EXPERIMENTAL STUDIES ON THE SOIL CHARACTERISTICS OF KUTTANAD AFTER FLOOD

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Abstract – *Kuttanad, the rice bowl of Kerala is well known for its very low shear strength and high compressibility. This very low shear strength is due to its high initial moisture content and plasticity. In this project, undisturbed soil samples were collected at different depths from Pallathuruthy, in Kuttanad region after flood. Different tests (natural moisture content, specific gravity, sieve analysis, Atterberg limits, Tri axial test, consolidation test etc) were done on the collected soil samples to determine the basic properties of soil. The bearing capacity and settlement of the soil samples were also found out. Different modes of failures in the buildings and its causes are identified properly. The possibilities of improving the suitability of soil as a foundation material are discussed in detail. Suitable remedial measures should be taken to overcome the situation economically.*

Key Words: **Clayey soil, unconfined compressive strength, Shear strength, Load Settlement.**

1. INTRODUCTION

Kuttanad comprises an area of about 900 sq.km in Central Kerala. The place is well known for its very low shear strength and high compressibility. The soil deposit in this region is a soft organic silt or clay formed by the slow silting up of an extensive backwater tract. The soil is in such a loose state that it is very treacherous as a foundation material. The problem is further aggravated by the monsonnic floods and the general behaviour of the crowded river and canal pattern. The depth of the loose deposits extends to more than 30 m in many places. Difficulties are encountered in laying good roads in the area to provide transport facilities. At many places road embankments have failed due to the poor bearing capacity of the sub-soil. Continuous settlements of road embankments are not uncommon. Designing foundations for bridges and other bearing structures is a highly complicated problem in this area and there has been many examples of failures or heavy settlements of built in abutments of bridges.

In this project, the soil samples were collected from Pallathuruthy, Kuttanad (Kerala, India) at different depths in Kuttanad region. Different tests (natural moisture content, specific gravity, sieve analysis, Atterberg's limit, tri axial test, consolidation test etc) were done on the collected soil samples to determine the basic properties of soil. The bearing capacity of the soil is also found out. Different modes of failures in buildings and its causes are identified. The possibilities of improving the suitability of soil as a foundation material are discussed in detail. Suitable remedial measures are suggested to overcome the situation economically.

1.1 Scope

- Identifies the soil properties affecting strength
- Compare the soil properties and identify the cause of failure and suggest remedial measures to overcome the situation economically
- Suggest a new foundation to be used instead of the present raft foundation to achieve a more beneficial foundation strength

2. LITERATURE SURVEY

In 2015, Suganya studied the effect of changing water content on the properties of Kuttanad soil. This paper brings out various mechanisms that control the changes in the properties of Kuttanad soil due to removal of water upon drying. The detailed studies conducted include microfabric imaging, analysis of porefluid and evaluation of the index properties of soil before and after drying[1]. An attempt was made to characterize the soil in terms of its mineralogy, fabric, organic matter, and pH in order to understand its geotechnical behavior and suggest a suitable ground improvement technique. It was found that the soil has a unique combination of minerals such as metahalloysite, kaolinite, iron oxides, and aluminum oxides[3]. Chakchouk [2] studied the physical properties of Tunisian clay samples from different locations. Clays rich in kaolinite have demonstrated the highest resistance and best pozzolanic activity. Hanifi [4] conducted a study on Stabilisation of clay with using waste beverage can. This work presents an investigation of the effect of waste aluminum beverage cans strips on strength and swelling properties of lean clay. Suganya[5] conducted the study on role of Sodium Silicate additive in cement treated Kuttanad soil. This study aims at understanding various parameters that influence the performance of the sodium silicate (SS) additive along with cement in treating the soft Kuttanad soil. The strength of the cement-treated soil improves with increasing dosage of SS additive, and the effect of adding SS along with cement as binder becomes more significant with reducing W/C ratios. The presence of the SS additive along with cement has a marked influence on the cement hydration process, leading to substantial strength development of treated soil. Rinku [8] studied the effect of flyash on strength behaviour of clayey soil. He discussed about stabilization which includes various methods for improving the engineering properties of soil. Stabilization is used to increase the strength or stability of soil. The increase in UCS at 6% flyash was 10.9%. The use of flyash as a stabilizer with soil is a cost effective and environment friendly technique to make the soil mixes strong.

Ravi [6] studied to enhance the clay soil characteristics using copper slag stabilization. This paper investigates the feasibility of utilizing the industrial by-product copper slag as a stabilizer in the expansion soil where swelling characteristics are higher and causes severe damage to the structure and road pavement.

However, from the previous studies, it is clear that no effort is taken to judge the quality and suitability of locally available clayey soils for the fabrication of geopolymers. From the study on the composition and fabric of Kuttanad clay by K Suganya [5], it was found that soil has unique combination of Metahalloysite, Kaolinite, Iron and Aluminium oxides. Almost all clayey soils contain aluminosilicates which are the main constituent of geopolymer. Hence more chances are there for fabricating geopolymers with comparable strength and durability. Kuttanad comprises an area of about 900 sq.km in Central Kerala. The place is well known for its very low shear strength and high compressibility. The soil deposit in this region is a soft organic silt or clay formed by the slow silting up of an extensive backwater tract. The soil is in such a loose state that it is very treacherous as a foundation material. The problem is further aggravated by the monsonnic floods and the general behaviour of the crowded river and canal pattern. The depth of the loose deposits extends to more than 30 m in many places. Difficulties are encountered in laying good roads in the area to provide transport facilities. At many places road embankments have failed due to the poor bearing capacity of the subsoil. Continuous settlements of road embankments are not uncommon. Designing foundations for bridges and other bearing structures is a highly complicated problem in this area.

3. METHODOLOGY

3.1 Materials

The geotechnical properties of soil samples were tested as per Indian Standard specification (IS 2720) and as shown in table 1. Undisturbed Soil samples at different depths in Pallathuruthy,(Kuttanad) were collected using a PVC pipe of diameter 10cm and 30cm in height. The undisturbed samples collected from the site were transported to the laboratory after being closed using end gaps on either side, sealed in plastic bags then wrapped in gunny bags, ensuring minimum moisture changes during transportation.

Sl No	Properties	S1	S2	S3	S4	S5	S6
1	Water Content %	47	68	117	127	131	185
2	Specific Gravity	2.51	2.49	2.47	2.46	2.44	2.39
3	Soil Classification	CH	CH	CH	CH	CH	CH
4	Liquid Limit %	90	112	122	130	143	186
5	Plastic Limit %	29	33	37	40	44	50
6	Plasticity Index %	61	79	85	90	99	136
7	Dry Density (g/cc)	1.35	1.16	0.89	0.85	0.72	0.55
8	Field Density(g/cc)	1.98	1.93	1.93	1.93	1.67	1.57
9	Bearing Capacity (kN/m^2)	129	105	65	62	60	66
10	Cohesion (kN/m^2)	6.0	6.8	8.0	9.50	10.2	11.0
11	Angle of Internal friction (Φ)	17^o	14^o	6^o	3^o	2^o	2^o
12	Settlement(mm)	37	48	62	102	128	130

Table -1: Basic Properties of Soil

3.2 Collection of soil samples

The materials required for the experiment were (undisturbed) soil samples at different depths in Pallathuruthy, (Kuttanad). They were collected using a PVC pipe of diameter 10cm and 30cm in height. The undisturbed samples collected from the site were transported to the laboratory after being closed using end gaps on either side, sealed in plastic bags then wrapped in gunny bags, ensuring minimum moisture changes during transportation.

Fig- 1: Collected soil using PVC pipe

The soil samples were collected from six different depths like (0.5m,1.0m,1.5m,2.0m,2.5m,3.0m)from the top ground surface. Hence there were six different samples named S1, S2, S3, S4, S5 and S6. These undisturbed soil samples were collected using core cutter method only.

Fig- 2: Collected soil samples from six different depths

4. STRENGTH - SETTLEMENT CHARACTERISTICS

4.1 Physical properties of clay

The basic properties of the soil samples taken from the Pallathuruthy, Kuttanad were determined. The properties like field density, dry density were determined. Also the test index properties like liquid limit, plastic limit and plasticity index were found. The index properties and engineering properties of the undisturbed soil sample is calculated and represented in table 1.

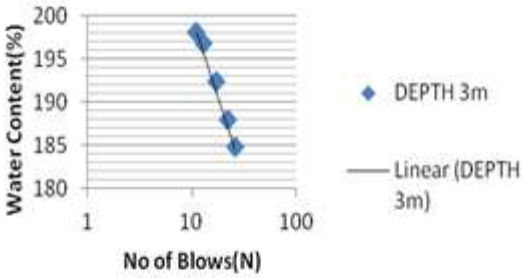

Fig- 3: Flow curve for 3.0 m depth soil sample

In order to find out the Atterberg limits the flow curve were drawn for all the six depths collected soil samples. The flow curve obtained in case of 3.0m depth is as shown in figure 3. The liquid limit was found to be 186% with a plasticity index of 136%. The plastic limit of the soil sample was found to be 50%.

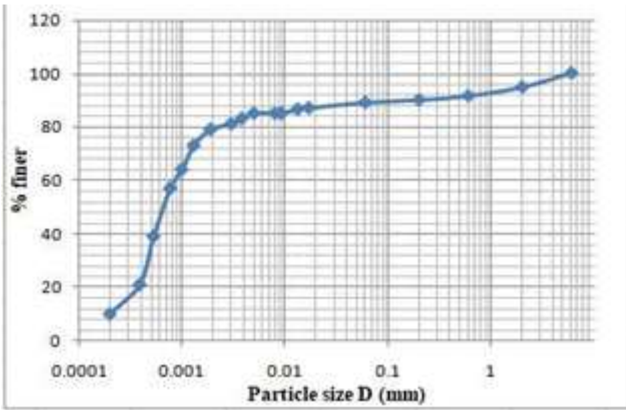

Fig- 4: Particle size distribution curve

The soil samples collected were subjected to hydrometer analysis and the particle size distribution curve of all the samples were found as shown in figure 4. From the %finer v/s particle size graph the percentage of clay particles were found to be 78%, silt 16% and that of sand were 6% respectively. Accordingly, the undisturbed soil samples collected at different depths were classified as CH(Clay of high compressibility) also.

4.2 Strength characteristics of Kuttanad clay

In case of clayey soil its strength plays a vital role in its usage. For finding out the strength characteristics of Kuttanad clay, tri axial test is preferred. The tri axial test of the six soil samples were done and found that the sample bulged suddenly on the application of load with increase in depth value as shown in figure 5.

Fig- 5: Bulging of soil sample in tri axial test

After conducting the tri axial test, Mohr circles were drawn for each of the undisturbed soil samples collected at different depths as shown in figure 6. The value of cohesion and angle of internal friction were obtained from the graph. With the utilization of these two shear parameters Bearing Capacity of the soil samples were found using Meyerhof's Bearing Capacity Theory for the individual depths considered. The value of cohesion and angle of internal friction obtained is shown in table 1 respectively.

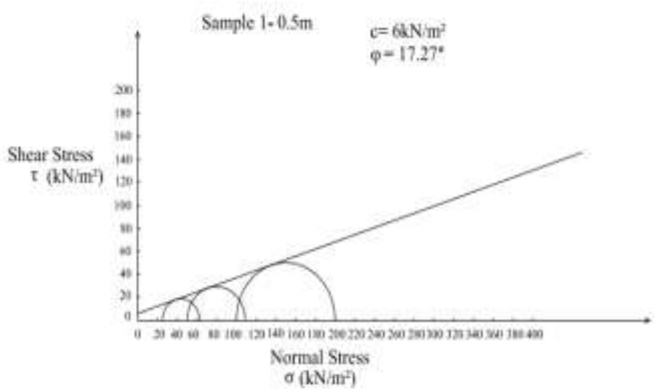

Fig- 6: Mohr Circle of soil sample in tri axial test

4.3 Consolidation characteristics of Kuttanad clay

Using the 1D consolidation test the settlement characteristics of the Kuttanad clay can be found easily. The results of the consolidation test conducted and the corresponding settlement values of each layer are as shown in table 1.

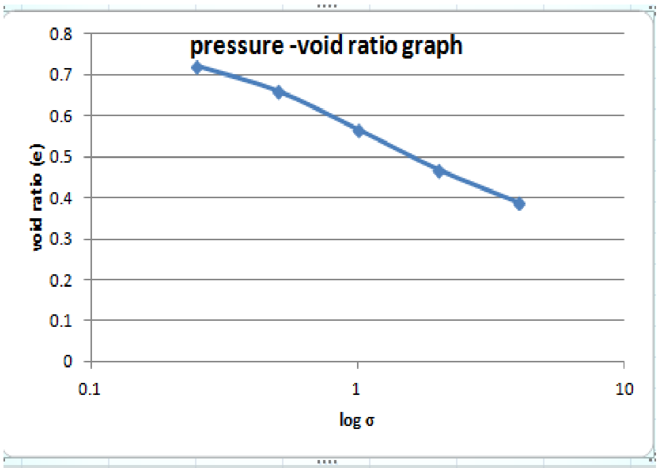

Fig- 7: Pressure - void ratio graph

The value of compression index (C_c) is obtained from the slope of the graph shown in figure 7. After obtaining the value of compression index, settlement values for each layer can be computed easily.

The settlement of each layer of soil sample were found using the settlement equation for 1D consolidation respectively. The settlement values for all the six depths of soil samples were found to be 37mm, 48mm, 62mm,102mm, 123mm, 130mm respectively. With the increase in depth of the soil sample the settlement values were also increasing accordingly . Hence the total settlement was found to be 502mm, which is one of the major reasons behind the failure of the structure.

5. CONCLUSIONS

In order to judge the suitability of Kuttanad clay on the basis of its strength and settlement characteristics , the undisturbed soil samples were collected from different depths and a series of physical property tests , strength tests and settlement values were found accordingly. The following conclusions can be drawn from this work: -

1. No large variations were seen in field density and specific gravity along the vertical soil profile of the undisturbed soil samples collected.
2. The liquid limit values obtained after conducting the test was found to high (186% for 3m depth) ie,

LL increases with the increase in depth. They were found to be proportional.

3. Both plastic limit as well as plasticity index increased with the increase in depth of the soil samples collected by core cutter method.
4. The soil samples obtained from every depth were classified as CH ie, clay of high compressibility respectively.
5. The bearing capacity of the soil samples were found using Meyerhof's bearing capacity equations and found that the bearing capacity decreases with the increase in depth of the soil sample. The bearing capacity of the 3m depth soil sample was 66kN/m^2, much lower than the 0.5m depth soil sample.
6. Settlement value obtained for the lower layer was very high compared to the top layer of soil samples collected. Total settlement was found to be in a range of 502mm, which contributed the major reason for the failure of the structure.

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