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Experimental Study on Water Retention Capacity of Lateritic Soil by Using Varying Percentage of Bentonite Clay

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Abstract - *Lateritic soil which is mostly found in Konkan region of Maharashtra state possess high percentage of sand content. Therefore rate of percolation is high in lateritic soil. On the other hand bentonite clay mainly found in Kacch region of Gujarat have high swelling property which control permeability rate. This paper investigates on effect on permeability of lateritic soil with uniformly varying percentage of bentonite clay in it. Experiment of constant head method of permeability test is carried out on sample of lateritic soil in which bentonite clay is added as percentile rate like 5%, 10%, 15%, 20%, 25%. The observations shows that as the rate of bentonite content increases, the permeability is decreases. 25% is the optimum level of bentonite clay content where permeability comes zero. Also to check effect on strength, UCS test is also carried out in this project*

Key Words: Lateritic soil, Konkan region, Bentonite clay, Swelling permeability test, UCS test.

1. INTRODUCTION

Lateritic soil is widely available in Konkan region. This red colored soil has many engineering as well as index properties. This soil is formed by sedimentation action of parent rock. High sand content in this soil makes it more pervious, resulting in high rate of percolation or infiltration. This type of soil is good for drainage purpose. But if we think about water retention capacity of this soil then we will get poor results. This tends to low cultivation of crops. Lateritic soil which comes in group like CL i.e. low compressible inorganic clay gives reverse result than mentioned above. It is observed that, such soil have high water retention capacity and less water retention capacity. This type of soil is not good for drainage purpose. The effect on water retention capacity can be studied by adding suitable percentage of Bentonite clay because of its high expansion property. Physiochemical properties of bentonite such as swelling, strength, cohesion, compressibility, plasticity, particle size, pore structure, cation exchange capacity, surface area as well as mineralogy can be affected from the acid activation, ion exchange, hydrothermal treatment, heating, and some other physiochemical processes. Bentonite clay is formed by weathering action of volcanic ash containing high amount of montmorillonite. A proper mixture of lateritic soil and bentonite clay can form a well stabilized strata having better seepage control property than lateritic soil alone. Bentonite has a good ability in absorbing, so it can be used to absorb organic matter, and Fe which contained in the peat water. To prove this, permeability test is carried out on various samples of lateritic soil having varying percentage of Bentonite clay. Addition of bentonite clay not only affect permeability but also change shrinkage limit and liquid limit also. This report shows various results of constant head and variable head permeability results with valid conclusions. For comparison black cotton soil is also used for permeability test. BC soil is a most expansive type of soil. It absorbs water and swell. Due to this water holding property this soil is suitable for agriculture but not good for foundation of any construction. Therefor for future scope some test are performed on BC.

2. MATERIALS AND METHODOLOGY

1. Lateritic soil

Lateritic soil used in this project is collected from Lavel village, Dist- khed, (Longitude 17.650524 Latitude 73.464473) in Maharashtra state. During Collection of soil it had high moisture content about 40-45% due to rainy season.

2. Bentonite clay

Bentonite clay used in this project is exported from "Rock Chem Pvt. Ltd" Bhivandi, Mumbai. Due to relatively high swelling property sodium Bentonite clay is used. It is yellowish gray colored.

3. Black cotton soil

This project is not based on Black cotton soil. Still we are doing one experiment on BC for future scope. It is imported from Patan city (Longitude 17.372704 Latitude 73.9027254), Dist Satara in Maharashtra State..

3. EXPERIMENTAL PROGRAM

1. Liquid limit

Test was performed in general accordance with the procedure described in IS 2720 part 5, 1985. For determination of liquid limit in the present studies, about 50 gm of soil passing at 425 microns sieve was taken and mixed with water to make creamy paste, in investigating soil

2. Compaction test

Test was performed in general accordance with the procedure described in IS 2720 part 7, 1980. The laboratory compaction test was conducted on investigating soils to get MDD and OMC of investigating soil.

3. Sieve analysis test

Test was performed in general accordance with the procedure described in IS 2720 part 12, 1981. The test was performed on investigating soil to get particle size distribution and classification of soil

4. Specific gravity test

Test was performed in general accordance with the procedure described in IS 2720 part 12, 1981. This test was performed to get specific gravity as well as density of investigating soil.

5. Permeability test

Test was performed in general accordance with the procedure described in IS 2720 part 12, 1981. While performing permeability test it was not convenient to perform variable head method because flow of water from the outlet of permeability mould is very slow. Therefore all the experiments were performed by constant head method. 1000 gm of soil sample passing from4.75 mm sieve was taken with uniformly varing percentage of Bentonite clay in lateritic soil like 5%, 10% 15% 20% and 25%. Also sample of only lateritic soil with 0% of Bentonite clay was taken.

Table-1: Specifications of specimen

Sr. no.	Specifications	Dimensions
1	Length	12.7 cm
2	Area	78.54 m^2

6. Unconfined compression test

Test was performed in general accordance with the procedure described in IS 2720 part 12, 1981. The sample was prepared with their optimum moisture content, by adding different content of sand like 10%, 20%, 30%, 40%, 50%, and 60%, the soil sample extruded from the sampling tube, in which it has been stored, and trimmed to suit a split mould of the required sample size.

Table-2: Specifications of specimen

Sr. no.	Specifications	Dimensions
1	Length	8.8 cm
2	Diameter	3.6 cm

4. RESULTS AND DISCUSSION

Basic properties of investigating soil was drawn from laboratory experiments and field experiments are as follow

Table-3: Basic properties of lateritic soil

Properties	**Lateritic soil**	**IS Codes**
Specific gravity, G	2.53	IS 2720 part III/Sec-1,1980
Liquid limit, w_L (%)	33%	IS 9256-1979
Plastic limit, w_P (%)	23.51%	IS2720 partV,1985
Plasticity index, I_P (%)	9.49%	
IS classification	CL	
Field density,(gm/cc)	1.24	
Maximum dry density, Yd_{max} (gm/cc)	1.446	IS2720 partVIII,1983
Optimum moisture content, W_{OMC} (%)	23%	IS2720 partVIII,1983
Gravel and sand (%)	83.4%	
Silt & Clay (%)	11%	

1. Permeability test

Effect on permeability in lateritic soil with varying percentage of Bentonite clay have been shown in below table. It is observed that as the percentage of bentonite clay increases, the permeability of soil decreases.

Table-4: variation of coefficient of permeability due to varying percentage of bentonite clay

Cofficient of permeability (x 10^{-6} cm/sec)	**Bentonite clay content (%)**
18.87	0
1.538	5
1.233	10
0.565	15
0.261	20
0.000	25

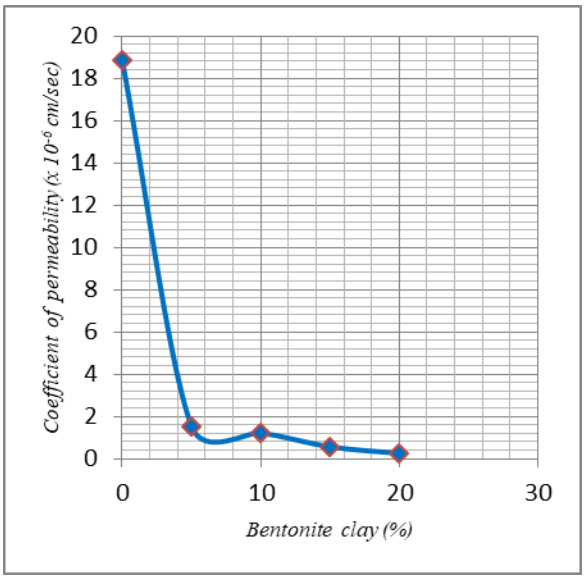


Chart -1: K vs Bentonite content (%)

The above graph clearly indicates that addition of Bentonite clay reduces the rate of percolation in lateritic soil. At pure lateritic soil, K value is 18.87 x 10-6 cm/sec whereas just 5 % addition of Bentonite clay reduces the K value to 1.538 x 10-6 cm/sec. that means there is 91% reduction in percolation by addition of 5 % bentonite clay. And further contamination of bentonite clay also reduces percolation in some extent. For 25% of bentonite clay content it is observed that after 48 hrs also there is no water obtained at the outlet of permeability mould. This indicates that no percolation is occurred for 25% percentage of bentonite clay.

Lateritic soil contains more than 80 % of particles which are greater than 425 micron. There is greater gap between two particles. As the percentage of Bentonte of clay increases this gap also filled up by bentonite particles. Due to property of montmorellonite mineral present in Bentonite clay, swelling is occurred and corresponding particles of lateritic soil get locked to each other. This creates a sealant layer which avoids passage of water through it. Therefore a layer of 120 mm thick of lateritic soil containing 25 % of Bentonite clay is able to resist seepage of water by 100%

2. Unconfined compressive strength (UCS) test

Addition of Bentonite clay is also affect the strength of soil. To prove this unconfined compressive strength test is performed and cohesion value is observed. Increasing cohesion value indicate increase in clay content which is adversely affect strength of soil.

Table-5: Effect on cohesion of lateritic soil with varying percentage of Bentonite clay

Cohesion (x 10^{-3} N/mm^2)	Bentonite clay content (%)
2.870	0
6.870	5
7.078	10
7.60	15
7.85	20
6.8	25

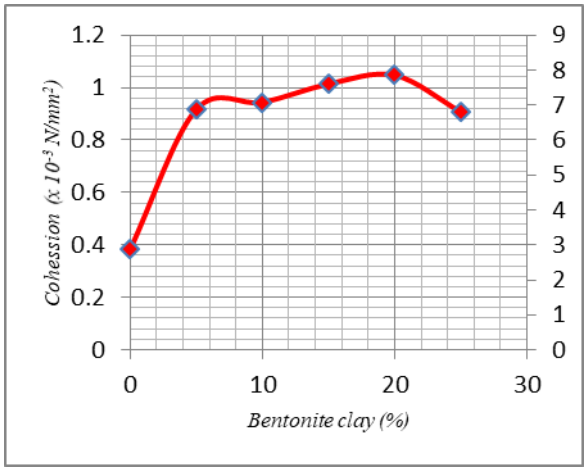


Chart -2: C vs Bentonite clay (%)

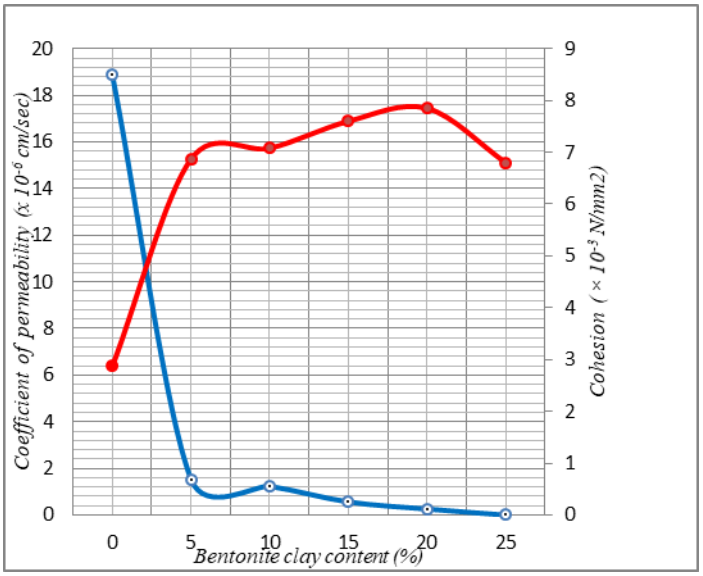
Discussion –

Variation of cohesion value of lateritic soil due to mixing of Bentonite clay in uniform proportion is shown in above graph. Pure lateritic soil shows less cohesion i.e. 2.87 x 10-3 N/mm2. After addition of 5 % Bentonite clay there is considerably increase in cohesion i.e. 6.87 x 10-3 N/mm2 that means there is approx. 140 % increment in cohesion. Also rate of cohesion remain increased with increase in bentonite clay. Cohesion affects the strength of soil. More cohesion, SBC of soil is less. By referring the above results a conclusion can be made as increase in the Bentonite clay content in lateritic soil decreases the strength of soil. Such soil is not suitable for foundation.

For comparison of cohesion with black cotton UCS test is performed on black cotton soil and cohesion was determined as C=7.41 ×10-3 N/mm2

The cohesion of pure black cotton soil is obtained as 7.41 ×10-3 N/mm2. In black cotton soil clay contain is very high. That's why cohesion value obtained is also high. By comparison with mixture of lateritic soil and bentonite clay cohesion of pure black cotton soil is nearly equal to cohesion of mixture of 10% bentonite clay with lateritic soil.

Fig -1: UCS test sample



Series 1 = line showing Coefficient of permeability (x 10^{-6} cm/sec)

Series 2 = Line showing Cohesion (× 10^{-3} N/mm^2)

Chart -3: Relation between permeability and cohesion with varying bentonite content

5. CONCLUSION

Several conclusions may be drawn based on this experimental study. Generally lateritic soil consist of sandy particles are more around 80%. Hence percentage of seepage loss is more in Konkan region around 35%. The additive material Bentonite clay acts as a binding material in between lateritic soil particles. From the permeability test (constant head test) the results noting that as the bentonite clay increases the rate of infiltration is decreases inside the soil body. Up to optimum level of bentonite clay in the mixture of lateritic soil, this is marginal and significant increase in the strength to minimize the air voids present in lateritic soil. Also a conclusion can be made on the basis of permeability test is a layer of 120 mm thick of lateritic soil containing 25 % of Bentonite clay is able to resist seepage of water by 100%. As the rate of permeability decreases due to Bentonite clay the cohesion of that sample increases up to 20% use of Bentonite clay. Further addition of Bentonite clay reduces value of cohesion.

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