Stabilization of Expansive Soil Treated with Barites powder and Aluminum chloride

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Abstract:

Expansive soils are basically susceptible to detrimental volumetric changes with changesin moisture content causes distortions to the structures constructed on these soils.Keeping in view the research findings outlined above, in the present work, experimentation was carried out to investigate the efficacy of different additives, viz., Aluminium Chloride and Barites powder, in stabilizing the Expansive Soil, thereby, improving the strength, swell characteristics of the expansive soil. A systematic methodical process was followed, involving experimentation in the laboratory under controlled conditions.The main objective of this study is to investigate the effectiveness of homogeneous layer formed by mixing the Barites Powder and Aluminum Chloride chemical (AlCl3) with the expansive soil. In this paper, the test results such as Atterberg limits, compaction, California Bearing Ratio, and Differential Free Swell obtained on expansive soils mixed with Aluminum Chloride (AlCl3) in varying percentages of 0.5%, 1.0%, 1.5%, 2.0% of the expansive soil and at each percentage of chemical, addition of Barites Powder in percentages of 10%, 20%, 30%. From the results, it is observed that at optimum percentage, i.e., 1.5% AlCl3 and 20% Barites Powder, there is a marked improvement in the strength of soil.

Keywords: Expansive soil, Barites Powder,$AlCl_3$,Atterberg limits, Compaction, Soaked CBR

I Introduction

Expansive soils of India are more commonly known as black cotton soils. These soils have their origin subaqueous decomposition of basalt rocks or weathering of basalt traps in situ. These soils are mostly residual in character and the thickness of their deposits is less than 4m in most cases. These soils are very hard in the dry state and possess a high shearing strength, which is reduced appreciably with the ingress of water.

The swelling potential of clay is dependent upon the amount and kind of clay minerals present in it.Any structure built over expansive soils; prevent evaporation of moisture content, which results in swelling of expansive soils under excessive moisture content. If the pressure exerted by the pavement or building is less than swelling pressure, then it results in development of heave which is uneven and causes structural damage.

Additives such as lime, cement, Calcium chloride,Aluminum chloride, rice husk, baritesm powder,Baggase ash,Barites powder,Marble dust etc. are also used to alter the characteristics of the expansive soils. The characteristics that are of concern to the design engineers are permeability, compressibility and durability

Due to insoluble nature of Barites powder and high specific gravity it gives maximum dry density and high bearing capacity and further increase the properties of expansive soil Aluminum chloride also used henceBarites Powder and Aluminum Chloride can be used best for various construction purposes like sub grade, foundation base and embankments. Barites powder and Aluminum Chloride exhibits high shear strength which is highly beneficial for its use as a geotechnical material.

IIReview of Literature

Swelling soils lift up and crack lightly loaded, continuous strip footings, and frequently causes distress in floor slabs. Because of the different building loads on different portions of a structure's foundation, the resultant uplift will vary in different areas. Some of the typical case histories involving damage to civil engineering structures due to the presence of expansive soil are reviewed critically in the following sections.

Light structures resting on footings or piles penetrating the more active clays have been badly cracked by foundation movements in both horizontal and vertical directions as shown in plate 2.3. Fills under floors have heaved, damaging floors and grade beams (Chen, 1988). Because of their alternate swelling and shrinkage, they result in detrimental cracking of lightly loaded civil engineering structures such as foundations, retaining walls, pavements, airports, sidewalks, canal beds and linings (Chen, 1988)

Abdullah et al., (2006) reported that expansive clay caused wide spread damage to low-rise buildings in Tabuk. (Saudi Arabia). Lucian (2006) presented the geo-technical aspects of buildings in expansive soils in Kibaha, Tanzania.

Sustained efforts (Petry and little, 2002; **Sharma and Phanikumar**, 2005; **Anand** et al., 2006; **Sree RamaRao** et al., 2007) are on throughout the world in the direction of providing specific solutions with varying filed conditions. Stiffening the foundation and superstructure, mat foundation, under reamed pile foundation, cohesive non-swelling layer (CNS-layer) technique, soil replacement, surcharge loading, heat treatment, moisture control, chemical stabilization, pre-wetting, are some of the remedial measures to overcome the problems of expansive soils.

Srinivasulu and Rao (1995) studied the efficacy of barite powder as a soil stabilizer. They had added barite powder up to 20% to an expansive soil. The IP, OMC, differential free swell index and C decreased and MDD, Ø, UCS and CBR values increased with increase in percentage of barite powder.

AI-Azzo (2009) had studied the stabilizing effect of crushed limestone on engineering properties of expansive clayey. Different percentages of crushed limestone dusts added were 2, 4, 6, 8 and 10%.It was found that there was reduction in the plasticity of the clay and significant decrease in expansion.

Ogbonnaaya and **IIIoabachie** (2011) had examined the stabilizing effect of granite dust on expansive soil. The percentages of granite dusts added were from 10 to 20% at an increment of 5%. It was found that with increase in percentage of addition granite dust, there was continuous decrease in wL, Ls, OMC, C, continuous increase in wP, MDD, unsoaked CBR and Ø

Mishra et al. (2014) had studied the effect of granite dust (added from 0 to 30% at an increment of 10%) on index properties of an expansive soil stabilized with 5% lime. There was continuous decrease in wL, IP, DFS and increase in wS up to 30% addition of granite dust.

Marble dusts are the wastes/dusts produced during cutting and polishing of marble. **Swami** (2002) and, **Palaniappan** and **Stalin** (2009) had stabilized expansive soil using marble dust and were successful in improving different properties of expansive soil.

Sabat and **Nanda** (2011) had studied the effects of marble dust on strength and durability of rice husk ash stabilized expansive soil and found that addition of marble dust increased the strength, decreased the swelling pressure and made the soil-rice husk ash mixes durable. The optimum proportion of soil: rice husk ash: marble dust was found to be 70:10:20.

Zhang et al.(2013) had found the positive effects of marble dust on strength, swelling and durability of biomass ash stabilized expansive soil. The optimum proportion of soil: biomass ash: marble dust was found to be 75:10:15.

Gupta and **Sharma** (2014) had studied the effect of fly ash, sand and marble dust on compaction and CBR values of expansive soil ,there was approximately 200% increase in soaked CBR in the sample having soil -52.36%,sand-22.44%,fly ash -13.2% and marble dust- 12%.

Sharma et al. (2008) had investigated the behavior of expansive clay stabilized with lime, calcium chloride and RHA. The optimum percentage of lime and calcium chloride was found to be 4% and 1% respectively in stabilization of expansive soil without addition of RHA. From UCS and CBR point of view when the soil was mixed with lime or calcium chloride, RHA content of 12% was found to be the optimum. In expansive soil – RHA mixes, 4% lime and 1% calcium chloride were also found to be optimum.

In the present work, an attempt was made by using $AlCl_3$and Barites powder as stabilization material in expansive soil. In this investigation different laboratory experiments like Atterberg limits, differential free swell,compaction, soaked CBR tests conducted on stabilized expansive soil with Aluminum Chloride in varying percentages of 0.5%, 1.0%, 1.5%, 2.0% of to the expansive soil and at each percentage of chemical, addition of Barites Powder in percentages of 10%, 20%, 30%.

III Materials used

Black Cotton Soil

The soil used was a typical black cotton soil collected from Yentikona, Allavaram Mandal, in East Godavari District, Andhra Pradesh State, India. The black cotton soil was collected by method of disturbed sampling after removing the top soil at 150mm depth and transported to the laboratory. The soil was air dried and sieved with is sieve 4.75mm as required for laboratory test as shown in fig.1. The soil properties are WL=83.4%, WP=40.6%, PI=42.8, I.S. Classification=CH (Clay of high compressibility), OMC=21.90, MDD=1.575Kn/m3, Differential free swell = 100 %, Soaked CBR=1.82%, Specific Gravity=2.68

Barites Powder

Barites Powder was used in this study as shown in fig.2. Barites Powder is mixing in varying percentages of 10%, 20%, 30% of the expansive soil. The Barites Powder collected from Sri Balaji micro Pulverising mill,SVDC Road,Kadapa was used as a sub-base course in this work. The properties of Barite powder are MDD=8.263 kN/m3, OMC=18.94%, Soaked CBR=9.46%.

Aluminum Chloride ($AlCl_3$)

Commercial grade Aluminum chloride was used in this study. Aluminum Chloride (AlCl3) in varying percentages of 0.5%, 1.0%, 1.5%, 2.0% of the expansive soil. The quantity of Aluminum chloride was varied from 0 to 2% by dry weight of soil as shown in fig.3.

Fig.1 Expansive Soil **Fig. 2** Barites Powder**Fig.3**Aluminum Chloride

IV. Experimental Investigation

To find the effectiveness of Aluminum Chloride and Barites Powder i.e. Aluminum Chloride (AlCl3) is added separately in varying percentages 0.5%. 1.0%, 1.5%, 2.0% to the expansive soil and at each percentage of chemical, addition of Barites Powder in percentages of 10%, 20%, and 30% was investigated. The Liquid Limit & Plastic Limit tests were conducted as per IS:2720 (Part 5) – 1985, Heavy compaction testing IS2720 (Part 8) – 1983, Free Swell Index Testing IS:2720 (Part XL) – 1977 and California Bearing Ratio (CBR) Testing IS:2720 (Part 16) – 1987.

Testing is conducted with a view to find the gradual variation of different engineering properties by increasing the quantity of chemical and Barites powder and finally to determine the optimum percentage of chemical and Barites Powder i.e. at which the properties are reaching a definite improved value

V. Results And Discussions

Consistency Characteristics of Expansive soil and Barites Powder

The variation of different Atterberg limits with the addition of different additives is presented in this article. The influence of chemical and Barites Powder combinations on the index properties observed during the laboratory testing is shown in Fig.4 & 5

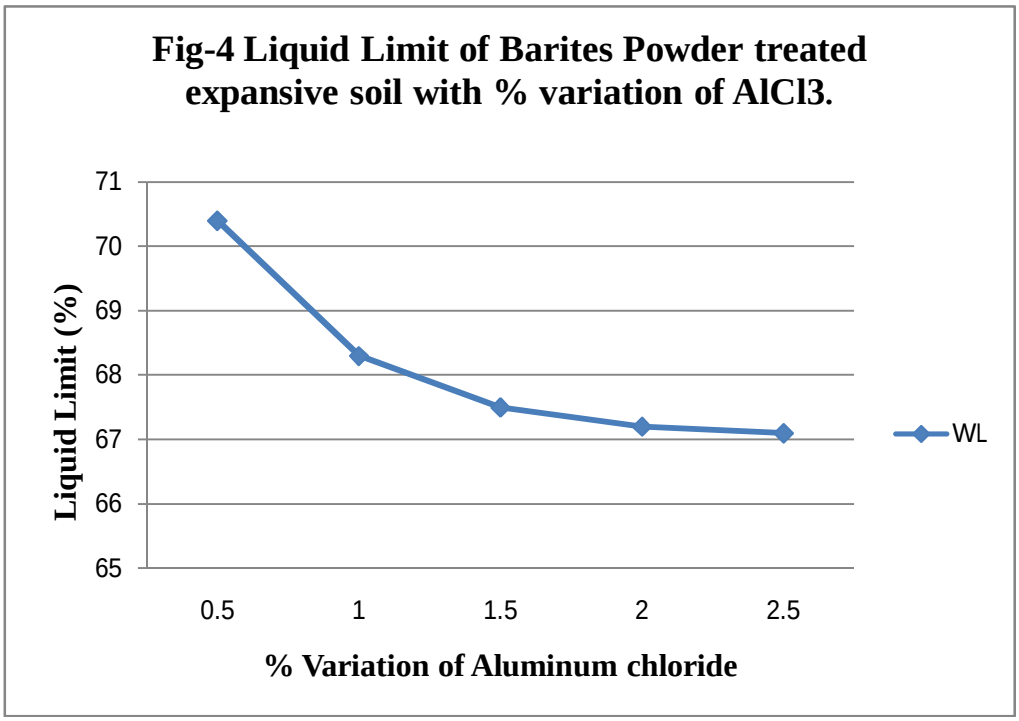
Fig-4 Liquid Limit of Barites Powder treated expansive soil with % variation of AlCl3.
Liquid Limit (%)
71
70
69
68
67
66
65
0.5
1
1.5
2
2.5
% Variation of Aluminum chloride
WL

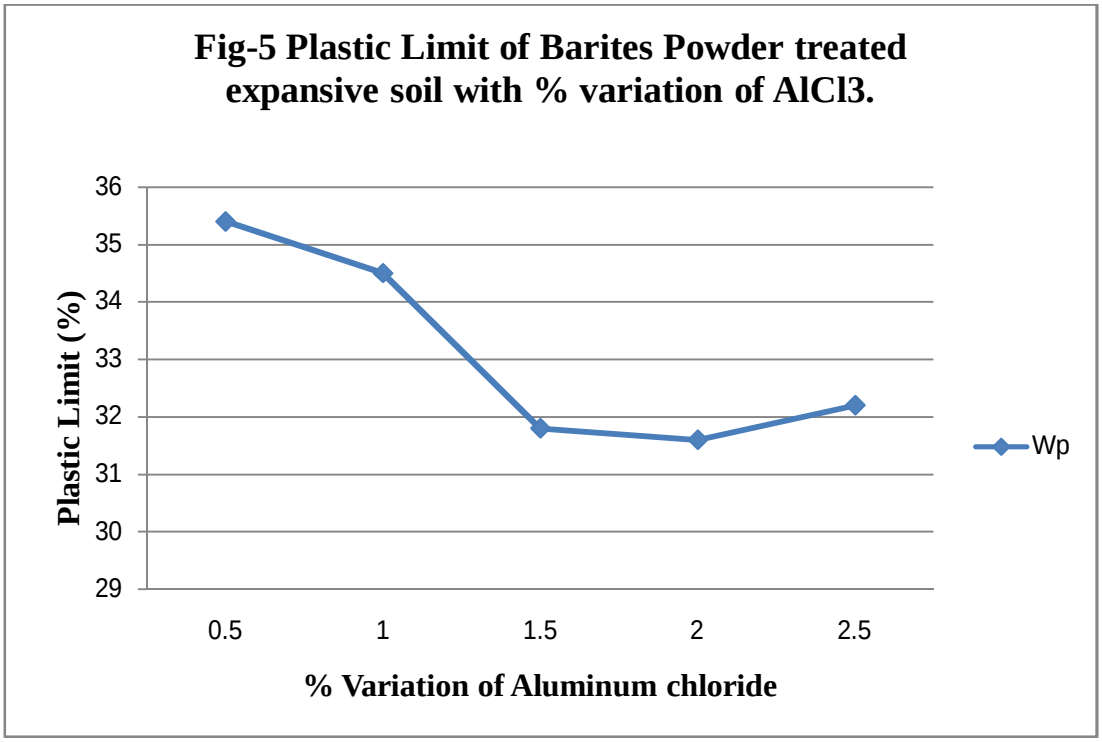
Fig-5 Plastic Limit of Barites Powder treated expansive soil with % variation of AlCl3.
Plastic Limit (%)
36
35
34
33
32
31
30
29
0.5
1
1.5
2
2.5
% Variation of Aluminum chloride
Wp

Fig. 4&5 Variation of Liquid Limit, Plastic limit for Expansive Soil with Different Percentages of AlCl3 and Barites Powder Mixes.

Compaction Test Results

IS heavy compaction tests were conducted as per IS: 2720 (Part VIII). All the expansive soil samples are mixed with different percentages of Barites Powder and Aluminum Chloride. Graphs are drawn between OMC and MDD for each percentage of Barites Powder and Aluminum Chloride mixing in the expansive soil. From the test results Optimum Moisture content increases and Maximum Dry Density values are decreases presented below in the Fig 6

Fig-6 OMC and MDD values of Barites Powder treated Expansive Soil with % variation of $AlCl_3$

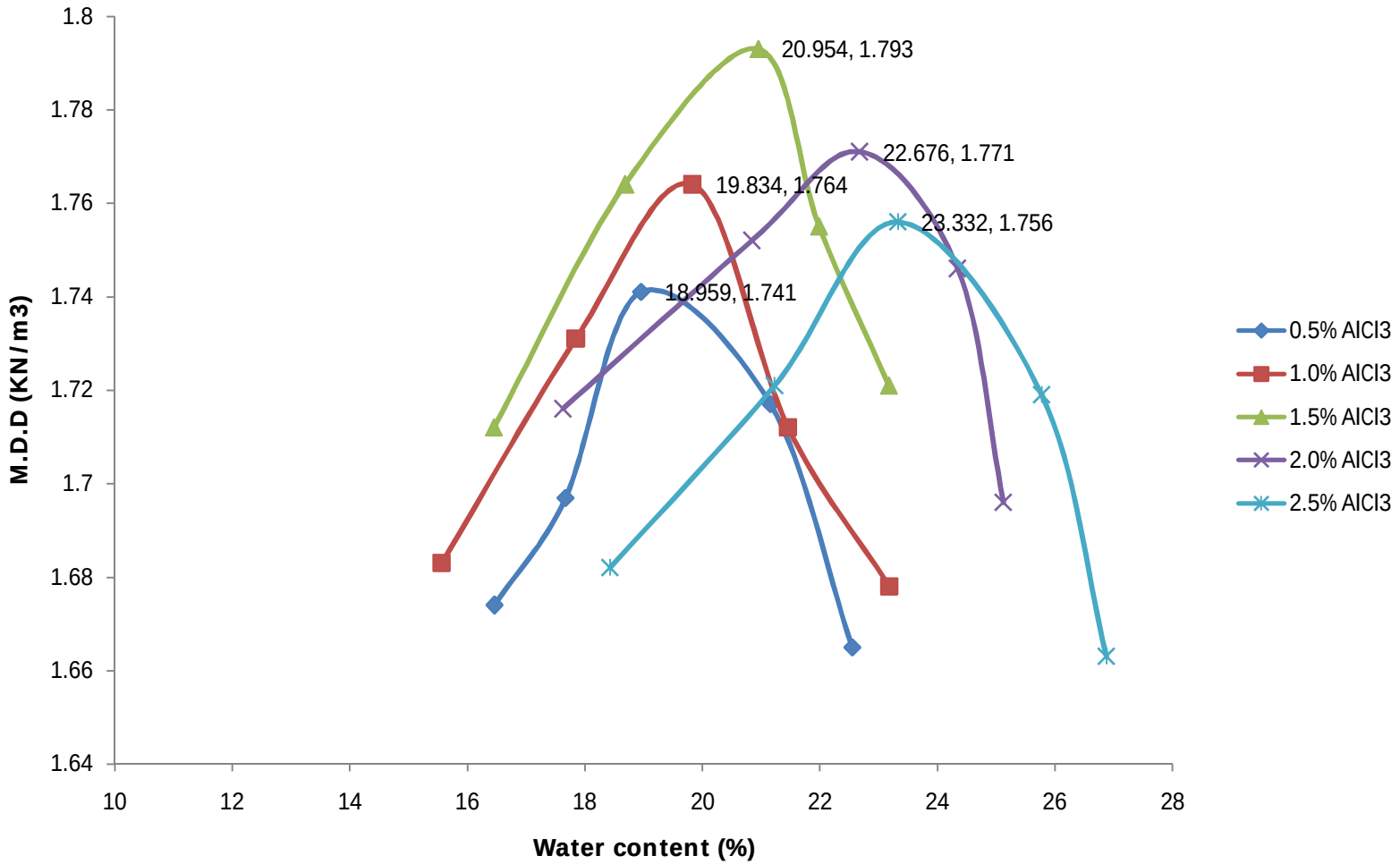

Fig. 6 Variation of Optimum Moisture Content and Maximum dry density for Expansive Soil with Different % of Barites Powder and aluminum chloride

California Bearing Ratio Test Results

Soaked CBR test was carried on a specimen prepared at Modified Proctors maximum dry density and optimum water content. Fig8shows the variation of soaked CBR values with increasing percentages of chemical AlCl3 and Barites Powder. Soaked CBR value of original expansive soil is 1.82. It is observed that the flattening of the curve at 0.5% addition of chemical indicates nominal improvement with the addition of further chemical

Fig-7 CBR Value of Barites powder treated Expansive Soil with % variation of $AlCl_3$

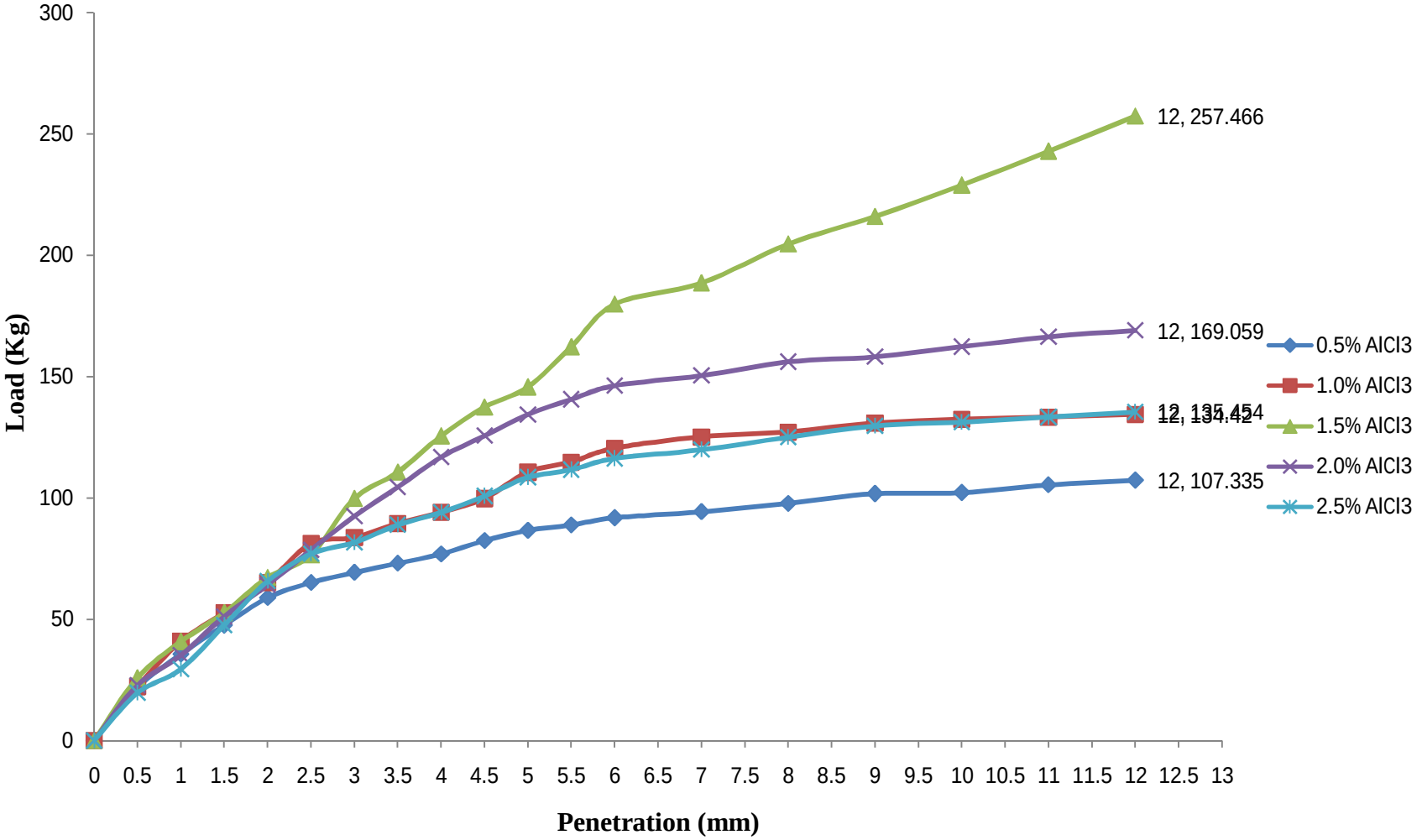

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Fig. 7 Variation of California Bearing Ratio for Expansive Soil with Different % of Barites powder and AlCl3

Shear strength parameters(C&Φ):

The cohesion of expansive soil was found to be decreased from and the angle of internal friction with the addition of Barites powder treated expansive soil with % variation of aluminum chloride.

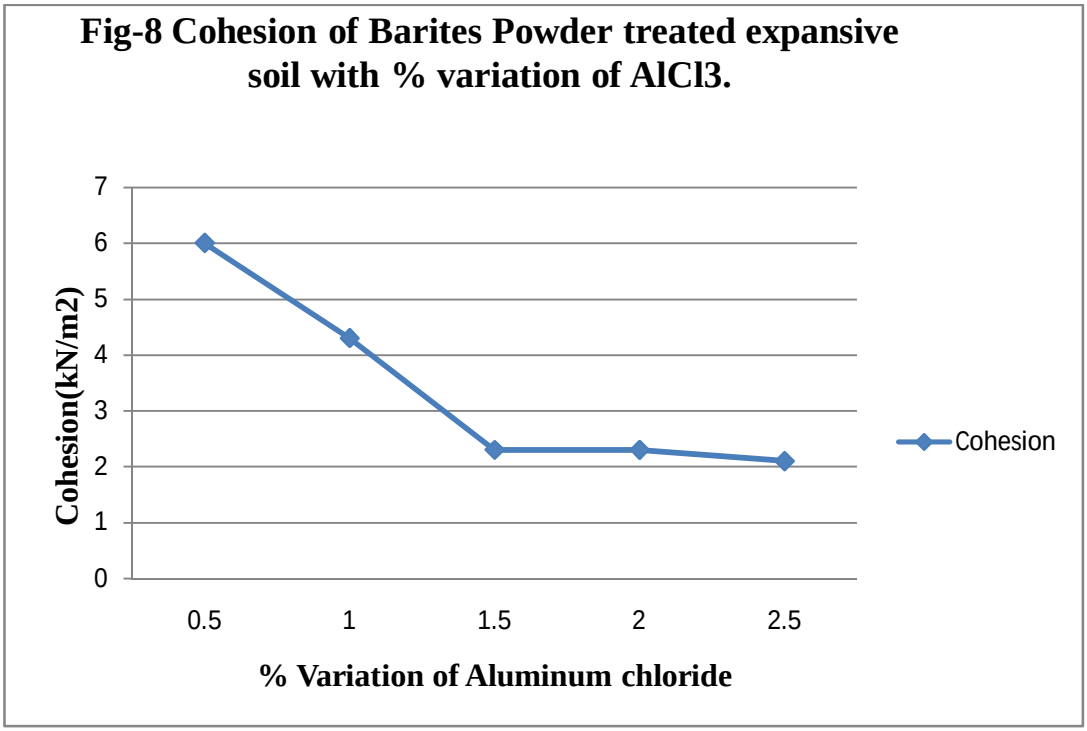

Fig. 8 Variation of Cohesion for Expansive Soil with Different % of Barites powder and AlCl3

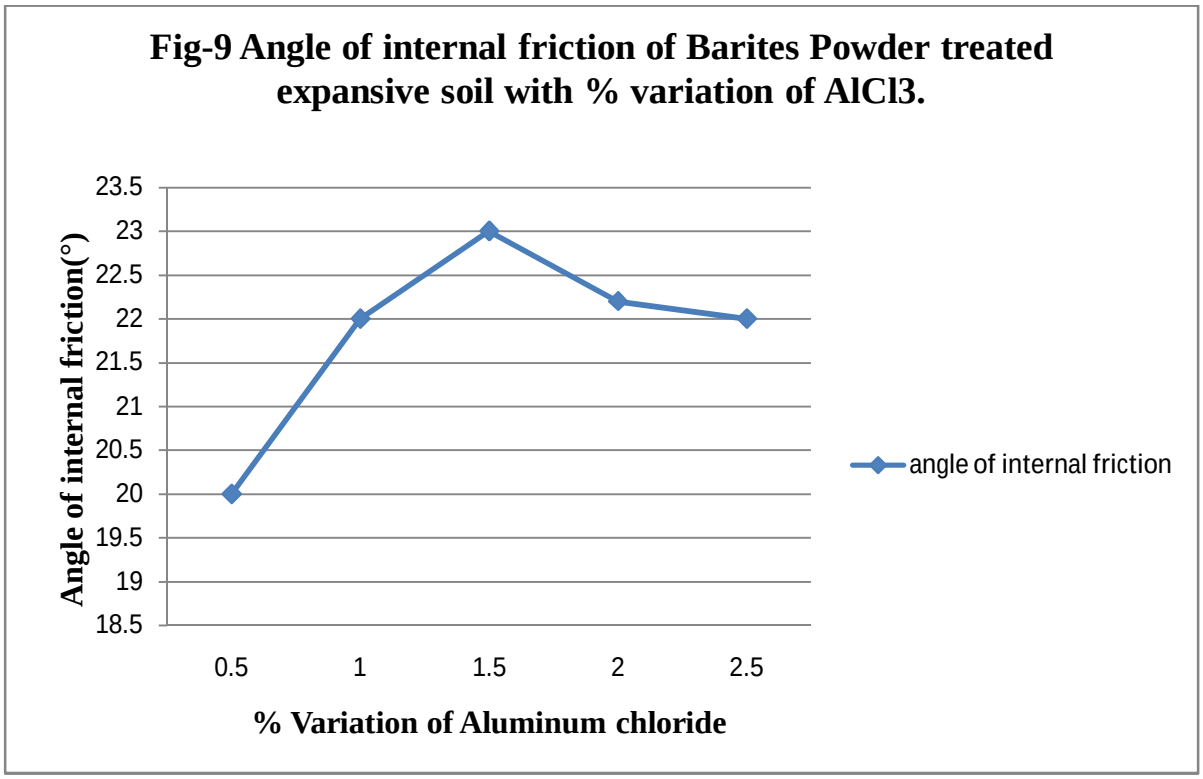

Fig. 9 Variation of Cohesion for Expansive Soil with Different % of Barites powder and AlCl3

VI. Conclusions

The following conclusions are obtained based on the laboratory studies carried out in this investigation.

(1) It was observed that the liquid limit and plastic limit decreasing by adding 20% barite powder+1.5% $AlCl_3$.

(2) It was found that the Maximum Dry Density increased and OMC goes on decreasingby adding 20% barite powder+1.5% $AlCl_3$.

(3)From the laboratory studies, it is observed that the Differential Free Swell of the expansive soil has been improved by 60% with the addition of 20% Barites Powder and further the Differential Free Swell of 20% Barites Powder treated expansive soil has been improved by 70% with the addition of 1.5% $AlCl_3$

(4) It was noticed that the Soaked CBR goes on increasing with optimum percentage of Barites Powder and further increased the strength properties it is treated with % variation of aluminum chloride and it gives 1.5% optimum value up to this CBR value increased and after increasing the chemical % its value decreases.

(5) It was found that cohesion goes on decreasing and angle of internal friction increases From the above experimental analysis by adding 20% Barites Powder and 1.5% Aluminum chloride.

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