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Strength Characteristics of Soil Reinforcement

by

J. N. Mandal*

Introduction

In recent years, the bulk of reinforced earth technique have been completed all over the world. The design, analysis and the construction of conventional reinforced earth structures is now well established but the basic mechanisms are not clearly understood. The rigorious works on soil improvement using reinforcement have been reported by several authors (Holtz, 1975, 1978, Lee adam and Vagneran, 1973, Mandal et al. 1980, Mandal and Char, 1985, Schlosser and Long, 1972, 1974, Uesawa and Nasu, 1973, and Zen, 1972, Ingold, 1983, Ingold and Miller, 1982). Hausman (1976) hypothesied that the strength characteristics of reinforced sand depends on the increased apparent friction angle. Broms (1977) observed that the ultimate strength increased with decreasing the distance between the fabric discs and that the discs which were placed at the two ends of the samples did not influence the ultimate strength. Lee (1976) carried out a limited unconfined compression tests on compacted clay samples reinforced with thin narrow strips of mylar tape. The results showed an increase in the ductility of the sample but no increase in compressive strength. Ingold (1979) indicated that the strength of the samples increases with decrease in the ratio of the height of soil element between consecutive reinforcing discs and the diameter of the sample. The stress-strain relationships for various reinforcement materials have been well documented by Holtz et al (1982). The stress-strain behaviour of reinforced soil depends on the type and form of reinforcing elements and the interactions between soil and the metal strips.

The effect of reinforcement on the stress-strain characteristics of soil under different moisture contents and the corresponding dry densities is the object of this experimental study using triaxial apparatus.

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*Asstt. Professor, Civil Engineering Department, IIT, Powai, Bombay, 400 076, India.

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Physical Properties of Soil and Reinforcements

The average grain size distribution for the soil is shown in Fig. 1. The specific gravity of the soil was 2.66. Liquid, Plastic and Shrinkage limits for the average sample were obtained as 39, 14, and 10.5 percent respectively. The maximum dry density and the optimum moisture content for the soil were 1.92 g/cc and 12.5 percent respectively.

Soil samples were reinforced by thin aluminium discs and mild steel fibres. For aluminium reinforcements since the plate thickness commercially available was 0.45 mm, thinner sheets were rolled out in the rolling machine. Thickness of plates were computed for different percentages of reinforcements. Alluminium discs 25 mm dia. and 0.16 mm thickness were used as plate reinforcements.

Mild steel sheets were obtained by cutting out empty kerosene tins. Several pieces were cut and chemically tested. These were found to be of mild steel with galvanised coatings. The average thickness of the sheet was 0.16 mm. The tensile strength of mild steel and aluminium sheets were obtained by testing tensile test specimens of the sheets in an Universal Testing Machine. The average stress-strain curves of reinforcing materials are given in Fig. 2.

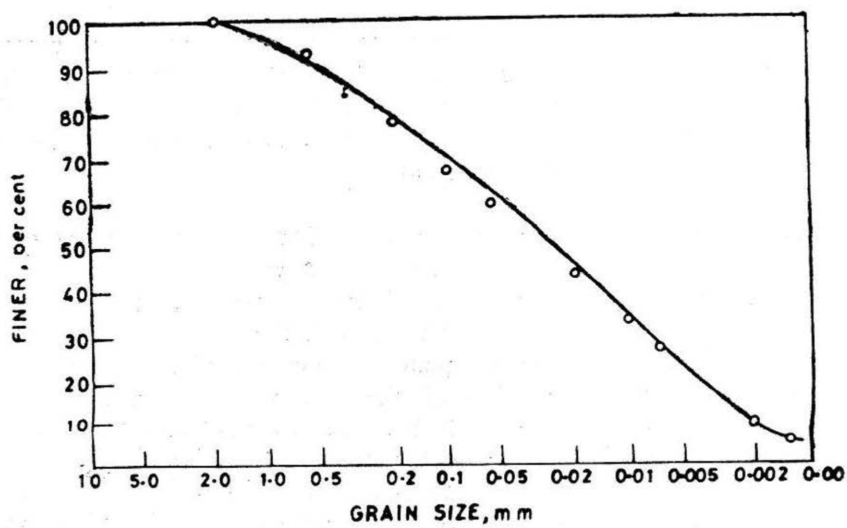

FIGURE 1 Grain Size Distribution Curve of Silty Clay

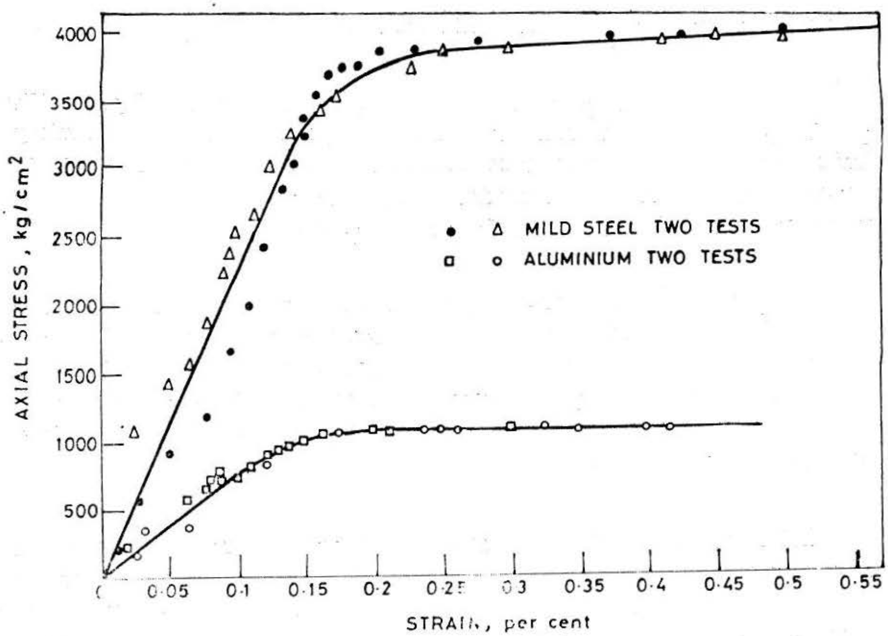

FIGURE 2 Stress-Strain Curves of Reinforcements

Laboratory Triaxial Tests

The conventional laboratory triaxial tests were performed in this present investigation. Standard sample size of 3.81 cm diameter and 7.62 cm height was used for the triaxial tests. It was observed that the compaction by tamping in the mould assembly gives a uniform dry density as against frce fall method of compaction.

Soil prepared for compaction in the mould was divided into five equal portions approximately. The surfaces of the mould and rammer were lightly oiled. The first portion of the sample was put into the mould, roughly levelled and compacted with the rammer. The surface was levelled as the reinforcement plate in the case of plate reinforcements was placed and the next portion of the soil was then put into the mould and the operation repeated till the full sample height was reached. The sample was trimmed at top and bottom for level ends and stored in a descicator. Only two and three circular solid aluminium plate reinforcements were used in this experimental programme. The plates were kept horizontally on the sample.

For samples with fiber reinforcements, requisite amount of soil to fill the mould was taken. Required percentage of fiber reinforcements (0.5 and 2 percent) by volume was taken and mixed throughly. The soil-fiber mixture was filled into the mould in five layers and compacted as mentioned above.

Three moisture contents (optimum moisture content, 12.5%, one dry of optimum moisture content and one wet of optimum moisture content) have been selected for the purpose of this investigation. The triaxial tests were performed on local silty clay at confining pressures of 0.703, 1.406 and 2.109 kg/cm². An initial set of reference tests were carried out for the case of no reinforcement. Strain controlled tests were used for all the undrained triaxial tests. A deformation rate of 1.27 mm/min. was used. Tests were carried out till either the failure of the specimen or 30 per cent strain was reached. Weight of the sample before and after the test were taken to check the moisture content and dry density of the sample. For convenience in expressing and comparing the data, the term strength ratio may be written as:

$$SR = \frac{R}{R_o} \qquad \ldots(1)$$

in which, R and R_o are, respectively, the maximum deviator stress of reinforced and unreinforced soil sample at any desired density. Therefore, the strength ratio may be used to express the effect of reinforcing elements for any desired density including the maximum deviator stress.

Results and Discussion

The deviator stresses and strains for the different tests have been plotted in the form of graphs and are given in Figs. 3 to 8. The variables involved in this experimental programme are given in Table 1.

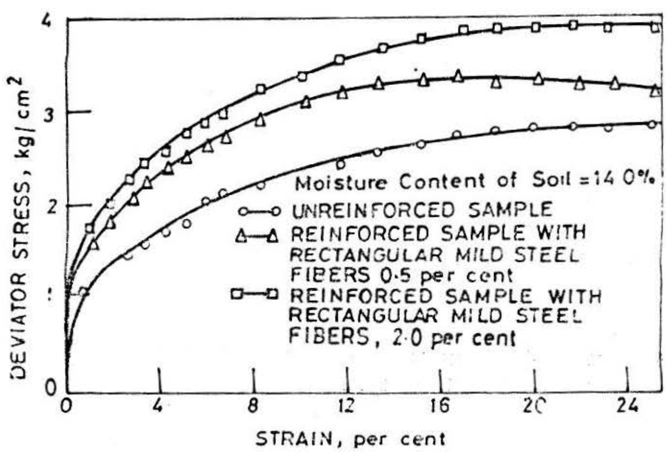

FIGURE 3 Stress-Strain Curves of Unreinforced and Reinforced Silty Clay Sample for Wet Side of Optimum Moisture Content

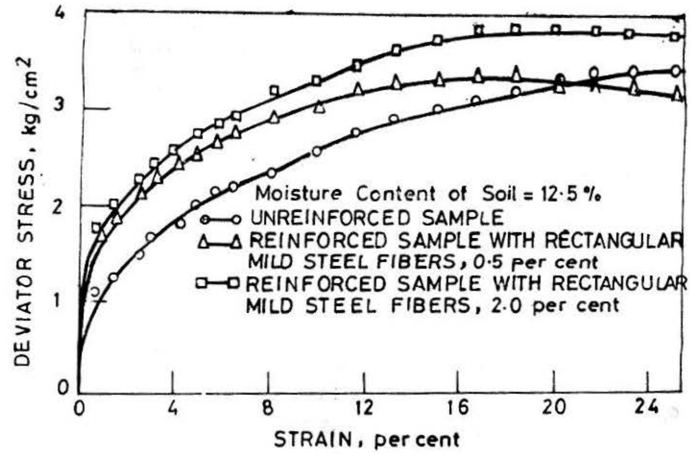

FIGURE 4 Stress-Strain Curves of Reinforced and Unreinforced Silty Clay Sample for Optimum Moisture Content

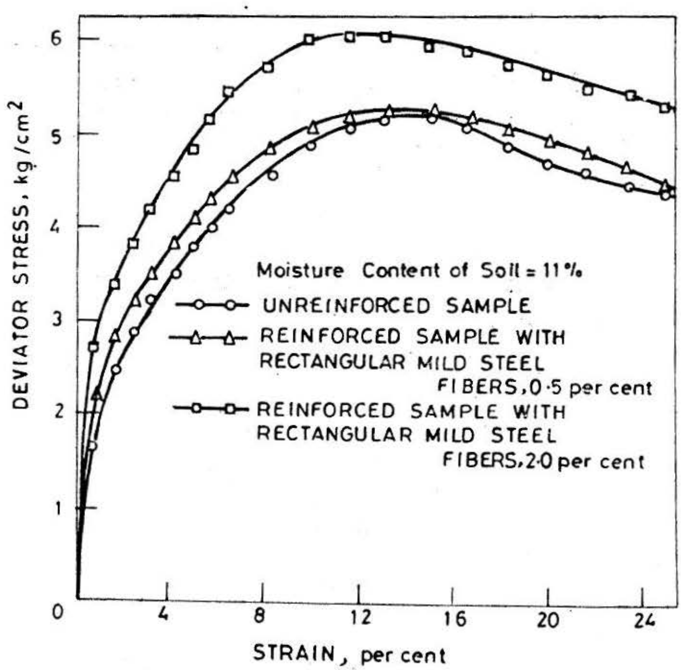

FIGURE 5 Stress-Strain Curves of Unfreinforced and Reinforced Silty Clay Sample for Dry Side of Optimum Moisture Content

The stress-strain behaviour indicates inprovement in mechanical properties of soil using different types of reinforcing mateirals.

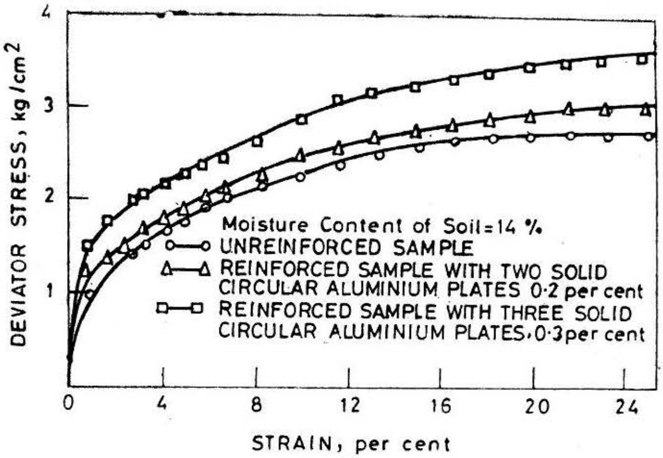

FIGURE 6 Stress-Strain Curves of Unreinforced and Reinforced Silty Clay Sample for Wet Side of Optimum Moisture Content

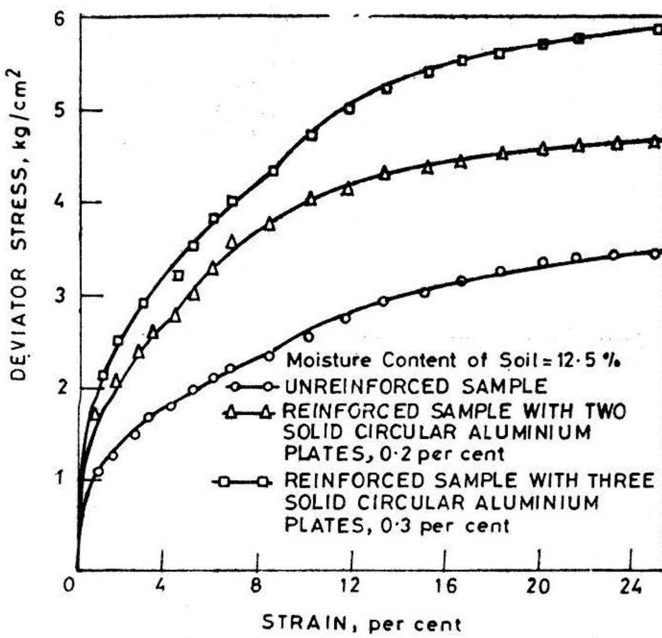

FIGURE 7 Stress-Strain Curves of Unreinforced and Reinforced Silty Clay Sample for Optimum Moisture Content

The degree of improvement due to the presence of reinforcement is more pronounced at lower strain levels. Addition of reinforcements in the cohesive soils is found to increase the peak deviator stress and the

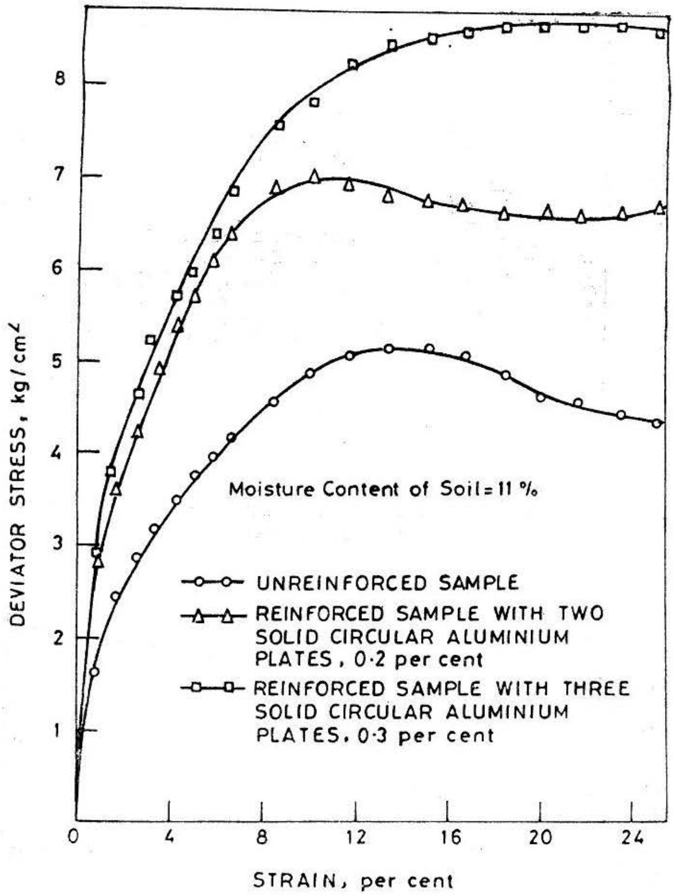

FIGURE 8 Stress-Strain Curves of Unreinforced and Reinforced Silty Clay Sample for Dry Side of Optimum Moisture Content

TABLE 1

Variables Involved in the Experimental Programme

Three moisture contents, %	:	11.00 12.50 (O.M.C.) 14.00
Three dry densities of the soil, g/cc	:	1.88 1.92 1.88
Solid circular aluminium plates (25 mm Dia. and 0.16 mm thickness)	:	0.2% and 0.3% by volume
Mild steel fibres (Length = 5 mm, Width = 1 mm and thickness = 0.16 mm)	:	0.5% and 2.0% by volume

initial tanhent modulus. The plate type of reinforcement seems to be better in improvement than the fiber reinforcements. By using plate type of reinforcements stress-strain relation improved considerably at compaction moisture contents on the dry side of optimum because of increased friction that is mobilised between the soil and reinforcement. However these are not so effective on the wet side of the optimum moisture content due to the reduction in friction. The secant modulus and the confining pressure curves of reinforced and unreinforced samples are given in Fig. 9 Figure 10 represents the curve of strength ratio and the moisture content while the peak stresmoisture content diagram of reinforced and unreinforced samples are shown in Fig. 11. It has been observed from the experimental investigation that the secant modulus increases with increasing confining pressure. Besides, the strength ratio decreases on the wet side of the optimum moisture content. From the Figs. 10 and 11, it may be observed that the peak stress of reinforced sample is proportional to the strength ratio of reinforced soil for the particular placement moisture content.

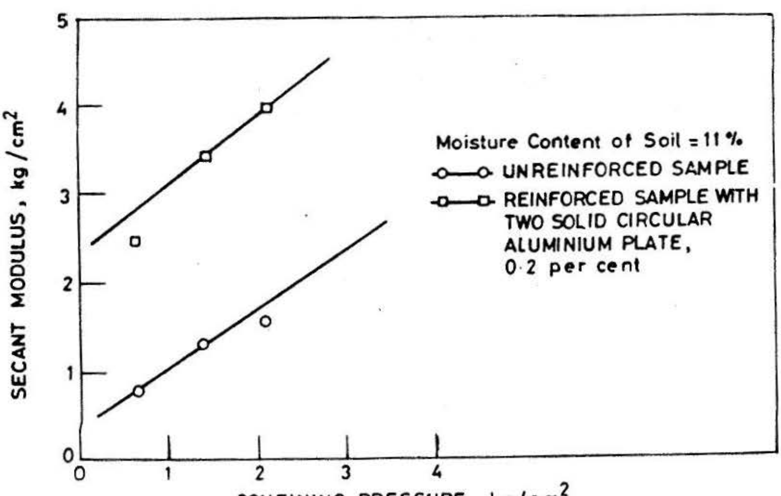

FIGURE 9 Secant Modulus-Confining Pressure Curves of Unreinforced and Reinforced Silty Clay Sample

Summary and Conclusions

The experimental evaluation of the effect of some types and forms of reinforcements on reinforced cohesive soil through a number of laboratory undrained triaxial tests have been presented in this paper. The studies reveal that the strength increases in cohesive soil samples with different types and forms of reinforcement and the dry of optimum placement moisture is advantageous for compacted fills of reinforced earth. Also the degree of improvement in deformation characteristics due to reinforcements is more pronounced at lower strain levels and placement moisture content is found to play significant role in the case of reinforced cohesive soil

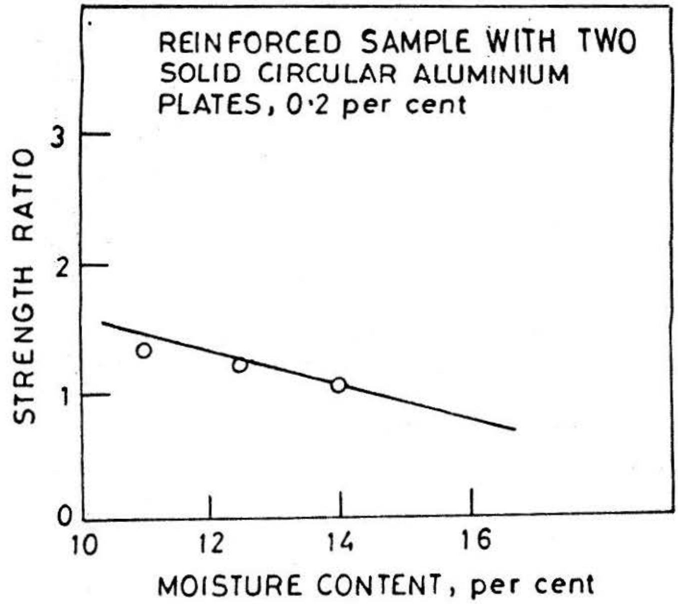

FIGURE 10 Strength Ratio-Moisture Content Curves

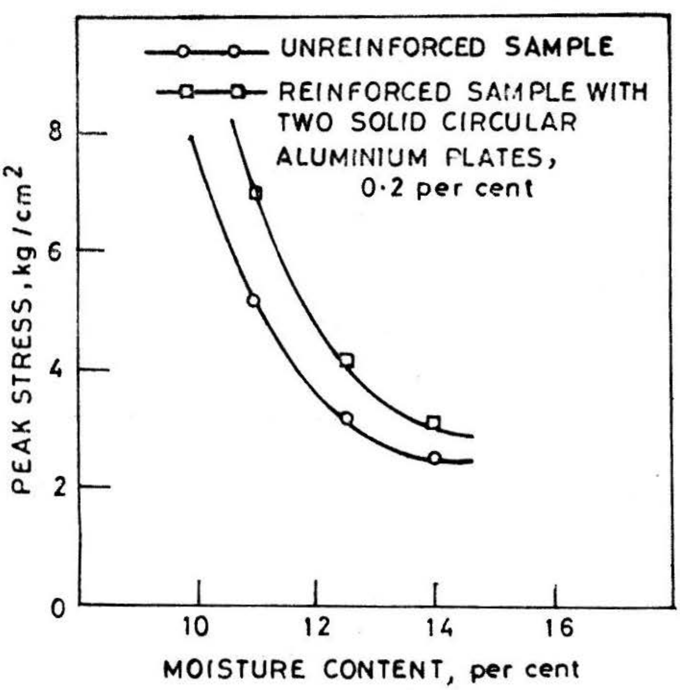

FIGURE 11 Peak Stress—Moisture Content Curves

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