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USE OF GEOTEXTILE FOR IMPROVING SHEAR STRENGTH OF SOIL

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ABSTRACT

Different methods such as consolidation, stabilisation, grouting and reinforcing the soil etc. are normally adopted for improving the mechanical properties of soil. Mechanical properties of soil can also be improved by using Geotextile as reinforcing material and this method leads to overall economy. Different properties of soil which can be improved by using geotextile are shear strength, permeability, consolidation, slope stability, bearing capacity, resistance to erosion etc. Resistance to deformation of soil is the shear strength which is one of the most important properties of soil. Shear strength of soil is improved by increasing friction, draining and confinement by using Geotextile.

The type of Geotextile, the position and placing of Geotextile, type of soil may also affect the improvement of soil properties. It is necessary to find out the type, position and the way of placing of Geotextile.

Extensive experimentation was carried out to find the improvement in shear strength of cohesive and C-ϕ soils with H.D.P.E. Geotextile as reinforcement in different positions and different directions. It was observed that the shear strength of cohesive soils can be increased by about 11 to 21 % and that of the sandy soils by about 27 to 75 %. It was also noticed that the placement of Geotextile at an angle of 135 degrees with horizontal increases the shear strength to maximum possible extent. Increase in shear strength will result in increasing the bearing capacity of soil. Results of experimentation are discussed in the present paper.

INTRODUCTION

Consolidation, stabilisation, grouting and reinforcing the soil etc. are the commonly used techniques for improving mechanical properties of soil. Reinforcing the soil is one of the most effective and economical method of improving the mechanical properties of soil. Use of geotextiles as reinforcement has been tried at many places. By using geotextile steeper embankments, retaining walls, dams, roads etc. can be constructed resulting in low construction and maintenance costs. The type of geotextile and its placement may also affect the improvement of soil properties. It is therefore, necessary to select the type of geotextile and its position and direction to be used with a particular type of soil for improving the properties of soil. With this view in mind, it was decided to carryout experiments to know the improvement in shear strength of C-ϕ and C soils. The other aims of the research programme were :

1. To study the behaviour of reinforced and unreinforced soil under laboratory direct shear test.
2. To sudy the effect of orientation of geotextile reinforcement with respect to the direction of applied load on shear strength of soil.

In this research program conventional direct shear tests were conducted to achieve above objectives.

MATERIALS USED

Following materials were used in the research program:

(i) Geotextile : The geotextile in the form of woven fabric made from H.D.P.E. was used in this investigation. The properties of the geotextile as supplied by the manufacturer are :

Thread Dia.	0.5 mm
Mesh	24/sq.inch (3.72/sq. cm.)
Weight	170 gms/sqm.
Opening Size	0.7 mm × 0.7 mm
Strip tensile strength	1028 kg/r.m.
Fracture Strength	6376.5 kg-m

(ii) Soils : C-ϕ soil brought from VALADGAON near Waluj industrial area of Aurangabad (M.S.) and Clayey soil(C-soil) from Tarapur industrial area,Tarapur (M.S.) has been used in this investigation. Grain size analysis of C-ϕ soil is given below:

Size	*Percentage*
2 to 1 mm	10
425 Microns -75 Microns	70
Below 75 Microns	20

Proctor density tests were conducted to determine the Optimum moisture content and maximum dry density of soils. The results of proctor test are given below.

Type of Soil	*O.M.C.%*	*Maxm: Dry Density Gms/cc.*
C-ϕ soil	11%	1.89
C soil	17%	1.46

TEST PROGRAM

It was decided to perform direct shear tests on two types of soils i.e. C-ϕ soil and C soil, with and without the use of geotextile.

For C-ϕ soil,tests were conducted on samples of size 6 cm × 6 cm × 2 cm. Geotextile was cut to match the sample size. The samples were prepared using optimum moisture content. Following five types of samples were prepared:

Type I – Samples without geotextile reinforcement
Type II – Samples with single horizontal layer of geotextile reinforcement
Type III – Samples with two horizontal layers of geotextile reinforcement
Type IV – Samples with single layer of geotextile reinforcement inclined at 45° to the direction of applied load
Type V – Samples with single layer of geotextile reinforcement inclined at 135° to the direction of applied load strain controlled tests were performed using deformation rate of 1.25 mm/ minute. Four different normal stress loadings were used i.e. 1, 2, 3, 4 kg/sq.cm

For clayey soil, tests were conducted on samples of size 30 cm × 30 cm × 30 cm. Three different normal stress loading were used i.e. 0.5, 1.0, 1.5 kg/sq.cm. Three types of samples were prepared:

Type I – Samples without geotextile reinforcement
Type II – Samples with single horizontal layer of geotextile reinforcement
Type III – Samples with single layer of geotextile reinforcement inclined at 135° to the direction of applied load

Results of the tests are given in Table 1 and Table 2.

It was observed during experiments that the failure in all the cases (except when the geotextile was inclined at 45° to the shearing plane,type IV) is due to slip of geotextile. For the samples in which geotextile was placed at 45° inclination to the shearing plane , the failure was due to twisting of geotextile.

Table 3 and Table 4 gives the general comparison of shear strength of reinforced and unreinforced samples and percentage increase in shear strength over unreinforced samples.

Table 1: Results of Direct Shear Tests on C-ϕ Soils

Details of samples	Normal stress kg./sq. cm	Shear stress kg./sq. cm	Strain % at failure
Type I	1.0	0.63	6.25
	2.0	1.01	6.25
	3.0	1.37	7.29
	4.0	1.77	8.33
Type II	1.0	0.97	7.29
	2.0	1.50	8.33
	3.0	2.02	8.33
	4.0	2.57	9.37
Type III	1.0	1.01	8.33
	2.0	1.62	10.41
	3.0	2.17	11.45
	4.0	2.70	11.45
Type IV	1.0	0.82	8.33
	2.0	1.30	8.33
	3.0	1.75	9.37
	4.0	2.21	10.41
Type V	1.0	0.97	10.41
	2.0	1.62	15.62
	3.0	2.30	17.70
	4.0	3.10	18.75

Table 2: Results of Direct Shear Tests on C-soils

Details of samples	Normal stress kg./sq. cm	Shear stress kg./sq. cm	Strain % at failure
Type I	0.5	0.30	5.83
	1.0	0.31	6.66
	1.5	0.31	7.50
Type II	0.5	0.32	8.33
	1.0	0.33	9.16
	1.5	0.35	10.83
Type III	0.5	0.33	9.16
	1.0	0.35	10.00
	1.5	0.38	10.83

Table 3: Comparison of Test Results of Reinforced and Unreinforced Samples of C-ϕ Soil

Details of samples	Normal stress	Shear stress at failure (unreinforced) kg./sq. cm	Shear stress at failure (reinforced) kg./sq. cm	% increase in shear strength kg./sq. cm
Type II	1.0	0.63	0.97	53.97
	2.0	1.01	1.50	48.51
	3.0	1.37	2.02	47.44
	4.0	1.77	2.57	45.19
Type III	1.0	0.63	1.01	60.32
	2.0	1.01	1.62	60.39
	3.0	1.37	2.17	58.39
	4.0	1.77	2.70	52.54
Type IV	1.0	0.63	0.82	31.16
	2.0	1.01	1.30	28.71
	3.0	1.37	1.75	27.73
	4.0	1.77	2.21	24.85
Type V	1.0	0.63	0.97	53.97
	2.0	1.01	1.62	60.39
	3.0	1.37	2.30	67.88
	4.0	1.77	3.10	75.14

Table 4: Comparison of Test Results of Reinforced and Unreinforced Samples of C Soil

Details of samples	Normal stress kg/sq. cm	Shear stress at failure (unreinforced) kg/sq. cm	Shear stress at failure (reinforced) kg/sq. cm	% increase in shear strength kg/sq. cm
Type II	0.5	0.30	0.32	6.67
	1.0	0.31	0.33	6.45
	1.5	0.31	0.35	12.90
Type III	0.5	0.30	0.33	10.00
	1.0	0.31	0.35	12.90
	1.5	0.31	0.38	22.58

CONCLUSIONS

From test results of C-ϕ soil it is observed that there is notable improvement in the shear strength of soil which ranges from 27 to 75%, depending on the number of layers of geotextiles reinforcement and its orientation.

For clayey soil, the increase in shear strength is in the range of 11 to 21% only.

For both type of soils, it is observed that the placement of geotextiles at 135 degrees inclination with the shearing plane is most effective. Placement of geotextile at 45 degrees to the shearing plane is least effective due to twisting of geotextile.

It is also observed that the placement of geotextile in two layers is more effective than single layer.

In most of the cases, failure is due to slipping of geotextile. It can therefore be concluded that more improvement in shear strength of soil is possible by anchoring the geotextile.

Geotextile, may prove to be economical for construction of retaining walls, earthen embankments, road etc. as it increases the shear strength of soil which may result in providing steeper slopes.

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