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Effect of Reinforcement on Properties of Silty Sand

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Abstract: The variation of the stress-strain behavior and shear -parameters of reinforced silty sand is studied. The geotextiles were provided at different heights in the sample and tested in unconsolidated undrained condition. Two types of geotextiles, woven and nonwoven were used as reinforcement and the experiment was conducted at three water contents. Tests were performed on samples prepared at OMC, dry of OMC and wet of OMC in order to study the effect of water content. The results demonstrated that geotextile inclusion increases the peak strength, axial strain at failure. The sample was found to fail due to bulging between the layers.
Keywords: Optimum Moisture Content, Maximum Dry Density, Unconsolidated Undrained, Deviator Stress, Normal Stress

I. INTRODUCTION

The properties of poor soil are improved by reinforcing with various materials. Various material such as straw, fibres, fabrics, geosynthetics etc. are used to improve the strength of soil. The concept of strengthening the soil using various materials is in practice from ancient times. Reinforced soil is a composite material, a combination of soil and reinforcement suitably placed to withstand the developed tensile stresses. The inclusion of reinforcement enables the use of poor quality soils to be used as structural components. Reinforcing soil with geosynthetics is used for many civil engineering applications. Geosynthetics include manmade polymeric products such as geotextiles, geogrid, geonets, geomembranes, geosynthetic clay liner and geocomposites. The shear resistance of the soil is improved due to inclusion of reinforcement thereby improving its structural capability.

II. LITERATURE REVIEW

Vidal (1969) [1] has adopted mechanical methods to stabilize the soils by incorporating different inclusions ranging from low-modulus, polymeric materials to relatively stiff, high-strength metallic elements within soils. Chandrasekaran et al. (1989) [2] conducted a series of model tests to study the failure modes of geotextile reinforcement soil wall. The backfill was uniform fine sand. The reinforcement was woven polyester. Under the uniform surcharge pressure, block sliding and slip failure modes were observed. Haeri et al. (2000) [3] made an attempt to study the stress-strain behaviour and dilation characteristics of geotextile-reinforced dry beach sand. The composite material was investigated through varying layers, types of geotextiles, confining pressure, and geotextile arrangement. Unnikrishnan et al. (2002) [4] showed the enhancement of strength and deformation properties of geotextile reinforced clays by monotonic compression and cyclic triaxial tests. A thin layer of high-strength sand was provided on both sides of the reinforcement. Nguyen et al. (2013) [5] investigated the stress–strain–volumetric response of geotextile-reinforced sand and the mobilization and distribution of reinforcement strain/loads and soil geotextile interface shear stress within reinforced soil.

III. OBJECTIVES

This study focuses on utilization of geotextiles for improvement of soil strength and stress-strain characteristics. The objectives of the work are

1) To study the index properties and to classify the unreinforced soil.
2) To study the engineering properties of unreinforced soil.
3) To study the properties of geotextiles i.e. mass per unit area, thickness, tensile strength.
4) To study the strength characteristics of reinforced soil.
5) To study the stress-strain characteristics of unreinforced and reinforced soil.
6) To study various parameters such as type of material, water content, confining pressure and geotextile arrangement on strength characteristics.

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IV. RESULTS AND DISCUSSION

The tests were conducted in order to determine the soil properties, compaction characteristics of the soil, geotextile properties and variation of properties when woven and nonwoven geotextiles are placed at different heights of the sample.

A. Soil properties

The soil is obtained in Andhra University engineering college campus, Visakhapatnam. The soil properties are shown in Table I. From the Table I, the soil has 85 % sand sized particles and 15% fines. It has liquid limit of 19% and no plastic limit. The soil is classified as silty sand of no plasticity (**S**M) according to IS 2720.

B. Geotextile Properties

The geotextiles used for the present study are woven geotextile and nonwoven geotextile. The properties of both textiles are given in Table II and Table III. The reinforcement were placed at Centre i.e. one layer reinforcement, two layer reinforcement spaced at H/3, three layer reinforcement spaced at H/4 where H is the height of the sample.

TABLE I
SOIL PROPERTIES

Gravel (%)	0
Sand (%)	85
Fines (%)	15
Liquid limit (%)	19
Plastic limit (%)	NP
Plasticity index (%)	NP
Soil classification	SM
Specific gravity	2.63
Optimum moisture content (OMC) (%)	8
Maximum Dry Density (MDD) (g/cc)	1.83
Cohesion (C) (kg/cm^2)	0
Angle of internal friction (Φ)	34°

TABLE II
WOVEN GEOTEXTILE PROPERTIES

Nominal Thickness (mm)	0.352
Mass per unit area (g/m^2)	142
Tensile strength(KN/m)	20.4

TABLE III
NONWOVEN GEOTEXTILE PROPERTIES

Nominal Thickness (mm)	2.827
Mass per unit area (g/m^2)	334
Tensile strength (KN/m)	27.5

V. TESTS CONDUCTED

Triaxial tests were conducted on unreinforced soil and reinforced soil with woven and nonwoven geotextiles placed at different heights. The tests were conducted for Samples prepared at three water contents OMC and MDD condition, dry of OMC condition and wet of OMC condition. The relation between normal stress and shear stress and stress-strain was obtained for unreinforced and reinforced soil specimens with woven and nonwoven geotextile at half height of the specimen, one third height of the specimen and one fourth height of the specimen at respective pressures 0.5 kg/cm^2 , 1.0 kg/cm^2 and 2.0 kg/cm^2.

A. Shear parameters at OMC condition

Table IV gives the shear parameters cohesion and angle of internal friction for woven and nonwoven geotextile reinforced soil. The angle of internal friction increased with increase in number of layers of both woven and nonwoven geotextile. The cohesion values also increased with increase in layers of geotextiles. The stress-strain curves for both unreinforced and reinforced soil follow the non-linear curve distribution. There is an increase in deviator stress with increase in number of layers of geotextiles.

TABLE IV

SHEAR PARAMETERS FOR REINFORCED SOIL

Type of sample	C-value (kg/cm^2)	Φ - value
Unreinforced soil	0	34^0
one layer woven geotextile	0	37^0
Two layer woven geotextile	0.1	39^0
Three layer woven geotextile	0.1	41^0
One layer nonwoven geotextile	0.05	40^0
Two layer nonwoven geotextile	0.1	42^0
Three layer nonwoven geotextile	0.1	43^0

B. Shear Parameters wet of OMC Condition

Table V gives the shear parameters cohesion and angle of internal friction for woven and nonwoven geotextile reinforced soil. The angle of internal friction increased with increase in number of layers of reinforcement. A slight cohesion is also observed with increase in number of layers.

TABLE V

SHEAR PARAMETERS FOR REINFORCED SOIL WET OF OMC

Type of sample	C-value (kg/cm^2)	Φ - value
Unreinforced soil	0	29^0
one layer woven geotextile	0	31^0
Two layer woven geotextile	0	40^0
Three layer woven geotextile	0.1	42^0
One layer nonwoven geotextile	0.05	34^0
Two layer nonwoven geotextile	0.1	41^0
Three layer nonwoven geotextile	0.1	42^0

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C. Shear Parameters Dry of OMC Condition

Table VI gives the shear parameters cohesion and angle of internal friction for woven and nonwoven geotextile reinforced soil. The angle of internal friction increased with increase in number of layers of reinforcement. A slight cohesion is also observed with increase in number of layers.

TABLE VI

SHEAR PARAMETERS FOR REINFORCED SOIL DRY OF OMC

Type of sample	C-value (kg/cm^2)	Φ - value
Unreinforced soil	0	31^0
one layer woven geotextile	0	34^0
Two layer woven geotextile	0.05	37^0
Three layer woven geotextile	0.1	40^0
One layer nonwoven geotextile	0.05	36^0
Two layer nonwoven geotextile	0.1	39^0
Three layer nonwoven geotextile	0.15	41^0

VI. MODES OF FAILURE OF REINFORCED SOIL

Geotextile inclusion increases the peak strength significantly. This is due to the increase in confinement. The increase in peak strength is more pronounced for greater number of geotextile layers.

The modes of failure are shown in Fig. 1 to 3, for geotextile reinforced samples. Bulging failure is observed rather than shear failure.

Fig 1. One layer reinforcement

Fig 2. Two layer reinforcement

Fig 3.Three layer reinforcement

VII. CONCLUSIONS

A. Geotextile inclusion enhances peak strength, axial strain at failure. The progress is more effective with a higher number of geotextile layers.

B. There is an improvement in cohesion value with increase in the number of geotextiles.

C. The angle of internal friction increases with increasing number of geotextiles.

D. The increase in confining pressure increases the peak deviator stress of the soil.

E. Failure of reinforced soil was observed by bulging.

F. The test samples reinforced with nonwoven geotextiles exhibited a significantly higher cohesion than the those reinforced with woven geotextiles

G. The values of cohesion and angle of internal friction are higher at the optimum moisture content than the wet of OMC condition and dry of OMC condition.

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