EFFECT OF ALCCOFINE, LIME ON GEOTECHNICAL PROPERTIES OF COHESIVE SOIL

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Abstract: Clayey soil is a problematic soil, which is cohesive in nature, highly instable, prone to volumetric shrinkage, having low shear strength and high moisture susceptibility. Cement, lime, fly ash, rice husk ash, furnace slag etc. alone or in combinations are widely used as soil stabilizer. These Pozzolonic materials added to clayey soils reacts with lime added as an admixture giving rise to a compound which is cementitious in nature. There is need of using the waste materials in stabilization of the soils. Soil samples were collected from village Lohatwadhi Distt. Ludhiana. In this paper, effect of alccofine alone and combination with lime in various ranges to the clayey soil were investigated.

IndexTerms **- Pozzolanic Materials, Waste Materials, Lime, Alccofine, Soil Stabilization.**

I. INTRODUCTION

Clayey soil being a problematic soil, which is cohesive in nature, highly instable, prone to volumetric shrinkage, having low shear strength and high moisture susceptibility. About 23% of total area is covered by clayey soil in India mostly in the central part of the country and in most of the areas these deposits are present up to an average depth of 3.7m. The commonly used admixtures for the stabilization of clayey soil are cement, lime, fly ash, rice husk ash, furnace slag or in the combination of more than one admixture. These are added due to the abundance of pozzolonic materials (SiO2 and Al2O3) in these waste materials.

The basic concept of using these materials for the improvement of clayey soils is based on the pozzolonic reaction between the pozzolonic materials and lime. Pozzolonic materials, when added to the clayey soils react with lime added as an admixture giving rise to a compound which is cementitious in nature. This compound is responsible for the improvement in the characteristics of clayey soil.

Yadu and Tripathi (2013) performed Compaction test and California bearing ratio (CBR) tests and 3% fly ash + 6% GBS were taken as optimum amount for stabilization of soft soil. Jha and Gill (2006) studied the evaluation of using rice husk ash (RHA) as a pozzolona for enhancing lime treatment of residual soil and concluded that with the addition of rice husk ash, the strength and durability of soil got improved. Compaction test results indicated that with increase in RHA contents there was increase in maximum dry density and decrease in optimum water content of soil. The CBR values were also increased with addition of RHA for both soaked and un-soaked samples. This paper presents the use of alccofine for the improvement of clayey soil in combination with lime. (Bilal Salman, et.al. 2014) used cement along with alccofine. Because Alccofine is having large amount of pozzolonic materials therefore it is proposed to use lime instead of cement in this study.

II.MATERIALS USED:

2.1 Alcoofine

Alccofine is very fine cementious GGBS (Ground Granulated Blast-furnace Slag), dry powder having light grey colour. It consists of slag of high glass content having high reactivity. The product used in proposed research is Alccofine 1109ss formerly known as Alccofine 1101s which is cementitious micro-fine injection grout used for soil stabilization.

Fig. 1 Alccofine 1109ss

2.2 Lime

Lime reacts with the clay minerals present in cohesive soils having high plasticity index. Due to this reaction plasticity of the soils decreases and their affinity towards water also reduces and it becomes easily to pulverize the lime treated soils. Lime treated soil also gain strength due to its binding capability.

III. EXPERIMENTAL INVESTIGATION

The results of geotechnical properties are Liquid Limit 36%, Plastic Limit 16.5%, Plasticity Index 19.5%, OMC 16.3%, MDD 1.65gm/cc, Specific gravity 2.56, CBR 2, UCS 2.66 kg/cm2, Indian Soil Classification is CI.

3.1 Alcoofine

The chemical constituent of alccofine in percentage are CaO(32-34), Fe2O3(1.8-2), MgO(8-10), Al2O3(18-20), SO3(0.3 - 0.7), SiO2(33 – 35) . The physical properties of Alccofine are Specific Gravity2.9, Bulk Density700-900 Kg/m³ Fineness>9000 cm²/gm, Particle Size D10, D50, D90, D95 are 1.5,5,9, less than 11.5 microns respectively.

IV. MIX PROPORTIONS

In first stage of study, only alccofine was used as stabilizer in which its percentage was 3%, 6%, 9%, 12% by weight of soil. In second stage combination of lime and alccofine having ratio 2:1, 3.5:1.5, 4.5:2.5, 6.5:3.5 respectively was used.

V. RESULTS AND DISCUSSION

5.1 Liquid Limit Test Results

Table 1: Atterburg's Limits for S:A

Soil:Alccofine	***L.L%***	***P.L%***	***P.I%***
100:0	36	16.5	19.5
97:3	34	15	19
94:6	32	14.5	17.5
91:9	31	14	17
88:12	30	13.5	16.5

Table 2: Atterburg's Limits for S: L: A

Soil:Lime:Alccofine	**L.L%**	**P.L%**	**P.I%**
100:0:0	36	16.5	19.5
97:2:1	36.5	16	20.5

95:3.5:1.5	34	16.5	17.5
93:4.5:2.5	31.5	18	13.5
90:6.5:3.5	29.5	17	12.5

5.2 Compaction Test Results

Table 3: Compaction Test Results for S: A

Soil:Alccofine	MDD(g/cc)	OMC%
100:0	1.65	16.3
97:3	1.645	17.2
94:6	1.630	18.4
91:9	1.621	19.2
88:12	1.615	19.6

Table 4: Compaction Test Results for S:L: A

Soil:Lime:Alccofine	MDD(g/cc)	OMC%
100:0:0	1.65	16.3
97:2:1	1.63	17.4
95:3.5:1.5	1.62	18.6
93:4.5:2.5	1.59	19.4
90:6.5:3.5	1.59	20

5.3 CBR Test Results

The CBR value for soil plus alccofine at 97:3, 94:6, 91:9, 88:12 are 2.2, 2.5, 2.9, and 3.6 respectively and after 14 days curing the CBR value are 5.85, 6.5, 7.45, and 9.55 respectively. For combination of soil, lime and alccofine at 97:2:1, 95:3.5:1.5, 93:4.5:2.5, 90:6.5:3.5 are 5.1, 8.15, 13.05, and 14.2 respectively. After 14 days curing the CBR results are 13.3, 19.25, 31.05 and 34.5 respectively.

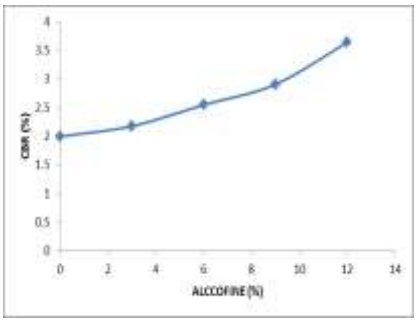

Fig. 2 Graph showing effect of alccofine on CBR value.

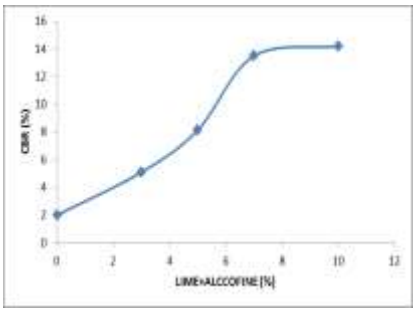

Fig. 3 Graph showing effect of lime and alccofine on CBR value

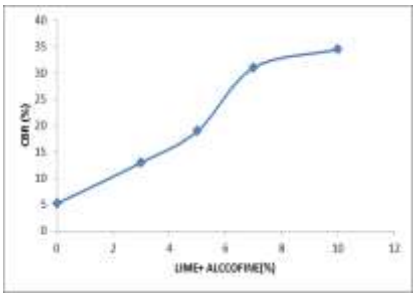

Fig. 4 Graph showing effect of alccofine on CBR value after 14 days curing

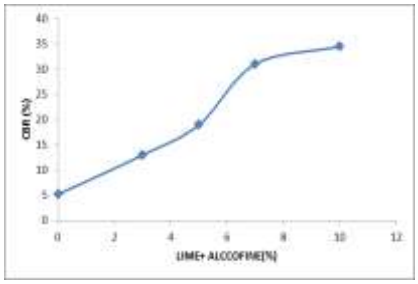

Fig. 5 Graph showing effect of lime and alccofine on CBR value after 14 days curing

5.4 UCS Test Results

Table-5 UCS Test Results for Soil and Alccofine at the start and after 14 days curing

Soil:Alccofine	UCS(kg/cm2)	UCS after curing	Cohesion	Cohesion after curing
100:0	2.65	5	1.325	2.5
97:3	3.05	6.6	1.525	3.30
94:6	3.6	8.10	1.795	4.05
91:9	4.5	9.50	2.25	4.75
88:12	4.05	8.70	2.025	4.35

Table-6 UCS Test Results for Soil, Lime and Alccofine at start and after 14 days curing

Soil:Lime:Alccofine	UCS(kg/cm2)	UCS after curing	Cohesion	Cohesion after curing
100:0:0	2.65	5	1.325	2.5
97:2:1	5	7.20	1.80	3.6
95:3.5:1.5	5.44	12.0	2.72	6
93:4.5:2.5	7.55	16.1	3.77	8.05
90:6.5:3.5	7	14.8	3.50	7.4

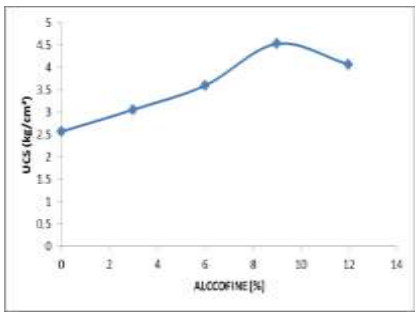

Fig. 6 Graph showing effect of alccofine on UCS value

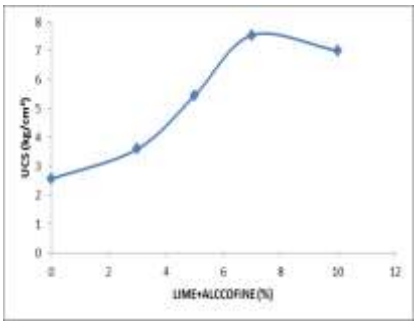

Fig. 7 Graph showing effect of lime and alccofine on UCS value

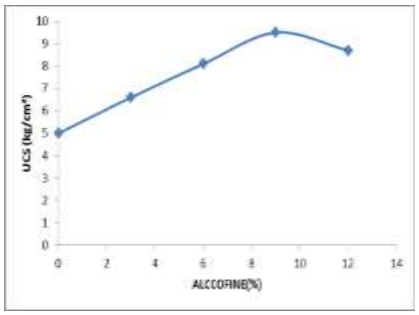

Fig. 8 Graph showing effect of alccofine on UCS value after 14 days curing.

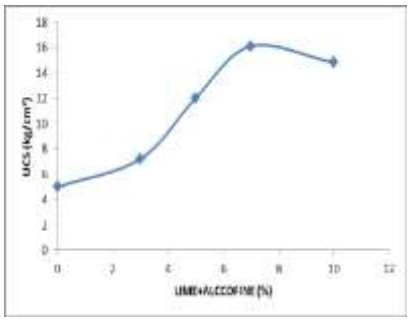

Fig. 9 Graph showing effect of lime and alccofine on UCS value after 14 days curing.

VI. DISSCUSSION:

The liquid limit obtained at addition of 3%, 6%, 9% and 12% alccofine is 34%, 32%, 31% and 30% respectively. It is observed that liquid limit decreases to 29.5% on addition of 6.5% lime and 3.5% alccofine. The plastic limit reduced to 13.5% on addition of 12% alccofine as the plastic limit for virgin soil is 16.5%. On addition of lime with alccofine, plastic limit test show that there is increment in plastic limit to 18 % for the sample of 4.5% lime and 2.5% alccofine. In case of alccofine only the PI value reduces from 19.5% for virgin soil and to 16.5% at 12% alccofine. Similarly for alccofine plus lime PI value reduces from 19.5% for raw soil to 12.5% for 6.5 lime and 3.5 alccofine. These variations in the plasticity characteristics of soil after adding alccofine and lime may be attributed to the mechanism of cation exchange, flocculation of clay particles, carbonation and pozzolonic reactions. Pozzolonic reactions are time dependent phenomenon and i.e. are why long curing is required. Carbonation may have adverse effect on the strength of the treated soil because of weak cementing agents.

MDD for virgin soil is 1.650 g/cc, which decreased to 1.621 g/cc on the addition of 9% alccofine alone to the raw soil. The results concluded from the compaction test by adding lime with alccofine in raw soil proves that there is gradual decrease in the MDD. The effect of alccofine and lime on the maximum dry density of the treated soil may be due to decrease in density of the treated soil may be due to variation of specific gravity of virgin soil and soil-lime mix. Addition of water causes bulking of soil which may be responsible for lower density of the treated soil. The capillary forces resisting the rearrangement of particles against the compressive energy may be responsible for low unit weigh. Standard proctor test results show that OMC for raw soil was increased on addition of 12% alccofine to virgin soil. The results for compaction test obtained when lime was added with alccofine in virgin soil samples proves that OMC increased to 20% after adding 6.5% lime and 3.5% alccofine to soil sample. The increase in OMC for different cases of treated soil may be due to higher requirement of water for exothermic reaction which takes place between the CaO and pozzolonic materials.

CBR test results show that there is minor improvement in the CBR value of soil i.e. CBR value increases from 2.0 for virgin soil to 3.65 for soil on the addition of 12% alccofine. Whereas, after 14 days of curing of samples the maximum CBR value obtained is 9.55 on the addition of 12% alccofine. Therefore, this amount of increment of CBR is not satisfactory and there is need to add a good binding material that is lime with alccofine to obtain better results.

On the addition of lime with alccofine give good results in which the CBR value is increased maximum to 14.20 on addition of 6.5% lime and 3.5% alccofine. It is obtained that this proportion gives the maximum improvement in the CBR value of soil. On the other hand, after 14 days of curing of samples the maximum value of CBR obtained is 34.50 on the addition of 6.5% lime and 3.5% alccofine. It is noticed that there is 2 to 3% rise in the CBR after curing of samples for 14 days.

UCS value of soil increased to 4.50 kg/cm² on addition of 9% alccofine as compared to virgin soil having UCS value of 2.65 kg/cm². After the curing of treated samples for 14 days, the unconfined compressive strength increased by almost 2%, i.e. 8.70 kg/cm² after adding 9% alccofine. On the addition of lime and alccofine to soil ,the results shows that the UCS value is increased to 7.55 kg/cm² on addition of 4.5% lime and 2.5% alccofine. On the curing of these samples for 14 days the UCS increased maximum to 16.10 kg/cm² for 4.5 lime and 2.5 alccofine sample.

Improvement in strength indicators i.e. CBR value and unconfined compressive strength is basically due to pozzolonic reaction that will take place when soil is treated with alccofine and lime. The cementitious reaction between the admixtures and clay minerals occurs in two processes that is primary and secondary process. In the first stage hydration i.e. primary process, a binder is produced which is responsible to keep the soil particles together. During the secondary process, the CaOH formed during the primary stage will react with the pozzolonic materials present in the clay and forming a cementitious gel which is responsible for strength gain. The addition of lime increases the strength upto optimum value of lime and thereafter strength may start reducing or becomes constant. This phenomenon maybe due to the reason that lime itself has very little friction or cohesion

VII. CONCLUSIONS

The strength characteristics of soil, lime and alccofine mix was studied. The main conclusions are given below:

The use of alccofine alone as a stabilizer shows little improvement in the CBR value of clayey soil. Therefore, a binder is needed in combination with alccofine, in order to obtain the satisfactory results.
The dosage of 4.5% lime and 2.5% alccofine by weight of soil can be taken as optimum to stabilize the soil.
There is increase in compressive strength of soil from 2.65kg/cm² for virgin soil up to 7.55 kg/cm² (without curing) and 16.10kg/cm² (14 days curing) for 4.5% lime and 2.5 % alccofine, Results show that there is 65% increment in UCS without curing and UCS value increased by 83.5% after 14 days curing.
With the increase in amount of alccofine there was decrease in liquid limit and plastic limit that leads to decrease in plasticity index of soil. Whereas adding lime with alccofine makes little increment in plastic limit but decrease in liquid limit.
With the increase in percentage of alccofine the maximum dry density decreased and optimum moisture content increases. Same results were obtained when the lime was also added with alccofine.

VIII. ACKNOWLEDGEMENT

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