*Grenze International Journal of Engineering and Technology, July 2015*

# Change in Shrinkage Characteristics of Fiber Amended Clay Liner Material

[1]Radhika V and [2]Niranjana K
[1]PG Scholar, Thejus Engineering College,Vellarakkad Thrissur
[2]Assistant Professor,Department of Civil Engineering, Thejus Engineering College,Vellarakkad Thrissur

***Abstract*—The change in shrinkage characteristics which is an abnormal behavior of clayey soils is the subject of investigation. The focus is on the impact of short random fiber inclusion on shrinkage characteristics of CH soil which is used as the clay liner material. To examine the possible improvements in the soil characteristics, soils were reinforced with 0.2, 0.4, 0.6 and 0.8 percent fibers as dry weight of soil with 10, 15, 20 and 25mm lengths. Results indicated that shrinkage limit showed an increase, whereas shrinkage index, shrinkage ratio and volumetric shrinkage decrease with increase in fiber content and length.**

***Index Terms*— Clay Liner, Nylon Fiber, Shrinkage limit, Shrinkage Index, Shrinkage ratio, Volumetric shrinkage.**

## I. INTRODUCTION

Wastes are increasing day by day and the method for storage or disposal is in great demand. The most frequently adopted disposal option for solid waste is landfill. For construction of environmental barriers low permeability clays are commonly used. The hydraulic properties of soil can be affected by the formation of shrinkage cracks which will reduce the efficiency of the barrier system as a barrier. Cracks will increase the hydraulic conductivity of the system and it will lead to leakage of leachate or gas to the surrounding soil. Mainly cracks on liner materials occurs due to low tensile strength of the soil. So by amending the soil with a material having high tensile strength can give a solution to this problem.

Lime, cement and sand have been the most common additives used for potential crack reduction. Effects of above additives have been investigated to study the hydraulic conductivity and volumetric shrinkage of clayey soils and it has been reported that soil shrinkage reduced and its hydraulic conductivity increased in certain cases. The soil plasticity was also found to be decreasing, thus decreasing the potential of cracking due to shear forces. Due to the shortcomings of the common materials, in recent years, synthetic fibers have been used for reinforcing the clay liner to improve its strength and performance.

## II. LITERATURE REVIEW

There is some potential for use of some fibrillated fibres with clays. The fibres are effective in reducing the desiccation cracking that occurs in clays subjected to drying. However, when subjected to wet/ dry cycles, the effectiveness of the fibres is not as evident. The inclusion of fibres also increased the tensile strength of the clay and provided a ductile behavior that was not present in the specimens without fibres. It was demonstrated that the usefulness of the fibrillated fibre might be improved if it could interact more effectively with clays that are subjected to negligible over burden pressure, such as through the use of grid

*Grenze ID: 01.GIJET.1.2.510*

like screen fibres.[9] From a series of shrinkage test on a block sample of Kaolin clayey soil it was found that Kaolin clay experiences shrinkage in all directions. Shrinkage of the clay layer was followed by cracking due to desiccation. Using fiber cause huge decrease in crack intensity factor and increasing in fiber content directly decrease the linear shrinkage.[1] Samples consisting of 75% kaolinite and 25% montmorillonite were reinforced with 1, 2, 4 and 8 percent fibers as dry weight of soil with 5, 10 and 15mm lengths. Results indicated that consolidation settlements and swelling of fiber reinforced samples reduced substantially whereas hydraulic conductivities increased slightly by increasing fiber content and length. Shrinkage limits also showed an increase with increasing fiber content and length. This meant that samples experienced much less volumetric changes due to desiccation, and the extent of crack formation was significantly reduced.

## III. RESEARCH MATERIAL

### *A. Soil Type*

According to Environmental Protection Agency norms the usually adopted clay liner materials are CH soil, CL soil and SC soil and maximum hydraulic conductivity should be $1x10^{-9}$ m/sec. The soil used for this project was a highly plastic clay (CH) with a liquid limit of 58 and a plastic limit of 30. The grain size distribution was 17.9% gravel, 15.4% sand and 66.7% fines. Atterberg limits (IS:2720(Part 5, Part 6)-1985) and specific gravity (IS:2720(Part 3)-1973) tests were also carried out on representative samples. The soil had a liquid limit of 58 (%), plastic limit of 30(%), plasticity index of 28(%), shrinkage limit of 15.55(%) and specific gravity of 2.50. The hydraulic conductivity was $7.39x10^{-10}$m/sec. The index properties of CH soil are shown in Table I.

### *B. Fiber Type*

Nylon fiber is selected for amending with the soil. This is one of the most commonly used synthetic material mainly because of its low cost and the ease with which it mixes with soils. It has a relatively high melting point, low thermal and electrical conductivity and high ignition point. It is also hydrophobic and chemically inert material which does not absorb or react with soil moisture or leachate. Nylon fibers having 10mm, 15mm, 20mm and 25mm lengths and contents of 0.2%, 0.4%, 0.6% and 0.8% by dry weight of soil were adopted in this research. The properties of Nylon Fiber is shown in Table II.

TABLE I. INDEX PROPERTIES OF CH SOIL

| Sl.No | Index properties of CH soil | |
|---|---|---|
| 1 | Specific Gravity | 2.50 |
| 2 | Liquid Limit (%) | 58 |
| 3 | Plastic Limit (%) | 30 |
| 4 | Plasticity Index (%) | 28 |
| 5 | Shrinkage Limit (%) | 15.55 |
| 6 | Free Swell Index(%) | 50 |
| Sl.No | Index properties of CH soil Sl.No | |
| 7 | Grain Size Distribution | |
| | Percentage Gravel (%) | 17.9 |
| | Percentage Sand (%) | 15.4 |
| | Percentage Fines (%) | 66.7 |

TABLE II. PROPERTIES OF NYLON FIBER

| Sl. No | Properties of Nylon Fiber | |
|---|---|---|
| 1 | Diameter | $0.78 \times 10^{-3}$ m |
| 2 | Water Absorption Capacity | 8.63 % |

## IV. Experimental Program

### *A. Shrinkage Limits*

The test for shrinkage limit of soil samples amended with fibers was done as in the case of un amended soil samples. Effects of random fiber inclusion on Shrinkage characteristics of soil samples were evaluated as function of fiber length and content and shown in Figures 1, 2 and 3. Prior to the fiber inclusion, shrinkage limit of unreinforced soil sample was determined. This is also shown in the above figures to be used for a comparison with those from different fibrous samples. It can be observed from Figures 1, 2 and 3 that at increasing the fiber contents i.e., 0.2%, 0.4%, 0.6% and 0.8% resulted in increasing shrinkage limit of the samples. Maximum and minimum shrinkage limit values of 15.55% and 28.86% were respectively measured for the unreinforced sample and the sample reinforced by 0.8% fibers having 25mm length. Also the other shrinkage characteristics like shrinkage index, shrinkage ratio and volumetric shrinkage were found out and their change in values were observed.

## V. Test Results

### *A. Shrinkage Limits*

Variations of the shrinkage limits as function of fiber content and length are shown in Fig.1. which shows that increasing fiber contents and lengths resulted in increasing the shrinkage limit of the samples. The shrinkage limit determined for the unreinforced sample was 15.55%. This was increased to 28.86% for the sample reinforced with 0.8% fibers having 25mm length. This is because samples reinforced with random inclusion of fibers experienced less volumetric changes due to desiccation. Increase in the shrinkage limits means that longer fibers having greater surface contacts with the soil have shown greater resistance to volume change on desiccation. It can be said that random fiber inclusion improved the soil tensile strength very effectively, thus resisting shrinkage on desiccation.

### *B. Shrinkage Index Values*

The shrinkage index values showed a decrease in value as the fiber content and length of fiber increased. For unreinforced soil the value was 14.55%. The minimum value was obtained in 25mm length and 0.8% fiber content. The minimum value reported was 1.14%. The variation of shrinkage index values are shown in Fig.2.

### *C. Shrinkage Ratio Values*

The shrinkage ratio values also showed a decrease in value as the length and fiber content increases. For unreinforced soil the value was 1.66. The minimum value was obtained in 25mm length and 0.8% fiber content and it was reported as 1.45. The variation in their values are shown in Fig.3.

### *D. Volumetric Shrinkage Values*

The volumetric shrinkage values decreased as the fiber content and length of fiber increased. For unreinforced soil the value of volumetric shrinkage was 69.95%. The minimum value was obtained in 25mm length and 0.8% fiber content and it was 60.89%. The variation is shown in Fig.4.

TABLE.III. SHRINKAGE CHARACTERISTICS OF CH SOIL

| Sl. No | Shrinkage Characteristics | |
|---|---|---|
| 1 | Shrinkage Limit | 15.55% |
| 2 | Shrinkage Index | 14.55% |
| 3 | Shrinkage Ratio | 1.66 |
| 4 | Volumetric Shrinkage | 69.95% |

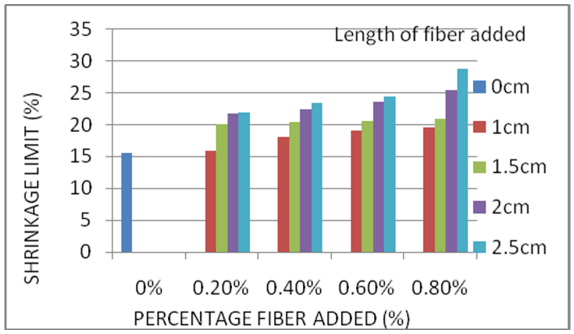


Figure 1.Shrinkage Limits of fiber amended CH soil

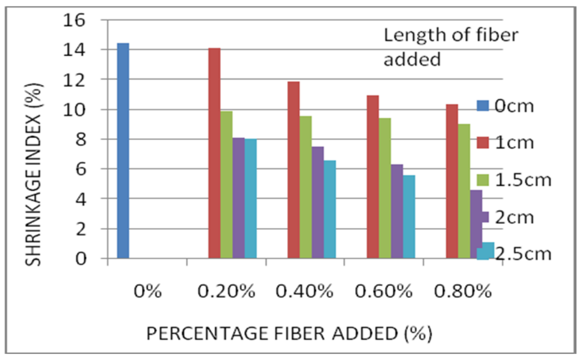


Figure 2.Shrinkage Index values of fiber amended CH soil

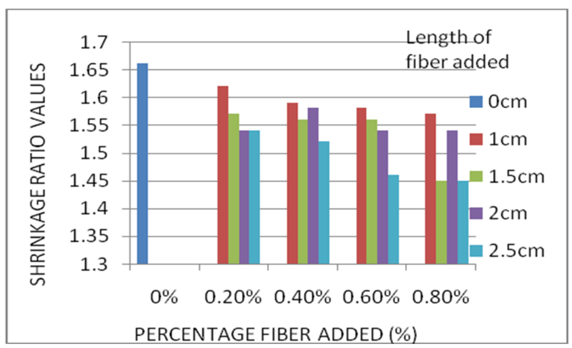


Figure 3.Shrinkage Ratio values of fiber amended CH soil

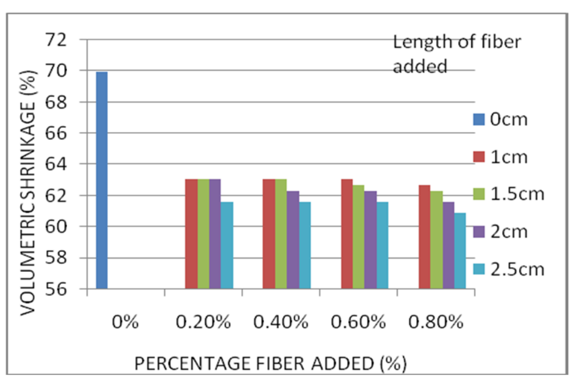


Figure 4.Volumetric shrinkage values of fiber amended CH soil

## VI. CONCLUSIONS

In the current study, the inclusion of randomly distributed Nylon fibers as reinforcing material affected the shrinkage characteristics of the CH soil investigated. By analyzing the experimental results, the following conclusions were made:

- Preliminary investigations showed that there is a maximum fiber content and length that can be used because of workability problems making uniform mixing of fibers with soil very difficult. In this investigation the maximum fiber content and length determined were 0.8% and 25mm respectively.
- Shrinkage limit of the CH soil reinforced with fibers was significantly increased as a result of increasing the fiber content and length.
- Shrinkage Index values were also decreased as the length and percentage of fiber increased.
- Shrinkage Ratio of soil also decreased as increasing length and percentage of fiber.
- Fiber reinforcement significantly reduced volumetric shrinkage of CH soil.

The over-all effects of random fiber inclusion on clays observed, suggests potential applications of fiber reinforced soils in shallow foundations, embankments over soft soils, liners, covers and other earthworks that may suffer excess deformations.

## REFERENCES


[1] Chegenizadeh,A., and Nikraz,H., (2011), "Investigation on shrinkage behaviour of Kaolin clay",*Unsaturated Soils: Theory and Practice*,663-666

[2] IS: 2720 (Part XL) 1977, "Determination of Free Swell Index of Soils"

[3] IS: 2720 (Part IV) 1985, "Grain Size Analysis"

[4] IS: 2720 (Part V) 1985, "Determination of Liquid and Plastic Limit"

[5] IS: 2720 (Part VI) 1972, "Determination of Shrinkage Factors"

[6] IS: 2720 (Part II) 1173, "Determination of Water Content"

[7] Southen,J,M., and Rowe.R.K (2005)"Laboratory Investigation of Geosynthetic Clay Liner Desiccation in a Composite Liner Subjected to Thermal Gradients", *Journal of Geotechnical and Geoenvironmental Engineering ASCE*, 131(7), 925-935.

[8] Zhou,Y., and Rowe,R,K., (2005) "Modeling of Clay Liner Desiccation", *International Journal of Geomechanics ASCE*, 5(1), 1-9

[9] Ziegler,S., et.al (1998), "Effect of Short Polymeric Fibers on Crack Development in Clays", *Soils and Foundations*,38(1), 247-253