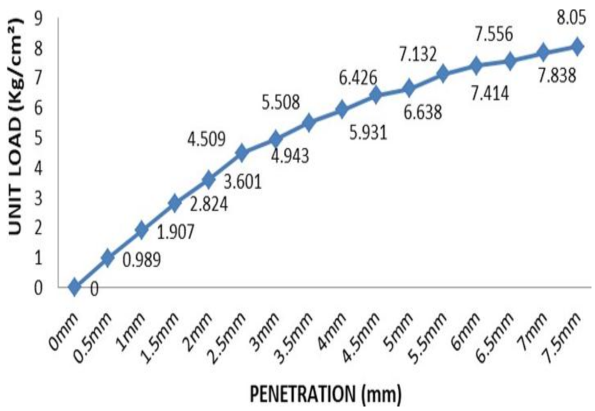

Fig.5 CBR results for clay sample in soaked condition

4. EFFECT OF GYPSUM AND PLASTIC IN SOIL STABILIZATION

4.1 Properties of Gypsum

Gypsum is a soft sulphate mineral composed of calcium sulphate dehydrate, with the chemical formula $CaSO_4.2H_2O$. Gypsum deposits are found as sediment in areas that were once covered by water. When rock gypsum is heated, it releases the water molecules bonded to it, and the resulting product is anhydrous gypsum, a dry powder. Gypsum powder is mainly used in building materials such as drywall, but it is also useful in agriculture as a soil fertilizer and conditioner. Gypsum can be also be used as a food additive to enhance the texture of ingredients in processed foods

4.2 Determination of optimum percentage of gypsum

In order to determine the optimum percentage of gypsum free swell index test is conducted, 2%, 4%, and 6% of gypsum by the drained weight of the sample is replaced and the optimum dosage is identified.

Table -3 Swell Index of soil sample with gypsum

Gypsum percentage (%)	2	4	6
Mass of dry soil passing 0.425 mm sieve (g)	10	10	10
Volume in water after 24 hrs (Vd) (ml)	10	11	11
Volume in kerosene after 24 hrs (Vk) (ml)	8	9	7
Free swell index [(Vd – Vk)/Vk] x 100 (%)	25	22.2	57.14

It can be seen that the free swell index value tends to be the least 22.22% upon addition of 4% of gypsum. Reductions in the free swell index indicate the reduction in the volumetric change The Optimum percentage of gypsum = 4%

4.2 Effect of addition of optimum percentage of gypsum

Since gypsum reacts with clay chemically, properties of clay such as liquid limit plastic limit shrinkage limit were determined for clay mixed with 4% gypsum.

Table -4: Properties of sample with 4% gypsum

Liquid Limit	34%
Plastic Limit	21.98%
Plasticity Index	12.02%
Shrinkage Limit	18.491%
MDD	1.771 g/cm^3
OMC	14.285 %

Liquid limit upon addition of gypsum has decreased. Thus compressibility decreases. Plastic limit has increased when gypsum was added. Thus upon adding 4% gypsum, the shrinkage limit increases. The lower the shrinkage limit, the greater is the possible volume change corresponding to a given variation in the moisture content of the soil. Increase in shrinkage limit is therefore beneficial.

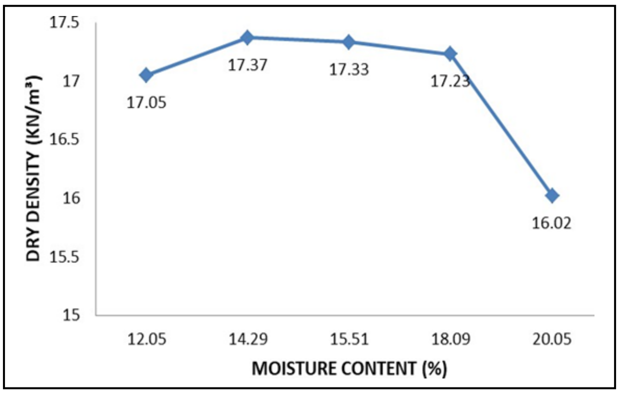

Fig.6: OMC & MDD of sample with 4% gypsum

4.3 Properties of (PET) plastic

Plastic is a non-renewable source and bio-degradable. The disposal of waste plastic bottles causes environmental pollution, it's a sustainable waste. Plastic can be recycled or reused i.e. reprocessing these plastic waste makes the useful products. Such waste of plastics can be used as additives for stabilized soil. This arrangement has discrete fiber distributed randomly in the soil mass. The mixing is done until the soil and the reinforcement form a more or less homogeneous mixture. Materials used in this type of reinforcements are generally derived from paper, nylon, metals or other materials having varied physical properties. Randomly distributed fiber has some advantages over the systematically distributed fiber. Somehow this way of reinforcement is similar to addition of admixtures such as cement, lime, etc. besides being easy to add and mix, this method also offers strength isotropy, decreases chance of potential weak planes which occur in the other case and provides ductility to the soil. We had cut bottles of plain surface whose dimension is almost of 5cm in length and 2 mm in width.

4.3 Determination of optimum percentage of plastic

Standard proctor test is used to determine the optimum % of the plastic to be used. Plastic of length 5 cm and width 2 mm is adopted. Three various percentage of plastic consider for addition. 0.3%, 0.5%, 0.7% by the drained weight of sample was tested

Table -5: Optimum % of addition of plastic

Samples tested	MDD	OMC
Natural clay + 0.3% of plastic	1.76 g/cm^3	15.354 %
Natural clay + 0.5% of plastic	1.79 g/cm^3	14.634 %
Natural clay + 0.7% of plastic	1.78 g/cm^3	15.36 %

Fig.7: Addition of gypsum and shredded plastic

Out of the three percentage considered addition of 0.5% of the plastic of size 5cm length and width 2mm had the highest maximum drained density and least optimum moisture content. Thus 0.5% of plastic is chosen as the optimum percentage.

4.4 Effect of addition of optimum percentages of gypsum and plastic

Maximum dry density, optimum moisture content, soaked

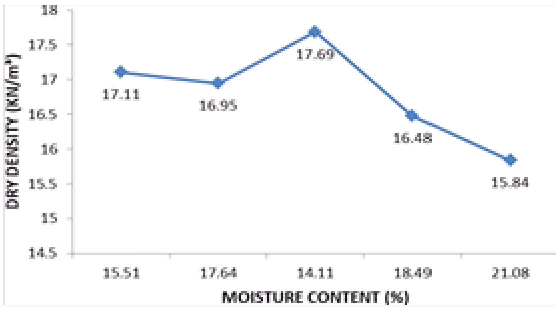

Fig.8: OMC & MDD for the 4% gypsum+ 0.5% plastic + clay

and drained CBR are determined to explain the effect of addition of optimum percentage of plastic and gypsum

4.4.1 California bearing ratio test (drained condition)

CBR test is conducted for the soil sample that contains the optimum 4% of gypsum and 0.5% of PET plastics shredded in a random way with the natural soil. The results obtained for drained and soaked conditions are shown in the graphs.
Load for 2.5mm penetration = 12.145 kg
CBR for 2.5mm penetration = 17.4%
Load for 5mm penetration = 16.947
CBR for 5 mm penetration =16.1%
CBR drained condition=17.4%.

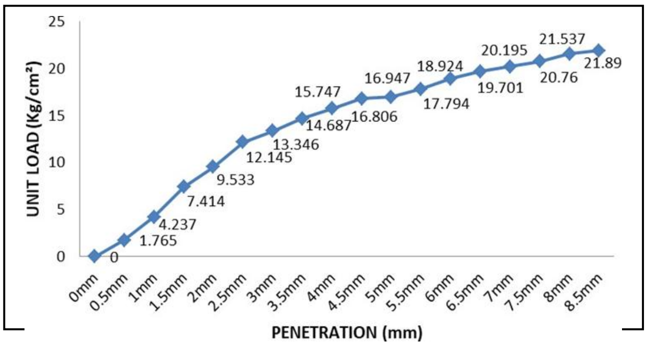

Fig.9: CBR for drained condition

Load for 2.5mm penetration = 11.157 kg
CBR for 2.5mm penetration = 15.9%
Load for 5mm penetration = 16.382 kg
CBR for 5 mm penetration =15.6%
CBR for soaked condition = 15.9%

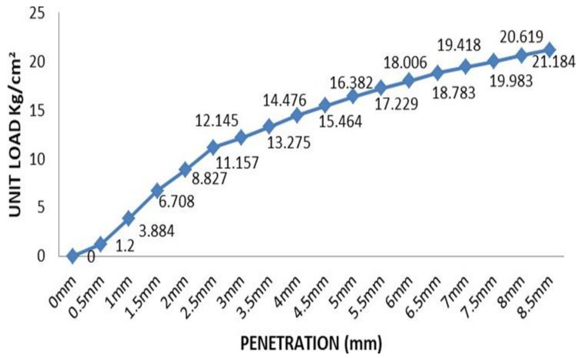

Fig.10: CBR for soaked condition

5. CONCLUSION

As far as plastic is considered, the maximum drained density was obtained for 0.5% plastic of size 5 cm in length and 2 mm in width. On addition it gave an increase in maximum drained density which indicates an increase in the bearing capacity. Gypsum was added to address the scouring and shrinkage properties and 4% is identified to be optimum. Decrease in liquid limit, plasticity index and increase in the shrinkage limit proved the effectiveness of the gypsum addition.

Table – 6 Sample with Gypsum & Plastic

Samples taken	MDD (KN/m^3)	OMC (%)
Natural Soil	17.04	16.36
Natural Soil + Gypsum	17.37	14.29
Natural Soil + 0.3% Plastic	17.26	15.35
Natural Soil + 0.5% Plastic	17.58	14.63
Natural Soil + 0.7% Plastic	17.53	15.36
Natural Soil+ 4%Gypsum 0.50% Plastic	17.69	14.11

The soil showed an improvement in both soaked and drained conditions while conducting CBR test when compared with that of untreated soil. Thus, it is concluded that these two materials could be effectively utilized separately or in combination with each other for subgrade stabilization.

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