A COMPARATIVE STUDY ON ENGINEERING PROPERTIES OF FLY ASH- POLYPROPYLENE FIBER MIX AND SAND-POLYPROPYLENE FIBER MIX

[1]Swarnima, [2]Kritesh Chouhan
[1]Assistant Professor, Jayoti Vidyapeeth Women's University, Jaipur, Rajasthan, India
[2]Assistant Professor, Geetanjali Institute of Technical Studies, Udaipur, Rajasthan, India

Abstract: In India fly ash is normally available at very low cost because it is one of the waste materials that come from the thermal power plants and from manufacturing industries. Fly ash is a waste material imposing hazardous effect on environment and human health. It cannot be disposed of properly and its disposal is not economically viable. It is highly useful as a geotechnical material for construction of embankment and reclamation of low lying areas, filling of underground, open mines, use in agriculture and reclamation of degraded/ waste lands, etc. Sand is also available at low cost and easily. Polypropylene fiber is a synthetic fiber which is also easily available at low cost. The properties of polypropylene fiber are also good. In this paper compare the experimental results of mixture of two cases: case one is fly ash- fiber and case two is sand- fiber. In these cases some laboratory tests as standard proctor test tests, CBR tests, and direct shear tests are conducted. As results found that adding fiber with fly ash have better results.

***Keywords*- Fly ash, Sand, Polypropylene Fiber, Angle of Internal Friction, Shear Strength, CBR.**

I. INTRODUCTION

The main objective of this study is to compare the results case one is fly ash- fiber and case two is sand- fiber, so that the construction of roadways, embankments and many more will be economical, and to achieve the similar strength which is needed in construction field. To satisfy this objective, an experimental study was carried to investigate the influence of fiber to Fly ash and sand different fiber content (0.5%, 1%, and 2%) and fiber length (24mm and 40mm) inclusion on the geotechnical behavior of fly ash and Sand.

Paper is organized as follows. Section II describes literature reviews. Section III having properties of material used in this study. Section IV presents experimental program used for this study. Section V presents experimental results showing results of images tested. Finally, Section VI presents conclusion.

II. LITRATUREREVIEWS

a) **EmillianiAnak Geliga1 and Dygku Salma Awg Ismail2:** UNIMAS E-Journal of Civil Engineering, Vol. 1: Issue 2/ April 2010: "**Geotechnical properties of Fly Ash and its Application on Soft Soil Stabilization**": This paper briefly describes the suitability of local fly ash to be used in the local construction industry in a way to minimize the amount of waste to be disposed to the environment causing environmental pollution. Several civil engineering laboratory tests are conducted to study the geotechnical properties of fly ash and strength gain when mixed with local clay sample. A different proportion of fly ash sample cured for 7 days results in as strength gain. A better understanding of properties of fly ash is gained from study and the tests indicate improvements strength and better properties of soft soil sample when stabilized.

b) **Ratna Prasad, R.1, Darga Kumar, N.2**: International Journal of Engineering Research and General Science Volume 3, Issue 4, July-August, 2015 ISSN 2091-2730***:* "CBR and Strength Aspects of Fly Ash-Granular Soil Mixtures":**The study of granular sub base stabilized at 25% fly ash showed better results in CBR and strength aspects. As the percentage of fly ash increases from 0% to 25%, the CBR values are decreasing for both the unsoaked and soaked conditions. For the fly ash content beyond 15% addition to soil is causing about 50% to 65% reduction in the CBR values for both the unsoaked and soaked conditions. The percentage of fly ash increases from 0% to 25%, the angle of internal friction of gravel soil is decreasing. This decrease in angle of internal friction is marginal up to about 10% of fly ash and. From 15% to 25% of fly ash, the angle of internal friction observed is almost constant and its value is in the range of 360 to 380. Up to 25% of fly ash can effectively be utilized along with the granular subbase in the pavement construction.

c) **Kamal Khetarpal#1, Bharat Bhushan Jindal*2**: *SSRG International Journal of Civil Engineering (SSRG-IJCE) – EFES April2015: "***Effect of Fly Ash on CBR Value of Sandy Soil":** In this paper, California Bearing Ratio (CBR) test has been carried out on sandy soil samples mixed with varying percentage of fly ash in the laboratory. It is concluded that the CBR value of the soil is increasing when fly ash is mixed with it and it further goes on increasing with the increase in the amount of fly ash.

d) **Shear Strength of Sands Reinforced with Polypropylene Fibers:** GeotechGeolEng (2013) 31:401–423 22 November 2012**: "Costas A. Anagnostopoulos • Theodosios T. Papaliangas •DimitriosKonstantinidis • Christos Patronis":**The inclusion of oriented or randomly distributed discrete elements, such as fibers, to reinforce soil has recently attracted increasing attention in geotechnical engineering. The present paper studies the shear strength parameters of reinforced sands, consisting of different mean grain sizes. The polypropylene fiber volumetric content of the sands ranges from 0.1 to 0.5 %. Specifically, a series of direct shear tests were conducted to determine the peak and residual shear strength parameters of unreinforced and reinforced sands. Laboratory results showed that fiber reinforcement substantially improved the residual strength of fine sands of medium dense state. On the contrary, reinforced sands of high dense state appeared to exhibit negligible strength increment. Based on the experimental results, a non-linear regression analysis was performed to correlate the shear strength of reinforced sand with some descriptor variables.

e) **Effect of Polypropylene Fiber on CBR Value of Sand:** Volume II, Issue IV, April 2015 IJRSI: **"Dhiren R Hasrajani1, Anuj K Shah1, Aditya M Patel1, Jay P Panchal1, Alka M Shah2":** This paper presents the CBR test conducted on fine sand reinforced with randomly distributed polypropylene fibers, under both soaked and unsoaked conditions with varying fiber content. Results of CBR tests demonstrate that inclusion of polypropylene fibers in sand with appropriate amounts improves strength and deformation behaviour of sub grade soils .Thefiber addition rate varies from 0% to 2.5% at 0.5% interval. In this paper CBR value of reinforced sand increases by 113% compared to unreinforced sand. The optimum fiber content was found to be 2.5% (w/w). The addition of fiber becomes impractical after 2.5%.The proposed technique can be used in embankment, road construction, industrial yards etc.

f) **Influence of Fiber-Reinforcement onCBR-Value of Sand**:EJEG Vol. 18 [2013], Bund. T: **"S. K. Tiwari, J. P. Sharma":** The California Bearing Ratio (CBR) Tests were conducted on fine sand reinforced with randomly distributed discrete polypropylene and coir fibers, under both soaked and unsoaked conditions. The paper describes the load penetration response obtained from CBR tests performed on fine sand. The CBR values of fine sand increase significantly due to inclusion of randomly distributed fibers under soaked and unsoaked conditions. The increase in CBR is as high as 100% due to addition of 1.5% fiber..

III. MATERIALUSED

a) FLYASH

The fly ash produced from Kota super thermal power plant. The material was by product from coal thermal electricity production power plant dumping area. Index properties of fly ash are following in table 1:

Table 1: Index Properties Of Fly Ash

S.NO.	PROPERTIES	RESULTS
1	Specific Gravity	1.8096
2	Average Grain Size (D50)	0.021
3	Liquid Limit	24.5
4	Plastic Limit	Non-Plastic
5	Grain Size Distribution	
	Gravel	0.16%
	Sand	29.18%
	Silt + Clay	70.22%
6	Coefficient of Uniformity (Cu)	6.2
7	Coefficient of Curvature (Cc)	1.26
8	OMC (%)	18.817
9	MDD (gm/cc)	1.363
10	CBR unsoaked (%)	3.0871
11	C	0.26
12	Φ (in degree)	25.6410

b) SAND

Sand is used in test was obtained from the Banas River, Rajasthan. Suitable amount of the sand was sieved on sieve 4.75mm, to have a suitable particle size, for better workability conditions. Index properties of sand are following in table 2:

Table 2: Index Properties Of Sand

S.NO.	PROPERTIES	RESULTS
1	Specific Gravity	2.5879
2	Average Grain Size (D50)	1.5mm
3	Grain Size Distribution	
	Gravel	0.12%
	Sand	99.82%
	Silt + Clay	0%
4	Coefficient of Uniformity (Cu)	1.8918
5	Coefficient of Curvature (Cc)	0.9652
6	OMC (%)	11.310
7	MDD (gm/cc)	1.690
8	CBR unsoaked (%)	16.4476
9	C	Non-cohesive
10	Φ (in degree)	40.2979

c) POLYPROPYLENE FIBER

Polypropylene is normally tough and flexible. The polypropylene synthetic fiber in different of fiber length (24mm and 40mm) was used in this investigation. Polypropylene fiber used in the present study was obtained from Walter Enterprises, Mumbai. Some Physical and Engineering properties of the polypropylene synthetic fiber are:

Table 3: Index Properties Of Polypropylene Fiber

S.NO.	PHYSICAL PROPERTIES	DESCRIPTION
1	Material	Polypropylene Fiber
2	Type	Fibrillated Mesh Fiber
3	Shape	Straight
4	Colour	White
5	Specific Gravity	0.91g/cc
6	Length	24mm, 40mm
7	Diameter	28 micron, 40micron (approx)
8	Aspect Ratio	860, 1000 (approx)
9	Thermal & electric conductivity	Low
10	Alkali resistance	100% Alkali Proof
11	Acid & salt resistance	High

IV. EXPERIMENTALPROGRAMME

a) STANDARD PROCTOR TEST (COMPACTIONPARAMETERS)

A soil sample is compacted in a mould having a capacity of 1/30 of a cubic foot and having an internal diameter of 4 inches. The soil in the mould is compacted in three layers with 25 blows per layer from a 5.5 pound hammer dropped from a height of 310mm; the blows should be uniformly distributed over the surface of each layer. The density and moisture content of the compacted specimen is plotted on curves and a maximum dry density and optimum moisture content obtain. Based on the Results of Standard proctor test classification is done as per IS 2720 (Part 7) (1980).

b) CALIFORNIA BEARING RATIO TEST (CBR)(UNSOAKED)

It is a load deformation test performed in the laboratory or the field whose results are then used with an empirical design chart to determine the thickness of flexible pavement, base and other layers for a given vehicle loading. In order to study the effect on CBR value of fly ash and sand, CBR test were conducted in accordance with IS (Part-16) (1987) and IRC 37 (1970).

c) DIRECT SHEAR TEST

In order to know the Shear Strength Parameters (C and Ø) of Reinforced Fly Ash and Sand, Direct Shear Test (UU test) in Accordance with IS 2720 (Part-13) (1986) were conducted in laboratory for each selected proportion of fly ash and sand.

IV. RESULTS ANDDISCUSSION

A. EFFECT ON COMPACTIONTEST

- It is observed that MDD is increases and OMC is decreases in both cases.
- In *case one* MDD is increase and OMC is decrease with increase and decrease respectively in proportion of *fiber to fly ash*. In results it is found that the mix is prepared with different fiber content (0.5%, 1%, and 2%) and fiber length (24mm and 40mm) then MDD increase from 1.363 to 1.423 and 1.363 to 1.527 respectively for different fiber length. On other hand OMC decreases from 18.817 to 17.355 and 18.817 to 15.533 respectively for different fiber length.
- In *case two* MDD is increase and OMC is decrease with increase and decrease respectively in proportion of *fiber to sand*. In results it is found that the mix is prepared with different fiber content (0.5%, 1%, and 2%) and fiber length (24mm and 40mm) then MDD increase from 1.690 to 1.766 and 1.690 to 1.894 respectively for different fiber length. On other hand OMC decrease from 11.310 to 17.355 and 11.310 to 9.292 respectively for different fiber length.

Table 4: Comparison Of OMC & MDD Of Fly Ash & Fiber

S.NO.	Fly Ash	% Fiber	OMC (%)		MDD (gm/cc)	
			Fiber Length 24mm	Fiber Length 40mm	Fiber Length 24mm	Fiber Length 40mm
1	100%	0	18.817	18.817	1.363	1.363
2		0.5	18.396	16.911	1.393	1.419
3		1	18.095	16.170	1.401	1.484
4		2	17.355	15.533	1.423	1.527

Table 5: Comparison Of OMC& MDD Of Sand & Fiber

S.NO.	Sand	% Fiber	OMC (%)		MDD (gm/cc)	
			Fiber Length 24mm	Fiber Length 40mm	Fiber Length 24mm	Fiber Length 40mm
1	100%	0	11.310	11.310	1.690	1.690
2		0.5	11.173	10.460	1.736	1.815
3		1	10.919	9.770	1.753	1.872
4		2	10.389	9.292	1.766	1.894

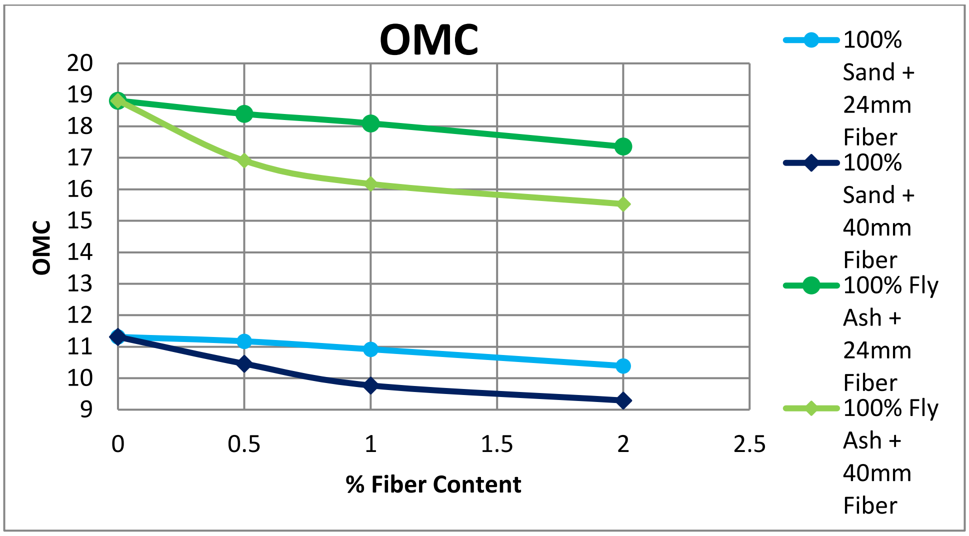

Figure 1: Variation of OMC vs different fly ash-fiber & sand- fiber mixtures

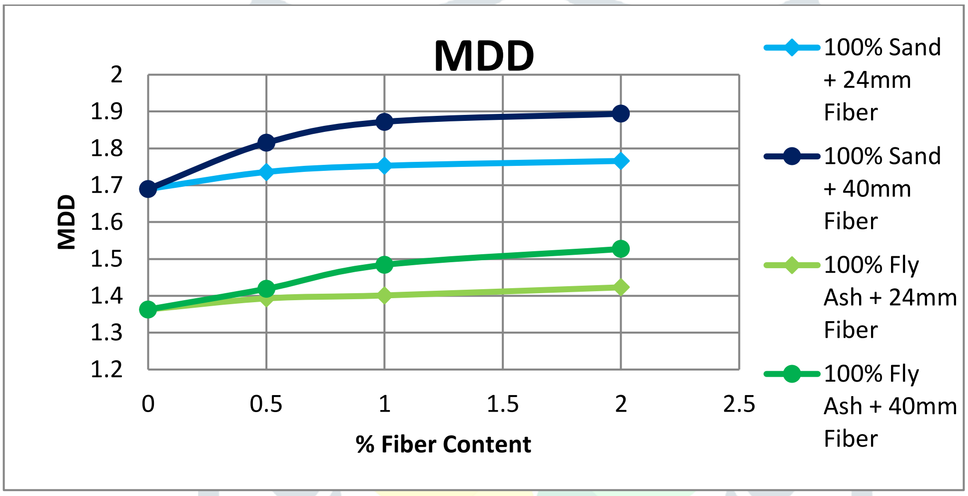

Figure 2: Variation of MDD vs different fly ash-fiber & sand- fiber mixtures

B. EFFECT ON CBRTEST

- It is observed that CBR is increases in both cases.
- In *case one* CBR is increase with increase in proportion of *fiber to fly ash*. In results it is found that the mix is prepared with different fiber content (0.5%, 1%, and 2%) and fiber length (24mm and 40mm) then CBR increase from 3.0871 to 11.8929 and 3.0871 to 12.3990 respectively for different fiber length
- In *case two* CBR is increase with increase in proportion of *fiber to sand*. In results it is found that the mix is prepared with different fiber content (0.5%, 1%, and 2%) and fiber length (24mm and 40mm) then CBR increase from 16.4476 to 28.3406 and 16.4476 to 29.8588 respectively for different fiber length.

Table 6: Comparison Of CBR Of Fly Ash & Fiber

S.No.	Fly Ash	% Fiber	CBR Value (In %)	
			Fiber Length 24mm	Fiber Length 40mm
1	100%	0	3.0871	3.0871
2		0.5	9.3625	10.8808
3		1	10.3747	11.6399
4		2	11.8929	12.3990

Table 7: Comparison Of CBR Of Sand & Fiber

S.No.	Sand	% Fiber	CBR Value (In %)	
			Fiber Length 24mm	Fiber Length 40mm
1	100%	0	16.4476	16.4476
2		0.5	24.0389	25.3041
3		1	26.0632	27.8345
4		2	28.3406	29.8588

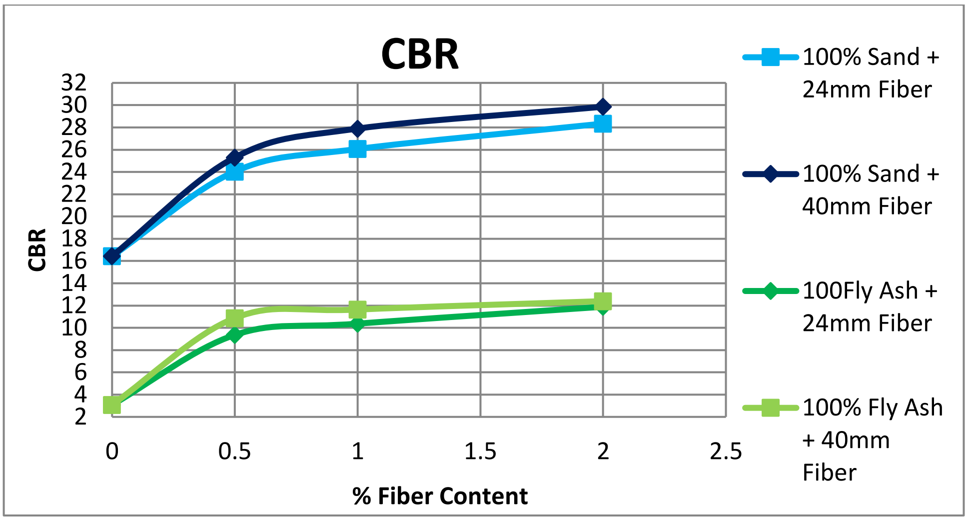

Figure 3: Variation of CBR value **vs** different fly ash-fiber & sand- fiber mixtures

C. EFFECT ON DIRECT SHEARTEST

- It is observed that angle of internal friction (Φ) is increases in both cases.
- In *case one* angle of internal friction (Φ) is increase with increase in proportion of *fiber to fly ash*. In results it is found that the mix is prepared with different fiber content (0.5%, 1%, and 2%) and fiber length (24mm and 40mm) then angle of internal friction (Φ) increase from 25.6410 to 29.7264 and 25.6410 to 32.0877 respectively for different fiber length.
- In *case two* angle of internal friction (Φ) is increase with increase in proportion of *fiber to sand*. In results it is found that the mix is prepared with different fiber content (0.5%, 1%, and 2%) and fiber length (24mm and 40mm) then angle of internal friction (Φ) increase from 40.0974 to 44.7988 and 40.0974 to 45 respectively for different fiber length.

Table 8: Comparison Of Angle Of Internal Friction (Φ) Of Fly Ash & Fiber

S.NO.	Fly Ash	% Fiber	Angle of Internal Friction (Φ) (in degree)	
			Fiber Length 24mm	Fiber Length 40mm
1	100%	0	25.6410	25.6410
2		0.5	27.4293	30.4981
3		1	28.7227	31.1320
4		2	29.7264	32.0877

Table 9: Comparison Of Angle Of Internal Friction (Φ) Of Sand &Fiber

S.NO.	Sand	% Fiber	Angle of Internal Friction (Φ) (in degree)	
			Fiber Length 24mm	Fiber Length 40mm
1	100%	0	40.0974	40.0974
2		0.5	42.7094	43.2893
3		1	43.9499	44.3920
4		2	44.7988	45.0000

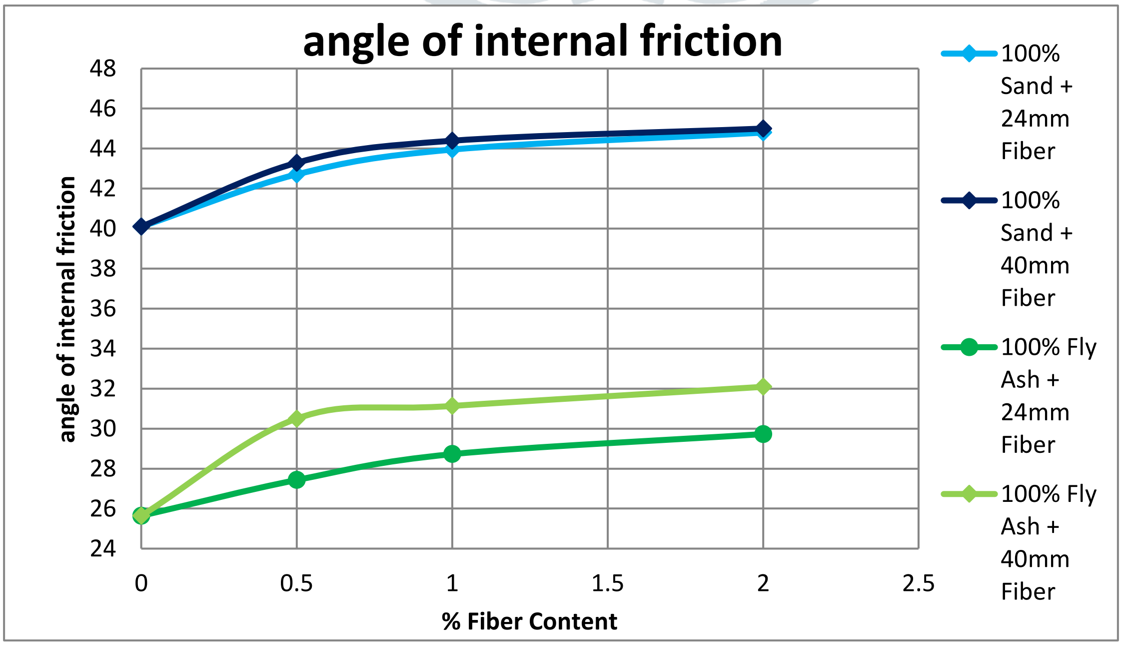

Figure 4: Variation of angle of internal friction (Φ)value **vs** different fly ash-fiber & sand- fiber mixtures

V. CONCLUSIONS

Moisture-Density relationship, CBR value and angle of shearing resistant are significantly affected by adding of fiber in both cases of Fly Ash and Sand. The maximum increase and decrease were found with mixing of 2% fiber of 40mm length in each result. In case one mixing of fly ash and fiber, maximum percent increment in MDD is 12.032%, maximum percent decrement in OMC is 21.142%, maximum percent increment in CBR is 301.639%, and maximum percent increment in angle of shearing resistant is 25.142%. In case two mixing of sand and fiber, maximum percent increment in MDD is 12.071%, maximum percent decrement in OMC is 17.842%, maximum percent increment in CBR is 81.538%, and maximum percent increment in angle of shearing resistant is 12.226%. Hence on the basis comparison of experiment results as percentage increment or decrement we can conclude that maximum performance can be achieved by using Fly ash and Polypropylene fiber mixing with 2% fiber content and 40mm fiber length.

REFERENCES

[1] Dushyant Kumar Bhardwaj, J.N.Mandal:International Association for Computer Methods and Advances in Geomechanics (IACMAG):October, 2008

[2] Boominathan, S. Hari:Soil Dynamics and Earthquake Engineering 22 (Elsevier Science Ltd.2002) 1027–1033

[3] Shenbaga. R. Kaniraj*, V. Gayathri : Geotechnical behavior of fly ash mixed with randomly oriented fiber inclusions : Geotextiles and Geomembranes 21 (2003) 123–149: accepted 7 January 2003

[4] IS 2720 (Part 7) (1980),"Methods of Test for Soils, Determination of Water Content-Dry Density Relation Using Light Compaction Method".

[5] Effect of Polypropylene Fiber on CBR Value of Sand Volume II, Issue IV, April 2015 IJRSI,"Dhiren R Hasrajani1, Anuj K Shah1, Aditya M Patel1, Jay P Panchal1, Alka M Shah2"

[6] Shear Strength of Sands Reinforced with Polypropylene Fibers GeotechGeolEng (2013) 31:401–423 22 November 2012, "Costas A. Anagnostopoulos • Theodosios T. Papaliangas •DimitriosKonstantinidis • Christos Patronis"

[7] Influence of Fiber-Reinforcement on CBR-Value of Sand:EJEG Vol. 18 [2013], Bund. T: "S. K. Tiwari, J. P. Sharma":

[8] A study on shear strength of sands reinforced with randomly distributed discrete fibers:Geotextiles and Geomembranes 21 (2003) 103–110: "TemelYetimoglu, Omer Salbas":

[9] IS 2720 (Part 7) (1980),"Methods of Test for Soils, Determination of Water Content-Dry Density Relation Using Light Compaction Method".

[10] IS: 2720, Part 4, "Grain Size Analysis".

[11] IS 2720 (Part-16) (1987), "Laboratory Determination of CBR".

[12] IRC 37(1970).

[13] IS 2720 (Part-13) (1986), "Methods of Direct Shear Test