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INFLUENCES OF FLY ASH AND CHEMICALS ON SWELLING SOIL

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***Abstract*:** Expansive soil cause serious problem in the civil engineering practice due to swelling and shrinkage. Volumetric changes (swelling) of expansive soils in presence of water are undesirable for stability reasons. As a result, damage to foundation systems, structural elements and architectural features defeat the purpose for which the structures are erected. In this paper, the effect of fly ash and chemicals on free swell index of expansive soil was studied. The fly ash and chemicals such as Aluminum chloride ($AlCl_3$), Magnesium chloride ($MgCl_2$) and Ammonium chloride (NH_4Cl) were used in varying percentage to reduce the free swelling index of soil. Reduction in swelling index was observed by using fly-ash, chemicals and combination of both. Also, the results were compared among them to get a percentage concentration of above mentioned additives which gives lower value of swelling index.

***Keywords*–** Expansive Soil, Fly ash, Chemicals, Free Swelling Index

I. INTRODUCTION

The term expansive soil applies to soils that have tendency to swell when their moisture content is increased and shrink when their moisture content is decreased. The moisture may come from rain flooding, leakage water from or sewer lines or from reduction in surface evapotranspiration when an area is covered by a building or pavement. To achieve the economy and for proper performance of structure it is necessary to improve the geotechnical properties of expansive soil.

Expansive soils occurring above water under go volumetric changes with changes in moisture content. Increases in water content causes the swelling of the soils and loss of strength and decrease in moisture content brings about soil shrinkage. Swelling and shrinkage of expansive soil cause differential settlements resulting in severe damage to the foundations, buildings, roads, retaining structures, canal lining, etc. The construction of foundation for structures on black cotton soils poses a challenge to civil engineers. Owing to moistures variations, this clay exhibit considerable variation of shear strength and compressibility and swelling, which causes differential movement, results in severe damages to foundations, buildings, roads, retaining structures, canal lining and more. In such situations, the undesirable characteristics and performance of expansive soil can be altered and improved with chemical additives like lime, cement, fly ash, inorganic salts, chemical compounds etc. Cement and lime are most commonly used for the stabilization of expansive soils to ensure high strength. As high strength may not always be required, cheaper additives such as chlorides and gypsum have been used to stabilize soils. Utilization of fly ash is a better solution as per Govt. rules sand reduces waste material to save the environment. The Indian coal is of low grade having high ash content of the order of 30-45% generating large quantity of fly ash at coal/lignite based thermal power stations in the country. The management of fly ash has thus been

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a matter of concern in view of requirement of large area of land for its disposal because ofits potential of causing pollution of air and water. A large number of technologies have been developed for gainful utilization and safe management of fly ash under the concerted efforts made by fly Ash Mission/Fly Ash Unit under Ministry of Science & Technology, Government of India since 1994. As a result, Fly ash earlier considered to be "hazardous industrial waste" material, has now acquired the status of useful and saleable commodity.

Expansive soil characteristics can be altered and soil performance can also be improved with chemical admixtures. The selection and success of the used additives depends on economy consideration, soil condition, level of modification required and availability of material and instrumentation required for particular techniques. If the soil is expansive in nature, the problems of construction increase as these soils have low shear strength, high compressibility, high swelling potential and so on. The phenomenon of swelling response is isotropic in nature, and hence, is a suitable additive technique that is effective in all direction is likely to be useful. In this paper a comprehensive experimental work undertaken to study the free swelling index of expansive soil treated with fly ash and chemicals (chloride salts). And the results of work were comparing for the development of knowledge base in this regard.

II. OBJECTIVES

The main aim of the study is to determine the performance improvement of swelling soil by adding different additives. The fly ash, MgCl2, NH4Cl and AlCl3 chemicals were used for addition. Following are the objective of study.

- To determine free swelling index of expansive soil by adding varying % of fly ash.
- To determine free swelling index of expansive soil by adding varying % of chemicals.
- To determine free swelling index of expansive soil by adding varying percentage of chemicals with varying percentage of fly ash

III. METHODOLOGY

Materials Used

Soil sample:

The soil sample used in the project work for the experimental purpose is excavated from a depth of 2.6m below the ground level from our college campus. The collected soil sample is expansive in nature and yellow in colour. Fig 1 shows a typical photograph of soil sample.

Fig. 1 Soil Sample

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Fly ash:

Fly ash is finely divided residue resulting from the combustion of powdered coal, transported by the fuel gases and collected by electrostatic precipitator. The fly ash used in this study for reducing the free swelling index of soil has been collected from Ready Mix Concrete Plant, Amravati. Fig 2 shows a typical photograph of fly ash.

Fig. 2 Fly Ash

Chemicals:

Chloride compound chemicals chosen in the present study are Magnesium Chloride (MgCl2), Aluminum Chloride (AlCl3) and Ammonium Chloride (NH4Cl). These chemicals are easily soluble in water and uniform mixing can be easily achieved. These chemicals are added to the expansive soil samples in varying percentages of 0.5%, 1.0%, 1.5%, 2.0% of dry weight of soil.

Aluminium chloride: Aluminium chloride (AlCl3) is a salt of white colour and when contaminated with iron tri-chloride becomes yellow. This salt has low melting and boiling points. It is mainly produced and consumed in the production of Aluminium metal, but large amounts are also used in other areas of chemical industry. It is an inorganic compound that cracks at mild temperature and reversibly changing from a polymer to a monomer. Fig 3 shows a typical photograph of aluminium chloride.

Fig. 3 Aluminum Chloride

Ammonium chloride: Ammonium chloride (NH4Cl) is a white crystalline salt that is highly soluble in water. Solutions of ammonium chloride are mildly acidic. Nushadir salt is a name of ammonium chloride. The mineral is commonly formed on burning coal dumps from condensation of coal-derived gases. It is also found around some types of volcanic vents. Fig 4 shows a typical photograph of ammonium chloride.

Fig. 4 Ammonium Chloride

Magnesium chloride: Magnesium chloride salts are typical ionic haldies, they highly soluble in water. The hydrated magnesium chloride can be extracted from brine or sea water. Magnesium chloride is also extracted out of ancient sea beds. Fig 5 shows a typical photograph of magnesium chloride

Fig. 5 Magnesium Chloride

IV PERFORMANCE ANALYSIS

a) Effect of fly ash

To determine the effect of fly ash on swelling index of expansive soil the percentage of fly ash varies as 45% to 70% are shown in fig 6.

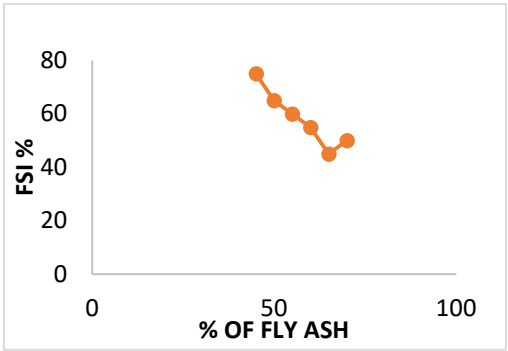

Fig.6 FSI of Original Soil + Fly Ash

From figure 6 it was observed that when varying percentage of fly-ash was added to the soil, the free swelling index decreases from 75% to 45% with increase in percentage of fly-ash from 45% to 65% respectively and further increase in fly-ash increases the free swelling index of the soil. Thus the optimum percentage of fly-ash observed was 65% on which the free swell index reduces to 45%.

b) Original soil + chemicals

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To determine the effect of chemicals ($AlCl_3$, $MgCl_2$ and NH_4Cl) on swelling index of expansive soil the percentage of chemicals varies as 5% to 30% are shown in Fig.7.

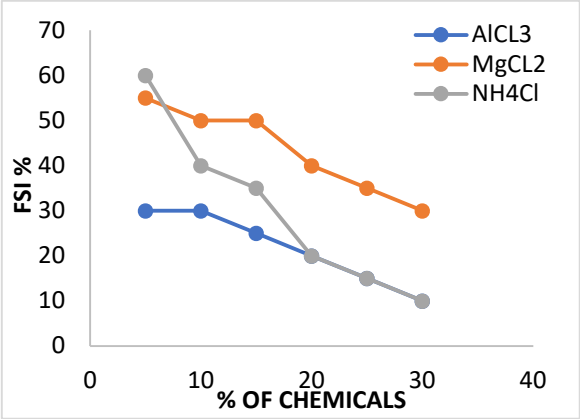

Fig.7 FSI of Original Soil + Chemicals

From figure7 it was observed that when percentage of magnesium chloride was varied from 5% to 30% with untreated soil, the free swelling index reduced from 55% to 30% whereas in case of aluminium chloride it reduces from 30% to 10% and on adding ammonium chloride it reduces from 60% to 10%. Thus comparing all three chemicals it can be concluded that aluminium chloride is more effective in reducing free swell index.

c) Original Soil + Fly Ash + Chemicals

i) Original Soil + 50% of Fly Ash + % of Chemicals

To determine the effect of chemicals ($AlCl_3$, $MgCl_2$ and NH_4Cl) on swelling index of expansive soil the percentage of chemicals varies as 0% to 2% at constant % of fly ash i.e 50% are shown in fig.8

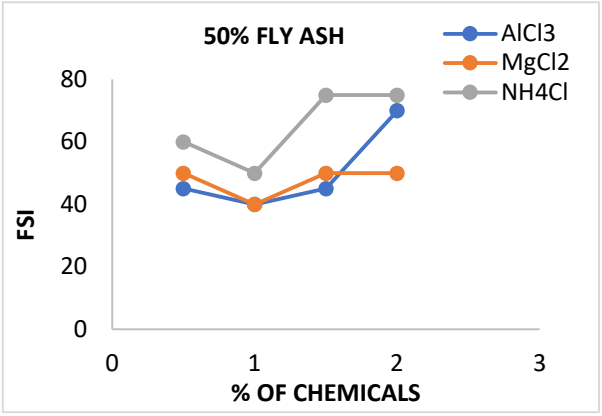

Fig.8 FSI of Original Soil + 50% of Fly Ash + Chemicals

From figure 8 it was observed that when varying percentage of chemicals was added to the combination of soil and 50% fly-ash, the optimum percentage of all chemicals was found to be 1%. On addition of 1% of ammonium chloride the FSI decreases to 50% whereas on addition of aluminium chloride and magnesium chloride it reduces to 40%. Thus aluminium chloride and magnesium chloride are more effective rather than ammonium chloride.

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ii) Original soil + 55% fly ash + % of chemicals

To determine the effect of chemicals ($AlCl_3$, $MgCl_2$ and NH_4Cl) on swelling index of expansive soil the percentage of chemicals varies as 0% to 2% at constant % of fly ash i.e 50% are shown in fig.9.

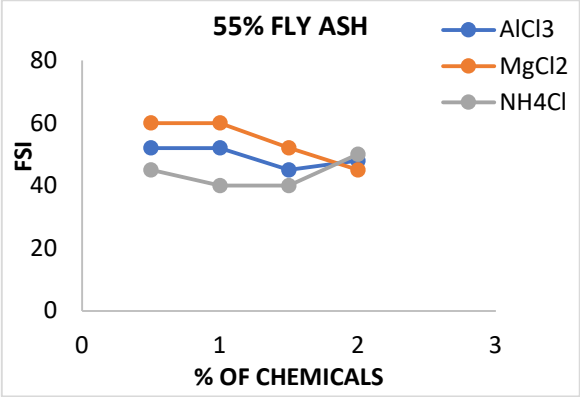

Fig.9 FSI of Original Soil + 55% of Fly Ash + Chemicals

From fig.9 it was observed that when varying percentage of chemicals were added from 0.5% to 2% with combination of 55% fly-ash and soil, the optimum percentage of aluminium chloride was observed as 1.5% on which FSI reduces to 45% and for ammonium chloride the optimum percentage was observed as 1% on which FSI reduces to 40%. Ammonium chloride was found to be more effective and economical as its optimum percentage is less than aluminium chloride.

iii) Original soil + 60% fly ash + % of chemicals

To determine the effect of chemicals ($AlCl_3$, $MgCl_2$ and NH_4Cl) on swelling index of expansive soil the percentage of chemicals varies as 0% to 2% at constant % of fly ash i.e 60% are shown in fig.10.

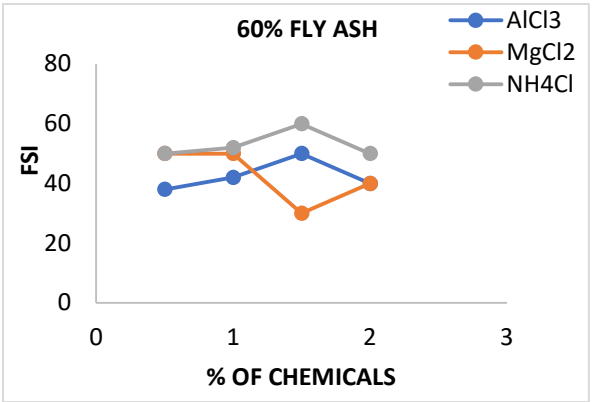

Fig.10 FSI of Original Soil + 60% of Fly Ash + Chemicals

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From fig.10 it was observed that when chemicals were added from 0.5% to 2% with combination of 60% fly-ash and soil, best result were obtained from magnesium chloride. Its optimum percentage was found as 1.5% on which FSI decreases to 30%.

iv) Original soil + 65% fly ash + % of chemicals

To determine the effect of chemicals ($AlCl_3$, $MgCl_2$ and NH_4Cl) on swelling index of expansive soil the percentage of chemicals varies as 0% to 1.5 % at constant % of fly ash i.e 65% are shown in fig.11.

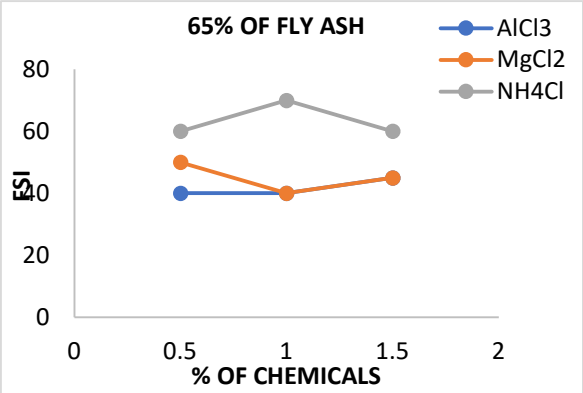

Fig.11 FSI of Original Soil + 65% of Fly Ash + Chemicals

From fig.11 it was observed that when varying percentage of chemicals were added to the combination of 65% fly-ash and soil, the optimum percentage of magnesium chloride was found to be 1% for which FSI decreases to 40%. Whereas for aluminium chloride same optimum results were obtained on 0.5% and 1%. But from economical point of view 0.5% is considered as the optimum percentage for aluminium chloride.

V CONCLUSIONS:

The study was conducted to investigate the effect of fly ash, chemicals (AlCl3, MgCl2, and NH4Cl) and combination of both on swelling properties of expansive soil from P.R.Pote (Patil) college campus Amravati. Based on the present laboratory study, the following conclusions are drawn:

- The engineering prosperities of soil tested showed that the soil is classified as high plastic clay of high expansiveness, PI is 46.31% and FSI is 90%
- On addition of fly ash with expansive soil swelling index decreases with increase in fly ash % from 45% to 65%. The optimum % of fly ash was calculated as 65%.
- A significant decrease in swelling characteristics of the expansive soil with addition of NH4Cl, MgCl2 and AlCl3 were observed. Maximum reduction of FSI of 88% was observed on addition of NH4Cl and AlCl3 individually. Whereas on addition of 30% of MgCl2 FSI decreases upto 66%.
- The combination of 1.5% MgCl2 with 60% of fly ash was found to be most effective treatment for reducing swelling of expansive soil.

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