International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 03 | Mar-2018 www.irjet.net p-ISSN: 2395-0072

Effect of Bentonite Clay on Compaction, CBR and Shear Behaviour of Narmada Sand

Yatesh Thakur[1], Prof. R.K. Yadav[2]

[1]ME Scholar Geotechnical Engineering, Dept. of Civil Engineering, Jabalpur Engineering College, Jabalpur, Madhya Pradesh, India
[2]Associate Professor, Dept. of Civil Engineering, Jabalpur Engineering College, Jabalpur, Madhya Pradesh, India

---

ABSTRACT - *Sand-clay mixtures have been utilized as a liner/barrier material in several engineering applications. These engineering applications include waste containments, such as landfill, cut-off walls, cores of earth dams, and buffer and backfill materials of radioactive nuclear waste containments, and also hydraulic containments, such as reservoirs. This study focuses on Shear behavior and Strength Characteristics of sand-bentonite mixes. Various tests were conducted on virgin soil for the determination of following parameters such as Atterberg Limits, Grain Size Distribution, Compaction Characteristic, Shear Behaviour and California Bearing Ratio (CBR) values. It is important to evaluate the hydraulic conductivity of the liner to avoid percolation of containments in ground water and surrounding soil.CBR strength of liner should also be known to get an idea of overburden it can support. Modified Compaction test, CBR and Direct Shear test were performed on mixes of 5%, 10%, 15%, 20%, 25% by dry weight of bentonite. It was found that there is increase in Maximum Dry Density (MDD) and Optimum Moisture Content (OMC) values of mixes. Direct Shear test resulted in increase in Cohesion and decrease in Friction angle values of mixes.*

Key Words: *Shear Behavior, Narmada Sand, Sodium Bentonite, Subgrade material, C.B.R.*

1. INTRODUCTION

Industrialization brought forth with it the associated problems. The industrial activities generated large quantities of wastes. Part of these wastes in different physical form such as solid, liquid and gas turn as pollutants in due course. Based on the safety level, these wastes can be hazardous or non hazardous. To minimize waste, and to neutralize it, the requirement for storage or disposal still exists. The most frequently used disposal option for solid waste in the landfills because of its low cost and efficiency. The landfill plays a vital role in the whole waste treatment/disposal process. Landfills are the most popular municipal solid waste disposal system. The design of liner is made so as to isolate the waste from the environment minimizing the passage of leachate into the groundwater. To ensure this the important characteristics for compacted landfill liners are selection of materials, hydraulic conductivity, strength, compressibility and contaminant retention capacity. Various types of isolated liners have been suggested, such as compacted clay liners, geo-synthetic clay liners, and sand-bentonite liners (Ghazi 2015) It has been found that the utilization of sand-bentonite mixtures as backfilling material is more advantageous rather than other natural clays, because during the process of drying, (Samingan and Schanz 2008) the void ratio of bentonite decreases which brings the sand particles present in the sand- bentonite mixture into contact.

This phenomenon reduces the decrease in the void ratio giving an overall mechanical stability and also reduces further shrinkage. Bentonite swells to fill voids and as an effect of which sand-bentonite mixture shows very low hydraulic conductivity (Studds et al. 1998)

2. MATERIAL USED AND METHODOLOGY

2.1 Material Used in Present Study

2.1.1 Sand

In the present study the sand sample is collected from alongside of river Narmada in Jabalpur district of Madhya Pradesh state of India. It is firstly passed through 4.75mm sieve and retained on 75 micron, then soil is oven dried, is taken. This sand was subjected to various laboratory tests as per IS codes to determine the various properties and results are as given in Table 1 and grain size distribution of Narmada sand is shown in Fig. 1.

Table -1: Basic Properties of Narmada Sand

Properties of Sand	Values
Soil type as per IS: 1498-1970	GW
Specific Gravity	2.84
Fine Content(<75μ),%	6.37
Coefficient of uniformity, Cu	6.32
Coefficient of curvature, Cc	2.35
Plasticity Index	-
Effective size of particle, D10 (mm)	0.212
Maximum Dry Density (g/cc)	1.96
Optimum Moisture Content	5.70
Cohesion, c (kg/cm^2)	Negligible
Angle of internal friction (Ø), degree	33.6

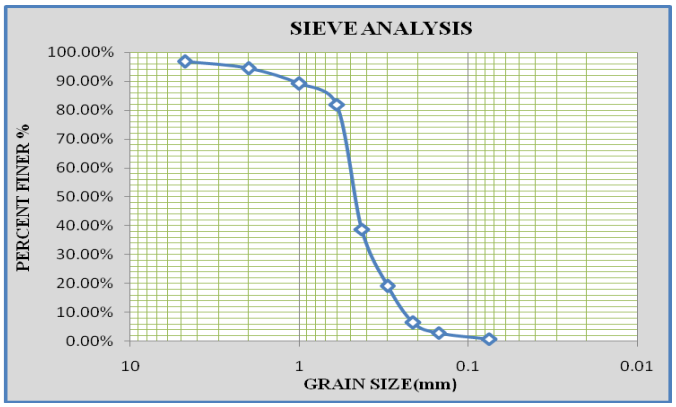

Fig. 1: Grain size distribution of Narmada sand sample

2.1.2 Bentonite Clay

The bentonite used for the project work was Sodium bentonite which is naturally occurring hydrated aluminum silicate clay. It exhibits extremely high swelling and water absorbency properties. Bentonite used in this study is sodium bentonite purchased from the market of Jabalpur in Madhya Pradesh. It was subjected to various laboratory tests as per IS codes to determine the various properties and results are as given in Table 2.

Table-2: Basic Properties of Bentonite

Properties	Values
Soil type as per IS: 1498-1970	CH
Colour	Cream
Specific Gravity	2.80
Liquid Limit (%)	210
Plastic Limit (%)	41.52
Plasticity Index (%)	168.48
Shrinkage Limit (%)	16
Free Swell index (FSI %)	510
Cohesion ,c (kg/cm^2)	1.27
Angle of internal friction (Ø), degree	0

2.2 Sample Mixes Used in the Study

Narmada sand was mixed with bentonite clay in different proportion and their effect on Compaction behaviour and shear behaviour of the Narmada sand was investigated. Sample mixes are as follows:

Table-3: Sample Mixes

Sample Name	Proportioning of material
SMB0	Narmada sand
SMB5	95% Narmada sand + 5% bentonite
SMB10	90% Narmada sand + 10% bentonite
SMB15	85% Narmada sand + 15% bentonite
SMB20	80% Narmada sand + 20% bentonite
SMB25	75% Narmada sand + 25% bentonite

3. LABORATORY EXPERIMENTS CONDUCTED

The particle size analysis of Narmada sand, bentonite clay is determined as per IS: 2720 (Part 3/Sec 1)-1980. The liquid limit and plastic limit of bentonite clay were determined as per procedure lay down in IS: 2720 (Part 5)-1985. MDD and OMC of Narmada sand with different proportions of bentonite is determined as per IS: 2720 (Part 8) 1980. Direct shear test was conducted on sample mixes as per IS: 2720 (Part 13)-1986.

3.1 Modified Compaction Test

Heavy compaction test was carried out on specimens as per IS 2720 (Part 8) 1980. The compaction curves for sand-bentonite mixture was obtained and the OMC and MDD values are given in Table. These OMC and MDD values obtained from laboratory compaction test provide a reference point while estimating the actual water content of the field-compacted soil liner. The variation of MDD and OMC of the compacted Sand-bentonite mixtures are presented in the Fig. 2 and 3.

3.2 California Bearing Ratio:

The CBR tests for the sample of Narmada sand and bentonite mixes for soaked condition with four days soaking were performed in accordance with IS: 2720 (Part 16) –1987. The CBR values of soaked condition for different proportions of Narmada sand and bentonite mixes are presented in Table 4. The Load vs. Penetration curve of CBR tests for different Narmada sand and bentonite mixes are presented in Fig.4.

3.3 Direct Shear Test

Direct Shear test were performed strictly according to IS: 2720 (Part 13)-1986 on Narmada sand and Narmada sand mixed with different proportions of bentonite clay. A standard size (60mm x 60mm) Direct Shear box was used for the investigation. The tests were conducted on three different normal stresses i.e. 50, 100 & 150 KPa and the angle of internal friction & cohesion values were obtained by plotting a straight line through the plot of shear stress versus the normal stress are presented in Fig.5.

4. RESULTS AND DISCUSSION

Table-4: OMC-MDD, CBR and C-Ø Test Results

Sample	OMC (%)	MDD (gm/cc)	CBR (%)	Cohesion,(Kg/cm^2)	Angle of internal friction
SMB0	5.70	1.96	15.41	0	33.6
SMB5	9.38	2.01	13.04	0.073	27.5
SMB10	9.06	2.04	8.14	0.094	24.5
SMB15	10.23	2.05	4.60	0.158	15.2
SMB20	17.38	1.86	6.23	0.115	16.9
SMB25	18.28	1.85	3.56	0.096	16.0

4.1 Modified Compaction Test

Compaction behaviour of different sample mixes is shown in Fig.2,3 and the Variation of OMC and MDD given in Table 4.

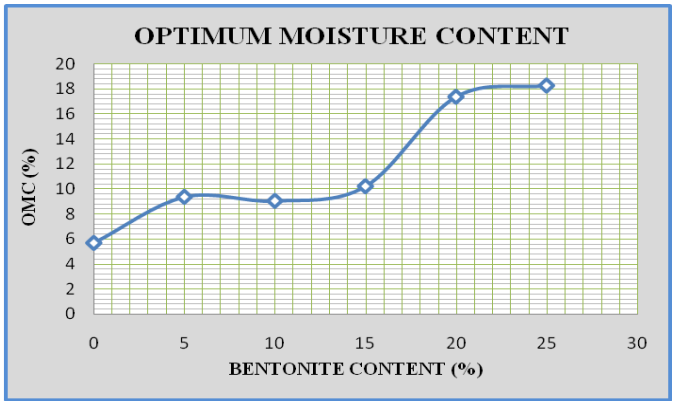

Fig. 2: Variation of OMC with increasing % of bentonite in sand

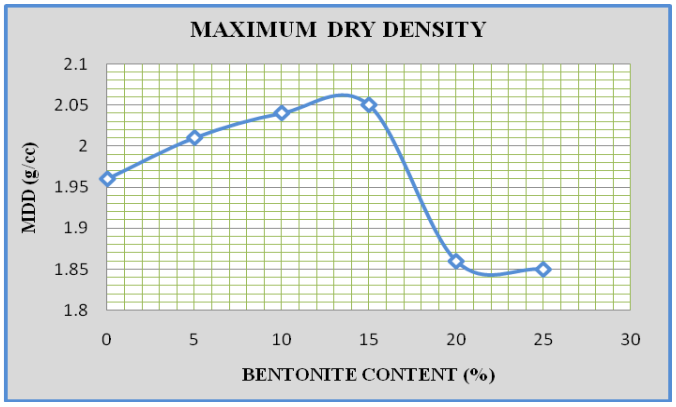

Fig. 3: Variation of MDD with increasing % of bentonite in sand

4.2 California Bearing Ratio

The variation of C.B.R Values of different sample mixes for 4-days soaked condition shown in Fig. 4 and their values given in Table 4.

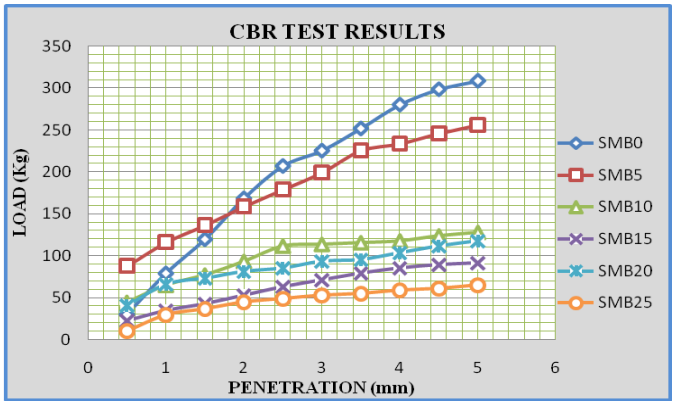

Fig. 4: Variation in C.B.R values with increasing % of bentonite in sand

4.3 Direct Shear Test

Shear behaviour of different sample mixes is shown in the Fig. 5 and Values of cohesion, c and angle of internal fiction, Ø is given in Table 4.

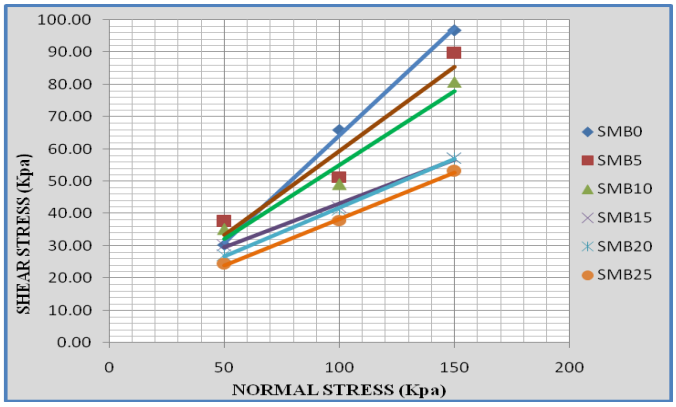

Fig. 5: Shear behaviour of various sand-bentonite mixes

5. Conclusion

From the results of investigation following conclusions can be drawn.

1. With increase in bentonite content there is increase in OMC of the mix increases. This may cause large water holding capacity and high specific surface of bentonite.

2. As the bentonite content increases there is increase in MDD up to 15% and with further increase in bentonite content up to 25% the MDD decreases. Decrease in MDD is due to the fact that clay particles start going up and the spaces are taken by the sand particles.

3. C.B.R value for soaked condition at 0% bentonite content is 15.41%. On addition of bentonite content the C.B.R value reduces and attains a value of 3.56% at 25% bentonite content. This may be because of softening of the mix due to presence of high bentonite content which eases the plunger to penetrate in the sample.

4. There is increase in cohesion with increase in bentonite content and the angle of internal friction reduces with increasing the bentonite content in the mix.

From the above points it can be concluded that sand mixed with 15-25% bentonite proportion can be use as a liner material for landfills and as subgrade material.

REFERENCES

1. Ameta N.K. and Wayal Abhay Shivaji(2008), "Effect of bentonite on permeability of dune Sand", Electronic Journal of Geotechnical Engineeering, Vol.13, Bund.A

2. Doley C., Das U.K., Phukan P.K., Dutta D., and Bora P.M. et al.,"A Study on use of brahmaputra river sand as a liner material for municipal landfills", IOSR Journal of Mechanical and Civil Engineering (IOSR-JMCE),Volume 13, Issue 4 Ver. III (Jul. - Aug. 2016), PP 91-96

3. IS 2720 (Part 3/Sec 2): 1980, "Method of test of soils-Determination of specific gravity", Bureau of Indian Standards.

4. IS 2720 (Part 4): 1985, "Method of test of soils -Grain size analysis", Bureau of Indian Standards.

5. IS: 2720 (Part-5)-1985 Determination of liquid limited plastic limit and Shrinkage limit Bureau of Indian standard.

6. IS 2720 (Part-7)1980 Determination Compaction parameters. Bureau of Indian Standard.

7. IS 2720 (Part 13): 1986, "Method of test of soils - Direct shear test", Bureau of Indian Standards.

8. IS-2720-(Part-40)1970 "Free swell index test for soils" ", Bureau of Indian Standards.

9. Proia Roberta, Croce Paolo and Modoni Giusepp et al. (2016) "Experimental investigation of compacted sand bentonite mixture", VI Italian conference of researches in geotechnical engineering (CNRIG 2016), Procedia Engineering 158(2016) 51-56

10. Rana Deepak, Soni Ankit, Ali Farukh et al.(2017) "Study of shear behaviour of Yamuna sand blended with soft soil", International Journal of Research in Engineering and Technology, Volume: 06 Issue: 03

11. Samingan Agus Setianto and Schanz Tom "A method for predicting swelling pressure of compacted bentonites", Acta Geotechnica 3(2):125-137 · June 2008

12. Shaker A. Abdullah and Tamer Y. Elkady (2016) "Investigation of the hydraulic efficiency of sand-natural expensive clay mixtures", International Journal of GEOMATE, Sept., 2016, Vol. 11, Issue 25, pp.2410-2415

13. Srikanth V. and Mishra A. K. (2016) "A laboratory study on the geotechnical characteristics of sand–bentonite mixtures and the role of particle size of sand", Int. J. of Geosynth. and Ground Eng. (2016) 2:3

14. Tiwari Anup, Suman Sanjeev and Sharma Subir et al. (2016) "Study of compacted sand-bentonite mixture as material of low hydraulic conductivity liner of landfill for solid waste disposal", Imperial Journal of Interdisciplinary Research, Vol-2, Issue-4.