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STUDIES ON CONTAMINATED SOIL-ACIDS AND ALKALIES

[1]GADDIPALLI SHRAMIKA, [2]DR. V. SAI KUAMR,
[1]Assistant Professor, [2] Assistant Professor,
[1]Department of Civil Engineering
[1]Chaitanya Engineering College, [2]GITAM, Andhra Pradesh, India

Abstract: Soil is a mixture, organic matter, gases and liquids. There are different types of soils based on their structure and composition. Soil characteristics vary when acid or alkali present in it. The present project emphasizes on the effect of acid and alkali on marine clay and red earth. This project also deals with diffusion double layer of ions surrounding colloidal and soil clay particles which is a major problem of soil chemistry. The prime focus of this project is to determine variation in properties such as liquid limit, plastic limit compaction. H_2SO_4 and NaOH are made of different Normality's 0.1N, 1N, 2N, and 4N respectively. These are added to samples of red earth and marine clay and tested for 7 days and 14 days. Results are tabulated and presented graphically.

Index Terms- Acids, Alkalies, Red earth, Marine clay.

I. INTRODUCTION

Soil is the mixture of minerals, organic matter, gases , liquids , and myriad organisms that together support plant life. Two general classes are topsoil and subsoil. Soil is a natural body that exists as part of the pedosphere and which performs four important functions. It is a medium for plant growth. Soil is considered to be the "skin of the earth" with interfaces between the lithosphere, hydrosphere, atmosphere of Earth, and biosphere. Soil consists of a solid phase (minerals and organic matter) as well as a porous phase that holds gases and water. Accordingly, soils are often treated as a three-state system. Soil is the end product of the influence of the climate, relief (elevation, orientation, and slope of terrain), biotic activities (organisms), and parent materials (original minerals) interacting over time. Soil continually undergoes development by way of numerous physical, chemical and biological processes, which include weathering with associated erosion.

1. Red Soils:

These are derived from weathering of ancient metamorphic rocks of Deccan Plateau. Its redness is due to iron composition. When iron content is lower it is yellow or brown. They cover almost the whole of Tamil Nadu, Andhra Pradesh, Chhattisgarh, Karnataka, Maharashtra and parts of Orissa.

Red soil

Marine clay

2. Marine clay:

This is a type of clay found in coastal regions around the world. In the northern, deglaciated regions, it can sometimes be quick clay, which is notorious for being involved in landslides.Clay particles can self-assemble into various configurations, each with totally different properties. When clay is deposited in the ocean, the presence of excess ions in seawater causes a loose, open structure of the clay particles to form, a process known as flocculation. Once stranded and dried by ancient changing ocean levels this open framework means that such clay is open to water infiltration. Construction in marine clays thus presents a geotechnical engineering challenge.

II. LITERATURE SURVEY

(A) Effect of Chemicals on Geotechnical Properties of Clay Liners: A Review(2010)- Seracettin Arasan

Description: This study presents a review of recent research on the geotechnical properties (consistency limits, hydraulic conductivity, shear strength, swelling, and compressibility) of clay liners conducted with organic and inorganic chemicals. Due to its low permeability, a clay liner is the main material used in solid waste disposal landfills. It is exposed there to various chemical, biological and physical events, and the clay liner is affected by the resulting leach ate. The geotechnical properties of clay liners are closely related to the chemistry of the leach ate. Therefore, when attempting to define the geotechnical characteristics of clay liners, the use of distilled water or tap water is far from being representative of the in-situ conditions.

(B) Effect of Soil Pollution on Geotechnical Behavior of Soils(2009)P.V. Sivapullaiah Professor

Description: Ground pollution arises from the impact of past and current industrial activity and due to improper disposal of waste generated by society. Geo environmental engineering deals with the most important aspects: (a) Soil pollution processes and effect on geotechnical properties, and (b) Waste Management. Soil-pollutants interaction changes soil behaviour and also can lead to various geotechnical problems. Attempts to understand the soil response to various pollutants and available methods to control the same are presented. While the changes in the behaviour of soil contaminated with variety of pollutant in the absence of strong interaction, the behaviour of soil interacted with contaminants leading to mineralogical changes is only getting attention recently. The effect of sulphate on different fine grained soil in alkaline and acidic environment is presented.

(C) Determination of Sulphate Content in Marine Clays (2006) Anitha G Pillai, Benny Mathews Abraham, A. Sridharan

Description: Improving the engineering behavior of soft clays using lime has been used for several decades. Even though chemical stabilization of clays has proved to improve the engineering properties, problems arise when calcium – based stabilizers are used in soils rich in sulphate bearing minerals. Therefore lime stabilization technique should be cautiously applied in sulphate enriched environment or in marine clays containing sodium sulphate. Sulphate content is thus clearly the most important property to consider when evaluating such soils as foundation medium or for construction purposes. Thus the key issue in deciding how to properly stabilize sulphate bearing soils using lime is to efficiently determine the sulphate content of soils and to determine the threshold quantity of sulphate likely to cause damage. This paper focuses on a comparison of different methods used to quantify sulphate in soils.

III. MATERIALS USED

In this chapter different materials and methods has been used

1. Red earth.
2. Marine clay.
3. Sulfuric acid.(H_2SO_4)
4. Sodium hydroxide.(NaOH)

IV. METHODOLOGY

- Liquid limit test of soil using cone penetrometer method (IS-2720-part-5-1985)
- Plastic limit test of soil (IS-2720-part-5-1985)
- Light/standard proctor compaction test of soil (IS-2720-part-7-1980)

V.EXPERIMENTAL INVESTIGATION

Atterberg's limits and related indices have become very useful characteristics of assemblages of soil particles. The limits are based on the concept that a fine-grained soil can exist in any of four states depending on its water content. Thus a soil is solid when it is dry, and upon addition of water it proceeds through the semi solid, plastic and finally liquid states. The water contents at the boundaries between adjacent states are termed shrinkage limit, plastic limit and liquid limit. The Atterberg's limits and related indices have proved to be very useful for soil identification and classification. They are extremely useful initial indicators of soil behavior for fine-grained soils. There is correlation between Atterberg's limits and shear strength, sensitivity, compressibility, etc. Atterberg's limits along with grain size distribution, specific gravity and density of solids are intrinsic soil characteristics that do not change over the life of a soil unlike void ratio, strength etc that may change due to application of loads and other external influences (*Lutenegger and Cerato 1992).*

The plasticity index, indicating the magnitude of water content range over which the soil remains plastic, and the liquidity index, indicating the nearness of as natural soil to the liquid limit, are particularly useful characteristics of soil. Liquid limit is regarded as the minimum water content at which soil behaves like a liquid. The liquid limit is considered as measure of water holding capacity of a given soil and is controlled by diffuse double layer forces and/or the shear resistance at particle level. All soils will have the same strength at liquid limit (*Sivapullaiah and Sridharan, 1985).* Plastic limit is regarded as the minimum water content at which soil behaves like a plastic material. Plasticity index is different between liquid limit and plastic limit. The liquid limit and plastic limit depends on both the type and amount of clay, but the plasticity index depends to a first approximation only on the amount of clay present. Their inter-relation can thus give information both about the type and amount of clay. Compressibility of soil increases markedly with increasing plastic limit, where as the soil's strength decreases. On the other hand, the strength of soil increases with increasing plasticity index.

VI.RESULT AND DISCUSSION

Effect of Acid & Alkali on Atterberg's Limits:

The significance of Atterberg's limits is explained in above section. To determine the effect of acid and alkali on the Atterberg's limits of soils, liquid limit and plastic limit tests were conducted using 0.1N , 1N, 2N and 4N concentration of sulphuric acid (H_2SO_4) and sodium hydroxide (NaOH) along with water as pore fluid. The samples were treated for 7 days and 14 days curing period at 1:2 ratios. The results of the tests are presented below.

Properties of Original Samples: The properties of the two soils (Red Earth and Marine Clay) used in this study were determined for the soil fraction passing 425 µm sieves and the results are summarized in table

properties of original soil samples:

PROPERTIES	RED EARTH	MARINE CLAY
Liquid limit(LL)%	24.6	69.6
Plastic limit(PL)%	13.3	30.2
Max.dry unit weight(KN/M3)	19.5	14.6
Optimum water content(%)	28.6	10.8

EFFECT OF ACID ON ATTERBERG'S LIMITS

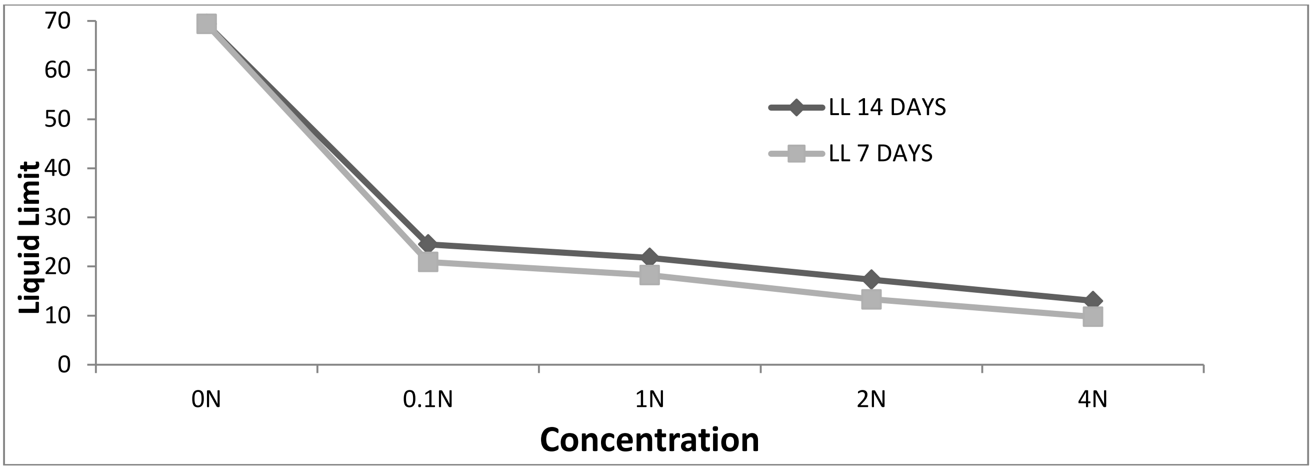
1.1 LIQUID LIMIT VARIATION OF MARINE CLAY WITH ACID: graph 1 the variation of liquid limit for various concentrations of acid in the pore fluid for marine clay after the contact periods of 7 days and 14 days. It is observed from figure that with increase in concentration of acid the liquid limit decreases for both contact periods. A reduction in liquid limit is generally due to increase in electrolyte concentration of the pore fluid and consequence decrease in the thickness of double layer developed. *Sanjeev Singh and Arun Prasad* also observed similar behavior with respect electrolyte concentration. However from figure it is observed that the decrease is rapid up to 0.1N and then it decreased gradually up to 4N. This indicates that, maximum electrolyte effect can be seen at lower concentration only. Any further increase in concentrations of ions will be present as free ions in bulk liquid showing marginal variations in liquid limit.

Further, it is observed that the reduction in liquid limit is higher for 14 days than 7 days contact period. This decrease in liquid limit with increase in contact period may be because of sufficient time for acid attack along with electrolyte effect. The acids attack clay particles at edges and releases Al ions (*Kenneth Torrence and Maria Prinat 1984).* There will be marked changes due to acid attack in the crystal structures of a*luminosilicate* of the structural minerals because of dissolution of structural ions and/or rearrangement of the structure (Grzegorz Jozefaciuk and Grzegorz Bowanko 2002). The results of liquid limit variation for marine clay with different concentrations of acids are tabulated in table 1

Table 1 Liquid limit of marine clay with concentration of acid and curing period

Acid concentration (N)	Liquid limit (%)	
	7 days	14 days
0.0	69.4	69.4
0.1	24.5	20.91
1.0	21.78	18.26
2.0	17.34	13.34
4.0	13.00	9.78

Graph 1 Effect of acid concentration on liquid limit of marine clay for different curing period

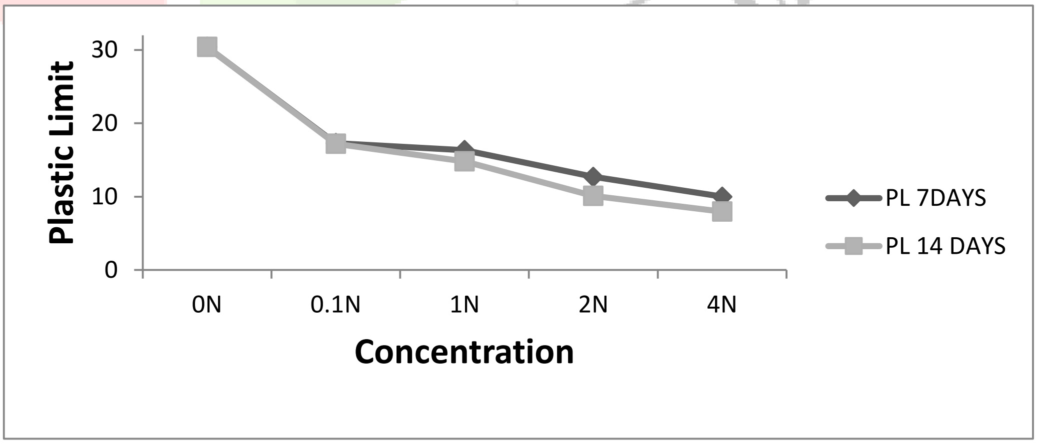


1.2 PLASTIC LIMIT VARIATION OF MARINE CLAY WITH ACID :

Graph 2 the variation of plastic limit for various concentrations of acid in the pore fluid for marine clay after the contact periods of 7 days and 14 days. From figure it is observed that the plastic limit of soil decreased with increase in the concentration of acid. The variations in plastic limit are generally in consistent with explanation given for their variations in liquid limit. However the decrease with 0.1N acid is same for different contact period, which indicates that the acid concentration is not sufficient for the increase in the loss of plasticity of the soil with contact period. The results obtained are tabulated in table 2

Table 2 plastic limit variation (marine clay)

Acid concentration (N)	plastic limit (%)	
	7 days	14 days
0.0	30.4	30.4
0.1	17.3	17.21
1.0	16.34	14.1
2.0	12.7	10.11
4.0	10.00	7.98



Graph 2 Effect of acid concentration on plastic limit of marine clay

1.3 EFFECT OF ALKALI ON ATTERBERG'S LIMITS:

The importance of Atterberg's limits is very well recognized. The reason is that the tests are relatively simple and the results can be correlated with various soil properties or parameters like surface area, mineralogy, activity, swelling behavior, and to use these correlations for purpose of checking new data/or to predict soil behavior for design work. Understanding the mechanism of change in Atterberg's limits of soils due to alkali interaction would be of great use to explain the variations in their geotechnical properties.In order to assess the behavior; tests were conducted after curing for different time period on thoroughly

mixed sample of marine clay with water and different concentration of alkali solution. The two basic mechanisms that affect the properties of alkali treated soil are: i) through increased pH which increases the negative charges on clay particles and causes repulsion of clay particles, ii) through increased electrolyte concentration which reduces the diffuse double layer repulsion and brings the particles closer.

1.4 LIQUID LIMIT VARIATION OF MARINE CLAY WITH ALKALI:

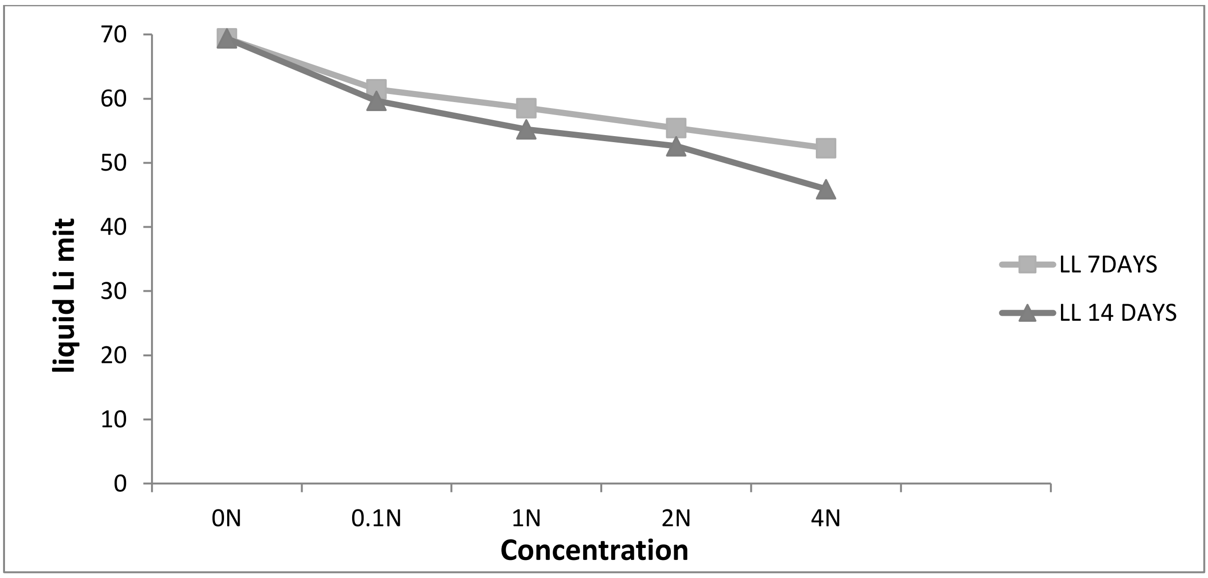
The variation of liquid limit for various concentrations of alkali in the pore fluid for marine clay after the contact periods of 7 days and 14 days. It is observed from figure that with increase in concentration of alkali the liquid limit decreased for both contact periods. The data shown in table 4 indicates that the decrease in liquid limit is gradual with different concentrations of alkali. This gradual decrease in liquid limit is generally due to electrolyte effect which reduces the diffuse double layer repulsion and brings the particle closer as explained earlier.

Further, it is observed that the reduction in liquid limit is higher for 14 days than 7 days contact period. This decrease in liquid limit with increase in contact period may be due to dissolution of silicates present in the soil at higher contact period. Slightly lesser liquid limit value (46%) at 4N alkali for 14 days compared to initial liquid limit value for water (69.4%) clearly indicates that the dissolution has taken place at higher concentration at longer duration of interaction.

Table 3 liquid limit variation (marine clay)

Alkali concentration (N)	Liquid limit (%)	
	7 days	14 days
0.0	69.4	69.4
0.1	61.45	59.67
1.0	58.53	55.21
2.0	55.41	52.6
4.0	52.3	45.9

Graph 3 Effect of base concentration on liquid limit of marine clay for different curing period

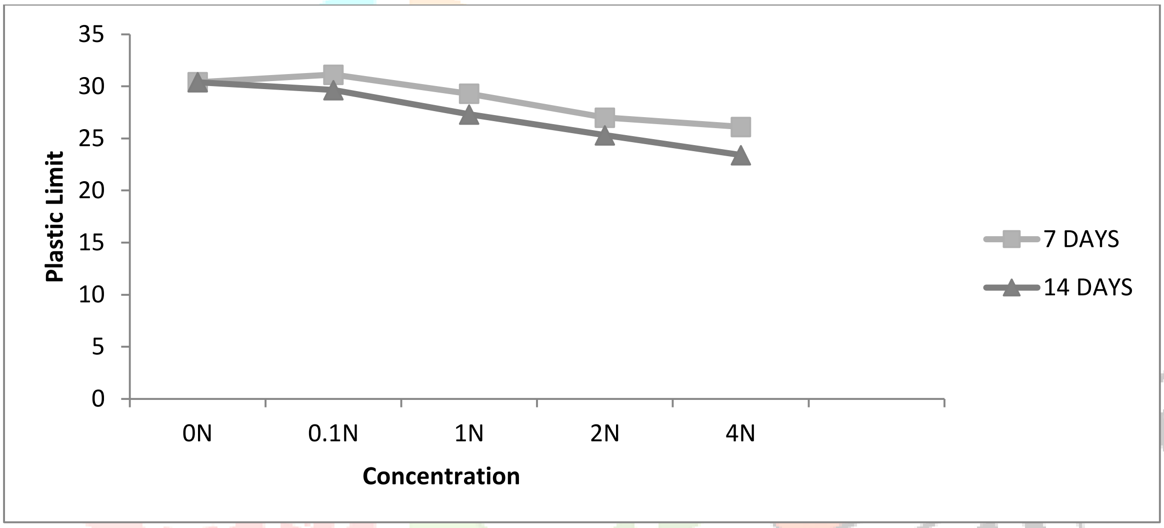


1.5 PLASTIC LIMIT VARIATION OF MARINE CLAY WITH ALKALI:

The variation of plastic limit for various concentrations of alkali in the pore fluid for marine clay after the contact periods of 7 days and 14 days. From figure it is observed that the plastic limit of soil decreased with increase in the concentration of alkali. The variations in plastic limit are generally in consistent with explanation given for their variations in liquid limit. However the results tabulated in table 5 shows that there is a marginal variation in the plastic limit values with different concentrations of alkali indicating negligible electrolyte effect on the soil. Only at higher concentrations (4N) and at longer duration of interaction (14days) the effect of electrolyte can be seen.

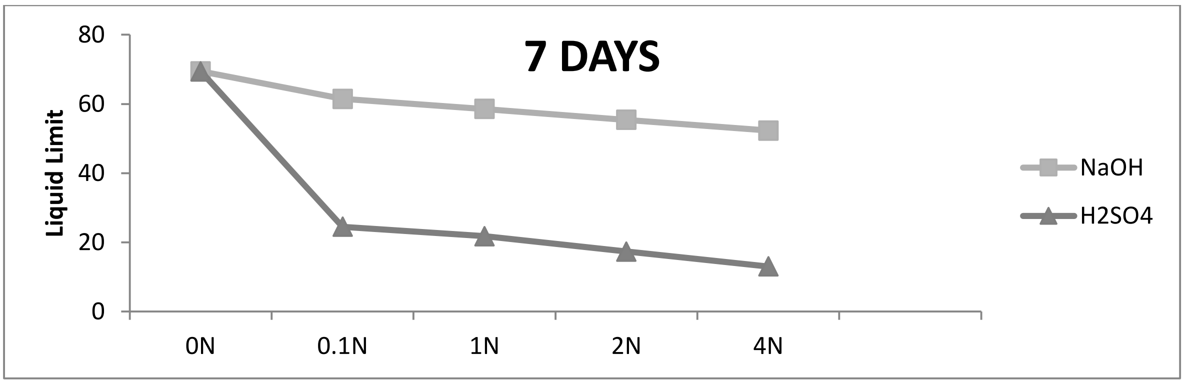
Table 4 plastic limit variation (marine clay)

Alkali concentration (N)	plastic limit (%)	
	7 days	14 days
0.0	30.4	30.4
0.1	31.12	29.65
1.0	29.3	27.31
2.0	27	25.31
4.0	26.12	23.41



Graph 4 plastic limit variations (marine clay)

1.6 COMPARISION OF ATTERBERG LIMITS FOR MARINE CLAY TREARED WITH ACID & ALKALI

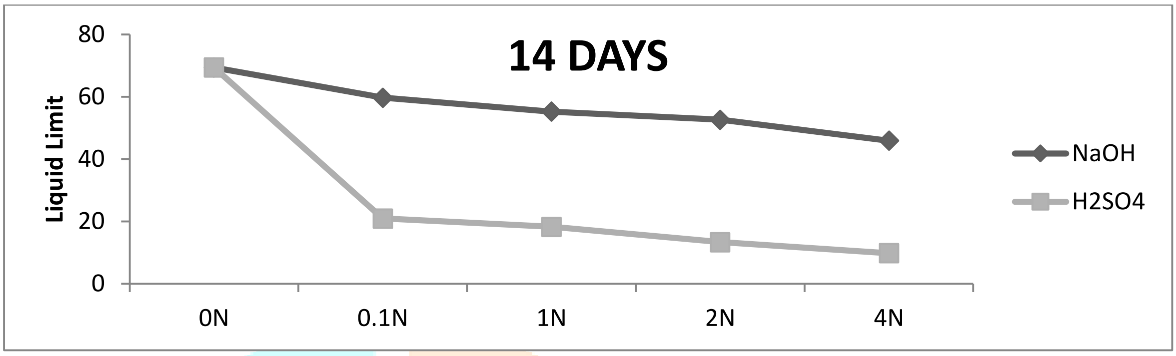


Graph 6 liquid limit variation of marine clay with acid & alkali

Graph 6 shows the variation of liquid limit of marine clay with different concentrations of acid and alkali solution for 7 days curing period. From graph it is clearly observed that the decrease in liquid limit with increase in concentration is high in case of acid compare to alkali. Thus it indicates that electrolyte effect of acid is faster than alkali in marine clay. This is mainly because marine clays contain sodium as the dominant caution. Further at lower pH conditions acid imparts positive charges on the clay surface which decreases its electrostatic potential leading to lowering of diffuse double layer and thus the liquid limit whereas in the case of high pH condition alkali imparts negative charges on the clay surface which increases its electrostatic potential leading to increase in diffuse double layer thus the liquid limit but due to the presence of sodium ions the liquid limit decreased marginally rather than increase. The variation in the charges due to change in pH can be explained by the following equations *(Brady, 1995)*

$$\underset{\text{No charge (soil solids)}}{\vdots Al - OH} + \underset{\text{Soil Solution}}{OH^-} \leftrightarrow \underset{\text{Negative charge (soil solids)}}{\vdots Al - O^-} + \underset{\text{soil solution}}{H_2O}$$

$$\underset{\text{No charge (soil solids)}}{\vdots Al - OH} + \underset{\text{Soil Solution}}{H^+} \leftrightarrow \underset{\text{Positive charge (soil solids)}}{\vdots Al - OH_2^{\,+}}$$

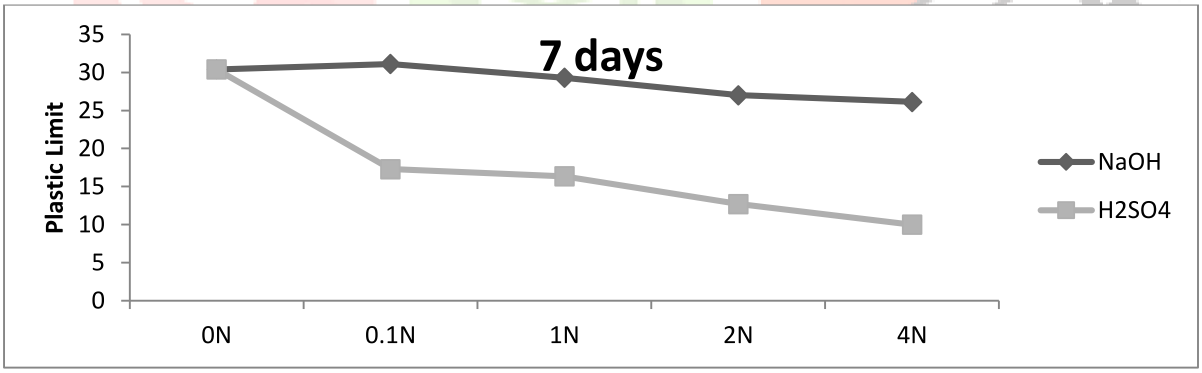


Graph 7 liquid limit variation of marine clay with acid & alkali

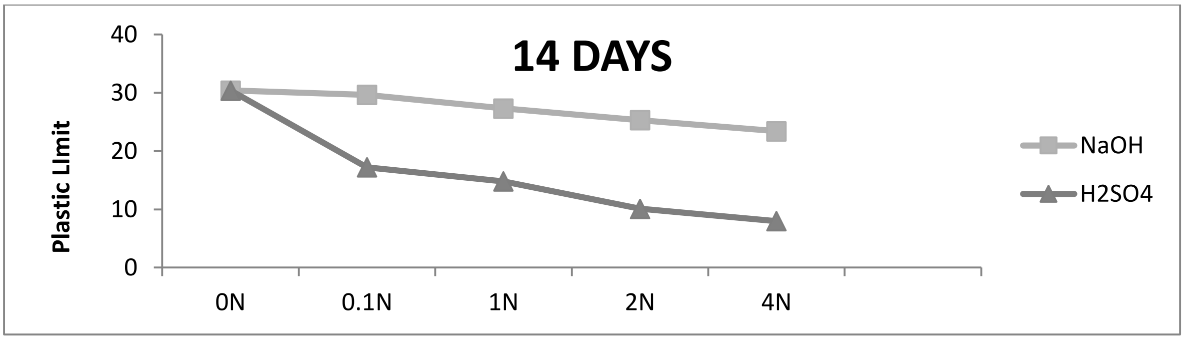
The variation of liquid limit (figure 6&7) of marine clay with different concentrations of acid and alkali solution for 14 days curing period can be explained in the similar manner as 7 days curing period.

1.7 PLASTIC LIMIT VARIATION OF MARINE CLAY WITH ACID & ALKALI

Graph 8 and 9 shows the variation of plastic limit of marine clay with different concentrations of acid and alkali solution for 7 days and 4 days curing period respectively. The variations in plastic limit are generally in consistent with explanation given for their variations in liquid limit.



Graph 8 plastic limit variation of marine clay with acid & alkali



Graph 9 plastic limit variation of marine clay with acid & alkali

1.8 EFFECT OF ACID ON RED EARTH:

Similar to marine clay, red earth samples were mixed with different concentrations of acid at 1:2 ratios for 7 days and 14 days curing period. After the desired curing period the solutions were drained out and the samples were washed with water. The washed samples were air dried initially and then oven dried. The dried samples were sieved through 425 µm sieved. Samples, after treating with acid has totally lost its weakly cemented iron oxide coating surrounding the particle transforming the colour of the sample from red to ash. Due to total loss in its plasticity the treated samples were not suitable for carrying atterberg's limits. Hence studies were restricted only to marine clay

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