Performance enhancement of sub-grade soil with marble dust and sisal fibers – comparative Study

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ABSTRAT

Making the use of locally available byproducts to encourage the proper management of economy and environment has now become an essential objective of an engineer. Treatment of soil with various materials to upgrade the soil properties and make if suitable prior any kind of construction is significant as working without testing and treating the soil conditions may lead to failures in all the sectors of work.

The intention and motivation of this study and research is to make use of waste marble dust and sisal fibers to enhance the soil quality sub-grade soil for the construction of road. Waster marble powder is taken in various content likewise sisal fibers of 10mm average length is taken and mixed together with the soil sample. Compaction test, CBR, consistency test is the basic tests performed in this study to verify the effect of additives of marble dust and sisal fiber on the soil.

This study is motivated towards the study of effect of marble dust and sisal fibers when mixed in various content with the clayey soil.

Keywords- Marble dust, Natural Fiber, Sisal Fibers, Compaction Test, California Bearing Ratio.

INTRODUCTION

Foundation is the basis of all types of construction which makes the workability of soil the most essential parameter. The soil on which the foundation is to be made should be capable of withstanding the allowable pressure. It is mandatory to check and compute the strength of the soil prior to construction because working on soil with weak strength may lead to various constructions fails resulting financial as well as human loss. When the soil is not well graded, expansive, collapsible, liquefiable, soft or contains high organic content (peat soil) they are considered to be weak soil.

There are various techniques and methods to treat these types of soils and make it suitable for any kind of construction depending upon the type of construction. The techniques includes the treatment, reinforcement and modifying various soil parameters in order to achieve the required and suitable condition for construction purposes. The chart below shows different methods for soil improvement

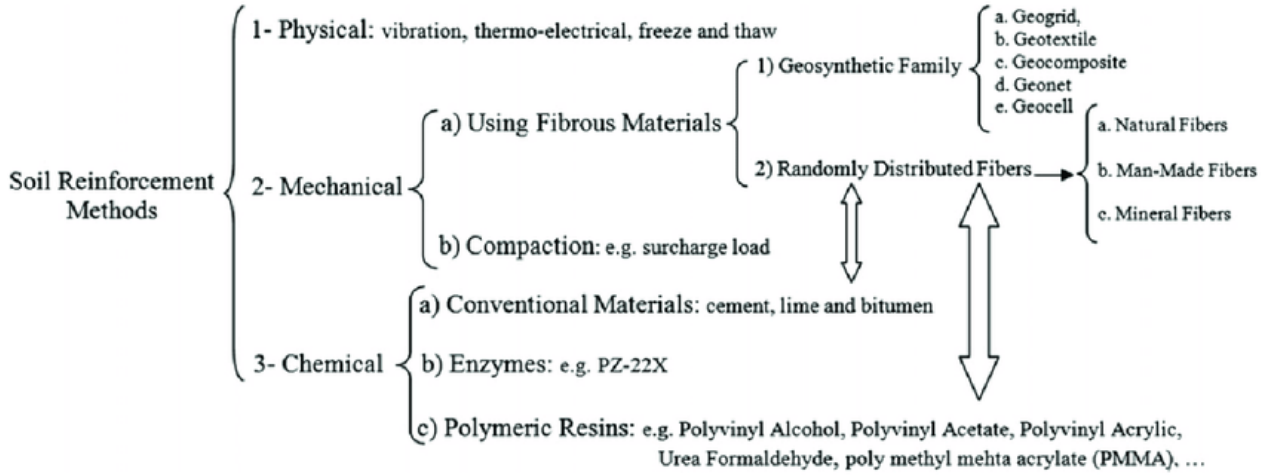

Figure: Soil Reinforcement/Stabilization Techniques. (Hejaji et al., 2012)

METHODOLOGY

The soil type that I have collected and worked on is clayey soil. Since my study is of enhanced clayey soil for sub-graded for the construction of road pavement the soil sample I collected was from 4-5 feet below the ground surface. The location of the soil sample was from a local thin forest area in Ramamandi near Jalandhar, Punjab.

SOIL PROPERTIES	DISCRIPTION
Liquid Limit (%)	42.3
Plastic Limit (%)	28
Plasticity Index (%)	14.3
IS Classification	Clay with Intermediate Compressibility
Specific Gravity	2.06
Moisture Content (%)	14.19
Dry Density (gm/cm^3)	1.76
CBR (%)	1.42

Table: Properties of Virgin Soil

Component	Wt%
CaO	30-68.8
MgO	20-22.13
SiO_2	3-6
Al_2O_3	2.75-4.8
Fe_2O_3	0.5-0.8
Cr_2O_3	0.2-0.4
ZnO	0.2-0.5
TiO	0.54-0.6

Table: Constituents of marble powder

Component	Compositional Range (wt%)
Cellulose	43-88
Hemicellulose	10-15
Lignin	4-20
Pectin	0.8-10
Water soluble	1-4
Fat and wax	0.15-2
Moisture	10-22

Table: Composition of Sisal Fiber

Source: Structural and Chemical Characteristics of Sisal Fibre
Benítez-Guerrero, M.a*, Pérez-Maqueda, L.A.b , Artiaga, R.c , Sánchez-Jiménez, P.E.b , Pascual-Cosp, J.

Sample Preparation

The clayey soil sample is then mixed with waste marble dust powder with and increment of 6% ranging from 6% to 30%. The soil sample taken for this research was 7 kilos of oven dried soil. The amount of sisal fibers to be added ranged from 0.25% to 1.25% with an increment of 0.25% of oven dried soil sample. Atterberg Limit tests i.e. Liquid limit and plastic limit test, Specific gravity tests, Modified proctor tests and CBR test were then conducted on the natural soil samples and soil samples with different percentages of additives

Since the soil is cohesive, the water content added was 12-16% below the plastic limit. The sample mix is shown in the table below.

S.No.	Sample Number	Soil %	Marble Dust %	Sisal Fiber %
1	S0	100	0	0
2	S1	94	6	0.25
3	S2	88	12	0.5
4	S3	82	18	0.75
5	S4	76	24	1
6	S5	70	30	1.25

Table: Sample mix

TEST RESULTS

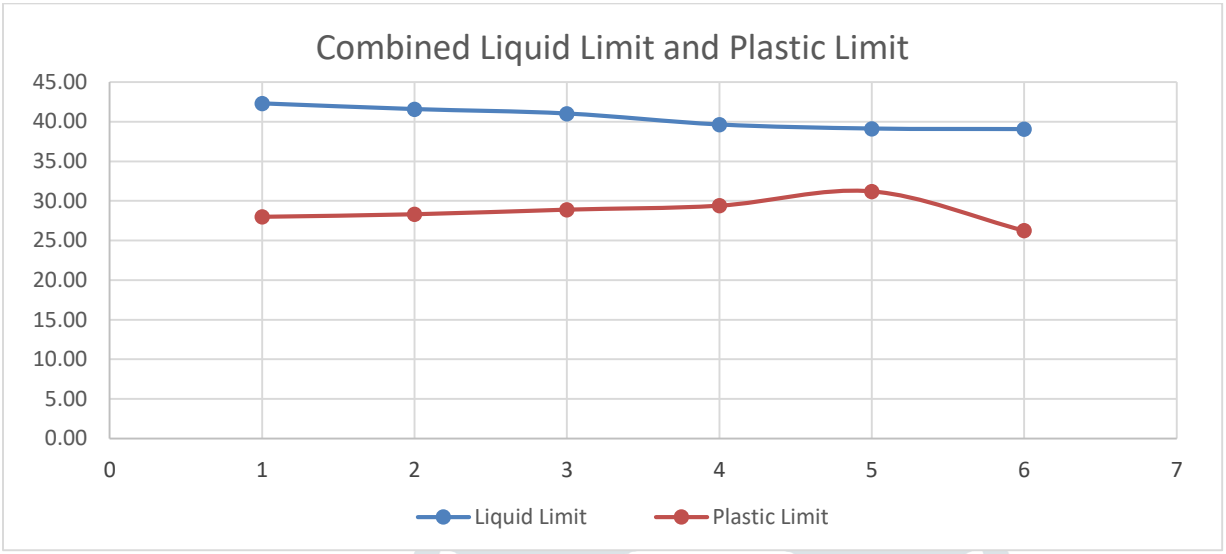

Figure: Combined Liquid Limit and Plastic limit graph

From the test conducted we can conclude that the liquid limit of the soil goes on getting reduced with the increase in the addition of marble dust and sisal fibers until it almost goes constant.
On the other hand the plastic limit of the soil increases till the point of mix of 20% marble dust and 1% sisal fibers. Further addition of the additives shows the decrement of plastic limit of the soil.

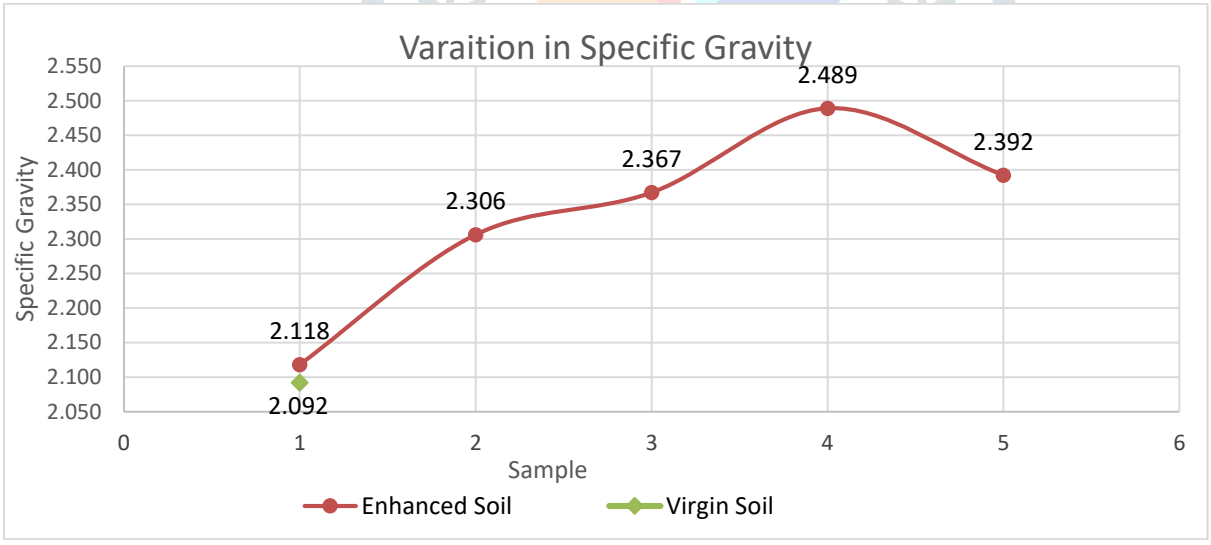

Figure: Variation of Specific gravity

From the graph we can conclude that there is an increase in the specific gravity till the 4th sample mix of marble dust and sisal fibers i.e. 24% marble dust + 1% sisal fibers

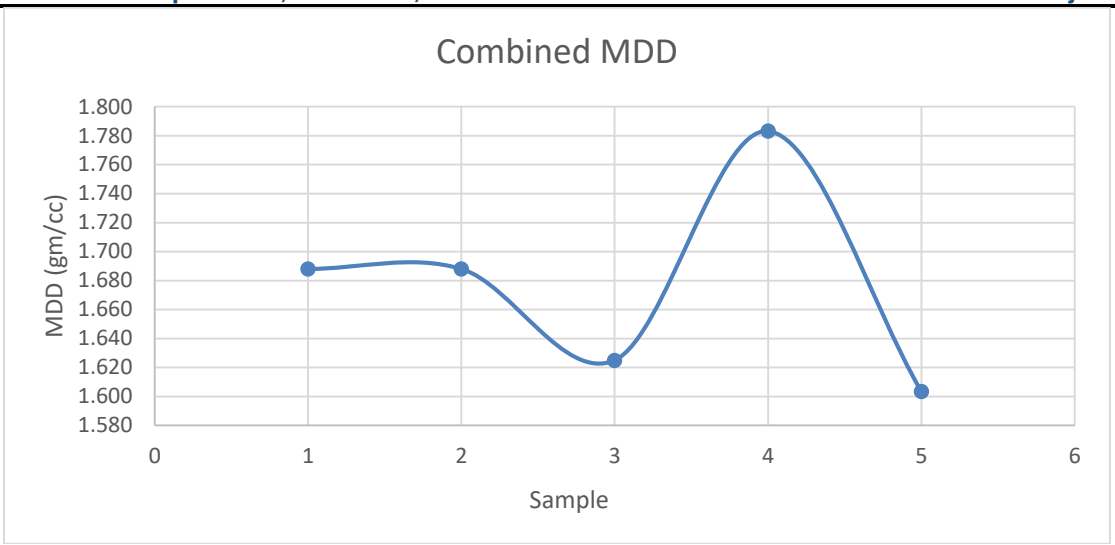

Figure: Combined Maximum Dry Density

As shown in the graph we can see that there is an increment of the dry density till the 4th sample of the mix i.e. 24% marble dust + 1% sisal fibers by weight of the dry soil sample. Further increase in the marble dust content and sisal fiber the dry density starts to decrease

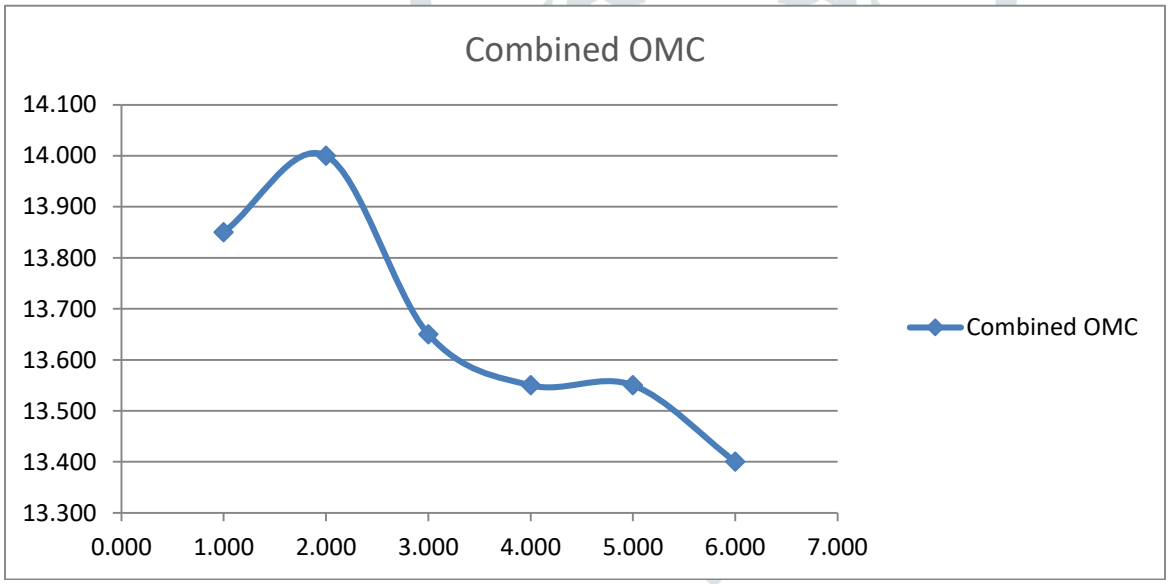

Figure: Combined OMC

As shown in the graph and on the basis of the research experiment we can see that there is an increment of the OMC till the 2nd sample of the mix i.e. 12% marble dust + 0.5% sisal fibers by weight of the dry soil sample. Further increase in the marble dust content and sisal fiber the dry density starts to decrease with only a minimum increment in the moisture content.

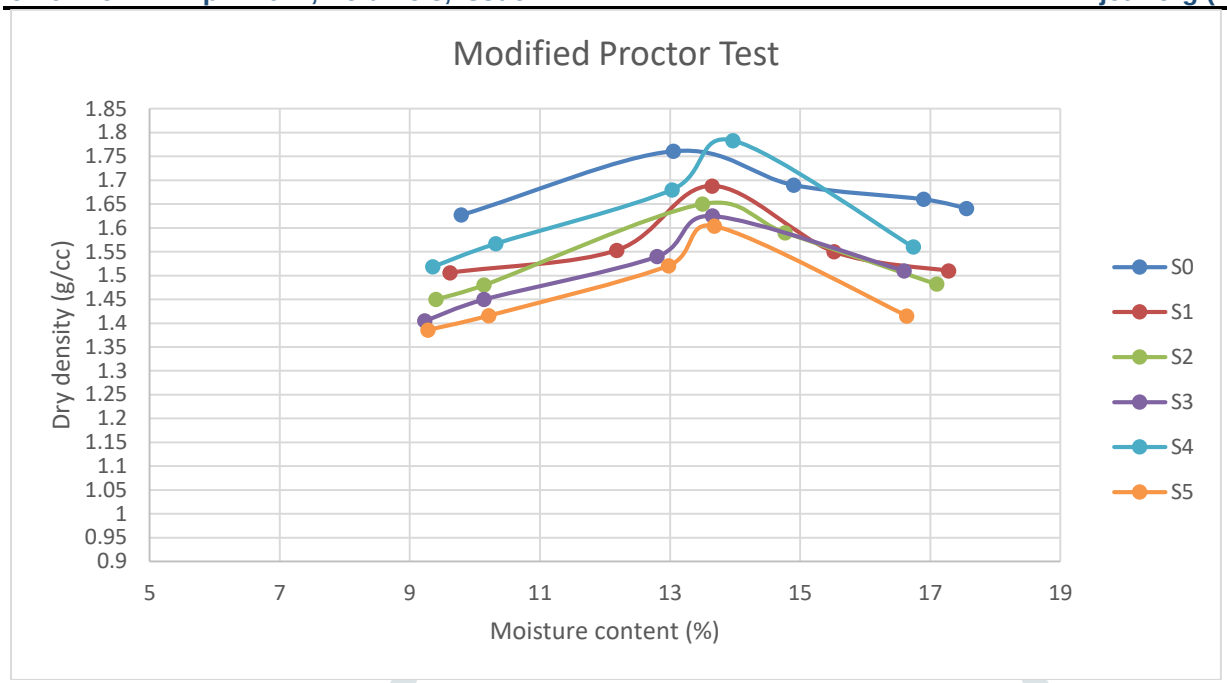

Figure: Combined Graph for modified proctor test

The different graphs for different test with different mixes are shown in the graph above. The 4th mix, S4 i.e. 24% marble dust + 1% sisal fibers showed the most prominent result and is taken as the mix with optimum moisture content and MDD.

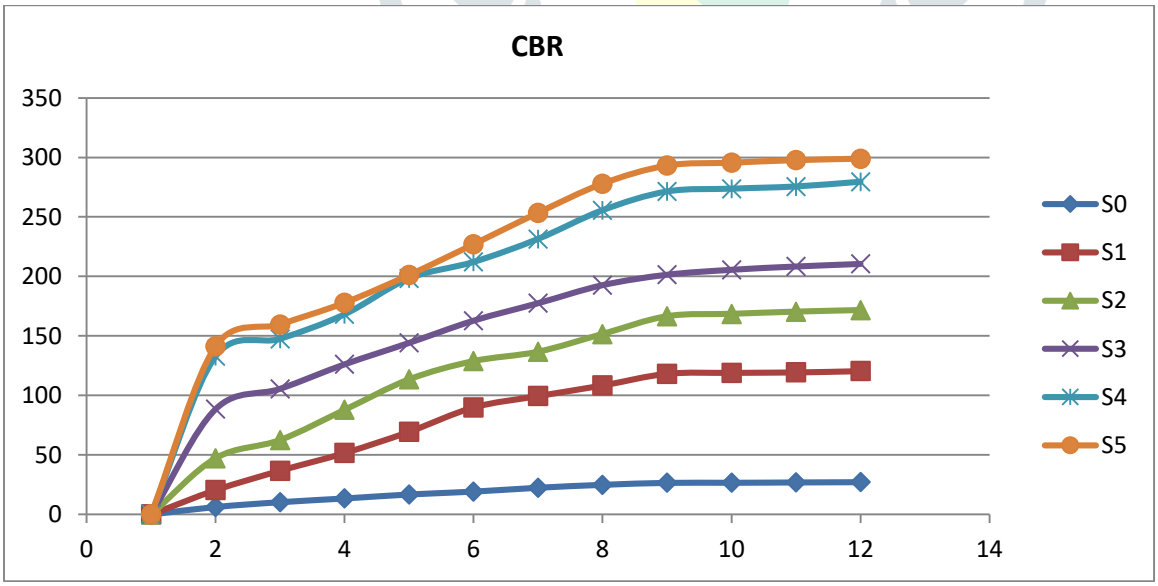

Figure: Penetration versus Load graph for different mixture of soil

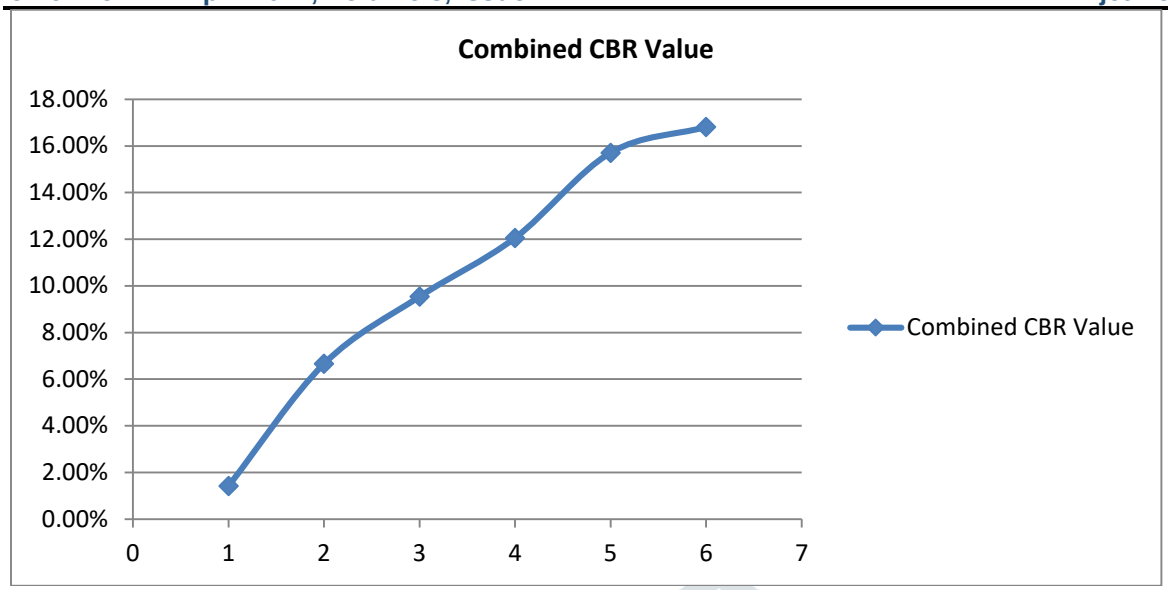

Figure: Combined CBR Value

The table below shows the penetration values for 2.5mm and 5mm for different soil samples that are mixed with varying percentage of marble dust and sisal fibers. The experiment and the calculations shows that the CBR value goes on increasing in a fundamental manner till the forth mix of marble dust and sisal fibers with the soil sample i.e. 24% marble dust with 1% sisal fibers by weight of the natural soil sample.

Sample No.	2.5mm Penetration value	5mm Penetration Value
S0	1.42%	1.27%
S1	6.66%	5.75%
S2	9.54%	8.10%
S3	12.06%	9.80%
S4	15.71%	13.20%
S5	16.81%	14.26%

CONCLUSION

1. From this study we can conclude that there was decrement in the liquid limit from 42.3% - 39.6% of the soil when it was mixed with marble dust and sisal fibers. From the graph we can see that there is minimal increment in the limit beyond the addition of marble dust with 24% and 1% of sisal fibers.
2. The plastic limit was seen to increase from 28% to 31.20% with the addition of 24% marble dust and 1% sisal fiber. Further increment in the admixtures resulted in the downfall of plastic limit.
3. The class of soil sample was classified as CI which is clay with immediate compression with the study if A- line graph plotted with the PL and LL.
4. The OMC of the soil sample had initial increment with the addition of 12% marble dust with 0.5% sisal fiber content. Further increment of the additives drastically reduced the OMC of the soil. The MDD of the soil had an increment when 20% of marble dust with 1% of sisal fiber were added beyond which the MDD started to get reduced. Thus, at 20% marble dust with 1% sisal fiber content is the optimum with 1.783 gm/cc MDD and 13.4% OMC.
5. The CBR value of the virgin soil sample was increased from 1.42% to 15.71% with the addition of

the optimum mix of marble dust and sisal fiber. Further addition of the additives showed only a slight increment in the CBR values.

6. The change of specific gravity of the soil was 2.094 to 2.489 with the mix of soil with 20% marble dust and 1% of sisal fiber. There was no increment followed by minimal decrement of the specific gravity beyond this addition of additives with the soil.

REFERENCES

1) J. Binquet and K. L. Lee, "Bearing capacity tests on reinforced earth slabs," *Journal of Geotechnical Engineering Division*, vol. 101, no. 12, pp. 1241–1255, 1975.

2) "Effect of Sisal Fibers and GGBS on Strength Properties of Black Cotton Soil"
Abhijith S1, Aruna T 2 P.G. Student, Department of Civil Engineering, East West Institute of Technology, Bangalore, India1 Assistant Professor, Dept of Civil Engineering, East West Institute of Technology, Bangalore, India, 2015

3) Negi, Ankit Singh., Faizan, Mohammad, Pandey, Deashish., Singh, Rehanjot., 2013, "*Soil Stabilization using lime", International Journal of Innovative Research in Science, Engineering and Technology.*

4) Prabhakar, J., Sridhar, R.S.,(2002)*,"Effect of random inclusion of Sisal Fiber on Strength Behavior of Soil", Construction and Building materials16(202) 123-131*

5) Choksi, Riddhi., Mishra, C.B., Patel, Nandan., (2018)*,"Pursuance of waste Marble Powder to improve soil stabilization", International Research Journal of Engineering and Technology (IRJET)*

6) N. Cesar Consoli; M. Antonio Vendruscolo; and Pedro D. Marques Prietto," *Behavior of Plate Load Tests on Soil Layers Improved with Cement and Fiber*."

7) N. Hataf *, M.M. Rahimi," *Experimental investigation of bearing capacity of sand reinforced with randomly distributed tire shreds*."

8) White, D.J., (2005)*,"Fly Ash Soil Stabilization for Non-Uniform Sub-grade Soils", Iowa State University. Volume I: Engineering Properties and Construction Guidelines (IHRB Project TR-461, FHWA Project 4).*

9) Hejazi, S.M., M. Sheikhzadeh, S.M. Abtahi and A. Zadhoush*, (2012)," A simple review of soil reinforcement by using natural and synthetic fibers", Construction and Building Materials, 30: 100-116.*

10) *"Stabilization of black cotton soil by using Sisal fiber" 2018,* Sandyarani1, Dr.Vageesha S Mathada2, Sharanakumar3."

11) M. Mamatha, S. Kommu*,"Improvement of Bearing Capacity of soil using Bamboo and Geo- Synthetics."*

12) . *"Effect of Random Inclusion Of Sisal Fibre On Strength Behavior Of Black Cotton Soil" 2013* Manjunath K. R Asst.Prof. Dept.of Civil Engg, Dayananda sagar college of Engineering, Bangalore Venugopal G Asst.Prof. Dept.of Civil Engg, Dayananda sagar college of Engineering, Bangalore ,Rudresh A. N M.Tech Scholar, Highway Technology, Dept.Of Civil Engg. D.S.C.E

13) Ankush Kumar Jain, Arvind Kumar Jha, Shivanshi*,"Geotechnical behaviour and micro analysis of expansive soil amended with marble dust"*

14) *Investigation on compaction and strength characteristics of expansive soil by using lime and marble dust powder"* J. SURYA NARAYANA1, P. DILIP KUMAR2, A. SIVA SAI3, SK. AMEER4 M.V.PRASANNA KUMAR5, P. FEROZ6

15) *Effect of Marble Dust and Glass Fiber on Expansive Soil",*Rajesh P. SHUKLA1), Mihir PAREKH1), Aditya SHAH1), Vivek KUMAVAT1), Mahendrasinh *RATHOD1)*

16) IS 2720 part 2 (1973)

17) Is 2720 part 3 (1980)

18) IS 2720 part 5 (1985)

19) IS 2720 part 8 (1980)

20) IS 2720 part 16 (1979)