

ENHANCING THE ENGINEERING PROPERTIES OF SOIL BY USING SISAL FIBRE AND FLY ASH

Ravinder Singh Panwar¹, Vinod Kumar Sonthwal², Sunil Kaswan³

^{1,3}PG Student, ²Associate Professor, Department of Civil Engineering,
National Institute of Technical Teacher Training and Research, Chandigarh, India, (160019)

Abstract— *The present study deals with use of fly ash and sisal fibre for improvement in CBR of clayey soil. The Fly ash is a thermal power plant waste and Sisal fibre is natural fibre. The soil collected from Chandigarh, North region of India for laboratory work. The test like Maximum Dry Density (MDD), Optimum Moisture Content (OMC) and California Bearing Ratio (CBR)) were conducted on the soil in the laboratory for different percentage of fly ash (10%, 20%, 30% & 40%) along with Sisal fibre (composition 0.25%, 0.5%, 0.75% & 1%) at the length of 1cm. The optimum combination recommended for clay soil is 30% Fly ash with 0.75% Sisal fibre 1cm length. The CBR value of clay soil treated with 30% Fly ash, 0.75% Sisal fibre, having a fibre of 1cm length is increased by 68.97% and 137.95% respectively.*

Keywords— Soil Stabilization, Sisal Fibre, Fly Ash, MDD, OMC and CBR Test

INTRODUCTION

The design of Infrastructure projects such as highways, railways; water reservoirs, reclamation etc. depend on type of soil available for foundation. Construction project requires earth material in very huge quantity. Many region, borrow soil is not easily available which has to be hauled from a far distance[1]. Quite often, large areas are covered with highly plastic and expansive soils, which is not suitable for foundation and sub-grade construction purposes. To eliminate these problems a soil stabilization process has conducted. Soil stabilization done with different stabilizing agent like sand, fly ash, lime and cement with or without fibre. Fibre gives tensile strength and also increases cohesion value. As fly ash is freely available from Thermal Power Plants, it can be used for stabilization of expansive soils for various uses[2]. Fly ash increase the strength of clayey soil significantly by pozzolanic action which increases the strength and reduces the cohesiveness of soil by the silty nature of the fly ash particles[3]. This study presents the laboratory work on soil stabilized with fly ash (FA) and Sisal fibre (SF). The samples soils were collected from Village Kaimbwala near Chandigarh, India. Chandigarh is beautiful city in North West region of India situated at the foothill of Shivalik (lower Himalaya) range. The total geographical area of village is 178 hectares. And its coordinates are 30.7333° N latitude and 76.779° E longitude.

Fly Ash is itself an industrial waste which imposes many health and environmental hazards. Dumping fly ash is not an environmental friendly, as it degrades the soil and water quality nearby the dumping area. Continuous infiltration of fly ash in the agricultural fields may lead to infertility of soil. Also the fly ash damages the natural habitat of ponds, it start floating over the pond water and prevents the sunlight entering in the pond. Sisal fibre is a type of natural fibre which acts as a reinforcement in soil. It is easily availability and cheap than the synthetic fibres such as, glass, plastic, carbon and Kevlar. Fibre extracted from the leaves of sisal plant is hard fibre a process known as decortications[4]. Fibre showed a significant improvement in the failure deviator stress, Shear strength parameters (C and ϕ) of the studied soil [5].

OBJECTIVE OF THE STUDY

- To analyse the effects of mixing material in soil sample on strength and structural parameters of the soil.
- To achieve an optimized percentage of fly ash and sisal fibre that gives a satisfactory strength and bearing capacity to the soil.

MATERIAL DETAIL

Soil stabilization is a process of improvising upon the soil properties by mixing various ingredients, in this case fly ash and sisal fibre, so as to improve usability of soil in pavement and foundation works. Following are the various materials used:

- a) **Soil:** Soil sample was obtained from Kaimbwala Village near Chandigarh which is covered with highly plastic clay affected construction works has led to swelling property and low load bearing capacity. Soil samples were obtained from surface not a digging any hole. Specific gravity of soil in the range of 2.68.



Figure 1: Clayey soil (CI)

- b) **Fly Ash:** Fly Ash was obtained from Panipat Thermal Power Plant. The fly ash obtained was of F Class with a specific gravity in the range of 1.968. MDD and OMC were found to be 1.16 (g/cc) and 31.5% respectively.



Figure 2: Fly ash F class

- c) **Sisal Fibre:** Sisal fibre had taken from Go Green product, Chennai. The sisal fibre obtained was of with a density (g/cc) 1.58 and diameter in range of 0.8 to 12 mm. The Average Tensile Strength (Mpa) and Young's Modulus (Gpa) of sisal fibre is 385 to 728, 9 to 22 respectively.



Figure 3: Sisal fibre 1 cm length

METHODOLOGY

A. Compaction Test

Modified Proctor Test was performed in this phase of study in accordance with IS: 2720 (Part8)-1983. Compaction Test was performed on virgin soil as brought from the site and also on blended sample constituting of varying percentages of fly ash. After establishing an optimized percentage of fly ash (30%) varying percentages of sisal fibre were added to the mix and again Modified Proctor Test was performed on the sample. Thus Maximum Dry Density and Optimum Moisture Content of virgin and blended mix were obtained.

B. California bearing ratio test

In accordance with IS: 2720 (Part16)-1987, CBR Test was conducted on virgin soil, soil blended with fly ash and lastly on fly ash optimized soil mixed with varying percentages of Sisal fibre.

RESULTS AND DISCUSSION

a) Effect of fly ash on MDD and OMC

The increase in fly ash was done in steps by increasing fly ash percentage in four increments – 10%, 20%, and 30%, and 40%. As a result, increase in fly ash content, the MDD decreases. Thus fly ash content was fixed at 30% on the basis of CBR for further blending of Sisal fibre material. The comparison curves are shown in Figure 4 and Figure 5. The decrease in MDD beyond has been marginal in nature but further addition would have resulted in decreasing the MDD value. Affect on OMC was decrease first at 10% fly ash and increase with addition of fly ash.

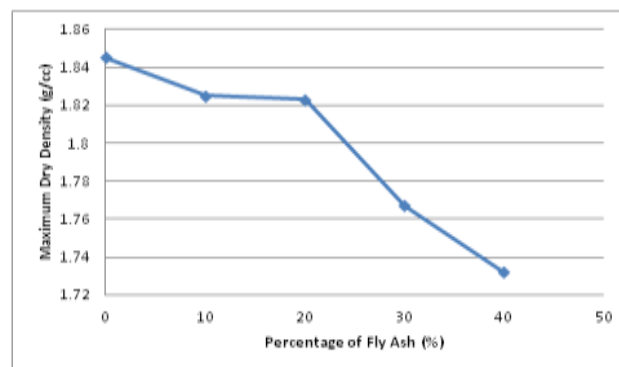


Figure 4: MDD of soil with fly ash in %

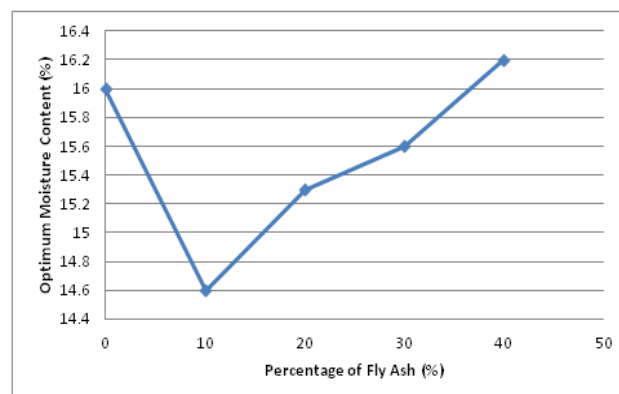


Figure 5: OMC of soil with fly ash in %

b) Effect of sisal fibre and 30% Fly Ash on MDD and OMC

While the amount of Fly Ash was kept constant at 30% (optimized value) on the basis of CBR test, the content of sisal fibre was blended in four different trials. The sisal fibre waste was added at (0.25%, 0.50%, 0.75%, and 1%). The length of fibre was kept constant to keep a check on the scope of work. It has been observed that MDD was decrease with addition of sisal fibre and OMC first decreases and then increase beyond 0.75% of sisal fibre. The comparison curves are shown in Figure 6 and Figure 7.

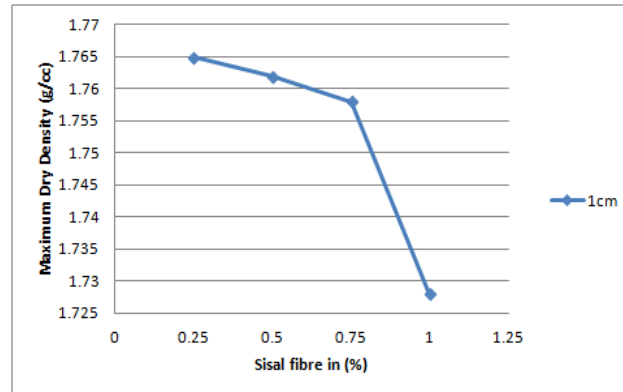


Figure 6 MDD of soil fly ash mix with sisal fibre in %

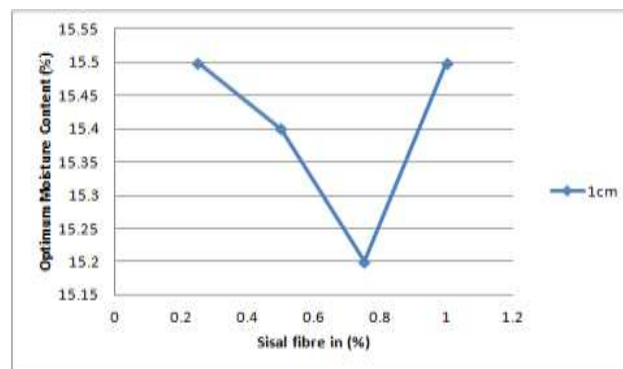


Figure 7: OMC of soil fly ash mix with sisal in %

c) Effect of fly ash on California Bearing Ratio of Soil

In comparison to virgin soil (Clayey intermediate plasticity – CI group) the soil mixed with 30% fly ash gave a substantial increment of 68.97% in CBR value. Incremental addition of fly ash was done – 10%, 20%, 30% and 40%. With increase in fly ash content, the CBR value was consistently found to be increasing up to the optimum limit. Beyond 30% fly ash content the value of CBR decrease with addition of fly ash in soil sample. The comparison curves are shown in Figure 8.

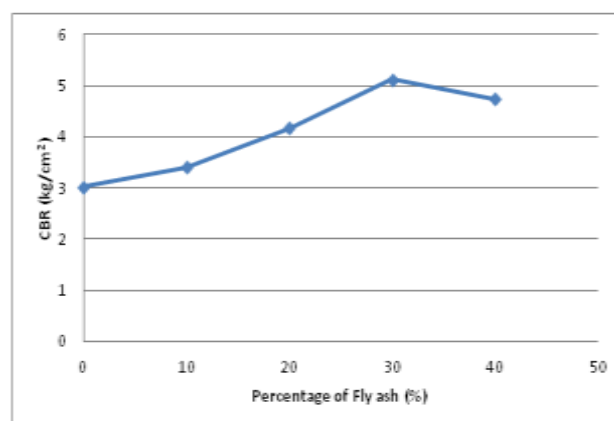


Figure 8: CBR of soil with fly ash in %

d) Effect of 30% fly ash and sisal fibre on California Bearing Ratio of Soil

With increase in sisal fibre content in the soil mix, at 30 fly ash the CBR value was found to be increasing up to 0.75%. Sisal fibre was added in 4 incremental values - 0.25%, 0.5%, 0.75%, and 1%. The CBR value dropped after at 0.75 % and the maximum value was achieved at 0.75%. The reason behind this fall was excessive fibre causing reduction in grain to grain contact and behaves as elastic medium that resulted in loss of strength. The comparison curves are shown in Figure 9.

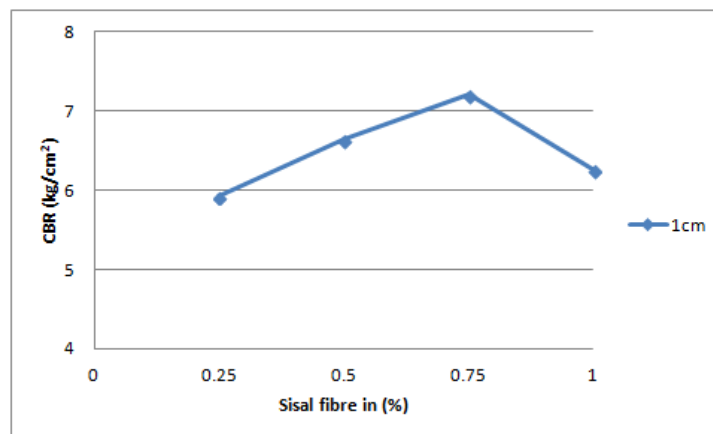


Figure 9: CBR of soil fly ash mix with sisal fibre in %

CONCLUSIONS

In these study strength characteristics of soil mixed with an optimized percentage of fly ash and varied percentage of sisal fibre mix has been studied. Based on the findings of laboratory tests conducted under controlled conditions, following observations can be made.

1. Through modified Proctor Test, it was concluded that Maximum Dry Density and Optimum Moisture Content were decrease and increase respectively by addition of fly ash content. Compared to virgin soil, a marginal (1.08%, 1.19%, 4.22%, 6.12%) decrease in Maximum Dry Density with (10%, 20%, 30%, 40%) fly ash was observed.
2. In comparison to virgin soil (Clay with intermediate compressibility – CI group) the soil mixed with 30%fly ash gave a substantial increment of 68.97% in CBR value. Thus it was concluded to fix the percentage of fly ash a 30% to further analyse effect of sisal fibre in the soil mix.
3. At 0.75% sisal fibre of 1cm length mixed with 30% fly ash content, a marginal decrease of 4.71% in MDD value was observed as compared to virgin soil.
4. As compared to soil mixed with 30% fly ash, 0.75% sisal fibre mixed with 30% fly ash gave CBR value of 5.92. Thus 40.82% increase in CBR value was observed.
5. In comparison to virgin soil, an overall gain of 137.95% of CBR value was obtained with 30%fly ash and 0.75% sisal fibre fibre 1cm length mix.
6. The mix develops resistance towards sudden failure due to fly ash particle size, which fills the voids in clayey soil and sisal fibre which reinforces the soil in much effective manner, in turn increasing the cohesion force.

REFERENCES

- [1] "Engineering Design and Construction Manual for Subdivision in Growth Areas," no. April, 2011.
- [2] S. Bhuvaneshwari, R. G. Robinson, and S. R. Gandhi, "Stabilization of Expansive Soils Using Flyash," *Fly Ash India*, no. 1, pp. 1–10, 2005.
- [3] A. Sridharan, J. P. Prashanth, and P. V Sivapullaiah, "Effect of fly ash on the unconfined compressive strength of black cotton soil," pp. 169–175, 1997.
- [4] P. Guideline, "Agriculture, Forestry & Fisheries."
- [5] N. Gamage, K. Liyanage, S. Fragomeni, and S. Setunge, "Overview of different types of fly ash and their use as a building and construction material," *Int. Conf. Struct. Eng. Constr. Manag.*, no. February, 2013.

- [6] A. Kumar, B. S. Walia, and A. Bajaj, "Influence of Fly Ash, Lime, and Polyester Fibres on Compaction and Strength Properties of Expansive Soil," *J. Mater. Civ. Eng.*, vol. 19, no. 3, pp. 242–248, 2007.
- [7] S. Sharma, Ravi Kumar; Babita, "Modification of Clayey Soil Using Fly Ash," *IJRET Int. J. Res. Eng. Technol.*, vol. 02, no. 10, pp. 356–361, 2013.
- [8] IS.2720.2, "Determination of water content," 1973.
- [9] IS-2720(III), "Determination of specific gravity," *Indian Stand.*, 1980.
- [10] IS-2720(V), "Methods of test for soils: Determination of liquid limit and plastic limit," *Indian Stand.*, 1985.
- [11] M. Kisan, S. Sangathan, J. Nehru, and S. G. Pitroda, "मृदा ंक," 1970.
- [12] IS:2720 (part 8)-1983 (reaffirmed 2006), "Determination of water content - dry density relation using heavy compaction," *Bur. Indian Stand.*, 2006.
- [13] IS-2720(XVI), "Laboratory determination of CBR," *Indian Stand.*, 1987.