

Effect of Polypropylene Fiber on Engineering Properties of Expansive Soils

Dr.MD.Subhan ¹

Professor, Department of Civil Engineering, AVNIET, Hyderabad, India¹

ABSTRACT: Soil reinforcement is defined as a technique to improve the engineering characteristics of soil. In this way, using natural fibers to reinforce soil is an old and ancient idea. The effect of randomly distributed polypropylene fibers on Maximum dry density (MDD), Optimum moisture content (OMC), unconfined compressive strength (UCS), soaked California bearing ratio (CBR), hydraulic conductivity and swelling pressure of an expansive soil stabilised with rice husk ash and lime has been discussed in this paper.

KEYWORDS: Rice husk ash, lime, polypropylene fiber, soaked CBR, hydraulic conductivity, swelling pressure.

I. INTRODUCTION

Soil can often be regarded as a combination of four basic types: gravel, sand, clay, and silt. It generally has low tensile and shear strength and its characteristics may depend strongly on the environmental conditions (e.g. dry versus wet) [1]. On the other hand, reinforcement consists of incorporating certain materials with some desired properties within other material which lack those properties [2]. Therefore, soil reinforcement is defined as a technique to improve the engineering characteristics of soil in order to develop the parameters such as shear strength, compressibility, density; and hydraulic conductivity [3]. Soil reinforcement can consist of stone columns, root piles or micro-piles, soil nailing and reinforced earth [4–6]. Mainly, reinforced earth is a composite material consisting of alternating layers of compacted backfill and man-made reinforcing material [6].

As it was mentioned, soil reinforcement is a procedure where natural or synthesized additives are used to improve the properties of soils. Several reinforcement methods are available for stabilizing, problematic soils. Therefore, the techniques of soil reinforcement can be classified into a number of categories with different points of view. However, on the basis of reinforcing performance, Fig. 1 presents a state of art review of different procedures of soil reinforcement prepared by the authors.

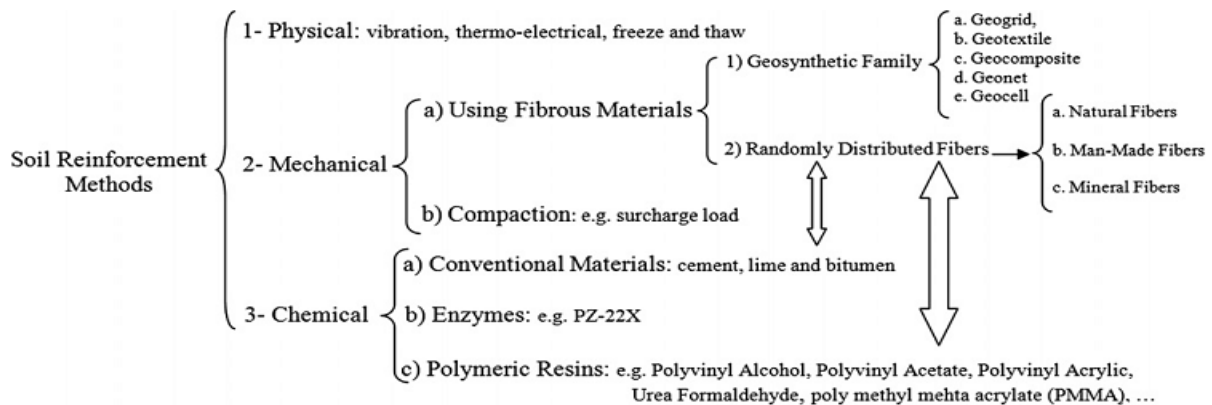


Fig. 1. Different procedures of soil reinforcement.

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

All the researchers have found varied success in improving the engineering properties of expansive soil. The effects of polypropylene fiber on MDD, OMC, UCS, soaked CBR, hydraulic conductivity and swelling pressure of expansive soil stabilized with rice husk ash and lime has been found to be limited in literature. The objective of this paper is to study the effects of polypropylene fiber on MDD, OMC, UCS, soaked CBR, hydraulic conductivity and swelling pressure of an expansive soil stabilized with optimum percentage of rice husk ash and lime. The effects of 7 and 28 days of curing on UCS, soaked CBR, hydraulic conductivity and swelling pressure have also been studied.

II. RELATED WORK

Stabilization is one of the methods of treating the expansive soils to make them fit for construction. Variety of stabilizers may be divided into three groups (Petry 2002): (a) traditional stabilizers (lime, cement etc.), (b) by-product stabilizers (fly ash, quarry dust, phosphor-gypsum, slag etc.) and (c) non-traditional stabilizers (sulfonated oils, potassium compounds, polymer, enzymes, ammonium chlorides etc.). Disposal of large quantities of industrial by products as fills on disposal sites adjacent to industries not only requires large space but also create a lot of geo-environment problems. Attempts are being made by various organizations and researchers to use them in bulk at suitable places. Stabilization of expansive soil is one way of utilization of these by products. Some of the research work conducted by earlier researchers on the above has been described below.

Srivastava *et al.* (1997) studied the change in micro structure and fabric of expansive soil due to addition of fly ash and lime sludge from SEM photograph and found changes in micro structure and fabric when 16% fly ash and 16% lime sludge were added to expansive soil. Srivastava *et al.* (1999) have also described the results of experiments carried out to study the consolidation and swelling behaviour of expansive soil stabilized with lime sludge and fly ash and the best stabilizing effect was obtained with 16% of fly ash and 16% of lime sludge.

Muntohar and Hantoro (2000) used rice husk ash and lime for stabilization of expansive soil by blending them together. The RHA used were 7.5%, 10% and 12.5% and lime as 2%, 4%, 6%, 8%, 10% and 12% as replacement of expansive soil. Their PI (plasticity index) decreased from 41.25% to 0.96% and swell potential decreased from 19.23% to insignificant with 12-12.5% of RHA-lime mixture. There was also increase in CBR value (3 % to 16 %), internal friction angle (50 to 240) and cohesion (54.32 kN/m² to 157.19 kN/m²), thereby increased bearing capacity to 4131 kN/m² from 391.12 kN/m²

Kumar *et al.* (2007) studied the effects of polyester fiber inclusions and lime stabilization on the geotechnical characteristics of fly ash-expansive soil mixtures. Lime and fly ash were added to an expansive soil at ranges of 1–10% and 1–20%, respectively. The samples with optimum proportion of fly ash and lime content (15% fly ash and 8% lime) based on compaction, unconfined compression and split tensile strength, were added with 0, 0.5, 1.0, 1.5, and 2% plain and crimped polyester fibers by weight. The MDD of soil-fly ash-lime mixtures decreased with increase in fly ash and lime content. The polyester fibers (0.5–2.0%) had no significant effect on MDD and OMC of fly ash-soil-lime-fiber mixtures. However, the unconfined compressive strength and split tensile strength increased with addition of fibers.

Table .1 Comprehensive studies on the stabilization of expansive soil using Industrial Wastes

SL.No	Types of waste	Investigation	Findings	Reference
1	Fly ash, Lime and Gypsum	SP and UCS	SP reduced and UCS of the soil increased	Sharma <i>et al.</i> (1992)
2	a) Fly ash and Lime sludge b) Fly ash and Lime sludge	a) Microstructure and Fabric b) Consolidation and SP	a) Remarkable change in micro structure and fabric, b) Improvement in consolidation and reduction in SP	a) Srivastava <i>et al.</i> (1997) b) Srivastava <i>et al.</i> (1999)
3	Class-C fly ashes	SP	75% decrease in SP with 7 days curing and 79% decrease in SP with 28 days curing	Cocka. (2001)
4	Class F Fly ash	CBR	20% addition of fly ash increased the CBR by 200%	Pandian <i>et al.</i> (2001)
5	Fly ash and randomly distributed Coir fibre	CBR	CBR values are improved and fibre inclusion increases both the strength and stiffness of the mix	Sivarama Krishna, K., <i>et al.</i> (2002)
6	Class C and F fly ash with sand	Swelling test	decrease in free swell	Turker <i>et al.</i> (2004)
7	Class F Fly ash and Lime	UCS, CBR and SP	UCS, CBR increased SP decreased.	SatyaNarayan <i>et al.</i> (2004)
8	Class F Fly ash	PI, K, SP, MDD, resistance to penetration	PI, K, SP, decreased MDD and resistance to penetration increased.	Phani Kumar <i>et al.</i> (2004)
9	Class F Fly ash and desulphogypsum	Swelling percentage and rate of swell	Swelling percentage and rate of swell decreased	Bayter (2005)

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

III. CASE STUDIES OF FIBERS

Coconut (coir) fiber: The outer covering of fibrous material of a matured coconut, termed coconut husk, is the reject of coconut fruit. The fibers are normally 50–350 mm long and consist mainly of lignin, tannin, cellulose, pectin and other water soluble substances. However, due to its high lignin content, coir degradation takes place much more slowly than in other natural fibers. So, the fiber is also very longlasting, with infield service life of 4–10 years. The water absorption of that is about 130–180% and diameter is about 0.1–0.6 mm [7].

Coir retains much of its tensile strength when wet. It has low tenacity but the elongation is much higher [8]. The degradation of coir depends on the medium of embedment, the climatic conditions and is found to retain 80% of its tensile strength after 6 months of embedment in clay. Coir geo-textiles are presently available with wide ranges of properties which can be economically utilized for temporary reinforcement purposes [9]. Mainly, coir fiber shows better resilient response against synthetic fibers by higher coefficient of friction. For instance, findings show that coir fiber exhibits greater enhancements (47.50%) in resilient modulus or strength of the soil than the synthetic one (40.0%).

Lime increases the strength of clayey soil. Soil stabilization occurs when lime is added to a reactive soil to generate long-term strength gain through a pozzolanic reaction. The strength of lime mixture depends to a great extent on the quantity of lime added above lime fixation point. It is generally found that beyond a certain % of lime the increase in strength ceases & in fact a lowering strength may result due to presence of unreacted free lime indicating that there exists optimum lime content for maximum strength gain. So after a certain limit of lime content no development of strength but cost increases.

IV. DISCUSSIONS & TEST RESULTS

The materials used in the experiments are expansive soil, Rice husk ash, lime and Polypropylene fiber.

Expansive soil: The expansive soil used in the experimental work was brought from Bhubaneswar. The geotechnical properties of the expansive soil are:

Property	Value
Sand size	18%
Silt size	26%
Clay size	56%
Specific Gravity	2.61
Liquid Limit	60%
Plastic Limit	32%
Plasticity Index	28%
Shrinkage Limit	11%
Swelling Pressure	130 kN/m ²
OMC	21%
MDD	16.1 kN/m ³

Figure 2 shows the variation of UCS of rice husk ash-lime stabilized expansive soil at 7 days curing. The UCS of expansive soil increases up to 10% addition of rice husk ash beyond 10% addition, the UCS decreases. The UCS of expansive soil reaches the value of 72 kN/m² from 60 kN/m² at 10% addition of rice husk ash. The strength increases because of the contribution of frictional resistance from rice husk ash along with the cohesion from expansive soil. The strength decreases because of the reduction of cohesion component. Addition of any percentage of lime to expansive soil -rice husk ash mixes increases the UCS. The maximum value of UCS obtained is found out to be 174 kN/m², when the percentage of rice husk ash was 10% and lime was 4%. The strength of the soil increases by the addition of rice husk ash and lime, because of the pozzolanic reaction of lime with the amorphous silica and alumina present in rice husk ash

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

and soils. Addition of lime beyond 4% decreased the UCS. The strength decreases resulting in carbonation reactions, due to addition of excess lime to react with insufficient amorphous silica and alumina present in rice husk ash and expansive soil.

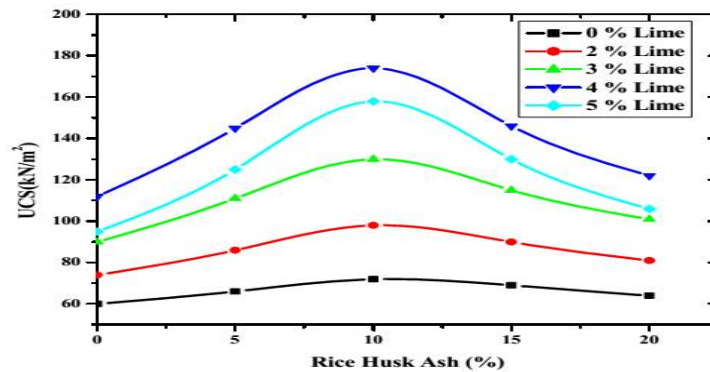
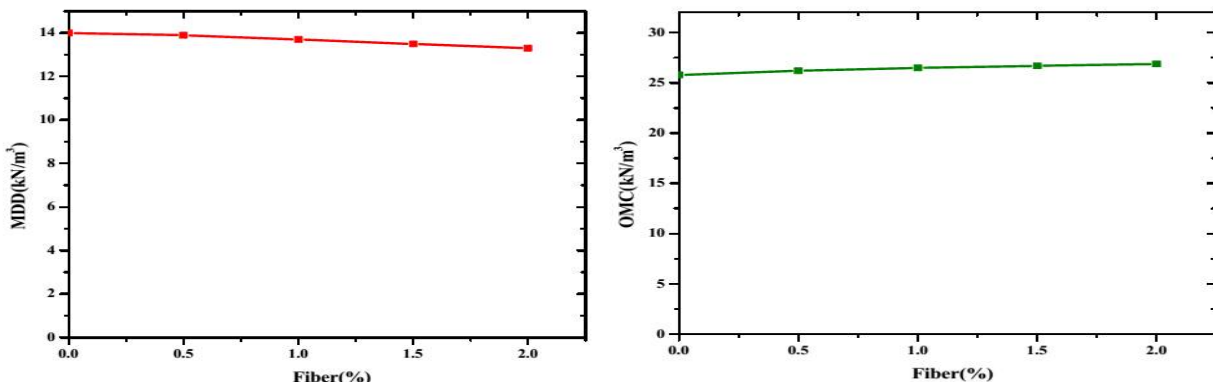


Figure 2: Variation of UCS with Rice husk ash and Lime at 7 days curing

Figures 3 (a) and (b) shows the variation of MDD and OMC with different percentage of polypropylene fiber (fiber) respectively. The MDD of soil decreases to 14 kN/m³ from 16.1 kN/m³ and OMC increased to 25.8% from 21% when stabilized with optimum percentage of rice husk ash and lime. With increase in percentage of fiber the MDD of rice husk ash-lime stabilized expansive soil goes on decreasing, decreases to 13.3 kN/m³ when 2% fiber was added which is attributed to the lower value of specific gravity of fiber as compared to soil. The OMC goes on increasing irrespective of percentage of addition of fiber. The OMC increases to a value of 26.6% when 2% fiber was added. Similar observations were made by Kumar et al. (2007) when polyester fibers were added to Fly ash-lime stabilized expansive soil.



(a) Variation of MDD with percentage of Fiber (b) Variation of OMC with percentage of Fiber

Figure 3: Variation of MDD and OMC with percentage of Fiber

Figure 4 shows the variation of UCS of rice husk ash-lime stabilized expansive soil with different percentage of fiber and curing period. The UCS of the soil increased to 68 kN/m² from 60 kN/m² when it was stabilized with optimum proportion of rice husk ash and lime at 0 day curing, increase in curing period further increases the UCS to 274 kN/m² at 28 days of curing which is 4.56 times that of virgin soil. Addition of fiber increases the UCS of rice husk ash-lime stabilized soil, UCS increases up to 1.5% addition of fiber and then after it decreases. The UCS found to increase with

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 5, Issue 3, March 2016

curing period irrespective of fiber content. The UCS increased to a value of 501 kN/m² at 28 days of curing at 1.5 % addition of fiber, which is 8.35 times that of the virgin soil.

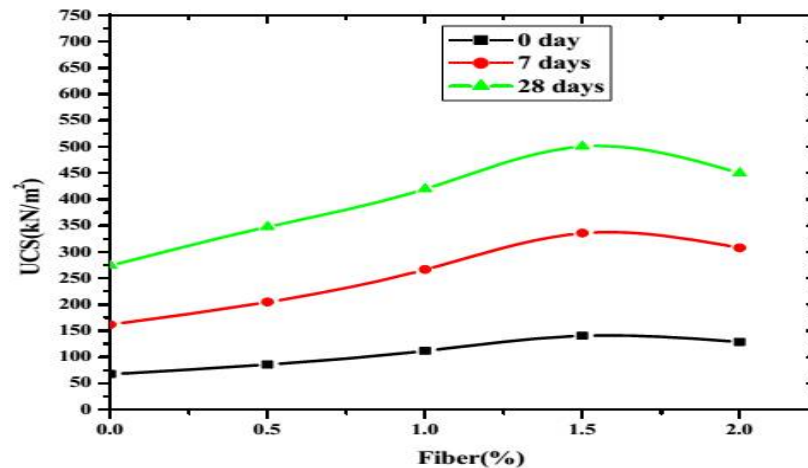


Figure 4: Variation of UCS with percentage of Fiber and Curing period

V. CONCLUSION

Following conclusions are drawn from this study: (i) The addition of rice husk ash and lime decreases the MDD and increases the OMC of the expansive soil. MDD goes on decreasing and OMC goes on increasing, with increase in percentage of polypropylene fiber in the rice husk ash-lime stabilized expansive soil. (ii) The addition of rice husk ash and lime increases the UCS and soaked CBR of the expansive soil. With the addition of polypropylene fiber to rice husk ash-lime stabilized expansive soil, the UCS and soaked CBR increases, up to 1.5 % addition of polypropylene fiber, and decreases with further increase in polypropylene fiber content. The UCS and soaked CBR increases with increase in curing period irrespective of the percentage of addition of polypropylene fiber in rice husk ash-lime stabilized expansive soil.

REFERENCES

- [1] Ling I, Leshchinsky D, Tatsuoka F. Reinforced soil engineering: advances in research and practice. Marcel Dekker Inc.; 2003.
- [2] Jones M. Mechanics of composite materials. 2nd ed. Taylor and Francis; 1999.
- [3] Kazemian S, Huat K, Prasad A, Barghchi M. A review of stabilization of soft soils by injection of chemical grouting. Aust J Basic Appl Sci 2010;4:5862–8.
- [4] Abtahi M, Allaie H, Hejazi M. An investigative study on chemical soil stabilization. In: 8th Int Cong Civ Eng, Shiraz, Iran; 2009.
- [5] Abtahi M, Sheikhzadeh M, Hejazi M, Hassani Y. Compressive behavior of composite soils reinforced with recycled waste tire cords and polypropylene fibers. In: 1st Int and 7th Nat Conf Text Eng, Rasht, Iran; 2009.
- [6] Ola A. Stabilization of lateritic soils by extensible fiber reinforcement. Eng Geol 1989;26:125–40.
- [7] Rowell M, Han S, Rowell S. Characterization and factors effecting fiber properties. Nat Polym Agr Compos 2000;115–34.
- [8] Babu S, Vasudevan K. Strength and stiffness response of coir fiber-reinforced tropical soil. J Mater Civil Eng ASCE 2008;20:571–7.
- [9] Subaida A, Chandrakaran E, Sankar N. Laboratory performance of unpaved roads reinforced with woven coir. Geotext Geomembr 2009;27:204–10.