Study on amended landfill liner using bentonite and zeolite mixtures

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Abstract – *Landfill liner system has great importance in preventing the movement of leachate to underground surfaces. The study makes an attempt to improve the locally available dump yard site soil using bentonite and zeolite mixtures. The variation in properties such as permeability (layered form) , dry density, OMC, consistency limits etc were studied. The result of permeability test shows that mix containing 40% dump yard site soil, 35% bentonite and 25% zeolite has the least permeability. Therefore the geotechnical properties make bentonite and zeolite mix an innovative material for liners in landfills.*

Key Words: **landfill liner , leachate ,dump yard site soil , bentonite , zeolite**

1. INTRODUCTION

The generation of municipal solid waste increases with increase in economic growth and rapid urbanization. Open dumping, incineration and land filling are the traditional methods used for waste management. Landfill liners located below the municipal solid waste are the most important part of landfills .The main function of these liners, sometimes referred to as bottom liners, act as a hydraulic barriers to prevent the leaching of inorganic and organic pollutants into groundwater surfaces. The minimum Hydraulic conductivity of liner material used in the landfill should be $1x10^{-7}$ cm/sec [1]. The commonly used liners are CCL, GCL and composite liners. But the usage of high-tech liner system like GCL may become uneconomical due to its import from elsewhere.

1.1 Local soil

In this study dump yard soil was collected from dump yard site at Vadavathoor near Kottayam, Kerala. The properties of local soil are summarized in Table 1.

1.2 Bentonite

Bentonite is an absorbent. It is composed of swelling clay mineral Montmorillonite Bentonite is naturally occurring clay with high swelling capacity, high ion exchange capacity and very low water permeability [2].The properties of bentonite is summarized in Table1.

Fig.1 Bentonite

Table -1: Properties of local soil and bentonite

PROPERTY	MATERIALS	
	LOCAL SOIL	BENTONITE
Specific gravity	2.22	2.4
Liquid limit	46%	464%
Plastic limit	39%	42.5%
% Clay	3	93
% Silt	8	7
% Sand	78	-
Maximum dry density	1.55g/cc	1.07g/cc
Optimum moisture content	18.5%	51.3%
Coefficient of permeability	$6.73x10^{-3}$cm/s	$20.53x10^{-9}$ cm/s
Free swell index	23.07%	1000%
pH	5.4	9.5

1.3 Zeolite

Zeolite is an adsorbent. It is hydrated aluminosilicate minerals made of interlinked tetrahedral of alumina and silica. They have open cage like framework that can trap heavy metals. They are very stable solids that resist kind of environmental condition that challenge many other materials. High temperatures do not bother them because they have very high melting point and they do not burn. The properties of zeolite are summarized in Table 2.

Fig.2 Zeolite

Table -2: Properties of zeolite

PROPERTIES	
Appearance	White Powder
Brightness	82+/-0.5%
Loss of ignition	14%(Max)
Coarse particle on 53Micron IS SIEVE (Max)	0.05%(Max)
pH	8.3
Particles less than 2 micron	68% w/w (Min)
Bulk density	0.8%+-0.1 gm/cc
Moisture	1%(Max)
Melting point	1735 Deg.C
Specific gravity	2.63

2. METHODS

2.1 Consistency limits (IS: 2720(Part 5)-1985)

The water content at which the soil changes from one stage to another is known as consistency limit. The Casagrande apparatus was used to determine the liquid limit and thread rolling method was used to determine the plastic limit .

2.2 Compaction test (IS: 2720 Part 7)

Standard compaction method was used to determine the maximum dry density (MDD) and optimum moisture content (OMC).

2.3 Permeability test (IS: 2720(Part17)-1986)

Permeability is the property of soil which permits flow of water through its interconnecting voids. Permeability of bentonite and zeolite mixtures is determined using falling head permeability test. Permeability test is performed in layered form i.e., first layer of local soil ,on top of that a layer of bentonite and at last a layer of zeolite with different mix percentages.

2.4 Combination study

Various mix combinations chosen for the study are listed below in Table 3.

Table -3: Description of combination mixes

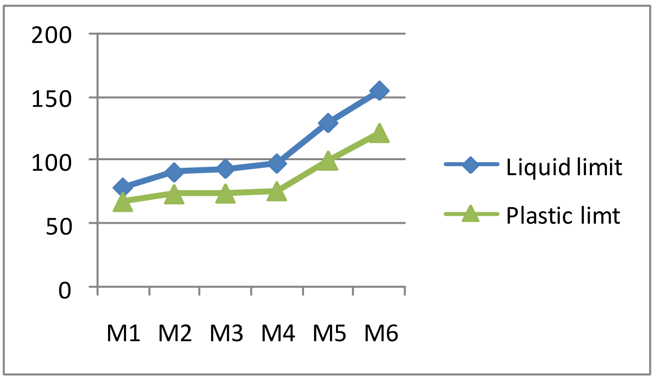
MIX	COMBINATION
M1	80%LOCAL SOIL+10%BENTONITE+10%ZEOLITE
M2	80%LOCAL SOIL+15%BENTONITE+5%ZEOLITE
M3	60%LOCAL SOIL+20%BENTONITE+20%ZEOLITE
M4	60%LOCAL SOIL+25%BENTONITE+15%ZEOLITE
M5	40%LOCAL SOIL+30%BENTONITE+30%ZEOLITE
M6	40%LOCAL SOIL+35%BENTONITE+25%ZEOLITE

Local soil –LS, Bentonite –B , Zeolite -Z

3. RESULTS AND DISCUSSIONS

3.1Consistency limits (IS:2720(Part 5)-1985)

Fig.3: Consistency limits



From Figure 4, liquid limit increased with increase in bentonite content because of its very high absorption capacity.

3.2 Compaction test (IS: 2720 Part 7)

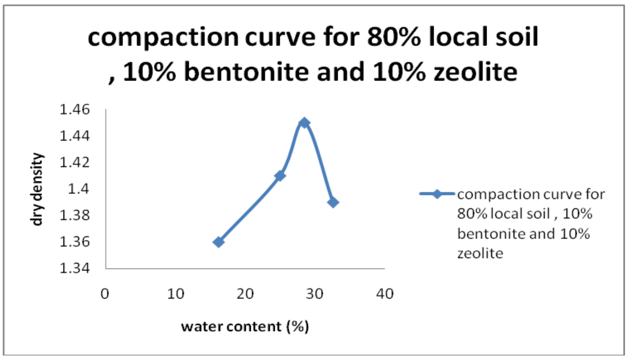


Fig.4: compaction curve for MIX1

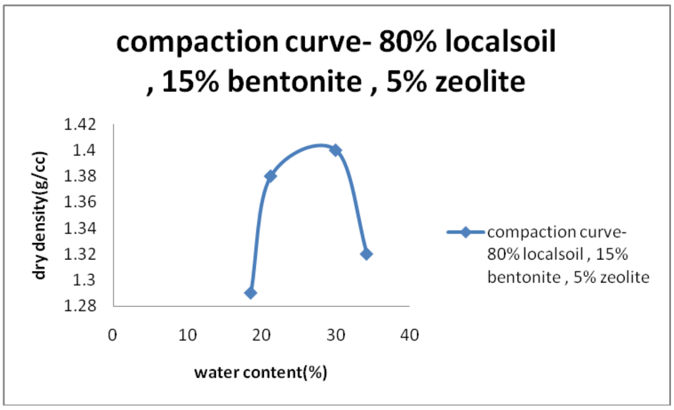


Fig.5: compaction curve for MIX2

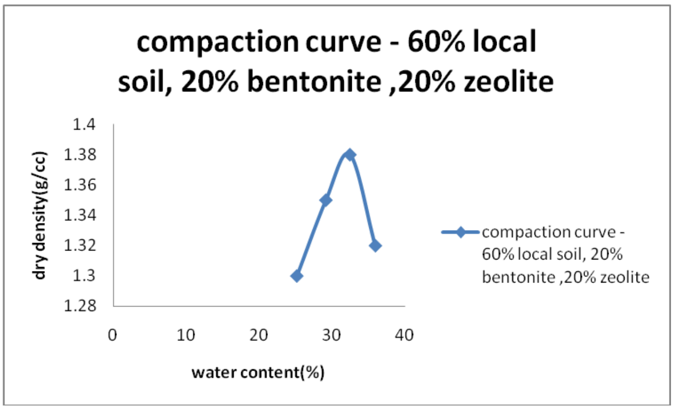


Fig.6: compaction curve for MIX3

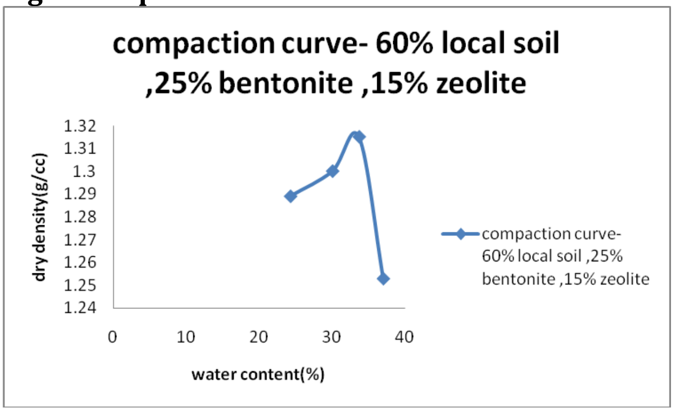


Fig.7: compaction curve for MIX4

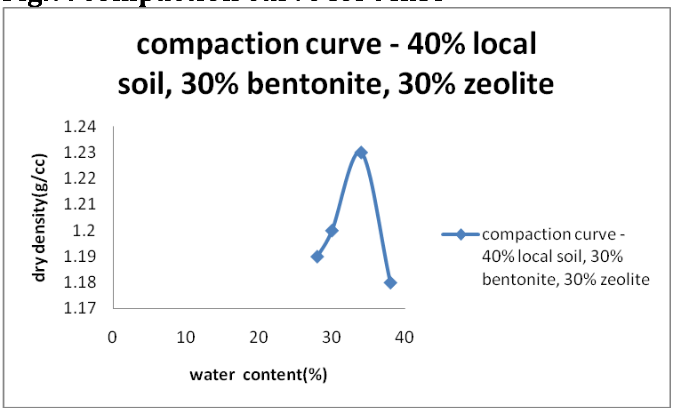


Fig.8: compaction curve for MIX5

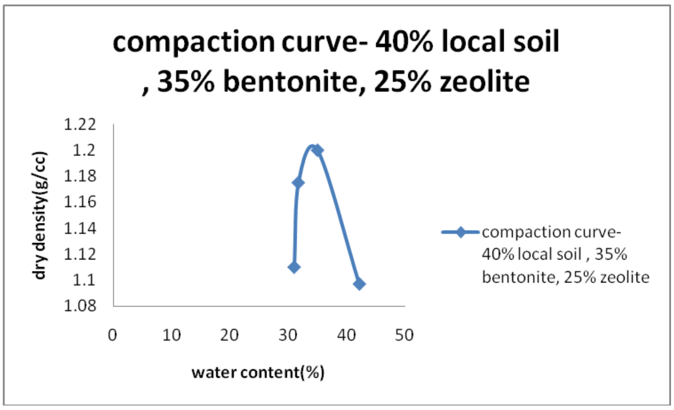


Fig.9: compaction curve for MIX6

The results of compaction tests for various mixes are tabulated in Table 4.

Table -4: Compaction test results

MIX	MDD(g/cc)	OMC (%)
M1	1.45	28.5
M2	1.402	29
M3	1.38	32.5
M4	1.315	33.77
M5	1.23	34
M6	1.2	35

Optimum moisture content increases and maximum dry density decreases with increase in bentonite content.

3.3 Permeability test (IS:2720(Part17)-1986)

Table -5: Permeability test results

MIX	COEFFICIENT OF PERMEABILITY (cm/s)
M1	7.85×10^{-5}
M2	3.36×10^{-5}
M3	6.318×10^{-6}
M4	4.99×10^{-6}
M5	6.32×10^{-7}
M6	8.77×10^{-8}

Coefficient of permeability decreases with increase in bentonite content. Least value for coefficient of permeability is for Mix, M6 i.e. 8.77×10^{-8} cm/s. This is due to the high specific area of bentonite which tends to absorb more water which fills the pores in soil structure and lowers the soil porosity and hydraulic conductivity.

3. CONCLUSIONS

Landfill is a popular method of waste disposal in which waste is contained by efficient liner and cover system. In this work an attempt is made to produce an amended soil liner by adding bentonite and zeolite with dump yard site soil. Various combination mixes were worked out and out of that mix M6 (40% local soil+35%bentonite+25%zeolite) was found to be the one with least permeability . The liner system shows a great importance in preventing leachate percolation into surroundings in which permeability is the main factor.

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