BEHAVIOUR OF RANDOMLY DISTRIBUTED FIBRE REINFORCED CLAY

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Abstract - *In most of the Civil Engineering Projects there is need to improve the properties of soil. One of the methods by which the soil properties can be modified, is the reinforcement of soil. In the present study an effort has been made to study the engineering properties of clay reinforced with randomly distributed fibres. The fibres could be of many types. However, in this work polypropylene fibres have been used. Fibres of different lengths have been used. They were added to the soil in different proportions.*

The study includes the improvement in various properties viz., optimum moisture content (OMC), maximum dry density (MDD) and California bearing ratio (CBR).

Key Words: **Polypropylene fibre, Optimum Moisture Content, Maximum Dry Density, California Bearing Ratio**

1. INTRODUCTION

The engineering properties of the clay soil need to be improved for most of the Civil Engineering Projects including roads, airfield construction etc. One of the methods by which the soil properties can be modified, is the reinforcement of soil. In the present study an effort has been made to study the engineering properties of clay reinforced with randomly distributed fibres. The fibres could be of many types. However, in this work polypropylene fibres have been used. Fibres of different lengths have been used. They were added to the soil in different proportions.

The study includes the improvement in various properties viz., optimum moisture content (OMC), maximum dry density (MDD) and California bearing ratio (CBR).

1.1 Details of Fibres Used

Polypropylene fibres were used in the present study. Polypropylene fibres are manufactured from high density polypropylene and polyethylene. The fibres are resistant to sea water, alkalis, chemicals and acids. Three different lengths of fibres i.e., 6 mm, 12 mm and 18 mm have been used in this work. The fibres were added to clay soil in three different proportions i.e., 0.1 %, 0.2 % and 0.3 %. The properties of Fibres used are given in Table 1.

Table 1 : Properties of Fibres

S. No.	Property	Value
1.	Specific Gravity	0.91
2.	Fibre Average Denier	3
3.	Fibre diameter (microns)	21.59
4.	Average breaking elongation (%)	45
5.	Average breaking tenacity (g/denier)	5.2
6.	Melting Point ^{0}C	162-170

Fibre average denier is the weight of the fibre in grams for a 9000 meter yarn. In the present work, 3 denier fibres have been used. That means having a weight of 3 grams for 9000 meter yarn. The diameter of the fibre is calculated from denier formula given below :

Fibre denier = 0.00707 X (diameter in microns)^2 X E X G_f

Where,

E = modulus of elasticity of polypropylene

G_f = Specific Gravity of fibre = 0.91

2. Experimental Investigation

2.1 Tests on Virgin Soil

The clay soil was obtained from Sultanpur, U.P., India. A number of preliminary tests were performed on the virgin soil. These tests include particle size analysis, specific gravity, Atterberg's limits (i.e., Liquid Limit, Plastic Limit and Plasticity Index).he tests for the determination of Optimum Moisture Content (OMC) and Maximum Dry Density (MDD) were performed. Triaxial tests and California Bearing Ratio (CBR) tests were also performed on the virgin soil.The properties of virgin soil so obtained are given in Table 2.

Table 2 : Properties of Virgin Soil

S. No.	Property	Value
1.	Classification of Soil	CI
2.	Specific Gravity	2.7
3.	Optimum Moisture Content (OMC)	19
4.	Maximum Dry Density	1.695 g/cc
5.	Liquid Limit	42.50 %
6.	Plastic Limit	20.59 %
7.	Plasticity Index	21.91 %

8.	C Kg/cm^2	0.451
9.	φ	35.72
10.	Soaked CBR	3.03
11.	Unsoaked CBR	6.12

2.2 Effect of Fibre Length and Content on the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD)

Tests were conducted to study the effect of length and content of fibres on the Optimum Moisture Content (OMC) and Maximum Dry Density (MDD). The results obtained are given in Table 3

Table 3: Effect of Fibre Length and Fibre Content on Optimum Moisture Content (OMC) and Maximum Dry Density (MDD)

Fibre Length (mm)	Fibre Content (% by weight)	Optimum Moisture Content (OMC) %	Maximum Dry Density g/cc
-	0.0	19.00	1.695
6	0.1	18.15	1.820
	0.2	16.75	1.816
	0.3	16.25	1.887
12	0.1	18.75	1.822
	0.2	17.35	1.808
	0.3	17.00	1.832
18	0.1	18.50	1.815
	0.2	18.00	1.812
	0.3	19.25	1.689

2.3 Effect of Fibre Length and Fibre Content on Strength Parameters

The tests to determine the strength parameters (c and φ) were conducted on virgin soil and soil mixed with fibres of varying length and in different proportions. The results obtained are given in Table 4.

Table 4 : Effect of Fibre Length and Fibre Content on Strength Parameters (c and φ)

Length of Fibre	Fibre Content (%)	C Value (Kg/cm^2)	φ value
-	0.0	0.451	35.72
6	0.1	0.654	33.77
	0.2	0.675	34.73
	0.3	0.921	34.09
12	0.1	0.834	33.36
	0.2	0.870	33.86
	0.3	1.063	31.40

2.4 Effect of Fibre Length and Fibre Content on California Bearing Ratio (CBR)

California Bearing Ratio (CBR) test was carried out on virgin soil and soil mixed with fibres of varying length and in different proportions to study the effect of fibre length and fibre content on the CBR values. Both the types of tests i.e., soaked and unsoaked tests were conducted. The values of Soaked and Unsoaked CBR are given in Tables 5 and 6. These are also exhibited in Figs 1 and 2.

Table 5 : Effect of Fibre Length and Fibre Content on Soaked CBR values

Fibre Length (mm)	Fibre Content (%)	CBR Values
-	0.0	3.03
6	0.1	3.43
	0.2	3.78
	0.3	4.18
12	0.1	3.55
	0.2	3.95
	0.3	4.46
18	0.1	3.72
	0.2	4.12
	0.3	4.64

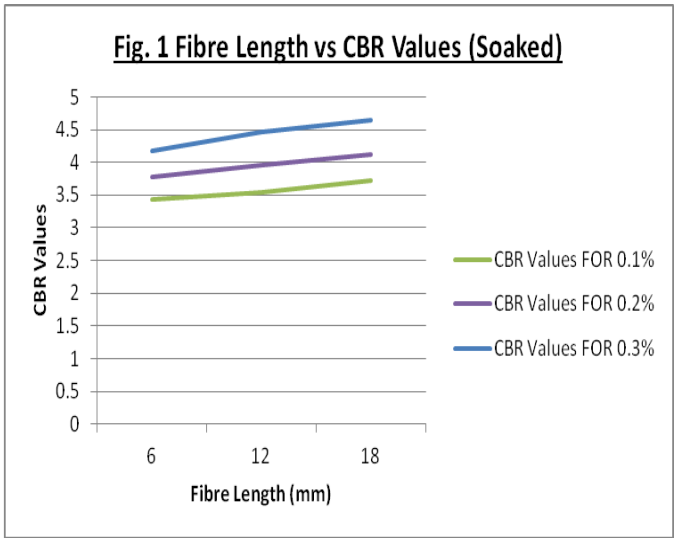
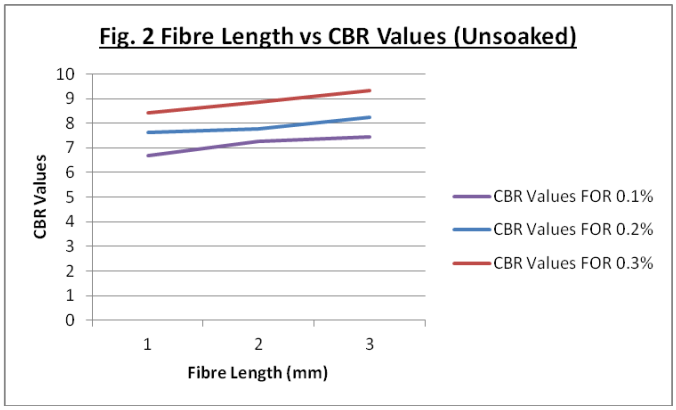


Table 6 : Effect of Fibre Length and Fibre Content on Unsoaked CBR values

Fibre Length (mm)	Fibre Content (%)	CBR Values
-	0.0	6.12
6	0.1	6.70
	0.2	7.61
	0.3	8.41
12	0.1	7.27
	0.2	7.78
	0.3	8.87
18	0.1	7.44
	0.2	8.24
	0.3	9.33



3. Conclusions

Based on the experimental studies carried out, data obtained from experimental studies and the analysis of data for virgin soil and soil mixed with randomly distributed fibres of different lengths i.e., 6 mm, 12 mm and 18 mm in varying proportions i.e., 0.1 %, 0.2 % and 0.3 %, the following conclusions are drawn :

1. The specific gravity of virgin soil usedis 2.7 and has been identified as CI soil. The values of LL, PL, PI, OMC and MDD are obtained as 42.50 %, 20.59 %, 21.91 %, 19 % and 1.695 respectively.

2. The compaction characteristics of the fibre reinforced soil are similar to that of unreinforced or virgin soil.The maximum dry density of soil mixed with fibres is more than that of the virgin soil. The maximum dry density increases with increase in the fibre content with fibre length of 12 mm upto 0.3 % fibre content. As the length of the fibre increases the effect of increasing fibre content shows unpredictable results. At 0.1 % fibre content, maximum dry density increases with increase in length upto 18 mm. However, at 0.2 % and 0.3 % fibre content, maximum dry density decreases significantly. For 18 mm fibre length with 0.3 % fibre content, the maximum dry density reduces approximately by 3 % to that of the virgin soil.

3. The Optimum Moisture Content (OMC) of reinforced soil is less than that of the virgin soil.The Optimum Moisture Content (OMC) decreases with increase in the fibre content upto 12 mm fibre length with 0.3 % fibre content. However, decrease in Optimum Moisture Content (OMC) is less at 0.3 % fibre content as compared to 0.2 % and 0.1 % fibre content for 6 mm and 12 mm fibre lengths. For 18 mm fibre, Optimum Moisture Content (OMC) decreases with increase in fibre content upto 0.2 %, however it shows a high value of Optimum Moisture Content as compared to 0.1 % and 0.3 % fibre content with 6 mm and 12 mm fibre length. At 0.3 % fibre content with 18 mm fibre shows unexpected results as the Optimum Moisture Content increases suddenly.

4. The peak strength of soil mixed with fibres is more than that of the virgin soil. The peak stress increases with increase in fibre content with fibre length of 12 mm upto 0.3 % fibre content. As the length of fibre increases, the effect of increasing the fibre content from 0.1 % to 0.3 % shows significant increase in shear strength. The shear stress of soil mixed with fibres also increases with increasing confining pressure. At 12 mm fibre length with 0.3 % fibre content gives maximum strength.

5. The value of cohesion (c) increases linearly with increase in length of fibres. Upto 0.3 % fibre content, the cohesion increases linearly with increase in fibre content. There is no specific trend in the variation of friction angle (φ) with fibre length and fibre content.

6. The CBR value of soil mixed with fibres is more than that of virgin soil. The CBR value increases considerably with increase in fibre content from 0.1 % to 0.3 %. The CBR value of soil increases with fibres also increases with increase in fibre length from 6 mm to 18 mm. The CBR value shows maximum increase for 18 mm fibre length.

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