Strength Improvement of Expansive Soil By Plastic Powder

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Abstract- *Expansive soils exhibit generally undesirable engineering properties. They tend to have low shear strength which reduces further upon wetting or other physical disturbances. Hence, soil before construction by soil stabilization techniques. The main objective of this study is to investigate the use of plastic powder in geotechnical applications to evaluate the effects of glass and plastic powder on Specific gravity test, liquid limit test, plastic limit test,Consolidation test, Compaction test, Free swell index test and CBR test Unconfined Compression Test. The plastic powder material is added to the soil in different proportions like 2%, 4%, 6% find the percentage of which the maximum soil strength is obtained. The plastic powder is effectively reduced and clay soil fit for pavement construction.*

Keywords- Clay soil, CBR, Plasticpowder

I. INTRODUCTION

The word soil is derived from the Latin word “solium” means the upper layer of the earth that may be dug (or) plowed, specifically. The loose surface material of the earth in which plants grow as per definition point of view soil is a loose unconsolidated material. Which is obtained by weathering of rocks, it may be physical weathering (or) chemical weathering and decomposition oforganic matter which leads to the formation of organic (or) cumulose soil. Any kind of the civil structure which is constructed on the earth surface should ultimately transfer their loads to the soil. So in order to withstandto that loads the soil should process some engineering properties such as shear strength and bearing capacity. Shear strength is the term used in soil mechanics, to describe the magnitude of the shear stress that a soil can sustain. The shear resistance of soil is resulted from the friction between particles, interlocking of particles, and possibly cementation (or) bonding at particle contacts and bearing strength can be geotechnically be defined as the capacity of the soil to support the bads applied to the ground without causing failure. Thus bearing capacity of the soil is the maximum average contact pressure between the foundation and the soil which should not procedure shear failure in the soil. Apart from this engineering properties also involve in the decreasing of permeability and settlements. A material is porous if it contains interstices are interconnected or continuous. A liquid can flow througha permeable material electron photomicrographs of even very fine clays indicates that the interstices are interconnected. However, the size, cross-section, and orientation of the interstices in different soils are highly variable. In general, all the soils are permeable. The property of a soil which permits flow of water (or any other liquid) through it, a soil is highly pervious when water can flow through it easily. In an impervious soil, the permeability is very low and water cannot easily flow through it. A completely impervious soil doesnotpermit the water to flow through it. However such completely impervious soils donot exist in nature, as all the soils are previous to some degree. A soil is termed impervious when the permeability is extremely low.

Permeability is a very important engineering property of soils. A knowledge ofpermeability is essential in a number of soil engineering problems such as settlements of buildings, the yield of wells, seepage through and below the earth structure. It controls the hydraulic stability of soil masses. The permeability of soils is also required in the design of fillers to percent piping in hydraulic structures.

II. LITERATURE REVIEW

Akshat Malhotra and Hadi Ghasemain

The effect of plastic waste on the UCS of soil. In a proportion of 1.5%, 3%, 4.5% and 6% of the weight of dry soil, HDPE plastic (40 micron) waste was added. They concluded that the UCS of black cotton soil increased on addition of plastic waste. When 4.5 % plastic waste mixed with soil strength obtained was 287.32KN/m2 which is maximum because for natural soil it was 71.35KN/m2.

Achmad Fauzi

Waste cutting HDPE and crushed waste glass were used as additives. The variations of additive contents were 4%, 8 %, 12 % by dry total weight of soil sample respectively.

They evaluated engineering properties like sieve analysis, Atterberg limit, Specific gravity, Standard Compaction, soaked California bearing ratio and tri-axial test of the soil sample before stabilization and after stabilization. The result showed that on addition of waste HDPE and glass there was an increasein PI, about 10% for R24 and 2% for R2 samples respectively. The value of optimum water content decreases and MDD increases when content of waste HDPE and glass were increased but there was an increase in CBR value.Authors also observed that there was a decrease in the value of cohesion and increase in friction angle of R2 and R24 samples with additives.

A.I. Dhatrak

It was observed that for construction of flexible pavement to improve the sub grade soil of pavement using waste plastic bottles chips is an alternative method. In a proportion of 0.5%, 1%, 1.5%, 2%, and 2.5% of the weight of dry soil, plastic waste was added to calculate CBR value.He concluded that using plastic waste strips will improve the soil strength and can be used as sub grade. It is economical and eco-friendly method to dispose waste plastic.

Anas Ashraf

The possible use of plastic powder for soil stabilization. The analysis was done by conducting plate load tests on soil reinforced with layers of plastic bottles filled with sand. The bottles cut to halves placed at middle and one third position of tank. The test results showed that cut bottles placed at middle position were the most efficient in increasing strength of soil.

Bala Ramudu Paramkusam

An experimental study to investigate the stabilizationeffect of waste plastic on dry density and CBR behavior of red mud, fly ash and red mud, fly ash mixed with different percentage of waste plastic (PET) content. Based on light compaction tests, authors concluded that MDD value of the red mud, fly ash mixed with plastic increases as the waste plastic increases till 2%, further increase in plastic waste reduces the MDD value. OMC value remains same in each case. A marked increase in CBR value was also observed on adding 0.5%, 1.0%, 2.0%, of waste plastic and was found to be decreased after inclusion of 3% and 4%. Increase of CBR value indicates that the thickness of pavement can be reduced by addition of waste plastic content up to 2%.

Choudhary, Jha and Gill

The potential of HDPE to convert as soil reinforcement by improving engineering properties of sub grade soil. From waste plastic HDPE strips are obtained and mixed randomly with the soil and by varying percentage of HDPE strips length and proportions a series of CBR tests were carried out on reinforced soil. There results of CBR tests proves that inclusion of strip cut from reclaimed HDPE is useful as soil reinforcement in highway application.

Chebet

The laboratory investigations to determine the increase in shear strength and bearing capacity of locally available sand due to random mixing of strips of HDPE (high density polyethylene) material from plastic shopping bags. A visual inspection of the plastic material after tests and analysis indicates that the increased strength for the reinforced soil is due to tensile stresses mobilized in the reinforcements. The factors identified to have an influence on the efficiency of reinforcement material were the plastic properties (concentration, length, width of the strips) and the soil properties (gradation, particle size, shape).

III. EXPERIMENTAL PROGRAMME

3.1 Introduction

In this section, the details pertaining to soil, used in this investigation are discussed. This soil collected form Puttur, Puttur Mandal, Chittoor District. The soils are designated for reference. The soil samples are collected by digging trail pits. The top soil up to 1.0 m is excluded as it is in loose condition and contains microbial activity/ organic matters. The required amount of soils is collected from the trial pits at a depth of 2m below form the ground level, Sufficient care has been taken to see that the collected soils samples are fairly homogeneous. The soils so obtained are air dried, crushed with wooden mallet and passed through 4.75mm sieve. These soils so obtained are kept in polythene bags and stored in steel drums for further test.

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Fig: 12 Expansive soil collected in puttur

3.1.1 Characteristics of Expansive soil

Expansivesoils are inorganic clays of medium to high compressibility and form a major soilgroupinIndia.Expansive soil has a high percentage of clay, which is predominantly montmorillonite in structure and black or blackish grey in color. Because of its high swelling and shrinkage characteristics, the Expansive soil has been a challenge to geotechnical andhighway engineers. The soil is very hard when dry, but loses its strength completely when in wet condition (Bala Subramanian, et. al, 1989). The wetting and drying process causes verticalmovement in. The soil mass which leads to failure of a pavement, in the form of settlement, heavy depression, cracking and unevenness. It also forms clods which cannot be easily pulverized as treatment for its use in road construction (Holtz & Gibbs, 1956). This poses serious problems as regards to subsequent performance of the road. Moreover, the softened sub grade has a tendency to heave into the upper layers of the pavement, especially when the sub-base consists of stone soling with lot of voids. Gradual intrusion of wet soil invariably leads to failure of the road. However, since this soil is available easily at low cost, it is frequently used for construction purposes (Bell, 1988). Some of the factors which influence the behavior of these expansive soils are initial moisture content, initial dry density, amount and type of clay, Atterberg limits of the soil, and swell potential.

3.2 Plastic powder

The name Plastic is derived from the Greek word plastikos, which means able to be shaped. Plastic materials consist of long chain molecules (polymers). Plastic powder can be either found in natural substances or may be man-made. Most of the plastic powder used today are man-made. Man-made plastics are known as synthetic plastic powder. Natural 'plastic powder' occur in such things as animals' horns, animals'milk, insects, plants and trees.Plastic powderconsisting of any of a wide rangeof synthetic sores-synthetic organic thatare malleable andso can be molded into solid objects.

Plasticity is the general property of all materials which can deform irreversibly without breaking but, in the class of moldable polymers, this occurs to such a degree that their actual name derives from this specific ability.

plasticpower is any of a wide range of synthetic or semi-synthetic organic solids that are moldable. Plastics are typically organic plastic of height molecular mass but they often contain other substances. They are usually synthetic, most commonly derived from petro chemicals but many are partially natural. Mostly the plastic powder is otained from the graining of used plastic materials by use of the this kind of plastic powder in stabiization of expansive soil we can decrease the pollution of environment from plastic waste and also decrease the stabilization cost of expansive soil.

Fig: 13 Plastic powder

3.2.1 Properties of plastic powder

Table: 2 Properties of plastic powder

Properties	Plastic powder
Density	0.198 (g.cm^{-3})
Melting point	190 (°C)
Melt flow index (MFI)	2g/10 min (190°C, 2.16 kg).
Tensile stress at Yield	12 (MPa)
Impact Modulus	260 (MPa)
Vicat Softening Point	98 (°C)

Plastics powder have numerous properties that make them superior to other materials in many applications. Plastics generally have: resistance to corrosion and chemicals, low electrical and thermal conductivity, high strength-to-weight ratio, colors available in a wide variety and transparent, resistance to shock, good durability, low cost, are easy to manufacture, resistant to water and have low toxicity.it should not be used in concrete unless tests indicate that it is satisfactory. Water from such sources should be avoided.

3.4 Methods

➢ **Tests conducted on soil**

To obtained the objectives of the present investigations, Tests are conducted on the expansive soil plastic powder. The following tests are conducted Sieve analysis

- Sieve analysis
- Liquid limit
- Plastic limit
- Free swell index
- Specific gravity
- Light compaction test
- Unconfined compression test
- CBR (California Bearing Ratio) test

➢ **Sieve analysis**

A gradation test is performed on a sample of expansive soil in a laboratory. A typical sieve analysis involves a nested column of sieves with wiremeshcloth(screen). Seethe separate mesh(scale) page for details of sieve sizing.

FIG: 14 SIEVES ALONG WITH SIEVE SHAKER

A representative weighed sample is poured into the top sieve which has the largest screen openings. Each lower sieve in the column has smaller openings than the one above. At the base is a round pan, called the receiver. The column is typically placed in a mechanical shaker. The shaker shakes the column, usually for some fixed amount of time. After the shaking is complete the material on each sieve is weighed. The weight of the sample of each sieve is then divided by the total weight to give a percentage retained on each sieve. The size of the average particle on each sieve is then analysed to get a cut-off point or specific size range, which is then captured on a screen.

➢ **Liquid limit**

The liquid limit is the moisture content at which the groove, formed by a standard tool into the sample of soil taken in the standard cup, closes for 10 mm on being given 25 blows in a standard manner. This is the limiting moisture content at which the cohesive soil passes from liquid state to plastic state.

FIG: 15 CASAGRANDE APPARATUS

➢ **Plastic limit**

In this test that water content of soil is derived at which soil changes its state from plastic state to Semi-solid state. In the plastic state of soil, the soil can be Moulded to different shapes without rupturing it, due to its plasticity.

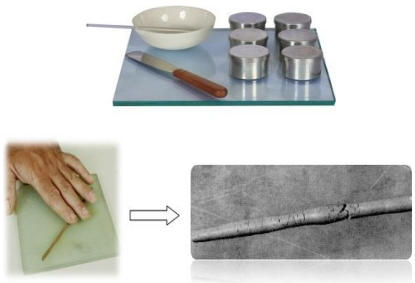


Fig: 16 Plastic Limit A3pparatus

➢ **Free swell index**

To determine the free swell index of soil as per IS: 2720 (Part XL) – 1977. Free swell or differential free swell, also termed as free swell index, is the increase in volume of soil without any external constraint when subjected to submergence in water.

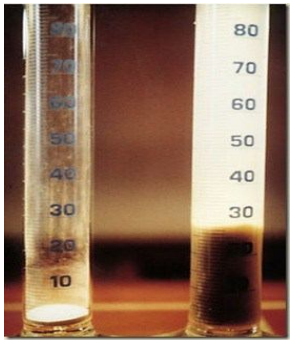


Fig: 17 Free swell index jars

➢ **specific gravity**

Specific gravity G is defined as the ratio of the weight of an equal volume of distilled water at that temperature both weights taken in air. The knowledge of specific gravity is needed in calculation of soil properties like void ratio, degree of saturation etc.

FIG: 18 DENSITY BOTTLE

➢ **Light compaction test**

This method covers the determination of the relationship between the moisture content and density of soils compacted in a mould of a given size with a 2.5 kg rammer dropped from a height of 30 cm.

FIG: 19 LIGHT COMPACTION TEST APPARATUS (RAMAR AND MOULD ALONG WITH BASE PLATE)

Divide the weight of the compacted specimen by 944 cc and record the result as the wet weight g_{wet} in grams per cubic centi-meter of the compacted soil. Remove the sample from the mould and slice vertically through and obtain a small sample for moisture determination. Thoroughly break up the remainder of the material until it will pass a no.4 sieve as judged by the eye.

Add water in sufficient amounts to increase the moisture content of the soil sample by one or two percentage points and repeat the above procedure for each increment of water added. Continue this series of determination until there is either a decrease or no change in the wet unit weight of the compacted soil.

➢ **Unconfined compression test**

Ucc determine shear parameters of cohesive soil, it is not always possible to conduct the bearing capacity test in the field. Sometimes it is cheaper to take the undisturbed soil sample and test its strength in the laboratory. Also, to choose the best material for the embankment, one has to conduct strength tests on the samples selected. Under these conditions it is easy to perform the unconfined compression test on undisturbed and remolded soil sample. Now we will investigate experimentally the strength of a given soil sample.

➢ **CBR (California Bearing Ratio) Test**

]The California Bearing Ratio (CBR) test is a measure of resistance of a material to penetration of standard plunger under controlled density and moisture conditions. It was developed by the California Division of Highways as a method of classifying and evaluating soil- subgrade and base course materials for flexible pavements.

CBR test may be conducted in remolded or undisturbed sample.

FIG: 21 CBR TEST APPARATUS (CBR TEST MACHINE ALONG WITH RAMARS)

IV. RESULTS AND DISCUSSIONS

4.1 Introduction

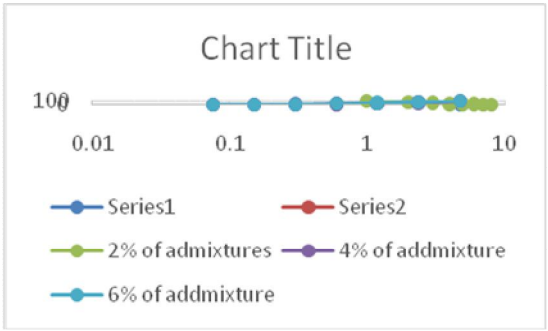
Index properties of soils such as Atterberg Limits, Moisture content, % FineFraction, Void Ratio and Density are which are properties of soils; define the behavior of soils. It is necessary to investigate the variation of behavior of soils with theseproperties. The % Fine Fraction is supposed to be the key parameter for the behavior ofsoils as mentioned in literature.

4.2 Variations in Test results

- **Sieve analysis**

S.no	% of admixtures	coefficient of uniformity C_U	Coefficient of curvature C_C
01	0%	4.56	1.70
02	2%	5.51	1.09
03	4%	7.27	1.39
04	6%	5.38	0.97

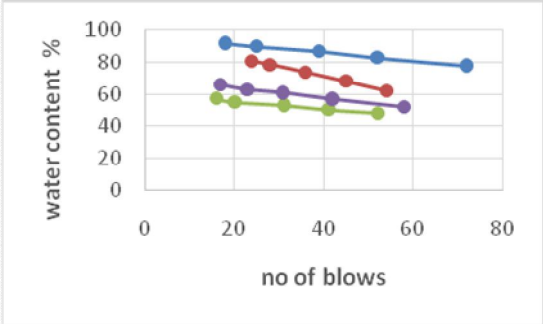
graph shown in sieve analysis



- **Liquid limit test**

S.no	% of plastic powder	% of liquid limit
01	0%	92%
02	2%	81%
03	4%	57%
04	6%	66%

Graph shown in liquid limit test



- **Plastic limit test**

S.no	% of plastic powder	% of plastic limit
01	0%	50%
02	2%	66.66%
03	4%	100.00%
04	6%	50.00%

- **Free swell index test**

S.no	% of plastic powder	% of free swell index
01	0%	51%
02	2%	50
03	4%	48
04	6%	52

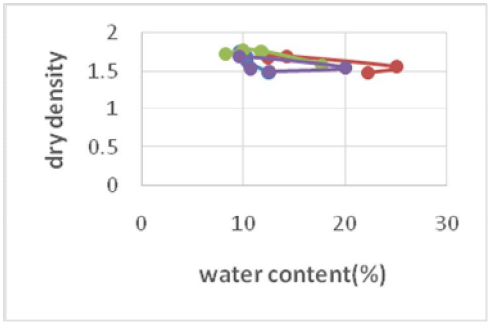
- **Specific gravity test**

S.no	% of admixtures	Specific gravity of clay
01	0%	2.28
02	2%	2.23
03	4%	2.14
04	6%	1.80

- **light compaction test**

S.no	% of admixtures	% of OMC	% of MDD
01	0%	9.60%	1.75%
02	2%	14.2%	1.70%
03	4%	10%	1.78%
04	6%	9.50%	1.69%

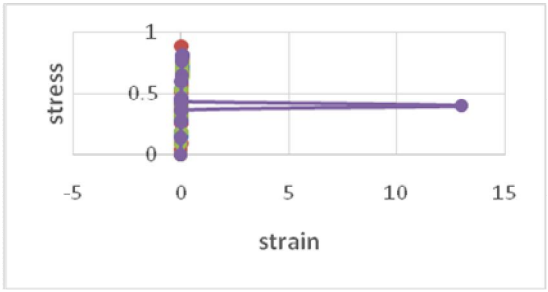
Graph shown in light compaction test



➢ **Unconfined compression test**

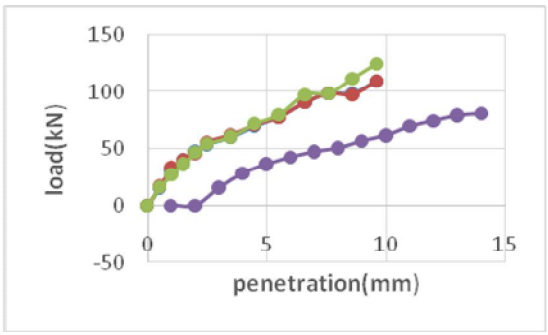
S.no	% of admixtures	Strength of UCC kg/cm²	coefficient of uniformity C_u
01	0%	4.56	1.70
02	2%	5.51	1.09
03	4%	7.27	1.39
04	6%	5.38	0.97

Graph shown in UCC



➢ **California bearing ratio test**

S.no	% of admixtures	2.5mm penetration of soil	5 mm penetration of soil
01	0%	0.36%	1.84%
02	2%	0.51%	1.94%
03	4%	4.23%	3.74%
04	6%	3.50%	2.96%



V. CONCLUSION

- The project is focused on the performance of Plastic powder as soil stabilization material. The study suggests that if the plastic powder are properly mixed and applied then it can be used as a great soil stabilization technique on the basis of the results obtained. Based on analysis of results on the plastic powder stabilized soils the following observations and conclusions are drawn.
- An immediate benefit obtained by the addition of plastic powder to swelling soils is to reduce the potential for swelling upon contact with water. The plastic nature of the soil decreases and the stiffness of the soil increases as the plastic powder content increases. For improving the properties described in this paper, the optimum plastic powder content was found to be within the range of 3% to4%.
- Increase in plastic powder content stabilized soil can significantly show the increase in strength up to 4% of plastic powder and there after it decreases. Deep foundations and raft foundations for structures on soil with low bearing capacity can be replaced by shallow foundation with soil stabilized by plastic powder.
- The results indicate that the initial void ratio was higher for plain soil and as the plastic waste was added it being lower. As the percentage of plastic waste increased in soil, the density of plastic waste being less, more voids were occupied with plastic waste and resulted in overall reduction of void ratio. The values of friction angle increases as the dry density of clay increases. The increase in strength in soil is due to increase in friction.
- This study suggests that if plastic powder content is properly mixed, it can be used as a great soil strength improvement technique.

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