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Compaction Behaviour and Grain Size Alteration of Sand -Clay Mix

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Abstract: ***Sand-bentonite mix is commonly used as liner material or backfill material in landfill sites. Bentonite belonging to group of montmorillionite clay provides higher density and less void ratio to lessen permeability of liner layer mixed with sand. This mix is inevitable and economical where soil nearby landfill site have sandy soil .Many literatures provided geotechnical aspects of using this mix.In this present study, the grain size distribution analysis and compaction of sand–bentonite mixture for 10%,20% and 30% bentonite mix is studied to propose economic and less permeable liner material with lower shrinkage. Locally available sand from different river , Odisha (India) was mixed with different proportions of commercial sodium bentonite. The following research output presented here elaborately show the effect of clay particle on compaction, Relative Density, Coefficient of uniformity,Coefficient of curvature, permeability by gradually adding commercial Sodium Bentonite 10% by weight upto 30%. The result show that there is a significant improvement in MDD and OMC of Sand-Bentonite mix along with decrease in void ratio. The grain size alteration eventually helped to increase the dry density and reduced void ratio will enhance the scope of this mix to be used as liner layer in landfill system.***

Keywords : Bentonite, Compaction, index properties, Relative density, Sand

I. INTRODUCTION

For locally available impermeable soil ,improving its geotechnical characteristics and altering its grain size distribution have found wide application as liner. To prohibit the percolation of leachate into the ground water ,landfills are designed with liner system which creates a fence between the contaminated waste and soil .Among different layers of liners, Sand-Bentonite mix can be provided either as top or bottom liner or both .In this work, various tests were conducted to determine suitable sand-bentonite mix proportion that could result in permeability below 1×10-7 cm/s, which is a general and mandatory requirement for water containment and waste containment liners. Every regulating authority of environment in almost all country have specified the minimum permitted hydraulic conductivity varying between 10-7to 10-9 m/s. Light weight compaction tests were carried out to get Maximum dry density value and Particle size distribution on different mixes were presented along with Hydraulic conductivity of different mixes using Bayer's Empirical formula.

II. METHODS AND MATERIALS

This paper represents laboratory tests to evaluate the effect of addition of commercial bentonite on geotechnical behaviour of four different river sand collected from different riversides of Odisha, India. The variation of result in terms of grain size distribution, Maximum dry Density, Optimum Moisture content, specific gravity, Coefficient of Uniformity and Coefficient of Curvature are studied and interpreted here following test procedures of Indian Standard Code.In this study, the grain size distribution analysis and compaction of sand–bentonite mixture for 10%, 20% and 30% bentonite mixes are studied to propose economic and less permeable iner material with lower shrinkage. Tap water was added to the sand-bentonite mixtures to obtain the desired water contents and light weight standard proctor hammer was used to compact the mixes. Dry and Wet Sieve analysis was done to clearly have knowledge of particle size distribution that will directly attribute to strength and permeability.

Table-I Physical Properties of Bentonite

Liquid Limit	220%
Plastic Limit	60%
Flow Index	110
Plasticity Index	160
Toughness Index	0.68
Specific Gravity	2.65
OMC	26.50%
MDD	1.4g/cc
D_{50}	0.004

Table 2: Physical property of River Sand

Property	*Sand 1 (Koel river)*	*Sand 2 (Kathajori river)*	*Sand 3 (Rushikulya river)*	*Sand 4 (Salunkhi river)*
Specific gravity	2.673	2.688	2.77	2.56
$D_{50(mm)}$	0.3	0.32	0.5	0.32
C_u	4.21	1.75	2.3	2.375
C_c	0.67	0.96	0.85	1.11
e_{max}	0.92	0.89	0.82	0.78
e_{min}	0.61	0.62	0.61	0.48
Dr	0.948	0.923	0.95	0.73
OMC(%)	13.19	11.13	14.61	14.94

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MDD(g/cc)	1.64	1.63	1.71	1.79

Table3:Physical properties of Sand 1-Bentonite mix

Property	*Sand-1*	*10%B,90%S-1*	*20%B,80%S-1*	*30%B,70%S-1*
Specific gravity	2.673	2.62	2.57	2.45
$D_{50(mm)}$	0.3	0.2	0.15	0.12
C_u	4.21	4.5	6.66	9.5
C_c	0.67	2	2.6	2.9
OMC(%)	13.19	10.9	12	13.2
MDD(g/cc)	1.64	1.87	1.85	1.83

Table4:Physical Properties of Sand 2 –Bentonite mix

Property	*Sand-2*	*10%B,90%S-2*	*20%B,80%S-2*	*30%B,70%S-2*
Specific gravity	2.688	2.65	2.56	2.5
$D_{50(mm)}$	0.32	0.3	0.28	0.2
C_u	1.75	5.33	6	7.5
C_c	0.96	2.75	2.94	3
OMC(%)	11.13	11.92	12.24	13.5
MDD(g/cc)	1.63	1.83	1.81	1.8

Table 5: Physical properties of Sand 3 – Bentonite mix

Property	*Sand-3*	*10%B,90%S-3*	*20%B,80%S-3*	*30%B,70%S-3*
Specific gravity	*2.77*	*2.7*	*2.63*	*2.58*
$D_{50(mm)}$	*0.5*	*0.45*	*0.41*	*0.39*
C_u	*2.3*	*6*	*7.05*	*8.33*
C_c	*0.87*	*1.7*	*1.91*	*2.34*
OMC(%)	*14.61*	*12.02*	*12.52*	*14.11*
MDD(g/cc)	*1.71*	*1.84*	*1.83*	*1.81*

Table 6: Physical properties of Sand 4 - Bentonite mix

Property	*Sand-4*	*10%B,90%S-4*	*20%B,80%S-4*	*30%B,70%S-4*
Specific gravity	2.56	2.52	2.41	2.38
$D_{50(mm)}$	0.32	0.31	0.3	0.26
C_u	2.375	4.22	5.83	10
C_c	1.11	1.54	1.84	1.87
OMC(%)	14.94	11.94	13.47	14.54
MDD(g/cc)	17.94	1.84	1.82	1.79

III. RESULT AND DISCUSSION

Commercial Bentonite powder ,locally available in market is used here. Commercial Clay (Bentonite) was brought from market, it was well dried and was passed through No. 75µ sieve before usage . The liquid limit and Plastic Limit of the clay content was found to be 220 and 60%.The PI value indicates it to be highly plastic in nature. The sieve analysis is done by hydrometer test for fine clayey bentonite powder and wet sieve analysis by mechanical sieving is done for the grain size characterization. Of four different sand types are shown in Fig.1,2,3,4 respectively. Typical grain size distribution curve It is clear that addition of clayey particle to sand reduces void paces thus imparting lesser permeability as required for liner .Further dry density increases imparting greater strength by adding bentonite to required weight Dry density increased to 10-15% and permeability reduced to 60% by addition of 30% bentonite mix giving rise to hydraulic conductivity value in the range of 10^{-6} .From the grain size characterization, it is clear that addition of clayey particle reduces void paces thus imparting lesser permeability as required for liner. When fine content with higher surface area of Montmorillionite group is added to water, more water content is required to achieve MDD(Holz and Kovac(1981) .Further dry density increases imparting greater strength by adding bentonite to required weight Dry density increased to 10-15% and permeability reduced to 60% by addition of 30% bentonite mix giving rise to hydraulic conductivity value in the range of 10^{-6} . The mean grain size of the sand particle (D_{50}) is an additional vital index property. Effort has been made to correlate the hydraulic conductivity with the grain size of the sand particles. It is being observed by many researchers that out of many properties, mean grain size of sand plays an important role in predicting the relative density and thus the compaction control of sand. The hydraulic conductivity value of Sand-Bentonite mixes calculated are less than only Sand, resulting lesser pores as required in liner layer.

The values of specific gravity (*G*),mean grain size (*D*50), coefficient of uniformity (*C*u), coefficient of curvature (*C*c), maximumvoid ratio (*e*max), and minimum void ratio (*e*min) were determined in the laboratory and shown in.The effective diameter term $(D_{10})^2$ is used in several published permeability equations, including the Beyer and Hazen equations (Vukovic and Soro, 1992).The Beyer equation has the form

$K=C.\ D_{10}^2$

Where $C=4.5\times10^{-3}\log(500/U)$

$U=D_{60}/D_{10}$

D_{10} represents Effective diameter of particle (mm) and K designates to hydraulic conductivity(m/sec)

Table 7: Effective size of different Sand-Bentonite mixes

Effective Size (D_{10})mm				
Type of Sand	**1**	**2**	**3**	**4**
sand	**0.25**	**0.2**	**0.18**	**0.17**
Sand-10%Bentonite	**0.07**	**0.06**	**0.09**	**0.09**
Sand-20%Bentonite	**0.05**	**0.05**	**0.07**	**0.06**
Sand-30%Bentonite	**0.03**	**0.03**	**0.04**	**0.03**

Table 8: Hydraulic conductivity using Bayer's Empirical Formula

Type of soil	Hydraulic conductivity(K)m/sec
Sand 1	5×10^{-4}
Sand 1-30%Bentonite mix	6×10^{-6}
Sand 2	4×10^{-4}
Sand 2-30%Bentonite mix	7×10^{-6}
Sand 3	3×10^{-4}
Sand 3-30%Bentonite mix	2×10^{-5}
Sand 4	3×10^{-4}
Sand 4-30%Bentonite mix	6×10^{-6}

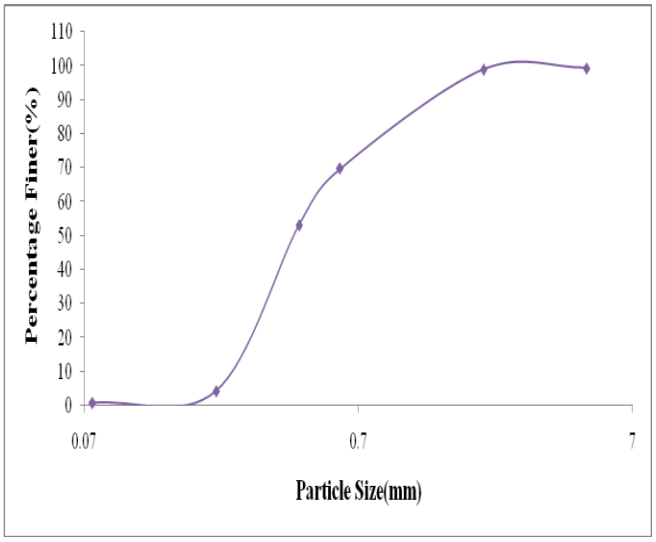

Fig:1 Sieve Analysis of Sand 1

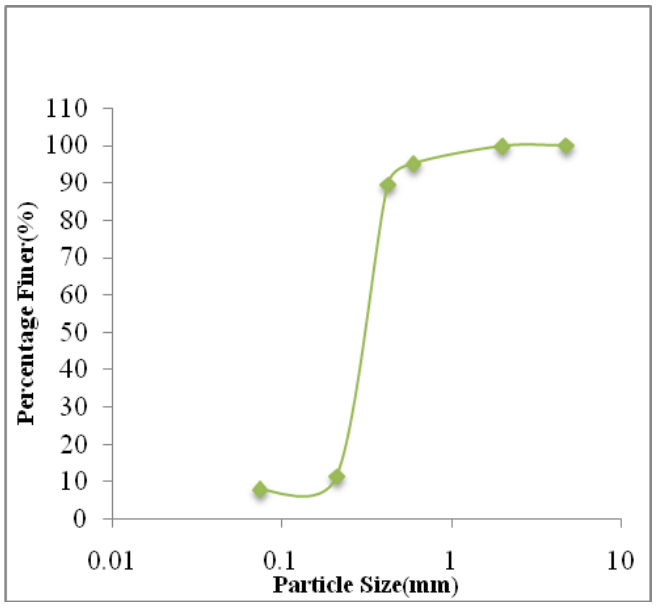

Fig: 2 Sieve Analysis of Sand 2

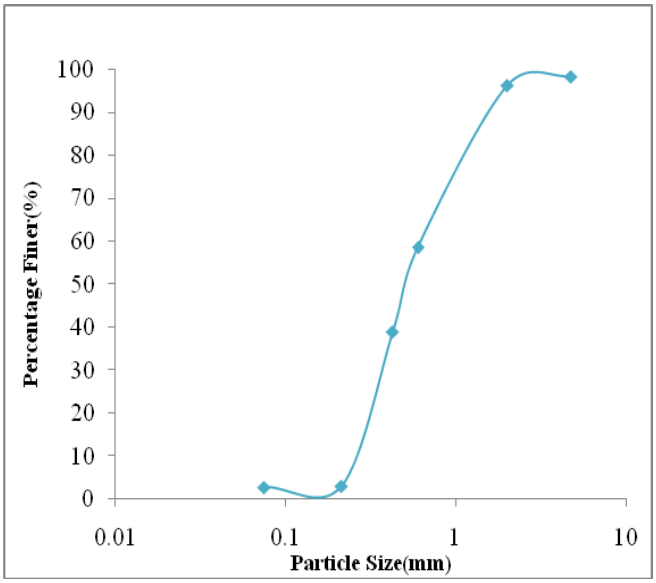

Fig 3: Sieve Analysis of Sand 3

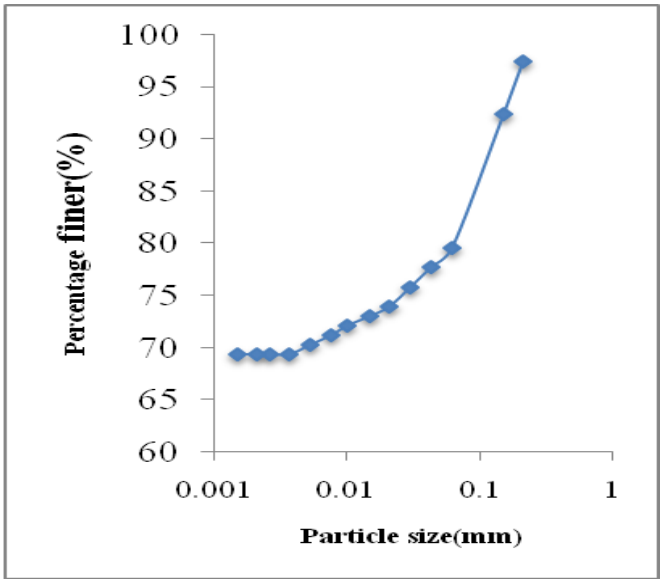

Fig 5: Sieve Analysis of Bentonite

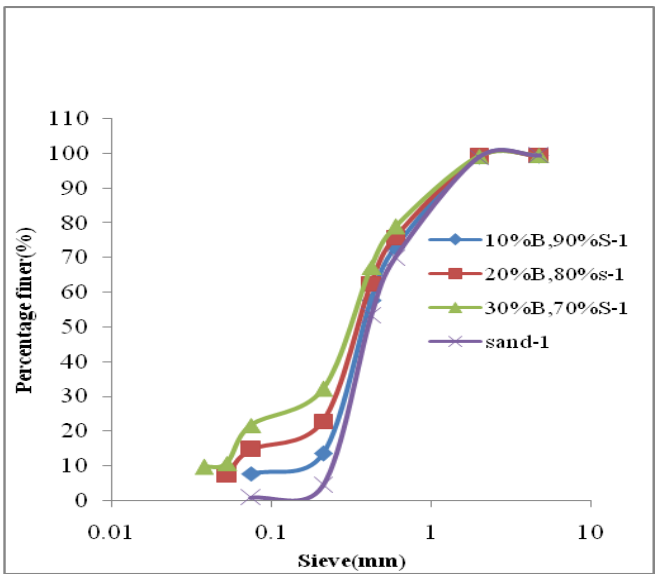

Fig 6: Sieve Analysis of Sand 1-Bentonite mix

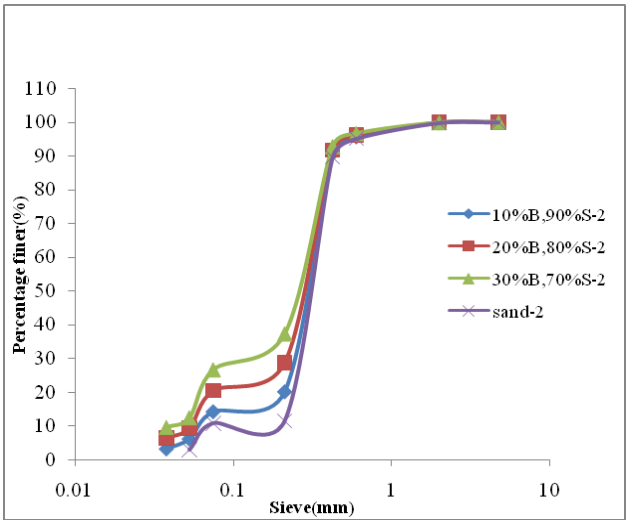

Fig 7: Sieve Analysis of Sand 2-Bentonite mix

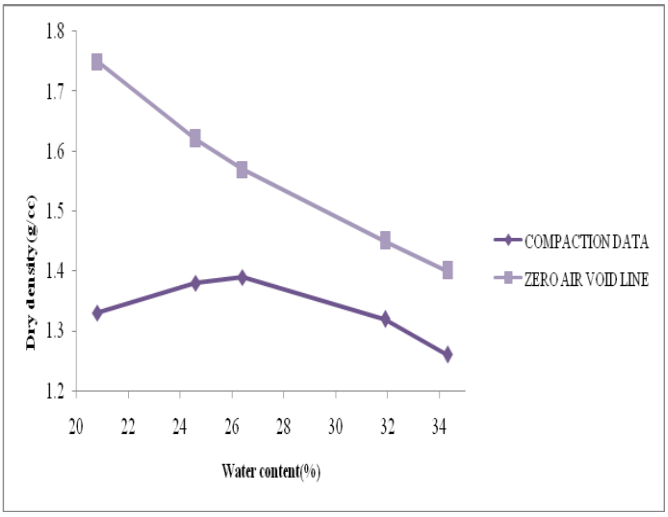

Fig10: Light weight compaction of Bentonite clay

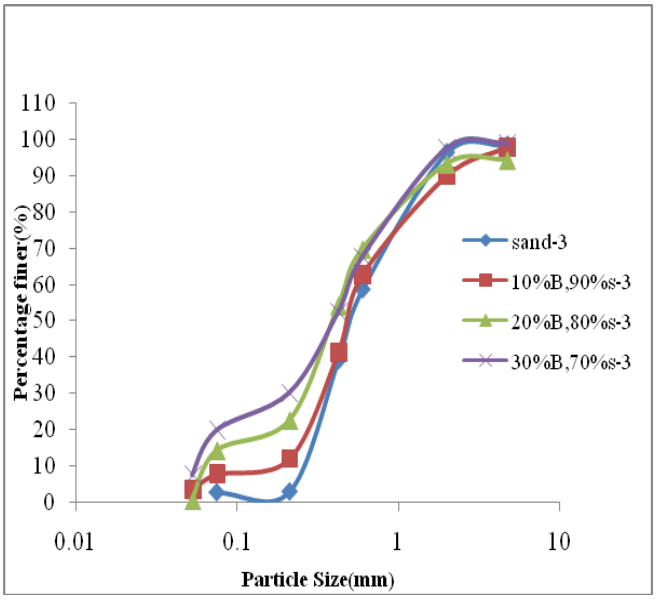

Fig 8 : Sieve Analysis of Sand 2-Bentonite mix

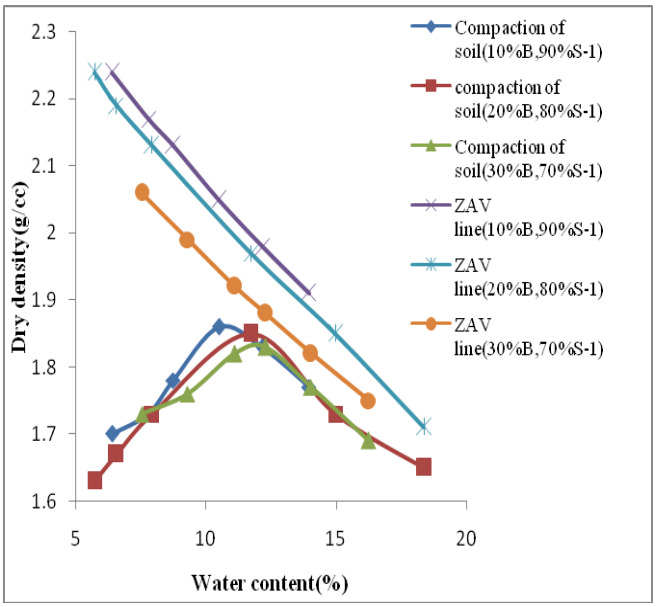

Fig 11: Light weight compaction of Sand 1-Bentonite clay mix

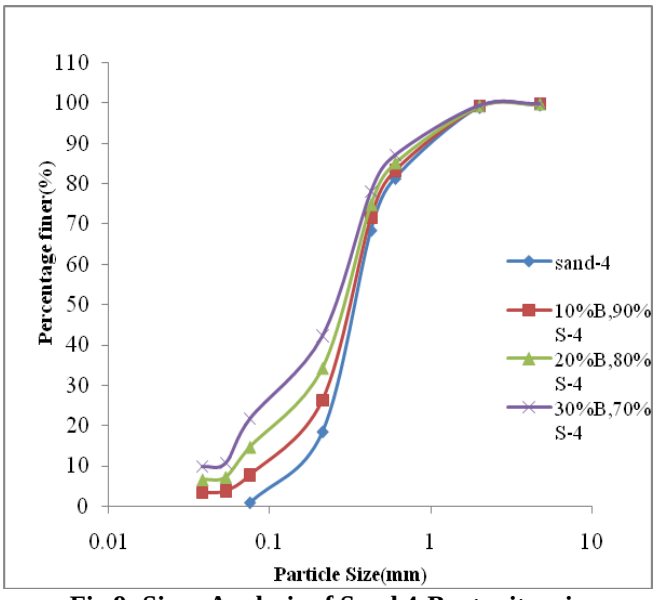

Fig 9: Sieve Analysis of Sand 4-Bentonite mix

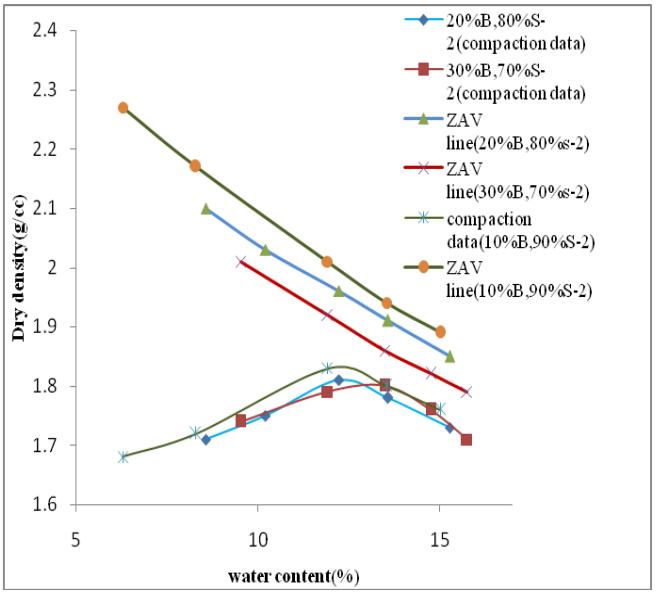

Fig 12: Light weight compaction of Sand 2-Bentonite clay mix

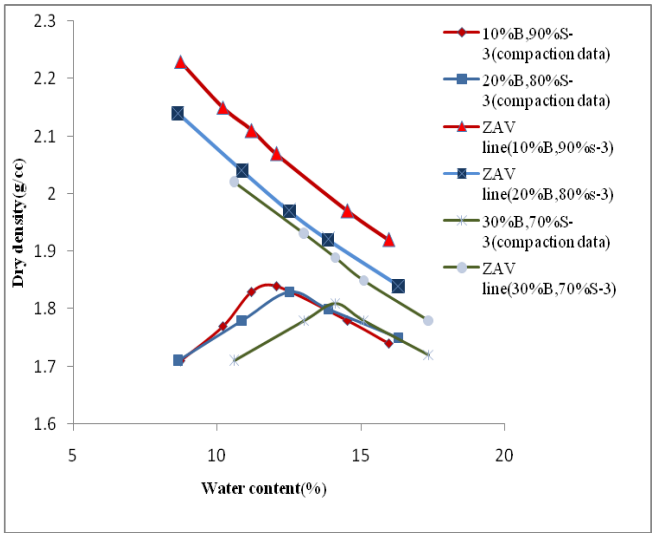

Fig13: Light weight compaction of Sand 3-Bentonite clay mix

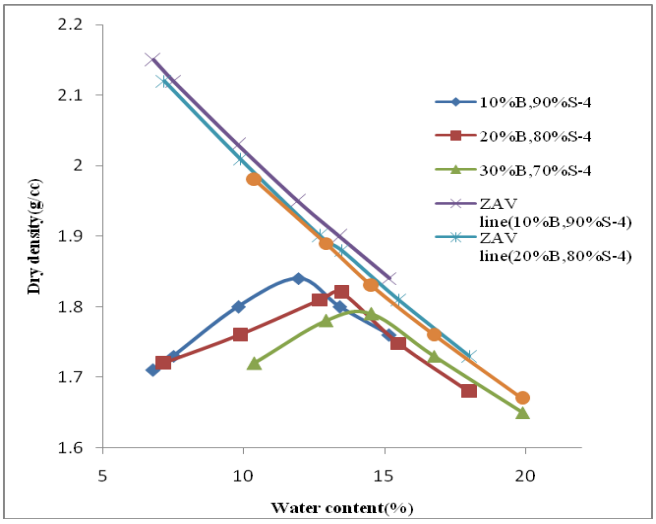

Fig14: Light weight compaction of Sand 4-Bentonite clay mix

IV. CONCLUSION

- Sieve analysis result shows that with increase in bentonite content, the mean grain size decreases ,with an increase in Cu & Cc.
- Althought Optimum moisture content increases and dry density decreases with increasing bentonite content of the compacted sand-bentonite mixtures,there is no reasonably deplete and it fulfills the permeability criteria of being used as a liner.
- Compaction test results show that when bentonite content varied from 10 to 30%, the maximum dry unit weight decreases from 1.86 to 1.35 g/cc , 1.83 to 1.8 g/cc, 1.84 to 1.81 g/cc and 1.84-1.79 g/cc & the corresponding optimum water content increases from 10.49 to 13.20 %, 11.92 to 13.50%,12.02 to 14.11% and 11.94-14.54%in case of sand-1,sand-2,sand-3,sand-4 respectively.

REFERENCES

1. Blotz, L. R, Benson ,C. H & Boutwell, G. P .(1998)"Estimating optimum water content & max dry unit weight for compacted clays". Journal of Geotechnical & Geo environmental Engineering) september1998/907
2. Chapuis, R. P , Mbonimpa .M , Aubertin .M & Dagenais , A. M(2006) " A Convenient Graphical Representation of Compaction Data" Geotechnical Testing Journal, Vol. 29, No. 3,Paper ID-GTJ12695
3. Gurtug .Y & Shridharan .A .(2004) " Compaction behavior and prediction of its characteristics of fine grains soil with particular reference to its compaction energy" Japanese Geotechnical society ,Vol.44,No-5,27-36
4. Holtz, R.D., and Kovac, W.D. 1981. An Introduction toGeotechnical Engineering, Prentice Hall, NewJersey.
5. Lawton, E.C, Fragaszy , R. J & Hardcastle, J. H. (1989) . "Collapse of compacted clayey sand." Journal of Geotechnical Engineering, ASCE, Vol. 115, No. 9
6. Masih, R. (2000). "Formula to get desired soil density", Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Vol. 126, No. 12, pp. 1145-1150.
7. Morales ,E.M & Morales,M.K(2004). " Expansive soil-Identification, Detection & Remedial statistics" www.pgatech.com.ph
8. Osinubi , K. J.(2006)." Compaction Delay Effects on Properties of Lime-Treated Soil" and Charles-Journal of materials in civil engineering © ASCE / MARCH/APRIL 2006 / 251
9. Pandian,N.S,Nagaraj,T.SandNarasimhaRaju,P.S.R.1995.Permeability and Compressibity behaviour of bentonite-Sand/soil mixes.Geotechnical Testing Journal,18-86-93
10. Sivrikaya. O, Togrol. E& Kayadelen.(2008) ." Estimating compaction behavior of fine-grained soil based on compaction energy " Canadian geotechnical Journal ".J.vol-45
11. Sridharan, A., and Nagraj,H.B.2005.Plastic limit and compaction characteristics of fine grained soils. Ground Improvement,9(1) :17-22.doi:10.1680/grim.9.1.17.58544.

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