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Soil Stabilization By using Basalt Fibers

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Abstract **– Basalt fiber is an inorganic fiber which uses natural basalt ore as raw material. The basalt fiber has natural compatibility, excellent mechanical properties, high temperature, and acid and alkali resistance. The objective of this study is to explore the potential use of natural basalt fiber in improving the geotechnical properties of soil. Both the content and length of basalt fiber were considered in this study. The study has been conducted with different fiber contents by weight of raw soil. For each fiber content 12mm, 18mm, 24mm lengths of fiber were used. The fiber reinforced soil was then subjected to number of tests. The two major test were Standard Proctor Test and Triaxial Compression Test. The experimental results indicate that basalt fiber can effectively increase the properties and strength of soil.**

Keywords **– Basalt fiber, length of fiber, fiber content, Standard Proctor Test, Triaxial Compression Test.**

I. INTRODUCTION

Basalt is a type of volcanic rock and a natural material. It can be used in civil engineering for many purposes. In addition to glass, carbon and aramid fibers, basalt originated fibers were also used in concrete as an alternative reinforcement material, after being subjected to a melting and spinning procedure. On the other hand, researches on the use of basalt fibers for soil improvement are rarely reported. Glass fibers offer an economical balance between cost and expected strength properties for concrete; this makes them preferable to carbon and aramid.

In recent years, basalt fibers have emerged as an alternative to glass fibers. Basalt fibers are environmentally safe, nontoxic, and possess high stability and insulating characteristics. In addition to the above mentioned properties, basalt fibers have better tensile strength than the E-glass fibers, greater failure strain in comparison with carbon fibers and provide good resistance against chemical corrosion, impact load and fire with less poisonous fumes.

The alteration of soil properties to meet specific engineering requirements is known as soil stabilization. Properties of soil may be altered in many ways, among which are included chemical, thermal, mechanical and other means. The chief properties of a soil with which the construction engineer is concerned are volume stability, strength, permeability and durability. In recent times, with the increase in the demand for infrastructure, raw materials and fuel, soil stabilization has started to take a new shape. With the availability of better research, materials and equipment, it is emerging as a popular and cost effective method for soil improvement. Here, in this project, soil stabilization has been done with the help of randomly distributed basalt fiber obtained from crushed basaltic rocks.

II. MATERIALS USED:

1. Soil

Soil was brought from the place adjacent to the college campus. It was dark brown in color. About 100-120 Kg of soil was brought, sieved and oven dried for 24 hours and various tests were conducted on the soil. The soil sample is shown in the following Fig.

Following are the properties of soil obtained after performing the tests:

Table –I: Properties of Soil

Sr. No	Property	Value
1	Field density	1.83
2	Liquid Limit	43.5%
3	Plastic Limit	28.2%
4	Shrinkage Limit	16.46%
5	Free Swell Index	27.27%
6	Water Content	16.93%
7	Specific Gravity	2.37
8	Color	Dark Brown

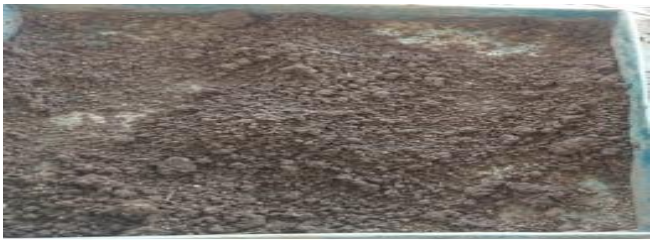

Fig.1. Collected soil sample.

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2. Basalt Fibers

The basalt fiber required for the project is collected from Nikunj.Pvt.Ltd., Mumbai. Color of fibers used is grey. The fibers is as shown in the following Figs. The basalt fiber is also known as the "21st Century non polluting green material". It is 100% natural and inert. Three types of basalt fibers of three different lengths (12mm,18mm and 24mm) were ordered. Cost of fibers was Rs.300/kg. Quantity ordered was 1.5kg of 12mm, 1.5kg of 18mm and 1kg of 24mm.Note: If large amount of fibers is to be ordered, then the cost per kg of fibers will be comparatively less, hence it is cost effective.

Fig.2 12mm fibers.

Fig.3 18mm fibers

Fig. 4 24mm fibers.

III. METHODOLOGY

Two significant test were performed in this research. They were Standard Proctor Test and Triaxial Compression Test. The details of tests with their respective results are as follows.

1. Standard Proctor Test: It was performed on 12mm,18mm and 24mm fibers with different and proportionate fiber content.

For 12mm fibers 1.5%,3%,4.5% and 6% fibers by weight of soil were used.
For 18mm fibers 1.5%,3%,4.5% and 6% fibers by weight of soil were used.
For 24mm fibers 1.5%,2%,2.5% and 3% fibers by weight of soil were used.

2. Observations on 12mm fibers

Table -II: Effect on OMC and MDD with % of basalt

Sr no.	Basalt fiber content (%)	OMC (%)	MDD (gm/cm^3)
1	0	21.06	1.83
2	1.5	19.91	1.86
3	3	13.27	2.00
4	4.5	16.67	1.97
5	6	19.2	1.91

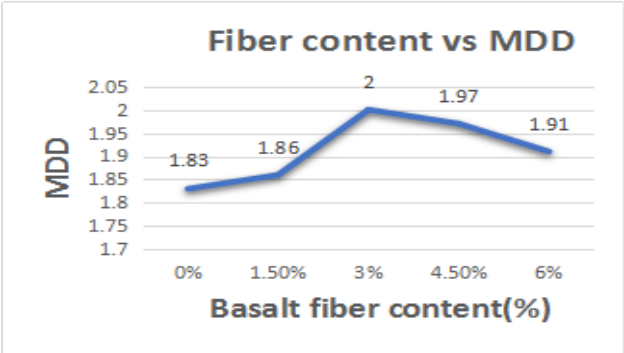

Fig. 6 Variation of MDD with % of basalt fibers

Initially as fiber content increases from 0% to 3%, OMC decreases but corresponding MDD increases. Further increase in fiber content from 3% to 6% causes increase in OMC value and decrease in MDD value.

3. Observations on 18mm fibers :

Table -III: Effect on OMC and MDD with % of basalt fibers

Sr no.	Basalt fiber content (%)	OMC (%)	MDD (gm/cm^3)
1	0	21.06	1.83
2	1.5	18.57	1.93
3	3	7.06	2.12
4	4.5	21.55	1.86
5	6	18.35	1.94

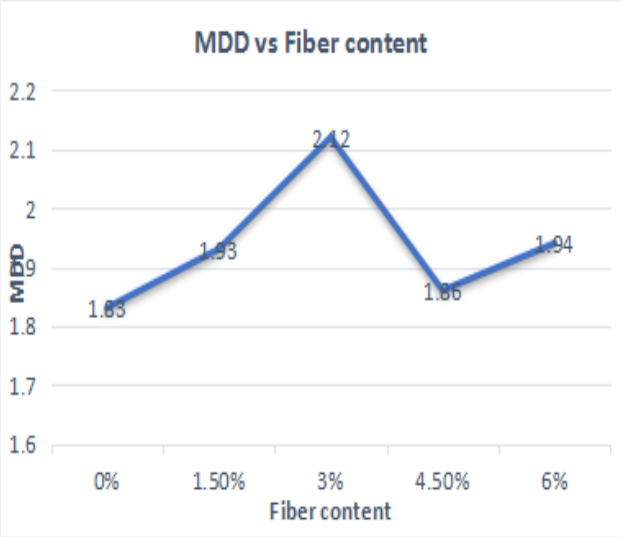

Fig.7 Variation of MDD with % of basalt fibers

 Initially as fiber content increases from 0% to 3%, OMC decreases but corresponding MDD increases

4. Observations on 24mm fibers

Table -IV: Effect on OMC and MDD with % of basalt fibers-

Sr no.	Basalt fiber content (%)	OMC (%)	MDD (gm/cm^3)
1	0	21.06	1.83
2	1.5	13.56	1.57
3	2	18.94	1.73
4	2.5	8.13	1.88
5	3	3.2	2.03

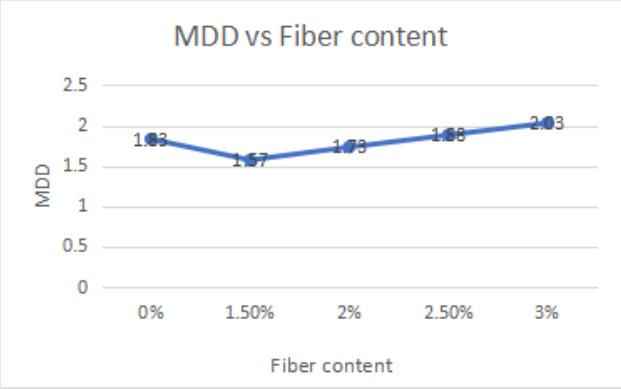

Fig 4. Variation of MDD with % of basalt fibers

 From 1.5% fiber content to 3% fiber content, MDD increases linearly and the corresponding OMC goes on decreasing.

5. Triaxial Compression Test : Graphical Representation of Triaxial Compression Test Results is as shown below.

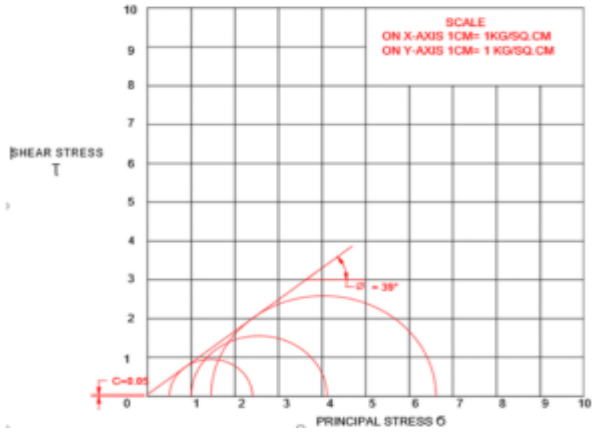

Fig 5. Mohr's Circle for Soil without Mixing Fibers.

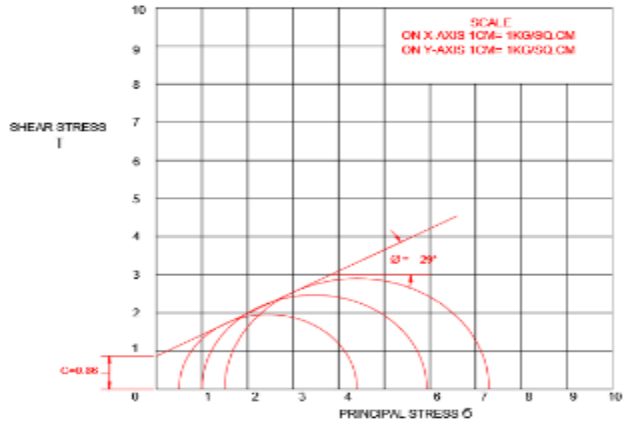

Fig 6. Mohr's Circle for Soil with Mixing 3% 12mm Fibers

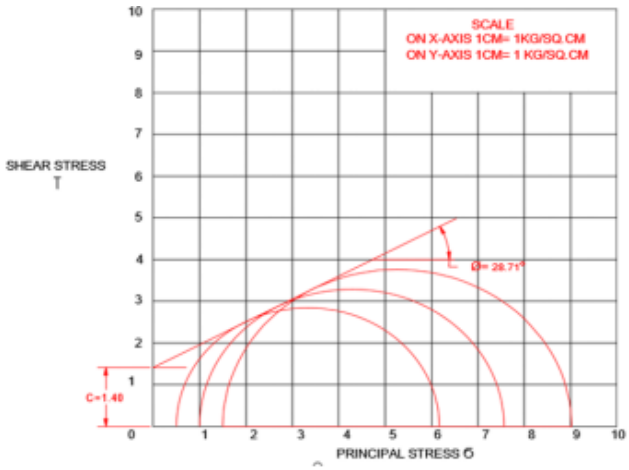

Fig 7. Mohr's Circle for Soil with Mixing of 18mm Fibers

IV. PRINCIPAL STRESSES AND SHEAR PARAMETERS

Table -V: For simple soil i.e. without mixing fibers

Test No.	Cell Pressure (σ_3) Kg/cm^2	Deviator Stress at Failure (σ_d) Kg/cm^2	Major Stress (σ_1)=(σ_d)+(σ_3) Kg/cm^2	Shear Parameters from Graph
1	0.5	1.9	2.4	C=0.05 Kg/cm^2 ?=39°
2	1	3.11	4.11	
3	1.5	5.05	6.56	

Table -VI: For soil with mixing of 3% of 18mm basalt fiber

Test No.	Cell Pressure (σ_3) Kg/cm^2	Deviator Stress at Failure (σ_d) Kg/cm^2	Major Stress (σ_1)=(σ_d)+(σ_3) Kg/cm^2	Shear Parameters from Graph
1	0.5	5.67	6.17	C=1.40 Kg/cm^2 ?=28.71°
2	1	6.56	7.56	
3	1.5	7.52	9.02	

Table -VII: For soil, with mixing 3% of 12mm Basalt Fiber

Test No.	Cell Pressure (σ_3) Kg/cm^2	Deviator Stress at Failure (σ_d) Kg/cm^2	Major Stress (σ_1)=(σ_d)+(σ_3) Kg/cm^2	Shear Parameters from Graph
1	0.5	3.90	4.40	C=0.86 Kg/cm^2 ?=29°
2	1	4.93	5.93	
3	1.5	5.80	7.30	

V.CONCLUSIONS

In Standard Proctor Test, inclusion of basalt fibers on soil increases the MDD of soil and decreases the OMC of soil, as compared to the soil without inclusion of fibers. MDD of soil with 3% of 18mm fibers i.e. 2.12 gm/cm3 is found out to be greater than the MDD of soil with 3% of 12mm fibers i.e. 2.00 gm/cm3. MDD of soil with 3% of 24mm fibers i.e. 2.03 gm/cm3 is found out to be less than the MDD of 3% of 18mm fibers.

OMC of soil with 3% of 18mm fibers i.e. 7.06% is found out to be less than the OMC of soil with 3% of 12mm fibers i.e. 13.27%. OMC of soil with 3% of 24mm fibers i.e. 3.2% is found out to be less than both 3% of 12 &18mm fibers.

So, from above observations we can conclude that there is a marginal difference in MDD of 3% of 18 & 24mm fibers. Although MDD of 24mm fibers is slightly less, the OMC makes a huge difference here. OMC of 24mm fibers is almost half than that of 18mm fibers. This can make considerable saving of water and also in the cost of water.

In Triaxial Compression Test, it is concluded that undrained shear strength of soil increases with the inclusion of basalt fibers. The optimum fiber content corresponding to maximum improvement in strength is found to be at 3%. It is also concluded that fiber length has a significant effect on undrained shear strength of soil and 18 mm fibers added to samples give higher strengths related to 12mm fiber added sample.
Overall it has been observed that, incorporating fibers can effectively increase the properties and strength of soil.

VI.FUTURE SCOPE

-Basalt fibers of different length can be intermixed together in a soil sample and various tests can be performed to check their effectiveness.
-Basalt fibers along with different soil stabilizing agents or other fibers can be mixed with soil sample to improve the soil characteristics. -Consolidation Test on soil samples with basalt fibers can be performed to obtain rate and amount of settlement. -Modified Proctor Test can be performed on soil sample mixed with basalt fibers and the effect of higher compaction can be observed. This effect can then be compared with the Standard Proctor Test results.

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