SHEAR STRENGTH AND PERMEABILITY OF BENTONITE BLENDED CLAY LINER

[1]Indrawati Kumari
Department of Civil Engineering,
Madan Mohan Malviya University of Technology, Gorakhpur, India
Email: inkugkp2008@gmail.com

[2]Dr.S.M Ali Jawaid
Department of Civil Engineering,
Madan Mohan Malviya University of Technology, Gorakhpur, India
Email: smaj@rediffmail.com

Abstract: Compacted natural clays are widely used as liners in the engineering landfills because of their low hydraulic conductivity, high contaminant attenuation and cost effectiveness. Compacted soils are mostly used for liner systems of landfills. It is designed based on required permeability. The required permeability is less than 1×10^{-9} cm/s respectively (EPA 1993). Bentonite has greater influence in altering the geotechnical properties of soil. Keeping this in mind, an attempt was made to blend the local soil with Bentonite in order to achieve permeability in the required range Bentonite blended soil were prepared and compacted mixtures were compacted at maximum dry density and optimum moisture content and its permeability was determined. It was found that 30% is the optimum percentage of Bentonite to be blended with local soil for the landfills liner construction.

Keywords: built clay liner, bentonite blended soil, Hydraulic, Conductivity, shear strength.

INTRODUCTION

A landfill is a large area of land or an excavated site that is specifically designed and built to receive wastes. Today about 56 percent of our country's trash is disposed of in landfills (EPA, 2003). Items such as appliances, newspapers, books, magazines, plastic containers, packaging, food scraps, yard trimmings, and other wastes from residential, commercial, and some industrial sources can be disposed of in municipal solid waste landfills. Municipal solid waste landfills can also accept some types of hazardous waste, such as cleaning products, paint, and chemicals, as well as some industrial wastes from certain businesses. Many states and communities, however, promote the safe collection of these hazardous wastes through local programs. In the past, garbage was collected in open dumps. These uncovered and unlined sites allowed leachate a liquid formed by decomposing waste to soak into the soil and ground water.

Solid wastes are inevitable by products of human activities. One of the major challenges all nations face is the disposal of these solid waste in a safe and environmental friendly manner. Due to increase in population, urbanization, industrialization and change in lifestyle. there has been a radical change in the quantity and characteristics of the solid wastes. Hence solid wastes become more hazardous to environment and demands careful disposal practices. The major problem of solid waste disposal is contamination of ground water and pollution of the surrounding environment. The greatest threat to ground water posed by landfills is leachate.

Leachate consists of water and water soluble compounds present in the refuse that accumulate as water moves through the landfill. This water may be from rainfall or the waste itself. Leachate may migrate from the landfill and contaminate soil and ground water, thus posing the risk to human and environmental health. Hence to safeguard the ground water and surrounding environment from pollutants originating from land filled waste an effective lining and cover system is required.

Modern landfill is highly engineered containment systems designed for the safe and environmental friendly disposal of solid wastes. These facilities basically consist of a bottom liner and a top cover. These components play a vital role in reducing the leachate quantity and the ground water contamination and cover system reduces foul smell and pollution of the surrounding environment hence these are considered as the most critical components of landfill facility. There are different types of liners and covers are in practice However from economic considerations and long term stability against accidental puncture, composite clay liners and covers are most preferred. Composite clay liner is made up of a geomembrane overlying a compacted clay layer having hydraulic conductivity not more than 1×10^{-9}cm/sec.

Objective: The objectives of this study are as follows:

1. To study the engineering properties of local soil with an aim to construct a liner.

2. To study the effectiveness of using sodium bentonite or improving the permeability characteristics and shear strength of Local soil.
3. To determine the optimum percentage of bentonite to be mixed with local soil for the construction of compacted soil bentonite liner.

Materials Used

In this study, the following materials were used:

Soil

Soil sample was obtained from the campus of M.M.M University of Technology Gorakhpur. The engineering property of the soil is given in Table 1 respectively.

Table no.1: Geotechnical Properties of soil

S.no.	Properties	Typical value
1.	Specific gravity	2.40
2.	Atterberg limit	Non plastic
3.	Moisture dry density (MDD)	1.77 gm/cc
4.	Optimum moisture contents (OMC) %	14.92%
5.	Permeability cm/sec	2.4×10^{-5}

Table no. 2: Geotechnical Properties of Bentonite

S.no	Parameters	Bentonite
1.	Liquid limit	155
2.	Plastic limit	44
3	Plasticity index	111
4	Optimum moisture contents (OMC)%	26%
5	Maximum dry density (MDD)g/cc	1.43

Mix Preparation

Soil has been mixed with Bentonite in different proportion, thereafter, optimum mix has been found on the basis of Optimum Moisture Content and Permeability test and then to the best mix has been selected on the lowest basis of permeability for clay line. The following proportion of mix was prepared as shown in Table 3.

Table no.3: Geotechnical Properties of Soil mixed with Bentonite

S. No.	Denoted	Mix preparation
1.	M1	Soil + 3% Bentonite
2.	M2	Soil + 6% Bentonite
3.	M3	Soil +9% Bentonite
4.	M4	Soil +12% Bentonite
5.	M5	Soil +15% Bentonite
6.	M6	Soil +18% Bentonite
7.	M7	Soil +22% Bentonite
8.	M8	Soil +26% Bentonite

Results

The OMC, MDD, and Permeability of various Soil and Bentonite mix are given in Table 4.

Table no. 4: variation of OMC, MDD and PERMEABILITY with Bentonite

S. no.	Denoted	Determination of omc %	Determination of MDD (g/cc)	Permeability (cm/s)
1.	M1	13%	1.80	1.8×10^{-6}
2.	M2	13.50%	1.76	7.4×10^{-7}
3.	M3	13.95%	1.71	3.2×10^{-7}
4.	M4	14.2%	1.68	1.5×10^{-7}
5.	M5	14.5%	1.60	7.2×10^{-8}
6.	M6	14.7%	1.54	3.5×10^{-8}
7.	M7	14.95%	1.50	9.2×10^{-9}
8.	M8	15%	1.44	1.0×10^{-9}

The relation between bentonite percentage and OMC as well as MDD as shown in fig 1 & 2 respectively It is evident from Fig 1 & 2 that with addition of bentonite , the optimum moisture content increases and maximum dry density decreases. It is due to fact that since that density of bentonite in less than that the soil, the addition of bentonite leads to the decrease in MDD Abo, because of finess of bentonite , surface area of mix increases and hence OMC increases .

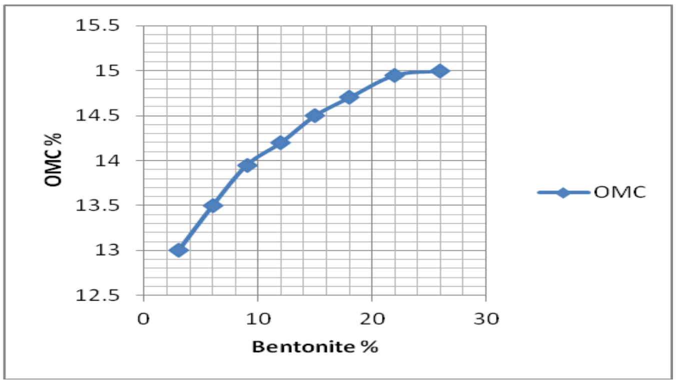

Figure no.1: Percentage of Mix vs. Moisture content %

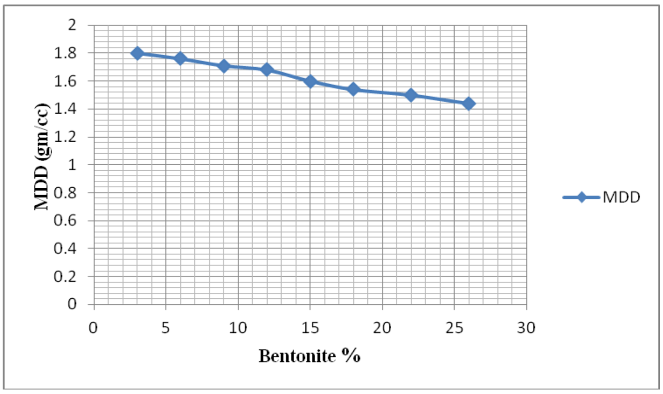

Figure No. 2: Percentage of Mix vs. MDD (g/cc)

The effect of addition of bentonite on the permeability of mix is shown in fig 3. It is found that the hydraulic conductivity of soil bentonite mixtures decreases with increasing bentonite content. Hydraulic conductivity decreased from 1.8×10^{-6}cm/s for the soil without bentonite to 1.0×10^{-9} cm/s for the soil with 26% bentonite. The common regulatory requirement for compacted soil liners states that the hydraulic conductivity should be less than 1×10^{-9}cm/s. For bentonite additions of 26%, the hydraulic conductivity is less than 1.0×10^{-9} cm/s.

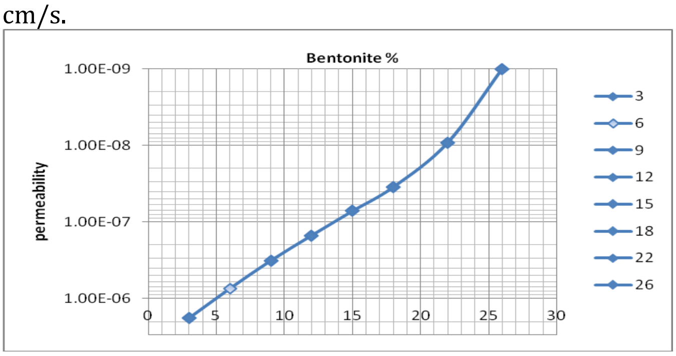

Figure no. 3: Mix % vs. Permeability

Table no. 5: C and ϕ of various soil and Bentonite mix

S.No.	Soil+BFS%	C kN/m²	ϕ⁰
1	3%	.05	33
2	6%	.06	26
3	9%	.08	20
4	12%	.01	16
5	15%	.14	9
6	18%	.17	3

Table 5 represents the direct shear strength of treated soil with different proportions Bentonite. The direct shear device is used to determine failure envelopes for soils. The direct shear strength was developed for measuring the shear capacity of the soil then Bentonite added to soil then values cohesive force increases ϕ angle values were decreases.

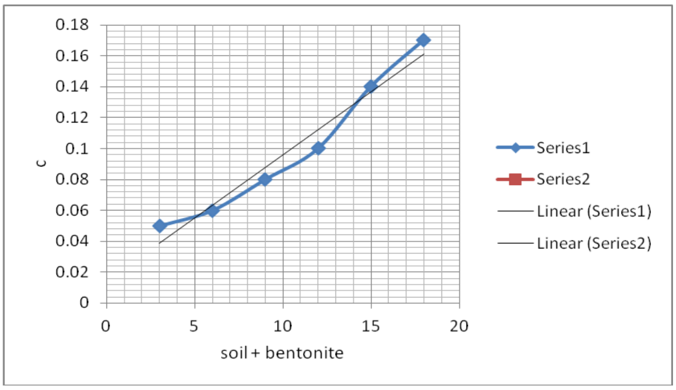

Figure no. 4 Variation of C values with Bentonite%

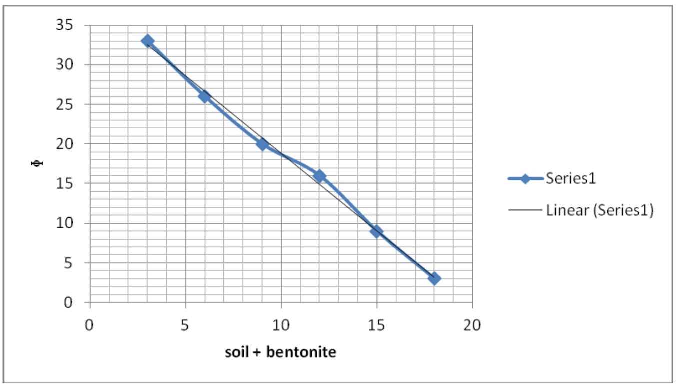

Figure no. 5 Variation of ϕ values with Bentonite %

CONCLUSION

To develop an optimum bentonite-soil mixture, which satisfies the minimum hydraulic conductivity requirement, is mechanically stable and cost effective, an intensive laboratory testing programme was carried out. For laboratory testing, various combinations of bentonite-soil mixtures were prepared in laboratory to assess their engineering parameters. The compaction behavior, hydraulic conductivity of soil bentonite mixtures studied. The following are the main conclusions.

1. It is found that when bentonite content varied from 3 to 26 %, the maximum dry density decreases from 1.80 g/cc to 1.44 g/cc and the corresponding optimum moisture content increases from 13% to 15%.
2. It is found that coefficient of permeability (k) decreases with increase bentonite content. Coefficient of permeability decreased from 1.8×10^{-6}cm/sec to 1.0×10^{-9} cm/sec when bentonite content increased from 3 to 26% and k also decreases with increase bentonite. An optimum 26% bentonite soil mixture satisfies the minimum requirements of permeability.
3. Thus 26 % of bentonite may be mixed with local alluvial soil for the construction of liner for the landfills in this region
4 It was noticed that the cohesion of the soil increased by addition soil.

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