iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** VII **Month of publication:** July 2022

DOI: https://doi.org/10.22214/ijraset.2022.45772

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue VII July 2022- Available at www.ijraset.com

Experimental Study of Engineering Properties of Fibre Reinforced Sand

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Abstract: ***Due to rapid infrastructure development, the need for ground improvement is increasing. Various materials are used for ground improvement. In the present study, Synthetic polyester fibre is used for stabilizing silty sand. Tests were conducted on plain sand and also fibre reinforced sand. The properties of stabilized soil such as compaction properties and shear strength characteristics are evaluated. The effect of fibre length, fibre content on strength parameters is observed. The results indicated improvement in strength for fibre reinforced soil compared to plain soil.***
Keywords: Fibre content, aspect ratio, Deviator Stress, Normal Stress, Shear Strength

I. INTRODUCTION

Soil stabilization is a method for improvement of properties of soil by addition of admixtures or without using admixtures. Materials such as cement, lime, bitumen etc. are the admixtures used for soil stabilization. Soil stabilization using fibres is also an effective technique for improving the strength and stability of soil. The use of fibres has gained importance in recent years. Fibres are also used in construction works. The natural fibres are being used from ancient times. Straw, hemp, jute, coir etc are mixed with soil for improving soil properties thereby increasing strength and stability. There are many synthetic fibres such as nylon, polyester, polythene etc. The synthetic fibres are more durable compared to natural fibres and hence their use for soil stabilization has also increased in the recent times..

II. LITERATURE REVIEW

Verma and Char (1978) [1] analysed the results of triaxial tests on mild steel fibre reinforced sand. they observed an increase in angle of internal friction from 360 to 450 with increase in fibre content from zero to 7% by volume. Maher and Gray (1990)) [2] investigated the effect of rubber, glass and reed fibres on coarse sand of nine types. Their conclusion was that low modulus fibres (rubber) contribute little to strength despite high interface friction.

An increase in soil grain size reduces fibre contribution to strength. Ranjan (1995) [3] found that soaked CBR value of sand increased by 2.2 times its unreinforced value due to addition of 2% polypropylene fibre. The effect of polyester fibre inclusions and lime stabilization on the geotechnical characteristics of fly ash soil mixtures was investigated by Kumar et. al (2007) [4] . Based on their results obtained, it can be concluded that the expansive soil can be successfully stabilized by the combined action of fibres, lime and fly ash.

Triaxial tests were conducted on plain fly ash as well as fly ash reinforced with fibres of polyethylene having different aspect ratios and fibre content by Choudary et. al (2010) [5] and it was observed that inclusion of reinforcement in general increased shear strength of fly ash. The stress-strain behaviour of fly ash improved considerably due to increase in fibre content and aspect ratio.

III. OBJECTIVES

The objectives of the work are to determine the index properties and to classify the soil based on IS 2720. The compaction characteristics of plain soil and fibre reinforced soil are to be determined . The shear parameters and strength characteristics of plain soil and fibre reinforced soil are to be analysed .

IV. RESULTS AND DISCUSSION

The soil is collected from Maddilapalem, Visakhapatnam. Extensive laboratory investigations are conducted to evaluate the engineering properties of the materials as per Indian Codes of Practice for Testing (IS 2720). Laboratory investigations in order to determine the soil properties are conducted. The soil properties are given in Table 1. From Table 1, based on gradation and plasticity characteristics, the soil is classified as silty sand.

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TABLE I
SOIL PROPERTIES

Gravel (%)	0
Sand (%)	82
Fines (%)	18
Liquid limit (%)	23
Plastic limit (%)	NP
Plasticity index (%)	NP
Soil classification	SM
Specific gravity	2.67
Optimum moisture content (OMC)(%)	10
Maximum Dry Density (MDD)(g/cc)	1.92
Cohesion (C) (kg/cm^2)	0
Angle of internal friction (Φ)	37°

A. Compaction Characteristics

Synthetic Polyester fibres are used for the study. Two lengths of fibre of 6mm and 12mm length are mixed to find the effect of aspect ratio. The diameter of fibre as given by manufacturer is 30 to 40 micron. The fibre content in the soil is varied from 0 to 2 percent by weight of soil. The compaction characteristics determined on plain soil and fibre reinforced soil are presented in Tables II. The results indicate that addition of fibre has no significant effect on OMC of the silty sand. However, the results indicate gradual decrease in MDD values with increase in fibre content for fibres of 6mm and 12mm lengths. The MDD values decrease with increase in fibre content.

TABLE II
Compaction Characteristics of Fibre Reinforced Sand

Fibre Content (%)	Fibre Length (mm)	O.M.C (%)	M.D.D (g/cc)
0	-	10	1.92
0.5	6	11.2	1.88
1.0	6	12	1.85
1.5	6	13	1.83
2.0	6	14	1.80
0.5	12	11.2	1.87
1.0	12	12.5	1.83
1.5	12	13.5	1.81
2.0	12	14.5	1.78

B. Shear Parameters

Triaxial tests are conducted on specimens of plain silty sand and fibre reinforced silty sand in the triaxial apparatus. The specimens are prepared at the respective OMC and MDD values. The samples prepared were of 38 mm internal diameter and 76mm height. Tests are conducted on silty sand mixed with 0% to 2% by weight of fibres in increments of 0.5 percent of 6mm and 12mm lengths. The fibres were separated and manual mixing was done. Care was taken so that the fibres were distributed in the soil. Three triaxial test samples were tested for each combination of fibre length and content. Unconsolidated undrained tests were conducted for each sample at confining pressure of 0.5,1 and 1.5 kg/cm^2.

The specimen was placed in triaxial cell. When failure does not occur, the experiment is stopped at 20% strain. The mode of failure of specimen is noted. The failure envelopes of unreinforced and fibre reinforced soil specimens in OMC & MDD state are drawn and the shear parameters are determined. The shear parameters of fibre reinforced sand are presented in Table III.

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From results presented in Table III, slight increase in cohesion is observed for fibre reinforced soil specimens with increase in fibre content. The friction angle increases with increase in fibre content up to 0.5 percent with 12mm fibre and decreases. An increase in value of angle of internal friction of silty sand by about 13.5 percent and 16 percent are observed for fibre content of 1.5 percent and 0.5 percent with 6mm and 12mm length fibres over unreinforced sample. Hence, 0.5 percent fibre content is considered as optimum fibre content. Increase in angle of shearing resistance is more for fibre of 12mm length in comparison to fibre of 6mm length . It is observed that the shear strength of silty sand increased with aspect ratio of fibre.

C. Conclusions

The study analysed the effect of fibre content and fibre length on the compaction characteristics and shear strength of plain silty sand and fibre reinforced silty sand. Shear strength parameter cohesion is observed to slightly increase with fibre content. An increase in frictional angle is observed with fibre content for both 6mm and 12mm length fibres. There is an increase in overall shear strength with 12mm fibres.

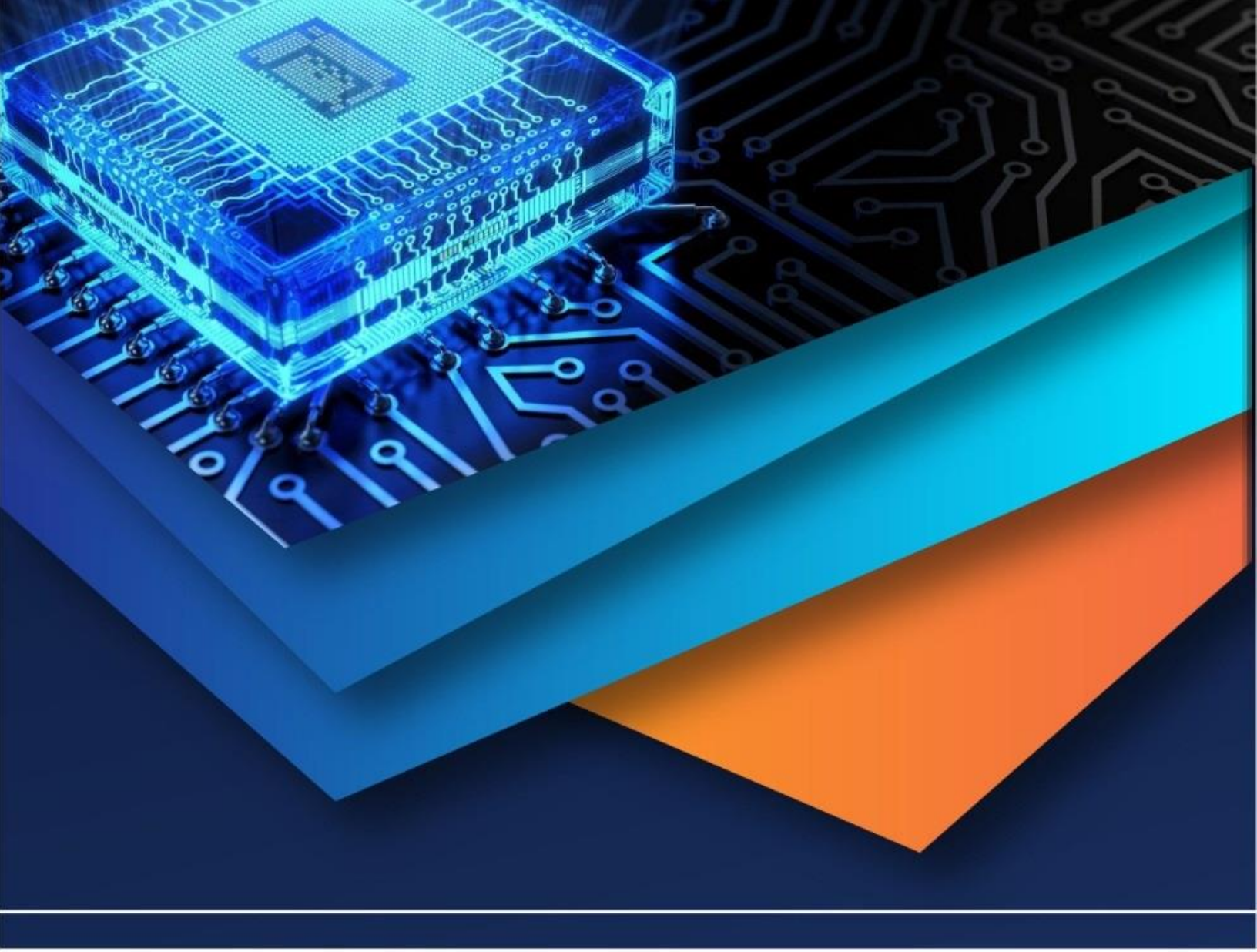
TABLE III
Shear Parameters of Fibre Reinforced silty sand at OMC and MDD

Fibre Content (%)	Fibre Length (mm)	Cohesion (kg/cm^2)	Angle of Internal Friction (Degree)
0	-	0	37
0.5	6	0.08	40
1.0	6	0.1	41
1.5	6	0.1	42
2.0	6	0.12	42
0.5	12	0.1	43
1.0	12	0.12	41
1.5	12	0.13	36
2.0	12	0.15	34

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