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Research article

The Permeability of Ocean Sand with Bentonite.

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ABSTRACT

Where there is no impervious natural soils, a compacted mixture of sand with bentonite has been used to form barrier of fluids, with success. Laboratory test results are presented in this paper, to show the permeability behavior of Atlantic Ocean shore sand/bentonite mixture. One dimensional consolidation and falling head permeability tests were conducted to evaluate permeability at 2%, 4%, 6%, 8% and 10% bentonite content bye weight in ocean sand. Laboratory results show that the coefficient of consolidation is inversely proportional to the consolidation. The coefficient ofvolume change is more susceptible to changing stresses and is inversely related to it. The permeability of ocean shore sand reduced significantly after addition of bentonite. Permeability values from falling head and one dimensional consolidation test are in good agreement.

Keywords: Barrier of fluids; sand/ bentonite mixture; permeability; consolidation; ocean sand

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Introduction

A dominant parameter in the design of waste disposal facilities and liner materials/moisture barriers is permeability. Clays are usually used for this purpose, but it is always associated with the problem of cracking during desiccation. Sandy silt is instead used (Abrahams1963). Folk (1954) indicate that sandy silt is an unconsolidated sediment containing 10-50% sand and having a ratio of silt to clay greater than 2:1. It is therefore better mixed with bentonite. The Atlantic Ocean shore sand with low amounts of bentonite appear to be promising in reducing permeability. Saturated sodium bentonite absorbs water up to 5 times its own mass to form a gel up to 15 times its own volume. A mixture of ocean sand and bentonite is less expensive, would not crack, contains hydrates and swells in the presence of water. The sand particles are therefore impervious inclusion in the matrix of hydrated bentonite. To obtain a low-permeability mixture requires adequate content of bentonite and adequate distribution of bentonite in the mix. Lundgren (1981), Chapuls (1981), Kenny et-al (1992) and Abeele (1986) Studied Soils-bentonite mixes for liners. So also, is this study focused on the permeability of ocean sand for its possible use as a liner material for waste disproval.

Materials and method

The properties of the materials used for the investigation are as follows:

Bentonite

The properties of the bentonite used are as shown in table 1

Table 1: Properties of bentonite

S/N	Description of properties	Value
1.	Specific gravity	2.20
2.	Liquid Limit	248%
3.	Plastic Limit	48%
4.	Maximum Dry Unit weight	11.8kN/m^3
5.	Optimum moisture content	46.8%
6.	Swelling water absorbed for gm oven dried bentonite	7-8 fines

Ocean Sand

The particle size distribution of ocean shore sand used for the investigation is shown in Table 2. The coefficient of permeability of the ocean shore sand is 2.0 x 10^{-4} cm/s.

Table 2: Grain size distribution of ocean shore sand

S/No.	Grain size	% Passing
1	2	99.8
2	1	99.3
3	0.6	98.1
4	0.425	98.0
5	0.30	97.4
6	0.15	12.4
7	0.075	2.0

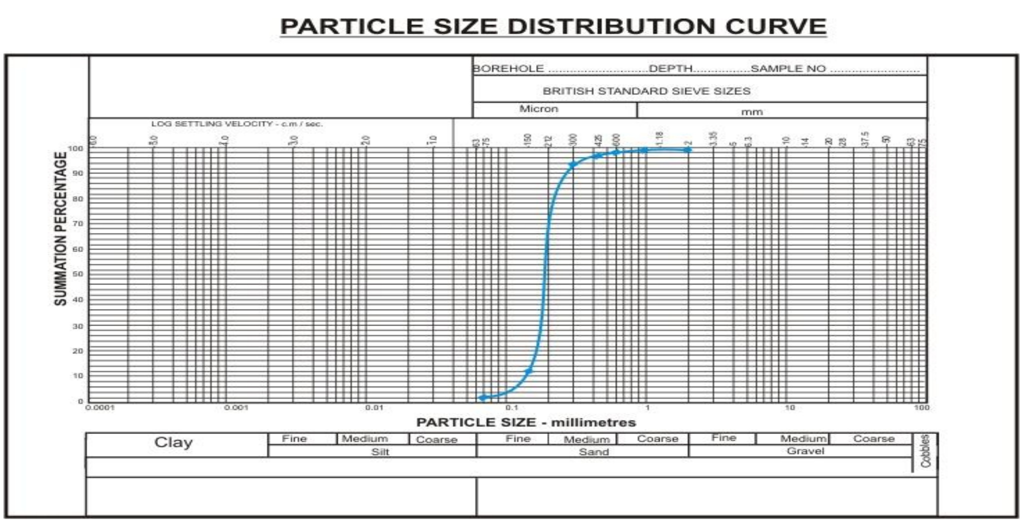


Figure1: Grain size distribution curve of ocean sand

Ocean sand/ Bentonite mixtures

Ocean sand/bentonite mixtures used for the investigation are as follows

Table 3: Ocean Sand/Bentonite Mixtures

S/No.	Symbol	% Bentonite	% Ocean sand	Maximum dried unit weight (kN/m3)	Optimum water content (kN/m3)
1	S/B1	2	98	17.0	15.3
2	S/B2	4	96	17.3	16.1
3	S/B3	6	94	17.8	14.2
4	S/B4	8	92	17.9	15.2
5	S/B5	10	90	17.7	15.8

Laboratory Permeability Tests

The required hydraulic conductivity for various projects is usually k< 10^{-6} to 10^{-8}cm/s. Laboratory permeability tests can be done by falling head or by consolidation test. The later is an indirect evaluation of permeability (e.g. Olson and Daniel, (1981), but is more rapid than the former i.e.

$$k = C_v.M_v.\Upsilon_w$$

where C_v = Coefficient of consolidation

M_v = Coefficient of volume compressibility

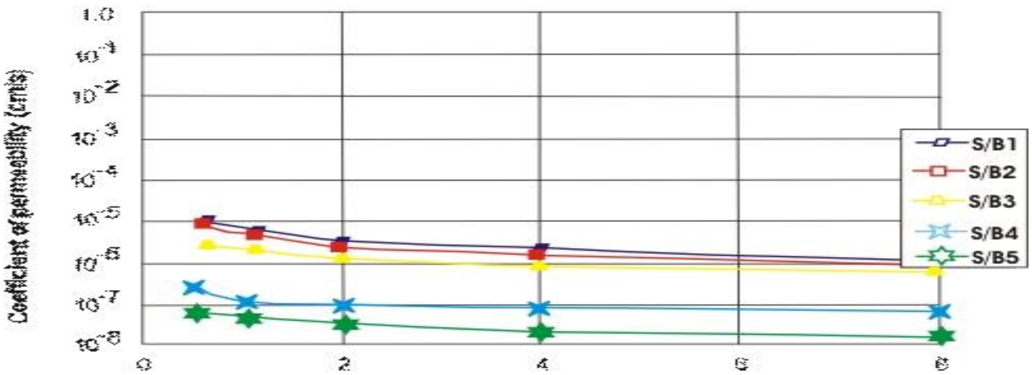
and Υ_w = Unit weight of water.

A 60mm diameter and 20mm high specimen was held in the Oedometer ring and loading pressures of 0.25, 0.5, 1.0, 2.0, 4.0 and 8.0 kg/cm^2 selected; each pressure being maintained for 24hrs. Porous stones were put to allow free drainage top and bottom.C_v was determined. Olson (1986) has shown that theestimated permeability values are always less than the measured values. Permeability from Taylor's method is closer to the measured values than that from Casagrande method. Therefore Taylor'smethod was used, and results shown in table 4.

Table 4: Permeability by Consolidation test at various pressure increments

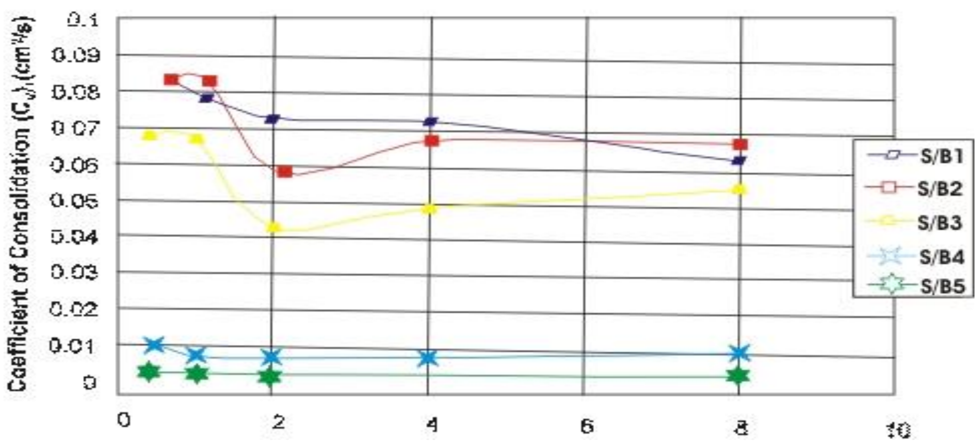
Pressure (kg/cm^2)	S/B1	S/B2	S/B3	S/B4	S/B5
0.5	1.03×10^{-5}	8.68×10^{-6}	2.61×10^{-6}	2.90×10^{-7}	6.35×10^{-8}
1.0	5.66×10^{-6}	5.14×10^{-6}	2.05×10^{-6}	1.22×10^{-7}	5.15×10^{-8}
2.0	3.28×10^{-6}	2.33×10^{-6}	1.30×10^{-6}	1.05×10^{-7}	3.57×10^{-8}
4.0	2.24×10^{-6}	1.56×10^{-6}	8.44×10^{-7}	8.34×10^{-8}	2.25×10^{-8}
8.0	1.15×10^{-6}	8.75×10^{-6}	6.26×10^{-7}	6.75×10^{-8}	1.60×10^{-8}

The coefficient of permeability for various bentonite contents various pressure increments is shown in fig 1; which fig 1 shows that C_v is decreasing for lower bentonite contents and little variation for higher contents. For 4% to 6% in variation is hapharzard. Fig. 3 shows the M_v decreasing with pressure increments for all bentonites.



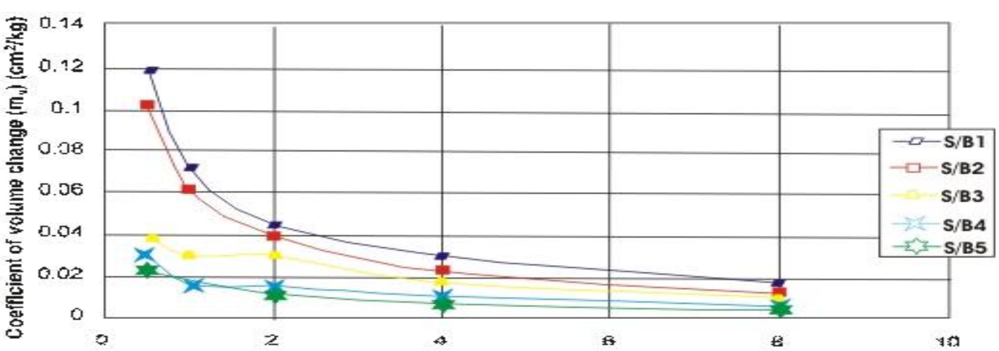
Pressure (kg/cm^2)

Figure 2: Pressure vs Coefficient of Permeability (k)



Pressure (kg/cm^2)

Figure 3: Pressure vs Coefficient of Consolidation (C_v) for S/B1 to S/B5



Pressure (kg/cm^2)

Figure 4: Pressure vs Coefficient of Volume change (M_v) for S/B1 to S/B5

Finally head permeability helps were conducted on the sample that were kept saturated for about 24hrs for one week and later connected to water column. Test result show that the degree of saturation varied from 96 to 100% for various sample as presented in table 5.

Table 5: Falling head permeability tests

S/NO	SAMPLE	PERMEABILITY(cm/c)
1	S/B 1	1.64×10^{-5}
2	S/B2	4.24×10^{-6}
3	S/B3	7.80×10^{-7}
4	S/B4	2.17×10^{-7}
5	S/B5	6.95×10^{-8}

Table 5 clearly shows that permeability by falling head test are in good agreement with that by consolidation tests for the ocean sand/betonite mixture.

CONCLUSIONS

While the coefficient of volume change is inversely proportional to the stresses, the coefficient of consolidation showed decrease pressure for lower bentonite content, little variations for higher bentonite content and mixed trend for intermediate bentonite content. Permeability result obtained from falling head Permeability tests are in good agreement with that obtained from consolidation test. In general, permeability reduced from about 10^{-4} cm/s to about 10^{-8} cm/s with addition of about 10% bentonite at optimum moisture content.

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