STUDY ON SWELL BEHAVIOUR OF SOIL ON PH VARIATION

Fathima Shajahan[1], Joe G Philip[2]

[1]M Tech Student, Department of Civil Engineering, Saintgits College of Engineering, Kottayam, Kerala, India.
[2]Assistant Professor, Department of Civil Engineering, Kottayam, Kerala, India.

Abstract - *An expansive soil shows high volumetric changes with changes in water content. Expansive soil deposits are problematic for engineering structures because of their swelling. These soils occurring above the water table swell with increase in moisture content and shrink with decrease in moisture content. Soil pH is considered a master variable in soils as it affects many chemical processes. Soil pH is a measure of the acidity or alkalinity of a soil. The optimum pH range for most plants is between 5.5 and 7.5. The effect of cyclic swell on pH variation and its strength is analysis in this project. It was found that prolonged interaction with both acid and alkali solutions lead to significant changes in swell behaviour of expansive soil. Shear strength of expansive soil was found to be increase with increase of pH value.*

Key Words: Black cotton soil, Soil pH, Shear strength, Tri-axial test, Swell test.

1. INTRODUCTION

An expansive soil shows high volumetric changes with changes in water content. When they imbibe water during monsoon, they expand and on evaporation thereof in summer, they shrink. Because of this alternate swelling and shrinkage, structures founded on them are severally damaged. Expansive soil deposits are problematic for engineering structures because of their swelling and shrinkage. These soils occurring above the water table swell with increase in moisture content and shrink with decrease in moisture content. This swell-shrink behaviour causes differential movements accompanied by strength reduction, causes severe damage to the foundation and to the structures which are founded on these types of soils. The predominant reason for this swell shrink behaviour is seasonal variations as the soil swells during rainy season and shrink during summer.

The shrink–swell capacity of clay refers to the extent certain clay minerals will expand when wet and retract when dry. Soil with a high shrink–swell capacity is problematic and is known as shrink–swell soil, or expansive soil. The amount of certain clay minerals that are present, such as montmorillonite and smectite, directly affects the shrink-swell capacity of soil.

Soil pH is a measure of the acidity or basicity (alkalinity) of a soil. pH is defined as the negative logarithm (base 10) of the activity of hydronium ions (H+ or, more precisely, H_3O^+ aq) in a solution. In soils, it is measured in a slurry of soil mixed with water (or a salt solution, such as 0.01 M $CaCl_2$), and normally falls between 3 and 10, with 7 being neutral. Acid soils have a pH below 7 and alkaline soils have a pH above 7. Ultra-acidic soils (pH < 3.5) and very strongly alkaline soils (pH > 9) are rare.

1.2 Objective

The main intent of the study is to find the swell behaviour of expansive soil on pH variation. The objective formulated for the study are:

- To analysis the swell behaviour based on pH.
- To determine swell index.
- To determine shrinkage index of soils with different pH.

2. LITERATURE SURVEY

Han-Yong Jeon (2017) has analyzed temperature effects and pH value on free swell behaviors of bentonite solutions. Swelling behaviors of powder and granular type sodium bentonites in permeate solutions such as NaCl, KCl, $MgCl_2$, $CaCl_2$, distilled water and in HCl and NaOH (with different pH values) under different temperatures were investigated. . Powder type sodium bentonite showed higher swells volume than granular type bentonite.

Sachin N. Bhavsar and Ankit J. Patel (2014) has conducted analysis of swelling & shrinkage properties of expansive soil using brick dust as a stabilizer. In this paper they have performed stabilization on expansive type of soil with marble dust which is a waste material and also widely available in large quantity.

Ravi Sharma et.al (2017) has studied impact of cyclic wetting and drying on swelling behaviour of stabilized and non-stabilized soil. The expansive soil in this study was amended by sand which reduced the swell-shrink potential significantly. Swelling of clay minerals is directly related with diffused double layer and cation exchange capacity.

Sangit P. Lajurkar et.al (2013) has conducted an experimental study on shrink- swell behaviour of expansive soil. Extensive research work has been done on expansive soil but an important aspect of the expansive soil mass is the volume reduction or shrinkage exhibited on drying is appears to be inadequately investigated in the available literature.

Masoumeh Mokhtari and Masoud Dehghani (2012) studied swell-shrink behavior of expansive soils, damage and control. Maher Omara et.at (2016) modification of the swelling characteristics of bentonite clay using alum.

Ponnapureddy Hari Prasad Reddy et.al (2017) studied swelling of natural soil subjected to acidic and alkaline contamination. A series of laboratory one dimensional free swell tests were performed to study the behaviour of soil in acidic and alkaline environment.

3. MATERIALS

The expansive soils are identified in alluvial plains, terraces and undulating plains of Chittur taluk in Palakkad district in patches. The elevations of the area ranges 100 to 300m above MSL with gentle to moderate slope and shown in fig 3.1. These soils are very deep, black and calcareous. The texture of the soil ranges from clay loam to clay. They possess high shrink-swell capacity and hence exhibit the characteristic cracking during dry periods.

Fig – 1: Black cotton soil

3.1 Aqueous Solutions

In this study, distilled water along with solutions of sodium hydroxide (NaOH) and sulphuric acid (H2SO4) of known concentrations were used as pore fluid. Sodium hydroxide solution of known concentrations of 1N was prepared by dissolving required molecular weights 40g of analytical grade sodium hydroxide pellets in distilled water to make 1 liter of solution. Similarly, commercially available sulphuric acid by required volume 27.25ml was diluted with distilled water to make one liter of solution of known concentrations of 1N.

4. RESULTS AND DISCUSSIONS

4.1 Properties of Soil

The basic properties of the soil sample taken were determined. The index properties and engineering properties of the untreated soil sample is calculated. They are listed in table 1.

Table-1: Physical properties of black cotton soil

Parameters	Description
Liquid Limit (%)	59
Plastic Limit (%)	28
Shrinkage Limit (%)	15
Plasticity Index	31
Specific Gravity (G)	2.6
Swell Index	36
Optimum moisture content (OMC) (%)	26
Maximum dry density (MDD)(g/cc)	1.6
Soil pH	6.8

4.2 Grain Size Analysis

The percentage of gravel, sand, silt and clay as obtained from hydrometer analysis were tabulated. It was found that the sample is very soft clay with 52% clay and 18% silt. The sample is found to be CH. The gradation curve is shown in chart – 1.

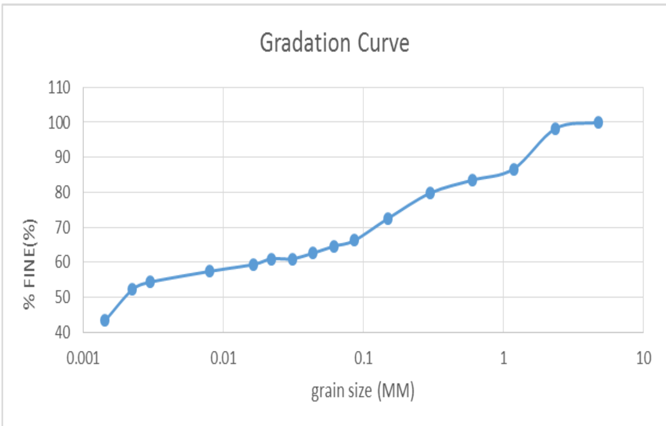

Chart -1: Gradation curve

4.3 Standard Proctor Test

Maximum dry density was obtained as 1.6g/cc corresponding optimum moisture content as 26 %. The compaction curve is as shown in chart - 2.

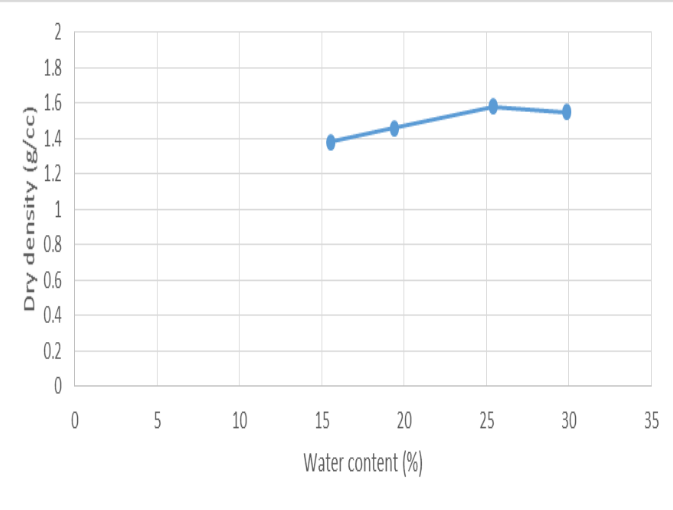

Chart -2: Compaction curve

4.4 Atterberg's Limit

It is widely accepted that liquid and plastic limit tests are very important geotechnical tests which can give valuable information about the engineering behaviour of fine-grained soils. The liquid limit is an indicator of the quantity of water held as double-layer water; a change in the liquid limit is related to a change in the double-layer thickness. Liquid limit is defined as the percentage weight of oven dried soil at the boundary between the liquid and plastic states of consistency. The moisture content corresponding to the intersection of flow curve with the 25 blow ordinate is the liquid limit of the soil. It is done as per the procedure given in IS 2720 (part V). It is determined using Cassagrande apparatus. The number of blows required to plot the graph were then determined. The moisture content corresponding to each number of blows taken were determined using oven dry method. Liquid limit is then determined from the graph thus plotted. The plastic limit of soil is the moisture content, expressed as a percentage of weight of oven dried soil, at the boundary between the plastic and semi-solid states of consistency. It is the moisture content at which the soil will just begin to crumble when rolled into a thread of 1/8 inch (3 mm).

From the results obtained it is observed that the increase in pH resulted in the decrease of liquid limit. The trend is similar in both acidic range and alkaline range, liquid limit is increasing with decrease in pH. At lower pH flocculation of particles increases, thus liquid limit increases. In the acidic range, a decreasing trend in the values of liquid limit is observed with increase in the hydrated ion radius. In the alkaline range with decrease in hydrated ion radii, liquid limit is found to increase in both lower pH and higher pH. The variation has been tabulated in the table - 2.

Table – 2: Variation of Atterberg with pH

pH value	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index (%)	Shrinkage Limit (%)
2	70	44	26	22
5.5	64	39	25	19
7	59	35	24	15
10	50	28	22	11
12	46	27	19	8

4.5 Swell Test

The swell in expansive soil is due to the high clay content and presence of swelling mineral. Prolonged interaction with both acid and alkali solutions lead to significant changes in swell behaviour of expansive soil. In case of alkalis, free swell is higher, more than that of water, whereas in case of acids the opposite trend is observed. These variations in free swell are mainly due to the influence of pore fluid on the mineral composition of soil. Swell index value with variation of different range of pH has been tabulated in table - 3.

Table – 3: Swell index with pH

pH Values	Swell Index
2	20
5.5	32
7	36
10	46
12	82

5. STRENGTH DETERMINATION

5.1 Tri-axial Test

Tri-axial test were conducted on all samples and the shear strength variation for different samples were found.

Shear strength of expansive soil is increase with increase of pH value. So if we want to increase shear strength of acidic soil we have to increase pH value. The most common amendment to increase soil pH is lime. A notable increase in undrained shear strength was observed for low and high pH values. At an acid pH, this behaviour could be related to the increased dissolution of Al_3, which acts as a coagulant increasing the internal resistance, whereas at an alkaline pH, the increasing ionic strength favours face to-face aggregation. The shear strength variation on pH value is tabulated in table - 4 below.

Table – 4: Shear strength with pH

pH value	Cohesion (C)	Angle of internal friction(φ)	Shear strength (kN/m²)
2	24	4	30
5.5	26	5	35
7	28	6	39
10	31	8	45
12	34	10	52

After completion of this project, it was found that the shear strength and free swell was increasing with increase in pH value, whereas the liquid limit is found to be decrease with increase of pH and this variation are shown in chart -3.

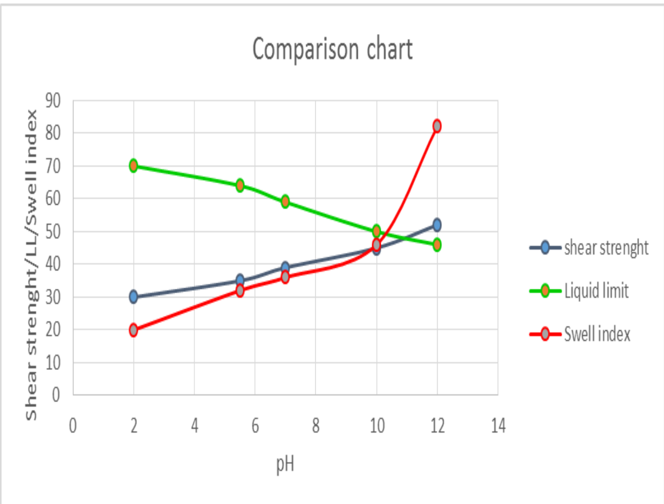

Chart- 3: Comparison chart

6. CONCLUSIONS

Based on the obtained experimental results, the following conclusions can be drawn:

- Liquid limit was found to be decreased as pH increased.
- The plasticity index is of lesser importance. There is no distinct trend in changes of plasticity index with pH were observed. Change in pH does not cause significant variations in the plasticity index.
- The plastic limit is thus more directly related to liquid limit than plasticity index.
- Prolonged interaction with both acid and alkali solutions lead to significant changes in swell behaviour of expansive soil.
- Shear strength of expansive soil is increase with increase of pH value.

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