Effect of Nacl And $Cacl_2$ on Plasticity, Hydraulic And Strength Characteristics of Clayey Soil

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Abstract- *Geotechnical properties of clayey soil influences the stability of structures. Clayey soil is a highly problematic type of soil. The construction in such soil will affect the safe existence of the structure. By understanding the behaviour of clayey soil geotechnical engineers can adopt appropriate control measures. There are many methods adopted to control the expansive nature of the clayey soils. Treating the clayey soil with chemical is one of the techniques to improve the behaviour of the ground. Hence this experimental work was carried out to investigate the influence of chemicals such as sodium chloride and calcium chloride on the properties of clayey soil. In the process, Atterberg's limits test (liquid limit, plastic limit), permeability test, vane shear test were conducted by adding 0.5%, 1%, 1.5% and 2% of Sodium Chloride and Calcium Chloride to the clayey soil by weight under controlled conditions in the laboratory after 4 weeks of curing. It was observed from the laboratory studies that the limitations of the construction in clayey soil can be reduced to an extent by adding the chemicals such as NaCl and* $CaCl_2$.

Keywords- Sodium Chloride,Calcium Chloride, Plasticity, Strength and Permeability Characteristics.

I. INTRODUCTION

Clayey Soil is one of the most commonly encountered materials in civil engineering. All the structures, except some which are founded on solid rock, rest ultimately on the soil. So, the soil must be capable of taking the load from the super structure.

Scarcity of land with good bearing capacity is the one of the major problems the world faces now. This leads to construction of buildings on the available land which may not be good with respect to its bearing capacity.

Clayey soil is one among the problematic soils that has a high potential for shrinking or swelling due to the change in moisture content. In this work an attempt is made to study the effect of $CaCl_2$ and NaCl on the properties of clayey soil.

The aim of this project therefore, is to evaluate the suitability of sodium chloride and calcium chloride on the plasticity, strength and permeability characteristics of clayey soil with different percentages in the laboratory. The result of this study is used to evaluate, compare results of different mixes and to generate a mix which can be safely used for the improvement of soil so that the structure can be built on the soil safely.

II. MATERIALS

Table 1: Materials Used

Clayey Soil	Collected from Kothamangalam, at a depth of 1m.
Calcium Chloride	Commercially Available
Sodium Chloride	Commercially Available

A. Clayey soil

Soil samples were collected from the lower land of Kothamangalam, Ernakulam district, Kerala. Soil is collected at a depth of 1 meter below the ground level. Chemicals (NaCl and $CaCl_2$) were purchased from Laboratory Equipments Store, Kacheripady. Hydrometer analysis indicates that the clay content is 42%. The Properties of the clayey soil are presented in Table 2.

Table 2: Properties of Clayey Soil

Properties	Results
Water content (%)	61.94
Liquid Limit (%)	58.5
Plastic limit (%)	23.69
Optimum moisture content (%)	14.05
Maximum dry density (g/cc)	1.2669
Shear strength (kg/cm^2)	0.138
Free swell index(g/cc)	10.9
Specific gravity	2.69
Percentage of clay size particles (%)	42
Percentage of silt & sand size particles (%)	58
Permeability (cm/sec)	$8.12*10^{-5}$

B. Calcium Chloride

Calcium chloride is an inorganic salt, which is a by-product of sodium carbonates. Calcium chloride has hygroscopic property. This means that calcium chloride absorbs and attracts water. It is deliquescent. That is it dissolves in the moisture which it absorbs and forms a clear liquid that does not evaporate easily. Calcium chloride has higher surface tension and a lower freezing point compared to water. Calcium chloride can be used as a dust suppressant and stabilizer because of its ability to alter the material properties such as compressibility, strength and permeability. Essentially, the function of this chemical is to agglomerate fine particles and bind them together. Calcium chloride has a major effect on shear strength, depending on soil type and curing.

Commercially available $CaCl_2$ was used for study. $CaCl_2$ was used as chemical to stabilize the soils. Four different percentages of $CaCl_2$ (0.5%, 1%, 1.5% and 2%) were used. Calcium chloride is highly soluble in water and calcium cations can easily replace other adsorbed cations in the adsorption complex of soil particles thereby facilitating the base -exchange phenomenon take place.

C. Sodium Chloride

Common salt is white in colour and is in the form of crystals. It is deliquescent and hygroscopic. It lowers the vapour pressure of water. It is very effective and dust palliative. It checks the formation of shrinkage cracks. Sodium chloride is extensively used in chemical industries. It is also widely used in metal treating, water softening etc.

Commercially available NaCl was used for study. NaCl was used as chemical to stabilize the soils. Four different percentages of NaCl (0.5%, 1%, 1.5% and 2%) were used.

III. TEST PROGRAMME

A. Atterberg's Limit

Liquid limit was determined according to IS 2720 (part 5)-1985. Liquid limit is the water content of the soil between liquid state and plastic state. It is defined as the minimum water content at which the soil, though in liquid state, shows small shearing strength against flowing.

Plastic limit test was conducted according to IS 2720 (part 5)-1985. Plastic limit is the water content of soil between plastic state to semi-solid state. Plastic limit is defined as the lowest moisture content expressed in percentage, at which the soil can be rolled into threads one-eighth inch in diameter without the soil breaking into pieces. It was determined using Cassagrande's apparatus. For both liquid limit and plastic limit test sample were prepared at different percentages (0.5%, 1%, 1.5% and 2%).

B. Permeability

Permeability test was determined according to IS 2720 (part 17)-1986. This test was carried out by using the apparatus called Permeameter. The property of the soil by virtue of which water can flow through the soil is said to be permeability. Soil samples were prepared at different percentages (0.5%, 1%, 1.5% and 2%).

C. Shear strength

Shear strength was determined according to IS 2720 (part 17)-1986. It was done by using vane shear apparatus. Shear resistance of a soil occurs as a result of friction and the inter-locking of the particles and also may be due to cementation or bonding at the particle contacts. It has a prime importance for foundation design. . Vane shear test was conducted on the assumption that shear strength on the soil is constant on the cylindrical sheared cylinder. The resisting torque on the sides is equal to the resisting force developed on the cylindrical surface multiplied by radial distance. Soil samples were prepared at different percentages (0.5%, 1%, 1.5%, and 2%).

IV. RESULTS AND DISCUSSION

Various laboratory tests were conducted on the samples prepared by adding different percentages of calcium chloride and sodium chloride to the clayey soil. Atterberg's limit, permeability and strength tests were conducted in a view to influence of adding various percentages of calcium chloride and sodium chloride on measured soil properties.

A. Effects of Chemicals on Plasticity Index

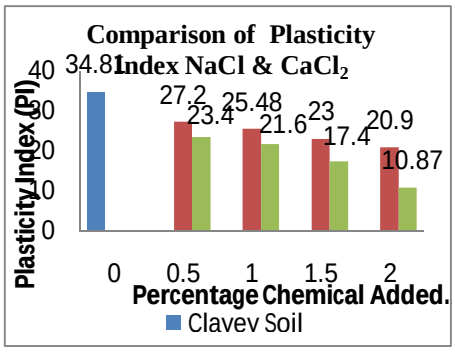

Fig:1 :Comparison of Plasticity Index of NaCl and $CaCl_2$

Liquid limit decreases with increase in the percentage of NaCl and $CaCl_2$ content after 4 weeks of curing. Increasing salt concentration and cation valence decreases the inter-particle repulsion. It results in particles moving more freely in lower contents, thus the liquid limit of mixtures decreases.

From the graphs it is observed that, plasticity index decreases with increase in the percentage of both NaCl and $CaCl_2$. The intervention of origin electrolyte would result in change in the ion exchange capacity, perhaps due to absorption. The ion concentration reduces the repulsive forces and increases effective stress leading to flocculation of clay particles, which reduces plasticity.

B. Effects of Chemicals on permeability

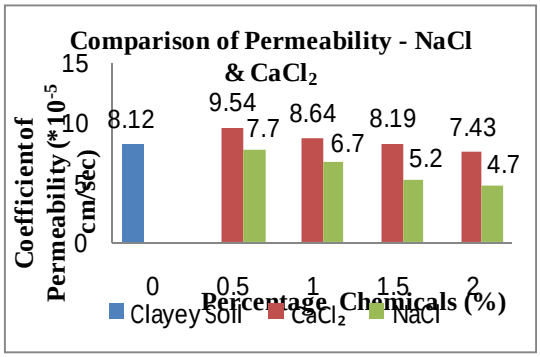

Fig:2 :Comparison of Permeability of NaCl and $CaCl_2$

The graphs show the variation of permeability on the clayey soil with different percentages of $CaCl_2$. It can be seen that the permeability of the soil decreasing with increase in the percentage of $CaCl_2$. The reduction observed in coefficient of permeability is as a result of attraction of Ca^{2+} to the adsorbed layers produced strong bond that would be hard to break and high resistance to the passage of water. This bond is responsible for reduction in coefficient of permeability obtained for the clay.

There is a significant increase in permeability happens due to increase in the percentage of NaCl after 4 weeks of curing. When sodium chloride is added to clay, crystallisation occurs in the pores of the clay and it forms a dense hard mat with stabilized surface. The pores in the clay get filled up and retard further evaporation of water.

The coefficient of permeability decreased more for $CaCl_2$ compared to the NaCl. This reduction as a result of attraction of Ca^{2+} to the adsorbed layers produced strong bond that would be hard to break the passage of water. This bond is responsible for more reduction in $CaCl_2$.

C. Effects of chemicals on Shear Strength

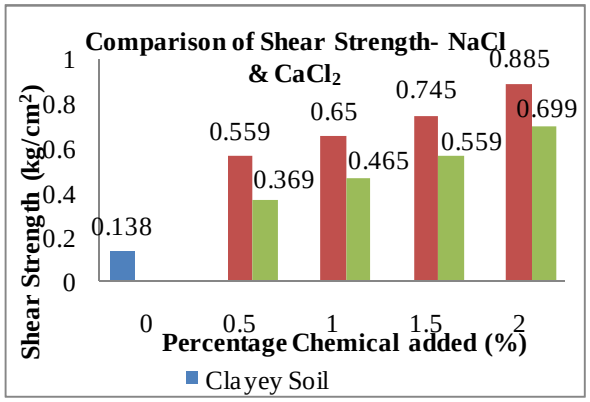

Fig 3 : Comparison of Shear Strength of NaCl and $CaCl_2$

The shear strength of the clayey soil prepared at with an addition of 0.5%, 1%, 1.5% and 2% $CaCl_2$ to the clayey soil. From the above graph it is observed that, there is a significant increase in the strength with % to addition of $CaCl_2$. It is found that calcium chloride increases the surface tension of the retained moisture within the soil matrix, thus increasing the suction pressure of the system. This in turn, increases the cohesive energy between the particles which results in greater strength.

The shear strength of the sample prepared with an addition of 0.5%, 1%, 1.5% and 2% NaCl to the clayey soil.From the above graph it is observed that, Shear strength increases with increase in percentage of NaCl. An increase in salt concentration according to colloidal theory reduces the thickness of the double layer, thereby decreasing the repulsive force between the particles. This should result in more flocculated clay structure and hence a higher shear strength.

Shear strength of $CaCl_2$ shows more increase in strength compared to NaCl. In case of clayey soil, loss of strength is mainly due to increase in the water content.$CaCl_2$ treated soil does not pick up the water easily when compared to NaCl. So the effect is more in case of $CaCl_2$.

V. CONCLUSION

- Plasticity index of the clayey soil was decreased with increased in the percentage of $CaCl_2$ and NaCl. The value of plasticity index is decreased more in $CaCl_2$ than NaCl.
- It can be seen that the permeability of the soil decreasing with increase in the percentage of $CaCl_2$ and NaCl. The value of permeability is decreased more in $CaCl_2$ than NaCl.

- The shear strength of the clayey soil increased with increase in percentage of $CaCl_2$ and NaCl. The value of shear strength is increased more in $CaCl_2$ than NaCl.

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