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APPLICATION OF WASTE PLASTIC MATERIAL USED IN SOIL STABILISATION

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Abstract: *The main objective of this study is to investigate the use of waste fiber materials in geotechnical applications and to evaluate the effects of waste polypropylene fibers on shear strength of unsaturated soil by carrying out direct shear tests and unconfined compression tests .The results obtained are compared for various tests and inferences are drawn towards the usability and effectiveness of fiber reinforcement as a replacement for deep foundation or raft foundation, as a cost effective approach. Plastic fibers are similar to the roots of trees and vegetation which provide an excellent ingredient to improve the soils and the stability of natural slopes.*

Key words - Soil Reinforcement, Stabilization, Waste Plastic Material, Strength Of Soil, Test on Soil.

I. INTRODUCTION

In India, the modern era of soil stabilization began in early 1970's, with a general shortage of petroleum and aggregates, it became necessary for the engineers to look at means to improve soil other than replacing the poor soil at the building site. Soil stabilization was used but due to the use of obsolete methods and also due to the absence of proper technique, soil stabilization lost favor. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. The failure of subgrade is largely reported in Sangamner, Nashik region. The soft sub grade in this region has been determined as a big problem in highway construction. The sub grade usually laid on soft clays may cause this matter and highway design can be classified as not economical because of the maintenance costs by this problem.

II. TESTS CONDUCTED

The experimental work consists of the following steps:

1. Specific gravity of soil
2. Particle size distribution by sieve analysis
3. Determination of soil index properties (Atterberg Limits)
    i) Liquid limit by Casagrande's apparatus
    ii) Plastic limit
4. Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test
5. Preparation of reinforced soil samples.
6. Determination of the shear strength by:
    i) Direct shear test (DST)
    ii) Unconfined compression test (UCS).
    iii) California Bearing Ratio test (CBR)

III. SAMPLE COLLECTION & INVESTIGATIONS

- Waste sample Location: At near Sangamner town city MIDC Area, Nashik region.
- Waste to be Added: Waste Plastic Water Bottle, Randomly oriented waste plastic crates, Waste Tire Scrap.

1) Soil:

Table 1 - Grain Size Analysis

Sand	28%
Fines (Silt + Clay)	71%

2) Waste Plastic Water Bottle:

Table 2 – Waste Plastic Properties

Type	Plastic Waste (bottles)
Size	4.75mm (passing)
Colour	White
Specific Gravity	1.8

Fig 1 - Preparation of Plastic Fibers from Waste Plastic

3) Waste Tire Scrab:

Table 3 - Waste Tire Properties

Material type	Waste Tire
Size	Passing From 600 µ Sieve and retained on 425 µ Sieve
Colour	Black
Specific gravity	1.2

Fig 2 - Tyre Waste Powder

4) Plastic Crates Granular Waste:

Table 4 – Plastic Granular Properties

Material Type	Plastic granules
Size	4.75mm (passing)
Colour	Multicolour
Specific Gravity	2

Fig 3 - Plastic Crates

IV. TEST RESULTS

1. Specific Gravity:

Table 5 - Specific Gravity of the Soil Sample

Particulars	Trial – 1	Trial – 2	Trial – 3
Wt. of Pyconometer (W1)	633	633	633
Wt. of Pyconometer+Soil (W2)	833	833	833
Wt. of Pyconometer+Soil+ Water (W3)	1700	1691	1701
Wt. of Pyconometer+Water (W4)	1570	1572	1572

Average Specific Gravity of Soil = 2.81

2. Liquid limit:

Table 6 - Liquid Limit of Soil Sample

No. of Blows	**Weight of wet soil(gm)**	**Weight of dry soil(gm)**	**Weight of water(gm)**	**Moisture Content (%)**
56	14	11	3	27.27
19	16	13	3	23.07
10	17	13	4	30.76

Liquid Limit (As obtained from the graph) = 27%

3. Plastic Limit:

Weight of Container (W1)	= 18g
Weight of wet soil with container (W2)	= 37g
Weight of Dried soil with container (W3)	= 34g
Weight of water (W2-W3)	= 3g
Weight of dry soil (W2-W1)	= 9g

4. Plastic Index:

Plastic Limit (W) $= \{(w_2\text{-}w_3) / (w_3\text{-}w_1)\} \times 100$
$= 23\%$

Plasticity Index (PI) $= LL - PL$
$= 27 - 23 = 4$

5. Particle Size Distribution:

Table 7 – Particle Size Distribution

IS Sieve(mm)	Retained Weight of Soil (gm)	% Retained	Cumulative % Retained (gm)	% Finer
4.75	251	50.2	50.2	49.8
2.36	82	16.4	66.6	33.4
1.18	58	11.4	78.2	21.8
0.6	22	4.4	82.6	17.4
0.3	35	7.0	89.6	10.4
0.15	32	6.4	96.0	4.0
0.075	17	3.4	99.4	0.6
Pan	3	0.6	100	0

The soil is of type GM – GW (Gravel well – Graded with silt), as the percentage fine passing through the IS-200 Sieve (0.075mm) is less than 5% (by IS code).

6. Moisture Content

Table 8 – Moisture Content of Sample

Wt. Of Container (gm)	Wt. of container + Wet soil(gm)	Wt. of Container + Dry Soil (gm)	Moisture Content (%)
19	57	52	15.15
18	69	63	12.33
18	54	49	16.12

Average Moisture Content = 14.86%

7. Standard Proctor Compaction

Table 9 - Standard Procter Test Results

Weight of empty Mould (Wm) gms	2059	2059	2059
Internal Diameter of Mould (d) cm	10	10	10
Height of Mould (h) cm	12.5	12.5	12.5
Volume of mould (V)	981.75	981.75	981.75
Trial No.	1	2	3
Weight Of Base Plate (Wb)	2065	2065	2065
Weight Of Empty Would + Base Plate	4124	4124	4124
Weight Of Mould + Compacted Soil + Base Plate gms	6089	6179	6271
Weight Of Compacted Soil (W)Gms	1965	2055	2149
Wet Density Of Soil (W/V)	2.001	2.093	2.188
Moisture Content (W)	4%	6%	8%
Dry Density (Wet/(1+W)) X 9.81	18.87	19.37	19.87

Optimum Moisture Content (OMC): 8%

Max. Dry Density (gm/cc) (MDD) : 19.87 KN/m^3

8. Direct Shear

A. Unreinforced Soil

Area of box: 36 cm^2
Providing ring constant (K) : 0.196

Table 10 - Direct Shear Test –Unreinforced Soil

Normal Stress (kg/cm^2)	Proving Ring Reading	Shear Load (Proving Ring) kN	Shear Stress (kN/cm^2)
0.5	54	10.584	0.294
1.0	84	16.464	0.457
1.5	106	20.776	0.577

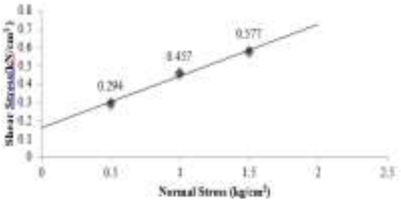


Fig 4 - DST – Shear Stress Vs . Normal Stress

From Graph,
1] Cohesion(c): 0.16 kg/cm^2
2] Angle (φ): tan^{-1} (0.362) = 19.902

Table 11 - Direct Shear Test – Reinforced Soil with 0.15% Plastic Fiber

Normal Stress (kg/cm^2)	Proving Ring Reading	Shear Load (Proving Ring) kN	Shear Stress (kN/cm^2)
0.5	78	15.288	0.424
1.0	121	23.716	0.658
1.5	164	32.144	0.892

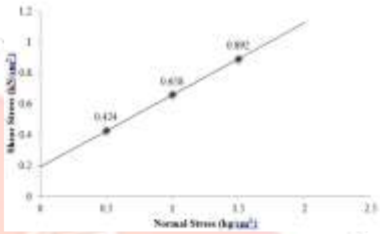


Fig 5 - DST – Shear Stress Vs. Normal Stress Graph for Reinforced Soil with 0.15% Plastic Fiber

B. Reinforcement = 0.15%

From Graph,
1] Cohesion(c): 0.198 kg/cm^2
2] Angle (φ): tan^{-1} (0.468) = 25.07

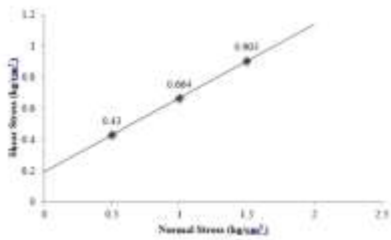
Table 12 - Direct Shear Test – Reinforced Soil with 0.25% Plastic Fiber

Normal Stress (kg/cm^2)	Proving Ring Reading	Shear Load (Proving Ring) kN	Shear Stress (kN/cm^2)
15.288	79	15.484	0.430
23.716	122	23.912	0.664
32.144	166	32.536	0.903

Fig 6 - DST – Shear Stress Vs. Normal Stress Graph for Reinforced Soil with 0.25% Plastic Fiber

C. Reinforcement = 0.25%

From Graph,
1] Cohesion(c): 0.199 kg/cm^2
2] Angle (φ): tan^{-1} (0.468) = 25.07



9. Unconfined Compression Strength Test

- Initial Length of sample: 6.9 cm
- Dia. Of sample: 3.7 cm
- Initial amount of soil taken: 3.5 kg
- Least count of dial gauge: 0.01 mm
- Proving ring constant: 4.14 N
- Initial cross sectional area of sample (A) : 3.14 x 1.85^2 = 1074 mm^2
- Strain = Deformation/Original Length
- Corrected Area = A / (1 – Strain)

A. Unreinforced Soil

B. **Table 13 -** Unconfined Compression Test – Reinforced Soil with Unreinforced Soil

Dial gauge reading	Strain(ϵ)	Proving Ring Reading	Corrected Area	Load (N)	Axial Stress (MPa)
50	0.0033	9	19.72	40.81	0.0207
100	0.0067	16	19.82	69.19	0.0349
150	0.0100	22	19.92	92.11	0.0462
200	0.0133	25	20.03	106.11	0.0530
250	0.0167	27	20.13	114.27	0.0567
300	0.0200	26	20.24	108.44	0.0536
350	0.0233	23	20.34	99.11	0.0487

C. Reinforcement = 15%

Table 14 - Unconfined Compression Test – Reinforced Soil with 0.15% Plastic Fiber

Dial gauge reading	Strain(ϵ)	Proving Ring Reading	Corrected Area	Load (N)	Axial Stress (MPa)
50	0.0033	13	19.72	54.8	0.0277
100	0.0067	20	19.82	82.79	0.0417
150	0.0100	26	19.92	109.6	0.0550
200	0.0133	29	20.03	122.43	0.0612
250	0.0167	31	20.13	128.26	0.0639
300	0.0200	29	20.24	120.1	0.0593
350	0.0233	26	20.34	107.27	0.0527

D. Reinforcement = 25%

Table 15 - Unconfined Compression Test – Reinforced Soil with 0.25% Plastic Fiber

Dial gauge reading	Strain(ϵ)	Proving Ring Reading	Corrected Area	Load (N)	Axial Stress (MPa)
50	0.0033	14	19.72	59.47	0.0302
100	0.0067	19	19.82	80.45	0.0406
150	0.0100	26	19.92	109.6	0.0550
200	0.0133	29	20.03	122.43	0.0612
250	0.0167	31	20.13	129.43	0.0643
300	0.0200	30	20.24	123.6	0.0611
350	0.0233	26	20.34	108.44	0.0533

10. California Bearing Ratio Test (CBR)

A. Unsoaked Soil Sample

Table 16 - CBR Unsoaked Soil Sample

Penetration (mm)	Load (kg) – Unreinforced Soil	Load (kg) – 0.15% Reinforced Soil	Load (kg) – 0.25% Reinforced Soil
0.5	300	305	310
1.0	305	310	315
1.5	310	315	320
2.0	315	325	330
2.5	320	330	345
3.0	325	350	350
4.0	400	395	395
5.0	410	420	422
7.5	440	460	460
10.0	485	490	490
12.5	500	515	515

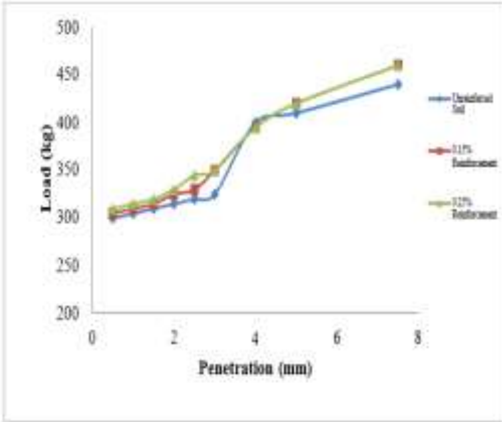


Fig 7 - CBR – Unsoaked – Load Vs Penetration Graph Comparison

CBR Value : Unreinforced Soil = 23.537
0.15% Plastic reinforced = 24.087
0.25% Plastic reinforced = 25.187

B. Soaked Soil Sample

Table 17 - CBR Unsoaked Soil Sample

Penetration (mm)	Load (kg) – Unreinforced Soil	Load (kg) – 0.15% Reinforced Soil	Load (kg) – 0.25% Reinforced Soil
0.5	160	175	180
1.0	165	180	185
1.5	170	185	190
2.0	175	190	195
2.5	180	195	200
3.0	190	200	210
4.0	210	220	220
5.0	235	245	245
7.5	260	275	275
10.0	275	285	285
12.5	290	300	300

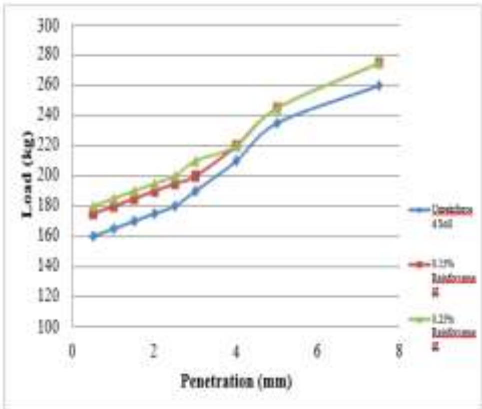


Fig 8 - CBR – Soaked – Load Vs Penetration Graph Comparison

CBR Value : Unreinforced Soil = 13.138
0.15% Plastic reinforced = 14.233
0.25% Plastic reinforced = 14.598

V. CONCLUSIONS

- The Unconfined Compression Strength of unreinforced soil is at a maximum of 0.0567 MPa, the sample which is made based on IS codes.
- The Unconfined Compression Strength soil, reinforced with 0.15% of waste plastic fibers is at a peak value of 0.0639 MPa which is an increase of **11.26%** from 0.0567 MPa for unreinforced soil.
- The Unconfined Compression Strength soil, reinforced with 0.25% of waste plastic fibers is at a peak value of 0.0643 MPa which is an increase of **12.10%** from 0.0567 MPa for unreinforced soil.
- There is improvement in CBR value when waste plastic fibers are mixed with the soil samples.
- The addition of reclaimed plastic waste material was to increase the CBR value of the soil.
- The increase in CBR value with addition of plastic fibers would mean that the thickness of the subgrade flexible pavement road would also be reduced.

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