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Stabilisation of Clay Soil with Gypsum Hemihydrate (Plaster of Paris) and Cement

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Abstract: Among various types of soil (according to particle size) clayey soil has tendency to show problems like swelling and shrinking when moisture variation occurs .This property of clayey soil is because of presence of minerals like montmorinollite. These minerals have hydrogen bonds in between their particles. The swelling and shrinking property of this soil results damages to the structures. So it's a major concern for Geotechnical engineers to improve this property of expansive soil and make soil durable and strong for long run. Gypsum has been used as a conditioner in agriculture, it makes soil workable. In this paper gypsum hemihydrate (POP) (Ca2So4.1.5H2O) has been taken as a stabilizer to improve the property of swelling and cement to improve the strength of the soil and improve the durability of gypsum hemihydrate in wet environment. Different quantities of gypsum hemihydrates like 3%, 5%, 7% and 10% and a small amount of cement 1% and 3% by dry weight of soil added to clayey soil and compacted to optimum moisture content obtained by test. Atterberg's limits, strength tests are performed on treated and untreated samples. Changes in plasticity index and strength with varying percentages of POP and cement have shown that both stabilizers can be used as an effective admixture.
Keywords: Gypsum hemihydrate, Expansive soil, Geotechnical Properties, Strength.

I. INTRODUCTION

The fine-grained or expansive soil because of their swelling behaviour need chemical stabilization to improve their Geotechnical properties and to evade the damages occurring in various constructions projects such as roadway structures, irrigation arrangements, water lines, sewer lines, building foundations etc. due to settlement and swelling action of soils.

Chemical stabilization includes mixing of chemically reactive substances like cement, lime, fly ash and lime by-products etc. in the soil. It improves the strength properties of the soil by eliminating moisture and showing binding action of admixtures. Generally the role shown by the stabilizing (binding) agent, also known as admixtures, in the treatment process is either strengthening the bonds of the soil particles or filling the pores.

Chemical stabilization also acknowledged as additive stabilization includes the addition of proper proportions of cement, lime, bitumen or combination of these. The proportion of additive depends upon soil type and the quality of improvement needed. In case of enhancement of soil plasticity, workability and gradation small amount of percentage is required as compared to large amount of additives required for improvement in strength and durability characteristics of soils. The use of cement and lime is determined by the plasticity of soil. If plasticity index of soil is greater than 10 the use of Portland cement is considered best for soil improvement.

The chemical formula for gypsum hemihydrate (POP) is CaSo4.1/2H2O. The gypsum hemihydrate universally known as Plaster of Paris is obtained from burning of gypsum rock at a temp of 1200C to 1800C. When gypsum is heated; it loses three-fourths of its water of crystallization and forms Plaster of Paris.

Plaster of Paris is also known as quick-setting gypsum plaster, white in colour which when comes into contact with water and gets dried, shows strength. Plaster of Paris does not generally shrink or crack when dried. It is frequently used to precast and hold parts of ornamental plasterwork done on ceilings and cornices. It is also used in medication industry to make plaster castings in order to immobilize the broken bones while healing after fracture. Plaster of Paris also recognized as expanding and non-shrinking cements, expands slightly on hydration.

Plaster of Paris is formed when gypsum powder is heated. When water is added to Plaster of Paris it rehydrates and gives a firm mass of gypsum. So the reaction amongst gypsum and plaster of Paris and water is all reversible. Gypsum when heated loses water resulting formation of Plaster of Paris and Plaster of Paris after adding water again converts into gypsum mass. Since gypsum plasterboard are mostly used in the construction of walls and ceilings of buildings, the waste generated by it is in large amounts. The disposal of gypsum waste plasterboard must be done in controlled landfill sites as per Japanese environmental regulations which makes it costlier. Recycled gypsum produced from gypsum wastes (like plasterboards, Gypsum Plaster used in the medical area, plastering used for ceilings) can be used as a stabilizer material in ground improvement since gypsum is one of the cementatious material (Ugai and Ahmed, 2009).

The studies on the use of Plaster of Paris as a stabilizer are not widely available. There are few studies done in Japan where Gypsum Plasterboards are used in ground improvement (Ugai et al., 2009; Ahmed et al., 2011). For improvement in the strength of weak roadway subgrade soil using traditional materials such as cement or lime requires larger quantities of these materials and consequently, the construction cost of such roads becomes costlier.

When cement is added in the soil, the voids of the soil get filled by cement, leading to the reduction in void ratio. Cement in pores when approaches in contact of water, it hydrates leading to stronger subgrade. High cement content in the range of 7-10% can give hard mass of strength 1962 kN/m2 or more and small percentage of cement 2-3% can give the CBR value more than 25%. Portland cement after hydration forms calcium-aluminum-hydrate (C-A-H) and Ca(OH) 2. C-S-H and C-A-H form a network and serve as the "glue" which provides a well-connected structure and strength in cement-modified clay. These hydrates help to stabilize the flocculated clay units through cementation. The utmost rapid strength increase is in between one day and one month, whereas smaller gains in strength (due to continued hydration and formation of cementitious material) continue to occur for years. his document is a template. For questions on paper guidelines, please contact us via e-mail.

II. MATERIAL USED

A. SOIL

Soil was collected from Sitargang area (Khatima), Udham Singh Nagar, Uttarakhand. After that it was dried and pulverized and sieved through 4.75 mm for further testing. The soil was classified as CL as per the IS 1498-1970 code system.

B. Gypsum Hemihydrate (Plaster of Paris)

Plaster of Paris was purchased from the local market in Rudrapur, Udham Singh Nagar (Uttarakhand). The chemical Formula of gypsum hemihydrate is CaSo4.1/2H2O, also known as Plaster of Paris. The gypsum hemihydrate gains strength after drying, when it comes in contact of water and gives a firm mass of gypsum. It doesn't show swelling and shrinking. The specific Gravity of gypsum hemihydrate was found by conducting Pycnometer test. The Specific Gravity of gypsum hemihydrate was found out as 2.30.

C. Cement

The sample of cement used in the proposed study was Ordinary Portland Cement-43 grade. The cement was kept in air tight polythene so that there won't be any lump formation. Portland cement as an additive is known to mend the quality of soil by increasing strength and durability. Portland cement after hydration forms calcium-aluminum-hydrate (C-A-H) and $Ca(OH)_2$.

C-S-H and C-A-H form a network and serve as the "glue" which provides a well-connected structure and strength in cement-modified clay

III.RESULTS AND DISCUSSIONS

A. Atterberg's Limit Analysis

Consistency limits of soil are the determination of liquid limit(wL), plastic limit (wP) and plasticity index (Ip) according to the IS 2720 (Part V)-1985 procedure. The Liquid limit of the soil is the minimum water content (w%) at which the soil shows negligible shear strength and flowing behavior. Plastic limit of the soil is that water content (w%) at which soil will start crumbling if it is rolled into a thread of 3 mm diameter. Plasticity index of the soil is the difference between liquid Limit and plastic limit. Plasticity index shows the range of plasticity present in the soil. The soil was mixed with four different percentages of GH and was subjected to liquid limit and plastic limit test. The addition of GH into the soil resulted in decrease in the value of liquid limit, plastic limit and hence plasticity index of soil. This was probably due to presence of the Ca2+ ions present in the GH which replaced the mineral ion present in soil which reduced double diffused layers of clay soil, hence decrease in the liquid limit and plastic limit. The results are shown in Fig. 1.

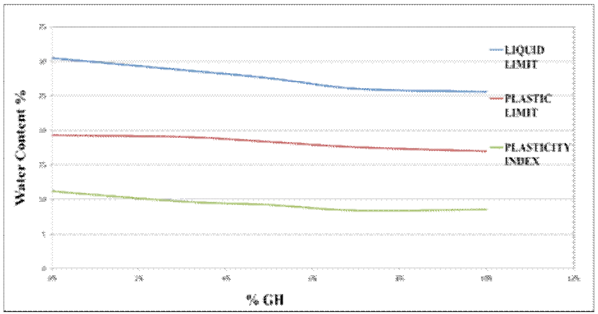

Fig. 1 Variation of LL, PL and PI of soil with GH

B. Compaction Characteristics

This test is performed to find out the compaction properties of the soil by correlating the quantity of water added (moisture content) to the amount of density (Dry Density) achieved, after compacting the soil in the mould of capacity 1000cc with a specified amount of energy. Results are plotted in a graph, water content (w %) as abscissa and dry density (KN/m3) as ordinate, the graph contains a curve having an inflection point, the coordinates of this point are known as OMC and MDD. The results of the test gives the value of that water content at which the soil will show the maximum dry density.

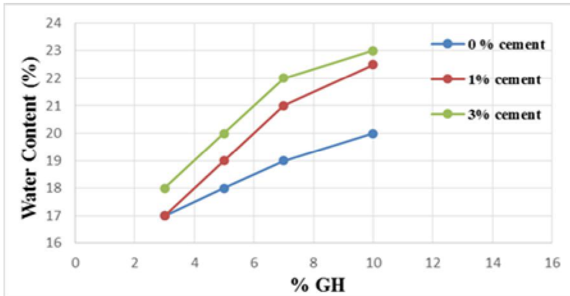

Fig. 2 OMC variation with GH and cement

The increase in the OMC was observed most probably due to the drying of POP in the process of compaction hence more moisture requirement leading to decrease in MDD.

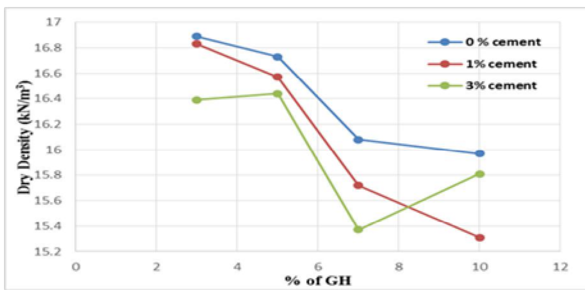

Fig. 3 MDD variation with GH and cement

All the results of Standard proctor tests indicated the increase in the value of OMC with decrease in MDD with the addition of increasing amount of GH and fixed amount of cement.

C. Unconfined Compressive Strength test

The procedure used for the performance of the test was as per IS 2720 (Part X)-1991. For conducting this test cylindrical specimen of soils of 38 mm dia and 76 mm height were prepared corresponding to their OMC in the mould of circular section. The initial length, diameter and weight of the soil specimen was measured and the specimen was placed on the loading device. Normal load was applied at a rate of 0.5 to 2% per minute, till the failure of the specimen occurred. The soil sample was weighed to find out the moisture content at which failure occurred. The soil samples were cured and tested for the change in strength at 3, 7 and 14 days.

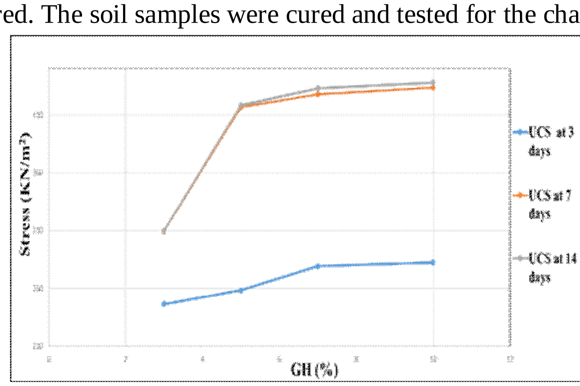

Fig. 4 Variation of UCS with GH (3, 7 and 14 days)

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It was observed from the results that the UCS value was increasing with the increase in the percentage of GH.

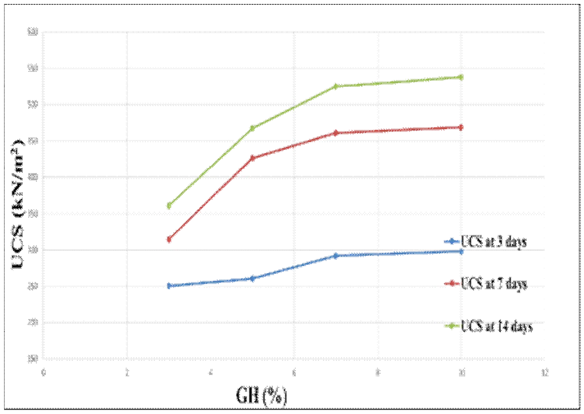

Fig. 5 Variation of UCS with GH (3,7 and 14 days) and 1% cement

The UCS value is increasing with the increase in the percentage of GH and cement for four different combinations of soil, GH and cement. Combination of cement with GH showed increment in the strength of the mix.

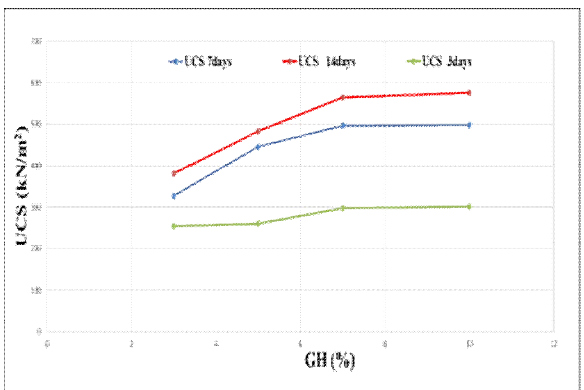

Fig. 6 Variation of UCS with GH (3, 7 and 14 days) and 3% cement

The UCS value was increasing with the increase in the percentage of GH and cement due to drying and hydration of pop and cement respectively. Addition of GH showed significant strength gain at 7 days of curing, after 7 days the strength gain was not large. Whereas after addition of cement the significant strength gain was observed even after 7 days of curing i.e. after 14 days of curing due to fact of later hydration of cement.

IV. CONCLUSIONS

A. At 7% amount of GH into the soil the decrease in the LL, Pl and PI was significant, beyond this amount the decrease was not that large.
B. At 5% GH amount into the soil the OMC and MDD of the mix were adequate. At 7% of gypsum hemihydrate addition in soil the strength parameters were increased significantly beyond this value the increase in the strength parameters was not that large.
C. At 7% GH amount and 1% cement addition into the soil the increase in the value of UCS is seen. Again, Increasing the amount of cement to 3% the UCS value increased.

V. ACKNOWLEDGMENT

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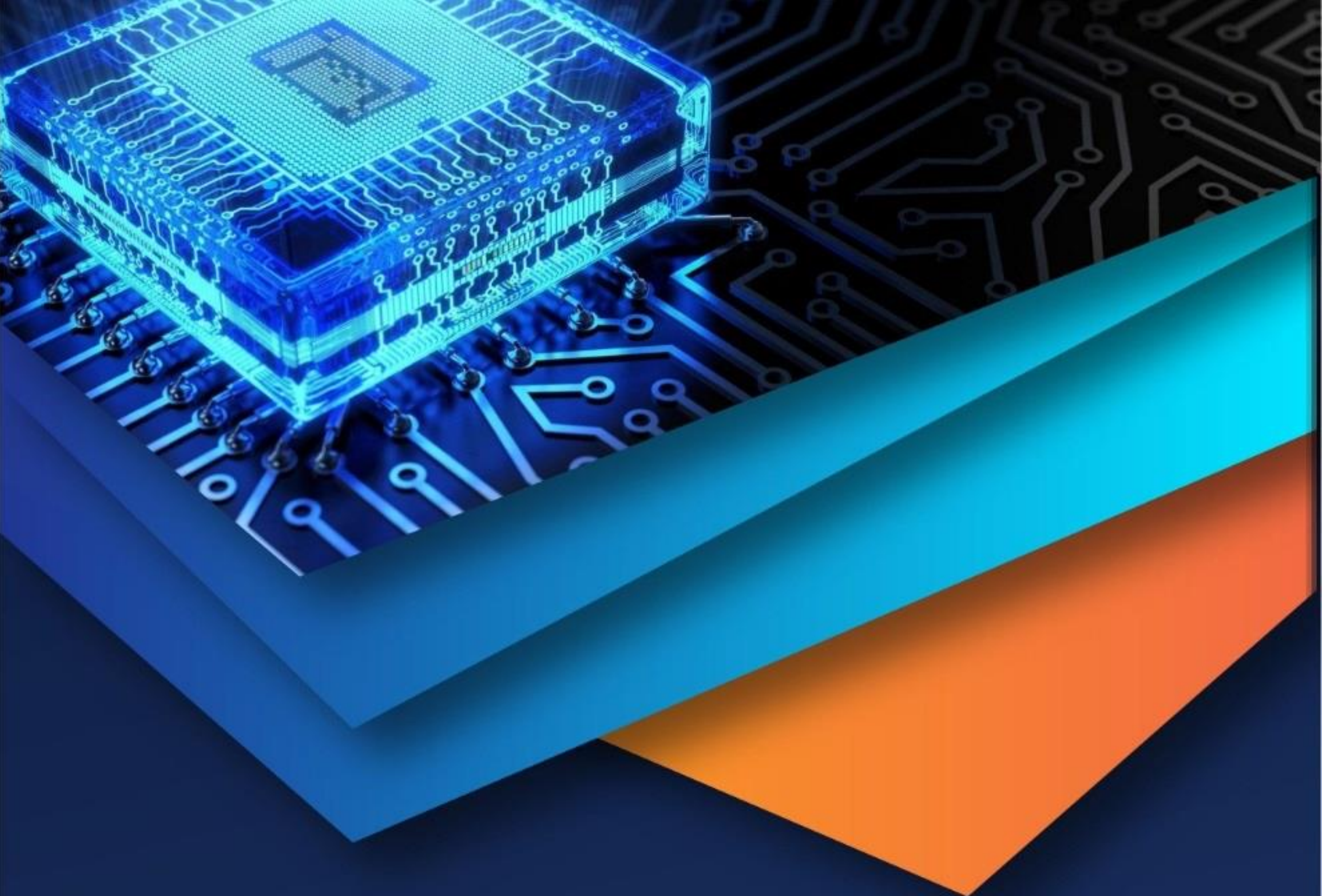

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