ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 23, April 2016

EFFECT OF BENTONITE ON HYDRAULIC CONDUCTIVITY OF COMPACTED SOIL LINERS

Kavya M.P., P.G student, Thejus Engineering College, Vellarakkad, kavyaprabhakaran2@gmail.com
Anjana T.R., Assistant Professor, Thejus Engineering College, Vellarakkad, anjanatr@gmail.com

ABSTRACT: This paper investigates the potential of amended soil barrier by mixing locally available soil with sodium bentonite for containment of municipal solid waste. The percentage of bentonite varied from 3, 6, 9, 12 and 15 % by weight. The variation in properties such as atterberg's limit, dry density, optimum moisture content, unconfined compressive strength and hydraulic conductivity of soil and soil bentonite mixture were found. With increase in percentage of bentonite, hydraulic conductivity is reduced and unconfined compressive strength increased. Among these five combination at 12% combination fulfill the criteria of liner and it was found that the optimum percentage.

INTRODUCTION

A landfill is property set aside for the purpose of safe disposal of solid waste either municipal or hazardous. And these landfill causes pollution to environment. To overcome these issues a liner is laid down under the landfill site intended to be a low a permeable barrier, which retards the migration of leachate, into underlying aquifers or nearby rivers causing spoliation of the local water. Compacted clayey soils are used as liners in landfill but unavailability of suitable clay force to use alternative liners. Compacted natural soils, compacted bentonite enhanced soil mixture, geosythetic clay liner can be use as liner material.

Compacted natural soils are used as hydraulic barriers in waste containment facilities. The principal factor affecting the performance of hydraulic barriers is their hydraulic conductivity. The hydraulic conductivity of compacted clay soils is in turn influenced by soil composition such as Atterberg limits and particle size distribution and compaction variables. When soil is compacted at wet of line of optimum soil that are more plastic and have a greater quantity of fines yield lower hydraulic conductivity. Typically, hydraulic conductivity value must be less than or equal to 1×10^{-9} m/ s for soil liners and covers used to contain hazardous waste, industrial waste, and municipal solid waste . Successful design and construction of soil liners and covers involves many factors e.g., selection of materials, assessment of chemical compatibility, determination of construction methodology, analysis of slope stability and bearing capacity, evaluation of settlement, consideration of environmental factors such as desiccation, and development and execution of a construction quality assurance plan. The objectives of this study are to evaluate the suitability of locally available soil as hydraulic barrier and to make a soil bentonite mixture which satisfies all the criteria of landfill liner.

MATERIALS AND METHODS

Soil

Compacted clay has traditionally been used as a lining material in municipal solid waste landfills. However, natural clays may not always provide good contaminant sorption properties.

One alternative material that is natural soil from Thrissur district was used for present study. The particle size distribution curve of soil is presented in the Fig.1. The geotechnical properties of these soils are determined according to bureau of Indian Standards and reported in Table 1.

Table 1: Properties of soil

Soil Property	Values
Specific gravity	2.41
Liquid limit (%)	34
Plastic limit (%)	13
Plasticity index (%)	21
Shrinkage limit (%)	18
IS classification	SC
Differential free swell (%)	5
Max. dry density (kN/m^3)	18.05
Optimum moisture content (%)	17.3
Unconfined compressive strength (kN/m^2)	111.8
Permeability (cm/sec)	1.31×10^{-6}
pH	5.3

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 23, April 2016

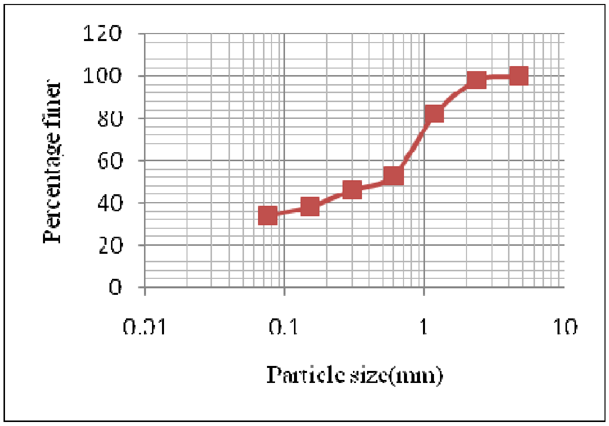

Fig. 1 Particle size distribution curve of soil

Bentonite

Bentonite is a highly plastic and swelling clay containing small quantities of inert mineral grains with relatively high specic and high net negative charge. The commonly used two type of commercially available bentonite are calcium and sodium bentonite. The bentonite used in this study is sodium bentonite. The properties of bentonite are listed in the Table 2.

Table 2: Properties of Bentonite

Property	Value
Specific gravity	2.6
Liquid limit (%)	347
Plastic limit (%)	61
Plasticity index (%)	286
Maximum dry density(kN/m^3)	10.01
Optimum moisture content (%)	52
Differential free swell (%)	180

Preparation of Sample

The soil sample used in this study was air dried and passing through 4.75mm sieve.For samples containing bentonite, the relevant quantities of dry soil and bentonite were mixed. The different percentage of bentonite used in this study are 0, 3, 6, 9, 12 and 15%.

LABORATORY ANALYSIS

The samples were analyzed in the laboratory using standard laboratory protocols. For the analysis of geotechnical parameters IS: 2720 was used.

Compaction Tests

The compactive effort used in study is Standard Proctor test to determine the optimum moisture content and maximum dry density of soil with different percentage of bentonites such as 0, 3, 6, 9, 12 and 15% by weight

Unconfined Compressive Strength Tests

The unconfined compression test is widely used as a quick, economical way of obtaining the approximate compressive strength of cohesive soils. The unconfined compressive strength values of samples were determined according to IS: 2720(part 10)-1973. The soil samples were prepared using the OMCs derived from moisture density relationship determined for the natural soil and soil replaced with various proportions of bentonite.

Hydraulic Conductivity

One dimensional consolidation tests were conducted to determine the hydraulic conductivity of the mixtures at their optimum moisture contents according to IS : 2720 (Part 15) – 1986 test method using a fixed-ring consolidometer apparatus having a ring diameter and height of 6 and 2.0 cm, respectively.

RESULTS AND DISCUSSION

Effects of Atterberg Limits with Bentonite Content

The soil-bentonite mixtures shows increases in liquid limt (LL), plastic limit (PL) and plasticity index (PI) with thie stepped introduction of bentonite into the natural soil .Fig. 2 shows the variation in Atterberg's limit with increase in percentage of bentonite content.

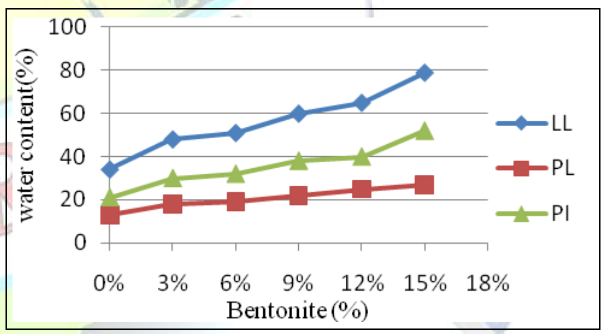

Fig. 2 Variation of Atterberg limits with bentonite content

Effects of Optimum Moisture Content with Bentonite Content

When bentonite was added into the soil some significant change in the compaction characteristic was observed. The fig.3 shows the variation of OMC with the increase in percentage of bentonite.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 23, April 2016

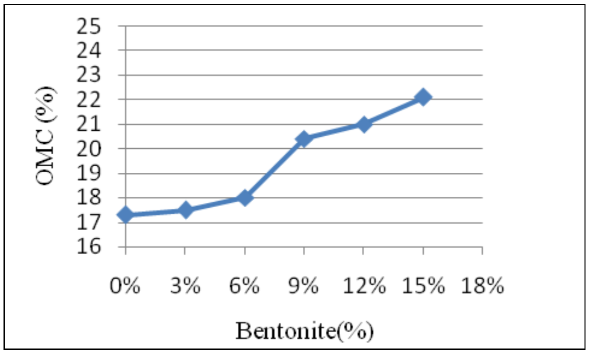

Fig. 3 Variation of OMC with Different Percentage of Bentonite

Effects of Dry Density with Bentonite Content

Variation of dry density with different percentage of bentonite is illustrated by data in Fig. 4. The dry density decrease with increase in bentonite percentage

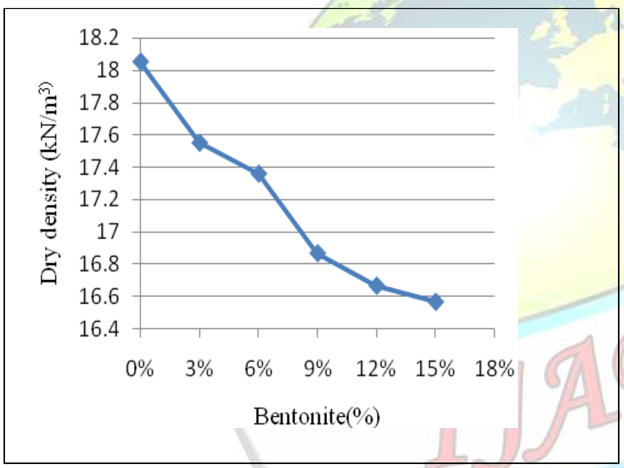

Fig. 4 Variation of dry density with different percentage of bentonite

Effect of Unconfined Compression Strength with Bentonite Content

The variation of unconfined compressive strength (UCS) at various OMC with increase in bentonite content is shown in Fig. 5. UCS of compacted samples generally increased with higher bentonite contents.

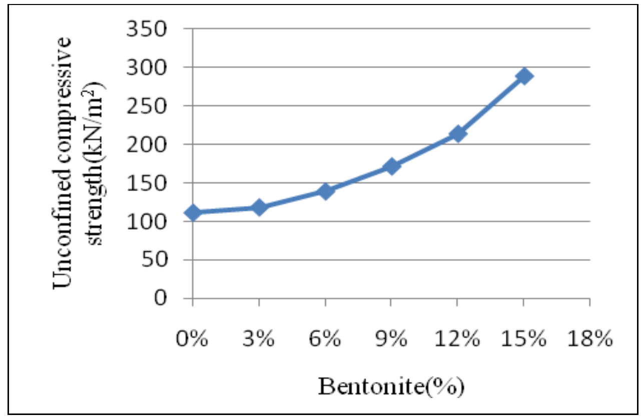

Fig. 5 Variation of UCS with different percentage of bentonite

Effect of hydraulic conductivity with bentonite content

Variation of hydraulic conductivity with various bentonite is illustrated in Fig. 6. The figure indicates that hydraulic conductivity decrease with increase in bentonite content. Soil mixture with the highest bentonite content of 15% recorded an average hydraulic conductivity of $9.07x10^{-11}$compared to $1.31x10^{-06}$for natural soil.

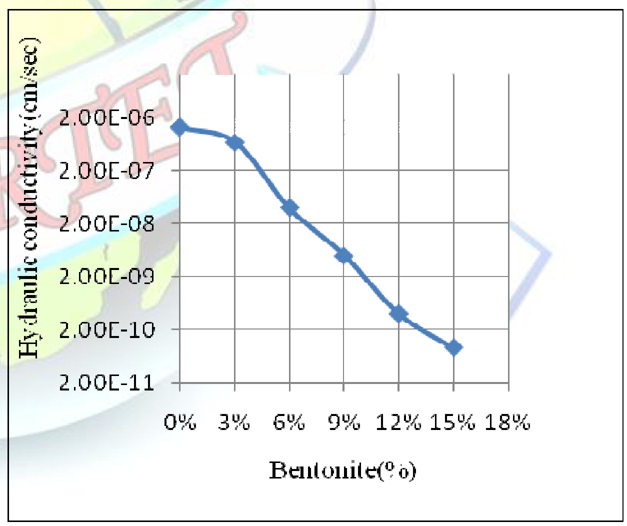

Fig. 6 Variation of hydraulic conductivity with different percentage of bentonite

5. CONCLUSIONS

This paper has described index and engineering properties of lateritic soil-bentonite mixtures for their suitability as barrier material in waste containment was carried out. Analysis of data obtained from the study indicate that when the bentonite content varied from 0 to 15%,

- Liquid limit, plastic limit and plasticity index vary linearly with increase in bentonite content.

- The maximum dry density of enhanced soil decreased from 18.05 to 16.57 kN/m^3 and optimum moisture content increased from 17.13 to 22.1%
- The unconfined compressive strength varied from 111.83 to 288.4 kN/m^2
- The hydraulic conductivity of the optimum soil-bentonite mixture varied from 1.31x 10-^{6} to 9.07 x10^{-11} cm/sec

REFERENCES

1. Kolawole J. O., et al (2006), "Design of Compacted Lateritic Soil Liners and Covers". *Journal of geotechnical and geoenvironmental engineering*., 132(2),203-213
2. Tanit, C., (2008), "Potential use of lateritic and marine clay soils as landfill liners to retain heavy metals." Elsevier Science ,117-127
3. Adrian, O. E., (2012), "Hydraulic conductivity of compacted lateritic soil treated with bagasse ash.", research papper
4. S.Y.Umar., et al. (2015), "Hydraulic Conductivity of Compacted Lateritic Soil Partially Replaced with Metakaolin", *Journal of Environment and Earth Science*, Vol.5, No.4
5. Thomas, L. S. and David, E. D.,(1993), "Effect of gravel on hydraulic conductivity of compacted soil liners",*Journal of geotechnical and geoenvirnmental engineering*., 119(1), 54-68
6. Abidin, K. and Seda, D., (2003), "Utilization of bentonite-embedded zeolite as clay liner", Elsevier Science ,83-91
7. Gleson, M., Daniel, D., and Eykholt, G. (1997). "Calcium and Sodium Bentonite for Hydraulic Containment Applications."*Journal of geotechnical and geoenvironmental engineering*., 123(5),438-445
8. KolawoleJ. O., et al (2005), "Hydraulic conductivity of compacted lateritic soil". *Journal of geotechnical and geoenvironmental engineering*., (131),1034-1041
9. Yucel G., et al. (2008), "Sepiolite as an Alternative Liner Material in Municipal Solid Waste Landfills", *Journal of geotechnical and geoenvirnmental engineering*., 134(8), 1166-1180
10. Dhanya.s., et al. (2010), "Study on Amended Soil Liner Using Lateritic Soil", Indian Geotechnical Conference, December 16-18
11. L.Jae-Myung, and Charles, S.D., (2005), "Impact of bentonite quality on hydraulic conductivity of geosynthetic clay liners", *journal of geotechnical and geoenvirnmental engineering.*, 113(1), 64-77
12. C. F. A. Akayuli., et al. (2013), "Geotechnical Evaluation of a Ghanaian Black Cotton Soil for use as Clay Liner in Tailings Dam Construction", *Ghana Mining Journal,* pp. 21 – 26