Permeability Study on Prefabricated Geosynthetic Clay Liners

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Abstract— Landfill site is a site for the disposal of waste materials It is the most common method of organized waste disposal and remain so in many places around the world The three most important problems with landfill are toxins, leachate and greenhouse gases. Geosynthetic clay liners (GCLs) represent a relatively new technology currently gaining acceptance as a barrier system in municipal solid waste landfill applications. Alternative technologies are allowed, however GCL technology offers some unique advantages over conventional bottom liners and covers. Geosynthetic clay liners (GCLs) have gained widespread popularity as a substitute for compacted clay liners in cover systems and composite bottom liners. They are being investigated intensively, especially in regard to their permeability characteristics.

Key words: Geosynthetic Clay Liner, Permeability, Variable Head

I. Introduction

Over the past decade, design engineers and environmental agencies have shown a growing interest in the use of geosynthetic clay liners (GCLs) as an alternative to compacted clays in cover systems. It is used as bottom lining of waste containment because they often have very low hydraulic conductivity and relatively low cost. Apart from environmental application, it is used as a component of liner or cover systems in solid waste containment. GCLs are also used as environmental protection barriers in transportation facilities roads and railways and geotechnical applications such as minimizing pollution of subsurface strata from accidental spills and seepage of chemicals from road accidents. GCLs are also used as secondary liners for underground storage tanks at fuel stations for groundwater protection, and used as single liners for canals, ponds or surface impoundments. GCLs, offer a volume advantage over Compacted Clay Liners. They are more capable of withstanding freeze-thaw and wet-dry cycles and offer substantial construction cost savings in reduced on-site and a thicker installation. Liner systems are usually designed to be reliable and robust, remaining active for years.

Waste is a byproduct of various human activities which lack any value and use. Safe and effective disposal of waste have always been a concern of the society. Various methods of disposing these wastes include land filling and incineration. of solid waste on the environment. In modern landfills, the waste is contained by a liner system and cover system on bottom and top respectively. The primary purpose of the liner system is to isolate the landfill contents from the environment and, therefore, to protect the soil and ground water from pollution originating from the landfill. Liner or cover systems consist of different layers such as vegetative layer, drainage layer, barrier layer, leachate detection and collection layers. Of this, barrier layer prevents the leakage of leachate. It was traditionally constructed by compacting locally available clay in layers called compacted clay liner (CCL). Important of landfill throughout world increases and need of engineered waste dumps is necessary.

The project aims to study the permeability characteristics of geosynthetic clay liner. As now days geosynthetic clay liners is being used as a protective barrier in the land fill sites

II. Objectives

- To evaluvate the percentage of bentonite blended with clay sample for the preparation of GCL.
- To study the permeability characteristics of prefabricated geosynthetic clay liner

III. Materials

The following are the materials used for this study;
1. Clay
2. Sodium bentonite
3. Geotextile
4. Geomembrane

1) Clay

Experiments were carried on locally available clay from Thonnakkal, Kerala

Fig. 1: Clay

The properties of sand are shown in the table below:

PROPERTY	VALUE
Liquid limit	66%
Plastic limit	40%
Specific gravity	2.68
Percentage of clay	66%
Percentage of silt	34%
Unconfined Compressive Strength	0.284 Kg/cm^2
Dry density	1.63gm/cc
OMC	24%
Permeability	3.13×10^{-4}cm/s

Table 1: Properties of Clay

2) Sodium bentonite

Bentonite is a clay mineral with expansive characteristics and low permeability, where montmorillonite is the chief mineral. Sodium bentonite from Ahmadabad, Gujarat has been used in this study

Fig. 2: Sodium bentonite

The properties of Sodium bentonite are shown in table below:

PROPERTY	VALUE
Liquid limit	280%
Plastic limit	43%
Specific gravity	2.6

Table 2: Properties of Sodium bentonite

3) Geotextiles

Geotextiles are widely used in various engineering projects to perform one or more of their recognized functions. The principal functions of geotextiles are filtration, drainage, separation, and erosion control. In this study woven geotextile of polyester with GSM 76.6 has been used

Fig. 3: Geotextile

The properties of geotextile are shown in the table below:

PROPERTY	VALUE
Mass per unit area	76.6g/m^2
Nominal thickness	1.03mm
Cone drop penetration	8mm
Pullout resistance	235N

Table 3: Properties of Geotextile

4) Geomembrane

Geomembrane for water proof protection and material made of polyethylene is used it was very effective and act as a durable cover for the clay liners. It used to prevent damages to the clay liner during its deployment and the placement of overlying materials. Due to the small opening size of the geomembrane it prevents the water to take away the clay layer from the geosynthetic clay liner

Fig. 4: Geomembrane

The properties of geomembrane are shown in the table below:

PROPERTY	VALUE
Mass per unit area	94.5g/m^2
Nominal thickness	.56mm
Cone drop penetration	32mm
Pullout resistance	410N

Table 4: Properties of Geomembrane

IV. METHODOLOGY

The required hydraulic conductivity could not be achieved from clayey soil alone hence clay is blended with 7%, 9%, and 11% bentonite . The maximum dry density optimum moisture content of the clay-bentonite samples has been determined by using standard proctor test. While designing a landfill liner, the strength and deformation behavior of the material is evaluated by testing the sample compacted to maximum dry density .After determining the percentage of bentonite to be blended with the clay. The mixture has to be properly sandwiched between two geotextile and geomembrane layers

PERCENTAGE OF BENTONITE ADDED WITH CLAY	DRY DENSITY (g/cc)	OPTIMUM MOISTURE CONTENT (%)
7%	1.6	24.5
9%	1.582	25.15
11%	1.57	23.37

Table 5: Dry density and optimum moisture content of clay betonite sample

The permeability of the clay bentonite sample was determined permeability within the range of 10^{-6} to 10^{-7} for clay liners was obtained in7%, 9% and 11% of clay bentonite samples.

Parameters	Permeability Value (Cm/S)
Clay	3.13x10^{-5}
Clay + 7% bentonite	4.35 x10^{-6}
Clay + 9% bentonite	2.69 x10^{-6}
Clay + 11% bentonite	1.72 x10^{-6}

Table 6: Permeability of clay bentonite samples

The clay sample with 9% bentonite has been selected for the preparation of GCL. Different samples of thickness 1.5, 2 and 2.5 cm thickness with diameter 9 cm was prepared

Fig. 5: Sample of thickness 1.5,2 and 2.5cm

Experiments were conducted by using variable head permeability method. This method is used to determine the permeability of fine grain soils such as silts and clays. Stand pipe is connected to the mould. The height of the mould was 55cm.Samples was placed above the porous circular disk which is 10 cm from the bottom. River sand and gravel were used as drainage layer above the sample. By varying the length of the drainage layer above the sample a load of 10N, 20N, 30N, 40N and 50N was applied above the sample

Fig. 6: Permeability test of samples

Permeability results of different smaple thickness 1.5, 2 and 2.5cm with varying load has been tabulated in the table 7

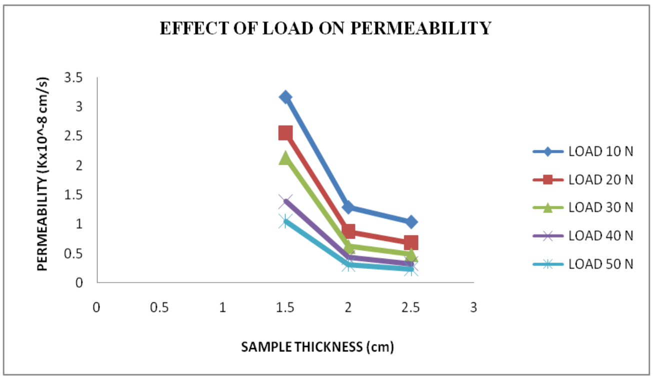
SAMPLE THICKNESS (cm)	LOAD 10N	LOAD 20N	LOAD 30N	LOAD 40N	LOAD 50N
	PERMEABILITY x 10^{-8}cm/s				
1.5	3.17	2.55	2.13	1.39	1.05
2	1.29	.872	.623	.434	.313
2.5	1.04	.682	.478	.326	.234

Table 7: Permeability of the GCL samples

V. RESULT AND DISCUSSION

Based on the test results, it was observed that the permeability of the GCL sample depends on the Effect of load and thickness of the clay layer of GCL sample

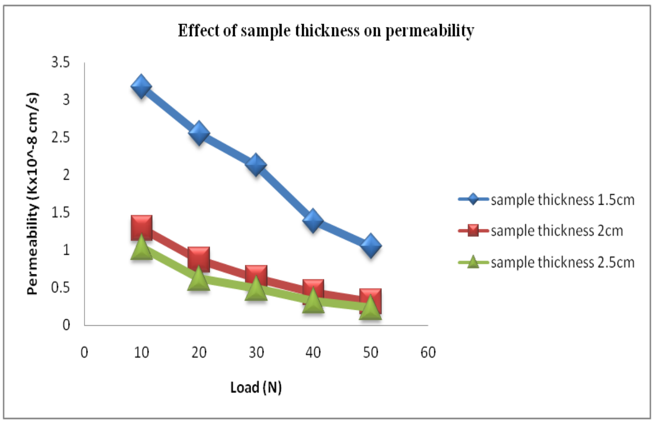
A. *Effect of load on permeability*



Graph 1: Permeability – Load curve

From this permeability result it has been observed that as the load increases the permeability decreases this is because as the clay layer is compressed by the fluid pressure they get compacted and decreases the thickness of the clay layer and decreases the porosity and hence permeability decreases. This can be clearly understood from the graph 1

B. *Effect of sample thickness on permeability*



Graph 2: Permeability – Sample thickness curve

The percentage reduction in the permeability of the samples from 1.5 to 2 cm shows a large percentage reduction in the range 60 to 70%. The percentage reduction in the permeability of samples from 2 to 2.5 cm shows a small percentage reduction in the range 20 to 25%. It is observed that permeability reduction for the sample thickness 1.5cm to 2cm shows a large variation in the permeability and that for the sample 2cm to 2.5cm shows a small variation in the permeability change

VI. CONCLUSION

- Permeability of the sample decreases with increase in bentonite percentage
- Permeability results for the GCL samples were obtained within the range 10^{-8} to 10^{-12}cm/s
- From load permeability graph all the curves showing similar curve as permeability decrease with increase in load
- Permeability of GCL depends on compressibility of clay liner
- For sample 1.5 to 2 cm the percentage reduction in the permeability for a load of 30N was 67.75%
- Similarly for the sample 2 to 2.5cm the percentage reduction in the permeability was 23.21%
- When comparing the percentage reduction in the permeability of these samples there is only a small reduction in the permeability for sample 2 to 2.5cm
- From economical point of view we can adopt a sample of 2 cm thickness as optimum and considered for the preparation of GCL
- Geosynthetic clay liners with this specification can be used as a substitute to compacted clay liners in municipal solid waste land fill

REFERENCES

[1] Van Daniel, D.E Shan, and Anderson J.D. Effects of partial wetting on the performance of the bentonite component of a geosynthetic clay liner. Geosynthetics '93, IFAI, St. Paul, MN, Vol.3, pp.1482-1496,1993

[2] Impe W.F and Van Den Broeck M. Hydraulic conductivity of a geosynthetic clay liner under various conditions. Proceedings of the Second International

Congress on Environmental Geotechniques Vol. 1, Osaka, Japan,1996
[3] Geosynthetic Clay Liners: A Technical and Economic Solution by Don Stewart, P.Eng., Terrafix Geosynthetics Inc.
[4] Shackelford C.D, BensonC.H, Katsumi.T, Edil T.B and Lin L. Evaluating the hydraulic conductivity of GCLs permeated with non-standard liquids. Geotextiles and Geomembranes 18 (2000) 133-161, 1999
[5] Heerten G,Vonmaubeuge K.P, Manufacturing of Geosynthetic Clay Liners. Naue Fasertechnik GmbH & Co. KG. Internal Report, 1992
[6] Emy poulose, A.R Ajitha and Y.Sheela Enangeline. Permeability Study on Different Prefabricated Landfill liners Developed Using Coir Geotextile and Polypropylene Felt IJIRSET Vol 3,Issue 5, 2014
[7] Aneesh.E, Anupama.S, Dhanasulthana.C and Vishak T.M. Experimental Studies On Landfill Clay Liners IJSER,Vol 7, Issue 4, 2016
[8] T.P Rimsheena and S. Remya. Effect of Organic and Inorganic fluids on bentonite –sand mixtures as landfill liners, Geotech. J. 36, 289–296,2013
[9] Chereminsinoff P.N and Gigliello K.A. Lechate from Hazardous waste, J. Environ. Eng. Sci, 135–156,1983\

