

Stabilization of Subgrade with Waste Plastic as Stabilizer in Flexible Pavements

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ABSTRACT: In the present era, disposal of waste material is a great challenge. Plastic is a waste material which harms the environment. With increasing demand of disposing waste materials, plastic such as shopping bags is utilized as a reinforcement material in this study. Plastic strips obtained from the waste plastic are mixed randomly with the soil sample. Failures of pavements are caused due to many reasons or combination of reasons. Subgrade should be stabilized to improve the performance of such pavements in long run and to minimize the maintenance cost. Stabilization if not done proper, may lead to fatalities in flexible pavements. Stabilization of soil can be performed in number of ways, but the stabilization using waste plastic strips is an economical method since the stabilizer used in current study is waste plastic materials, which are relatively cheap and easily available in the market. This paper presents the various laboratory tests conducted on fibre reinforced soil with varying fibre content and different aspect ratio and their test results are analyzed such that it can be used in the field. A number of California Bearing Ratio (CBR) tests were carried out on randomly reinforced soil by varying the percentage of plastic strips with different lengths and proportions. From the test results of CBR, the inclusion of waste plastic strips about 5% by weight of soil increased the strength characteristics and deformation behaviour of soil sub grade substantially. This preservation technique proved to be advantageous in embankment/road construction, industrial yards etc.

KEYWORDS: Stabilization, Expansive soil, Plastic Strips, Flexible Pavements.

I. INTRODUCTION

Expansive soils, also known as black cotton soils in India, undergo swelling by absorbing water and shrinking by loss of moisture. Therefore, during summer when evaporation from the ground and transpiration due to vegetation exceeds the rainfall, the expansive soil dries up and moisture deficiency develops in the soil, giving rise to soil shrinkage. During the rainy season, the soil absorbs moisture and swells. Soils possessing the clay mineral Montmorillonite generally exhibit these properties. Several methods were reported in literature for identification, determination, and prediction of swelling soils but with numerous limitations and with a little acceptance on universal basis. The developments in the selection and design of foundations are not much different from that of swelling characteristics. The successes and failures for each of the foundation alternatives proposed in literature are almost equal. Some techniques proved to be too uneconomical to adopt for all types of structures while others are too sensitive to environmental and climatic changes leading to high uncertainties in the safety of the structures supported. Structures are not only constructed on the soil, but the soil can also be used for constructing embankments, earthen dams, airfields and highway pavements. Soils in general are used as construction material as available in nature with a little processing. However, Expansive soils where necessarily cannot be used as a construction material without altering their properties suitably by some means. There are several techniques proposed in literature to improve the properties of expansive soils such as

- Addition of physical admixtures like another soil or industry generated by products such as cement and stone dust.
- Addition of Chemical admixtures such as cement, lime, gypsum etc.

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The choice of method of improvement is dependent on availability and relative cost of materials used for improvement. Cement and stone dust are widely used in practice, throughout the world, to stabilize expansive soils as they are relatively cheap and are available almost everywhere.

II. SOIL PROPERTIES

Various laboratory tests are conducted to ascertain the properties of soils. The properties of soils are classified into Engineering properties and Index properties.

1. Engineering Properties: The main engineering properties of soils are permeability, compressibility, and shear strength.

2. Index Properties: The main index properties of fine grained soils are particle size distribution and consistency limits.

3 Stabilization of Soil: Both hydrated lime and quick lime are used to stabilize the characteristics of the sub grade soil underneath the pavement surface. Stabilization of sub grade soil leading to longer life of the pavement is generally categorized into two ways:

i) Sub grade modification

ii) Sub grade or base stabilization

Modification is the addition of a smaller quantity of lime, typically to react with clay and excess moisture for quick and short term strengthening effect. Modification occurs because calcium cations supplied by the hydrated lime replace the cations normally present on the surface of the clay mineral, promoted by the high PH environment of the lime–water system. Modification has the following benefits:

i) lower the plasticity index of clay soil

ii) dry up the wet soil or mud

iii) reduces the tendency of clay soils to swell drastically

iv) increase in bearing capacity of soil



Fig. 1: Diagram showing the additon of waste plastic to Soil

4.Improved Properties of soil by plastic as soil stabilizer: The following parameters are improved by soil stabilization using plastic as stabilizer in flexible pavements.

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- i) CBR Value
- ii) Shear Strength
- iii) Reduction in Consolidation Settlement
- iv) Reduction in Swelling characteristics

5. Stabilization with Plastic Waste: The principle of resisting action of the strips is mainly visualized as given in Fig. 2 (a) and (b). In situation (a) the plunger pushes down particle 'C' to occupy position in between particle 'A' and 'B'. The strip resists the downward movement of particle 'C' until slippage between soil and strip occurs resulting into a development of situation(b). Thus, it is the interaction between soil and strips which causes the resistance to penetration of the plunger resulting into higher CBR values.

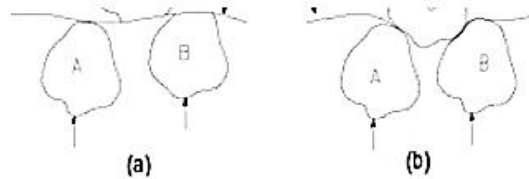


Fig. 2: Schematic diagram showing position of strip (a) Before and (b) After slippage between soil strip.

III. EXPERIMENTAL PROGRAMME

Soil Properties	Sample
1. Compaction Characteristics	
i) MDD gm/cm ³	2.02
ii) O.M.C %	12
2. Plasticity Characteristics	
i) Liquid Limit, %	34
ii) Plastic Limit, %	11
iii) Plasticity Index (P.I), %	23
3. CBR Value of Soil Sample in soaked conditions (%)	4.1
4. Shear Characteristics	
i) Shear Strength, S	4.34
ii) Angle of internal friction, Φ	27°

Table 3.1: Properties of Soil

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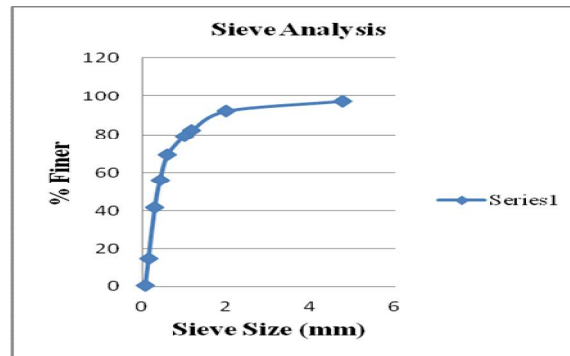


Fig. 3.1: Sieve analysis of soil

S.No.	Index Properties of Soil Sub Grade
1.	Specific Gravity = 2.2
2.	Swelling Index = 65%
3.	Sieve Analysis (a) Coefficient of uniformity, $C_u = 3.83$ (b) Coefficient of Curvature, $C_c = 1.043$

Table 3.2: Index Properties of Soil SubGrade

S.No.	Engineering Properties of Soil including waste plastic
1.	I.S. Light Compaction (a) MDD of soil with 2% plastic = 1.93 (b) MDD of soil with 4% plastic = 1.90 (c) MDD of soil with 5% plastic = 1.91 (d) MDD of soil with 6% plastic = 1.82

Table 3.3: Engineering Properties of Soil

S.No.	at Dry Condition
1.	CBR Values of soil with (a) 2% plastic by wt. of soil = 34.15% (b) 4% plastic by wt. of soil = 48.17% (c) 5% plastic by wt. of soil = 49.00% (d) 6% plastic by wt. of soil = 47.00%

Table 3.4.1: Dry CBR values of Soil+Plastic

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S.No.	at Saturated Condition
1.	CBR Values of soil with (a) 2% plastic by wt. of soil = 4.12% (b) 4% plastic by wt. of soil = 5.92% (c) 5% plastic by wt. of soil = 5.95% (d) 6% plastic by wt. of soil = 5.72%

Table 3.4.2: Soaked CBR values of Soil+Plastic

Soil Properties	Sample
1. Shear parameters of soil with 2% plastic	
i) Shear Strength, S	3.68
ii) Angle of internal friction, Φ	27°
2. Shear parameters of soil with 4% plastic	
i) Shear Strength, S	9.17
ii) Angle of internal friction, Φ	28.5°
3. Shear parameters of soil with 5% plastic	
i) Shear Strength, S	10.57
ii) Angle of internal friction, Φ	33°
4. Shear parameters of soil with 6% plastic	
i) Shear Strength, S	3.93
ii) Angle of internal friction, Φ	27°

Table 3.4: Shear characteristics of Soil

IV. RESULTS AND DISCUSSION

The findings showed that there is an improvement in properties of the soil sub grade soil by using plastic waste as a stabilising compound. The important finding is that the California Bearing Ratio (CBR) of soil by the addition of 5% waste plastic at dry condition is 49% at a depth of 2.5 mm penetration, which is higher value when compared with the addition of 2, 4 and 6% waste plastic to soil sub grade. The California Bearing Ratio (CBR) of soil by the addition of 5% waste plastic at soaked condition is 5.95% at a depth of 2.5 mm penetration, which is higher value when compared with the addition of 2, 4 and 6% waste plastic to soil sub grade.

V. CONCLUSION

Based on the experimental work carried out, the following conclusions have been drawn.

1. Improper stabilization causes cracks in roads.
2. It can be concluded that the engineering properties of soil are improved after stabilizing the soil with waste plastic when compared to properties of soil without stabilizing. So, plastic can be used as a reinforcement material for decreasing the fatalities in the soil sub grade in case of flexible pavements.
3. 5% of waste plastic by weight of soil sample is the optimum percentage that can be used in the stabilisation of soil sub grade.



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