A Critical Review on Effective use of Chemical Admixture to Reduce Swelling and Shrinkage Characteristics of Soil

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Abstract: Generally, swelling and shrinkage characteristics of the clayey soil is due to volumetric changes that occur in presences of water. Type of minerals present in clayey soil governs the amount of swelling-shrinkage in the soil. The swelling and shrinkage characteristics of the soil is causes minor to major problems to the infrastructure. This problems are reduced in many ways such as sand cushion. CNS layer technique, sand columns, stone columns, vibration technique and by adding chemical admixtures. The chemical additives method is expensive technique, but advantage of this method is that setting time and curing time controlled. This review paper, compares the work of various researchers to reduce swelling-shrinkage using different proportions of chemical admixtures.

In this review paper, some chemical salts and chlorides such as calcium carbonate, sodium carbonate, calcium chloride, magnesium chloride and ferric chloride are react with soil and reduced the maximum swelling and shrinkage properties of the soil.

Index Terms - Soil modification, Volumetric change, Swelling and shrinkage characteristics, Chemical additives;

I. INTRODUCTION

Generally, swelling and shrinkage characteristics of the soil are damage to the infrastructure. Swelling and shrinkage are occurring in the soil due to variation of the moisture fluctuations of water. The shrink-swell capacity of clay refers to the extent certain clay minerals will expand when wet and retract when dry. Soil with a high shrink-swell capacity is problematic and is known as shrink-swell soil or expansive soil.This problems are reduced in many ways. Chemical admixture technique is expensive to reduce the swell and shrink. The previous research shows that the various types of chemicals are already used in geotechnical field.

This review paper reflect some experimental work done on soil modification by using different chemical admixtures in dufferent proportions for reduced the swelling and shrinkage characteristics of the soil by different researchers and comparison of their results.

II. REVIEW OF PREVIOUS WORK DONE

A. Influence of Chemical Additives on Shrinkage and Swelling characteristics of Bentonite Clay:

In this research paper, the researchers are used three different chemical additives in montmorillonite (bentonite) clay and reduced the swelling and shrinkage characteristics of the soil. The chemicals are used in this research paper is Cocoamidoproply Betaine (CAPB), Benzalkonium (BKC) and Centrimonium Bromide (CTAB) with different proportions i.e. 1%, 1% and 3% respectively.

The aim of this research paper is to analyzed swelling-shrinkage characteristics, cation exchange capacity (CEC) and water wet ability of montomorillonite clay. The presence of Na^+ and Ca^{2+} captions on the surface of the montomorillonite clay, it could be replaced by organic cationic surfactant molecules. Cocoamidoproply Betaine (CAPB), Benzalkonium Chloride (BKC) and Centrimonium Bromide (CTAB) are generally used chemicals in montomorillonite clay for making the organic modified clay[1]. The modification of clay by those chemicals additives are generally used in montomorillonite clay for making the organic modified clay. The CAPB and CTAB chemicals having different long alkly chain. The ineterlayer spacing and partical size of the clay and swelling-shrinkage properties of the modified montomorillonite clay are mainly depends on the alkly chain length and substituent Groups of the chemicals[1]. The CAPB and CTAB chemicals having different alkly chain length of the non-aromatic substituent group and BKC having benzyl substituent group[1].

The initial procedure of this paper is to determine of the index properties of the montomorillonite clay, cation exchange capacity of the soil and also found out the chemical composition, properties and chemical formula of the CAPB, BKC and CTAB chemicals. After obtained the swelling and shrinkage characteristics of the virgin clay then it is treated by CAPB, BKC and CTAB by adding 1%, 1% and 3% respectively. The results obtained of the treated modified clay is given in below table.

Table 1: Results of Shrinkage limit test

Sample	Shrinkage Limit (%)
Untreated clay	51.67
1% BKC	36.65
1% CAPB	27.45
3% CTAB	42.28

Table 2: Results of Free Swell Index and Swell Pressure

Sample	Free Swell Index (%)	Swell Pressure (kPa)
Untreated clay	180	66.7
1% BKC	130	19.0
1% CAPB	120	14.0
3% CTAB	137	51.1

The results obtained of the treated modified clay is that the shrinkage limit of the soil decrease approximately 27% in 1% BKC, 50% in 1% CAPB and around 20% in 3% CTAB soil sample and the free swell index of the untreated soil decrease approximately 25% in 1% BKC, 20% in 1% CAPB and around 15% in 3% CTAB soil sample. And also concluded that swell pressure of the soil is decrease in the respective sample. In this research paper, the chemicals are selected based on the CEC of the soil.

B. Efficacy of Sodium Carbonate and Calcium Carbonate in Stabilizing Black cotton soil:

In this research paper, the researchers are used two different chemical additives are used for reduced plasticity characteristics, swelling characteristics, optimum moisture content and increase the maximum dry density, improved the CBR value, angle of internal friction, cohesion of the Black cotton soil. In this research paper, the chemicals are used is Sodium carbonate and Calcium Carbonate in various proportions such as 0.25%, 0.50%, 0.75%, 1.0%, 1.5% and 2%. The efficacy of sodium carbonate and calcium carbonate in stabilizing a black cotton soil is presented this paper.
The sodium carbonate is the compound of the sodium and carbon dioxide. It is soluble in water but insoluble in alcohol[2]. There are various uses of sodium carbonate in industrialization. Calcium carbonate is also soluble in water. It is generally used in medicinally as as a alkly calcium supplement[2].

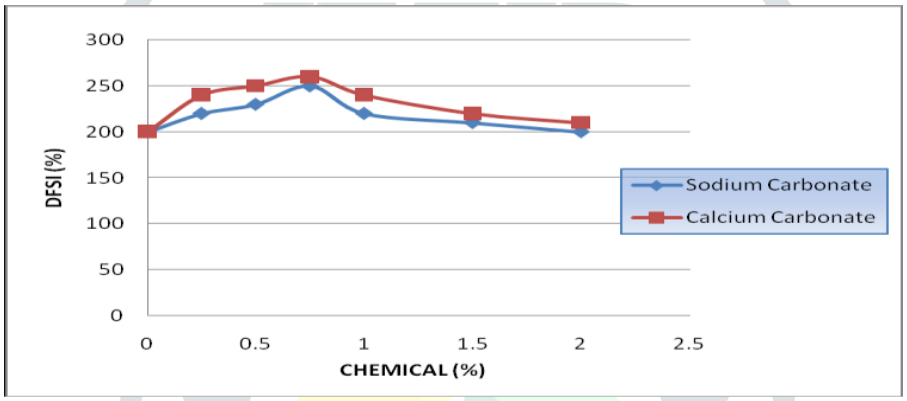

Fig: 1 Variation of Differential Free Swell Index with per cent chemical

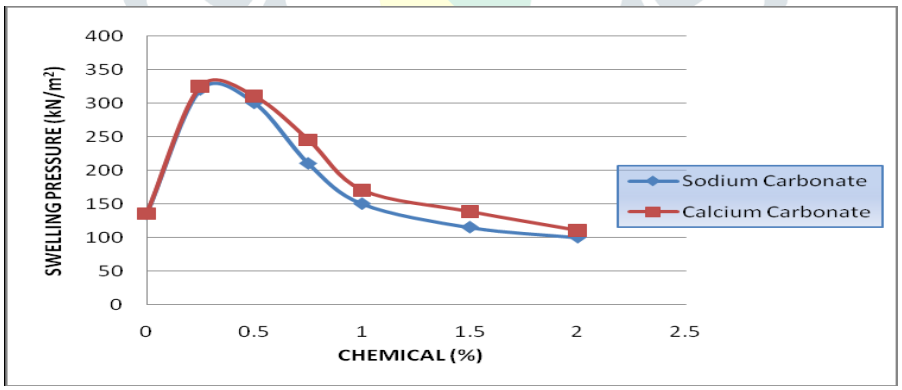

Fig: 2 Variation of Swelling Pressure with per cent chemical

In this paper, chemical is prepared by dissolving chemical powder in distilled water and it is used in different proportions such as 0.5%, 0.75%, 1.0%, 1.5% and 2.0% respectively by weight of the soil. The results are obtained after adding chemical is given shown in fig. 1 and 2.

The researcher is concluded that, two percent of the chemical is effective in reducing the swelling characteristics in the tested range and sodium carbonate is slightly better than the calcium carbonate[2]. In this paper not mentioned the any type of CEC value.

C. Effect of Some Chloride Salts on Swelling Properties of Expansive Soil:

The use of chloride salts to stabilize expansive clays has been investigated this researchers. In this regard an attempt has been made to evaluate the influence of adding three chloride salts ($AlCl_3$, $FeCl_2$, NH_4Cl) to an expansive clay of high swelling potential on its swelling properties.

Various amounts of each salt (0%, 5%, 10%, and 15%) were added to the soil to study their effect on plasticity and swelling characteristics. The objective of this research paper is to determine the effect of addition of chloride salts such as aluminum

chloride, ferric and ammonium chlorides ($AlCl_3$, $FeCl_3$, NH_4Cl) on expansive soil in term of change in index properties and swelling characteristics[3].

Ferric chloride and aluminum chloride have been found to be promising water proofers for heavy clays stabilized by phosphoric acid, and it has been postulated that the ferric and aluminum ions reduced swelling of the montmorillonite minerals in the soil by replacing the interlayer metallic cations[3].

Laboratory tests were conducted on samples prepared by adding different percentages of aluminum chloride, ferric chloride, and ammonium chloride to the expansive soil. After adding this chemical in the soil, the results is shows in fig. 3, 4, and 5. And the author are concluded that the free swell index (FSI) of the treated clay with addition of 0%, 5%, 10%, and 15% of each chloride salt ($AlCl_3$, $FeCl_3$, NH_4Cl) is presented in Fig 3. At 15% $AlCl_3$, $FeCl_3$ and NH_4Cl, the reductions in FSI are 67%, 80%, and 95% respectively[4]. A significant decrease in the swelling characteristics of the stabilized expansive clay with addition of NH_4Cl. The maximum reduction in swelling properties observed when NH_4Cl salt added to the soil, while the minimum reduction occurred in addition of $AlCl_3$ salt. When 5% of NH_4Cl added to the soil, the free swell index and swell pressure values greatly reduced by almost 70% of the initial values[4,5]

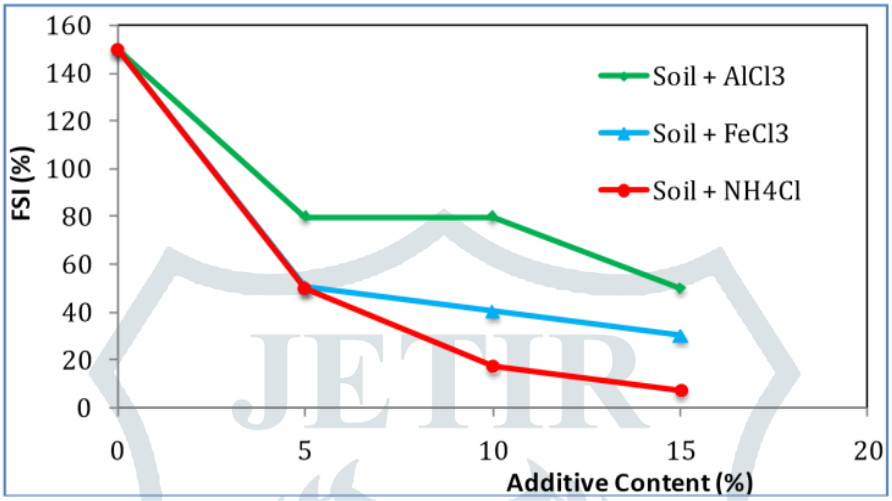

Fig. 3. Variation of free swell index of stabilized soil with $AlCl_3$, $FeCl_3$, and NH_4Cl

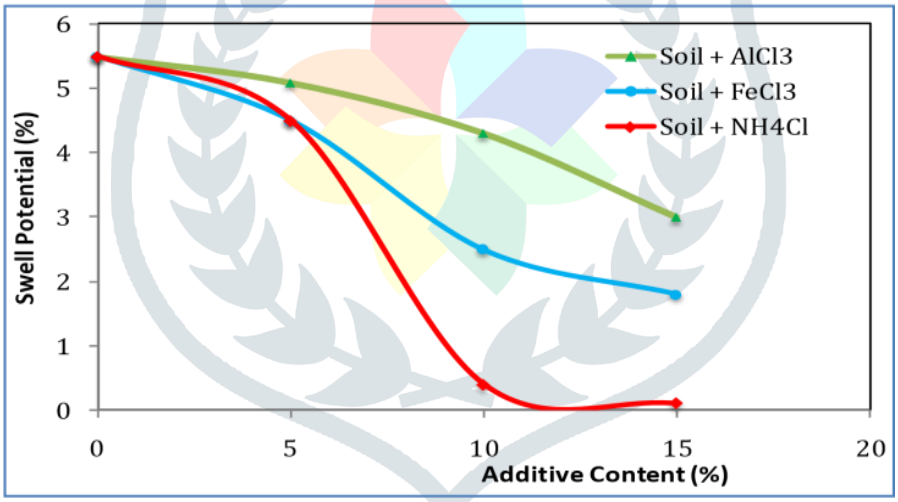

Fig. 4. Effect of $AlCl_3$, $FeCl_3$, and NH_4Cl on swell potential

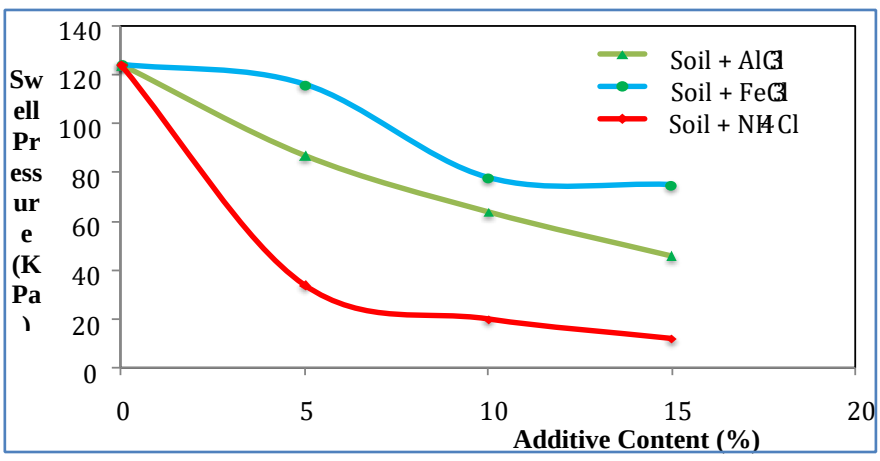

Fig. 5 Variation of swell pressure with various $AlCl_3$, $FeCl_3$, and NH_4Cl content

D. Study on Effect of Chemical Stabilizing Agents on Strength and Swelling Properties of soils:

In this research paper, the author are used two types of chemical additives and their name are Calcium chloride and Ferric chloride. The chemical used in different percentage such as 0.5%, 1%, 1.5% and 2% respectively, and reduced the dry density, liquid limit, and plastic limit, swell pressure, shrinkage limit, MDD and OMC of the soil. In this paper, the author are prepared soil with chemical addition in different way. Adding chemical in soil by used the formula which is given below:

$$Pb = Wb / Ws \quad (1)$$

Where, Wb = Weight of each chemical, Ws = Weight of soil sample, Pb= Percentage of each chemical.

Different percentages of calcium chloride and ferric chloride are 0.5%, 1.0%, 1.5%, 2.0% respectively. After treated soil with chemical, the results are obtained that reduced swelling pressure of the stabilized expensive soil is decreasing with increase in percentage of chemical added to the soil, and the author are concluded that the addition of chemical chlorides in different percentage is reduced the soil properties and swelling pressure of the soil[6].

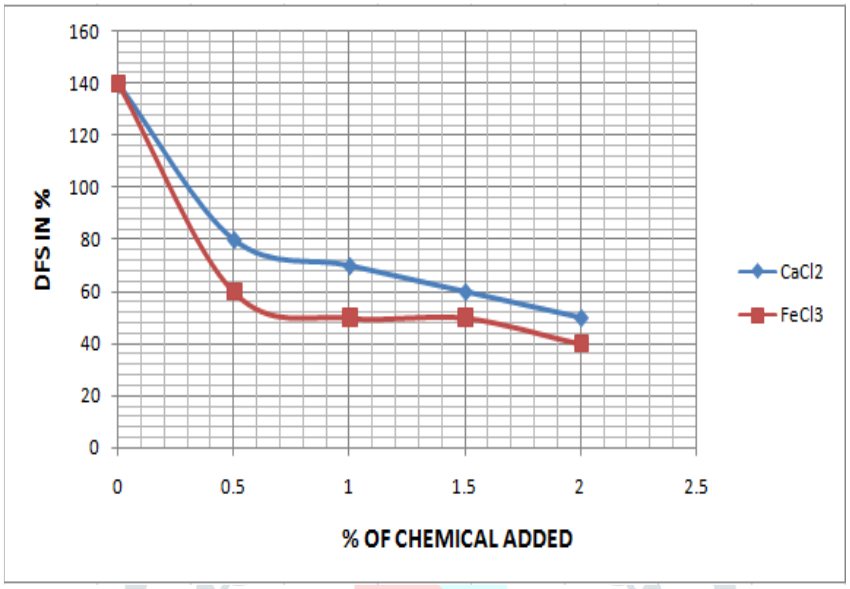

Fig. 6. Variation of DFS for different chemicals

The results are shown in fig. 6 and 7. It is observed that the Swelling pressure of the stabilized expansive soil is decreasing with increase in percentage of chemical added to the soil. The Swelling pressure of stabilized expansive clay is reduced by 26% and 35% when treated with 1 % chemical of $CaCl_2$ and $FeCl_3$ respectively. The decreasing in the swell with addition of chemicals may be attributed to the cation exchange of $CaCl_2$ & $FeCl_3$ between mineral layers and due to the formation of silicate gel[6].

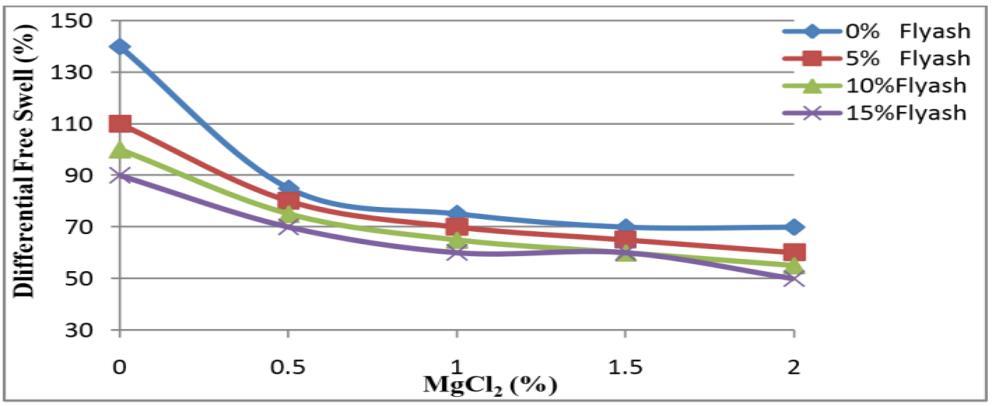

Fig.1 Variation of DFS for Soil+MgCl2+Flyash Mixes.

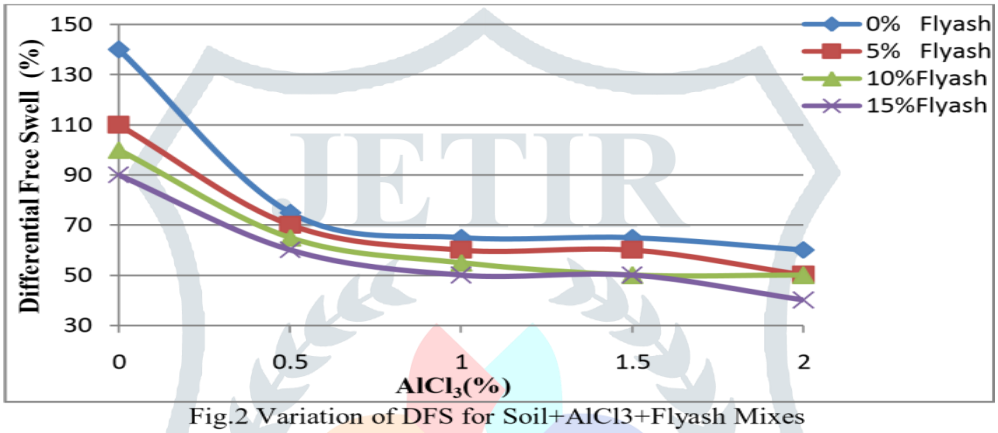

Fig.2 Variation of DFS for Soil+AlCl3+Flyash Mixes

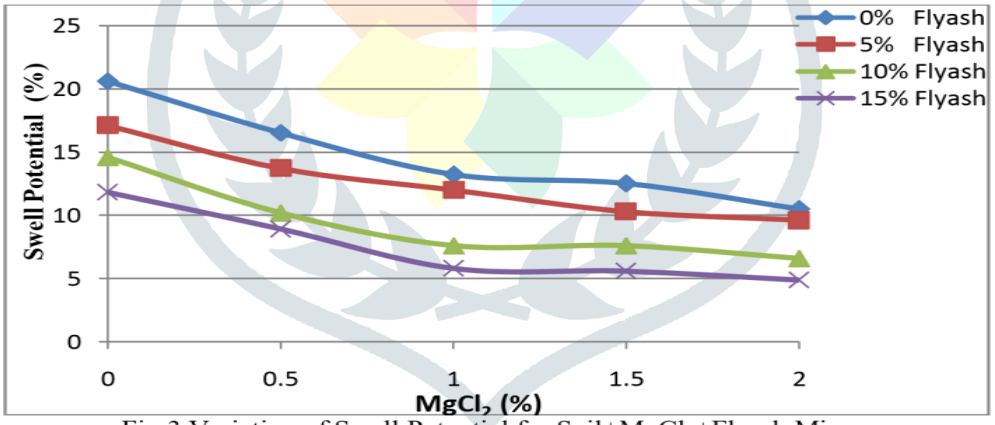

Fig.3 Variation of Swell Potential for Soil+$MgCl_2$+Flyash Mixes.

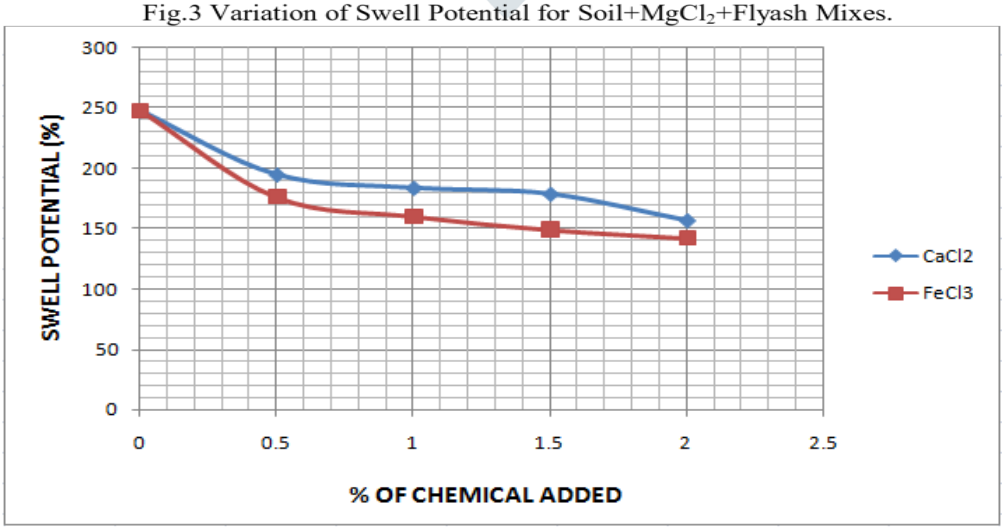

Fig. 7 Variation of swelling pressure for different chemicals

After results, the researchers are concluded that the swelling nature of the expansive soil is reduced considerably with the addition of the selected chloride chemicals. For an optimum value of chemical contents the percentage decrease in the swelling pressure are 26% and 35% for $CaCl_2$ and $FeCl_3$ treatments respectively.

E. Swelling Properties of Expansive Soils Treated with Chemicals and Flyash:

In this research paper, the author are used two types of chemicals with using flyash.The main objective of this work is the swelling properties of the expansive subgrade soil treated with chemicals like Magnesium Chloride ($MgCl_2$), Aluminum Chloride ($AlCl_3$) and also by adding flyash in varying percentages. The swelling properties of the collected expansive soil samples were determined based on the parameters like Free Swell Index, Swell Potential and Swell Pressure. The results obtained from the experimental study indicate that the measured Free Swell, Swell Potential and Swelling Pressure are reduced substantially with the increasing percent of chemicals and flyash and remain stable after reaching certain concentration[7].
After addition of chemical, the results are shown in fig.1,2,3,4,5, and 6[7].

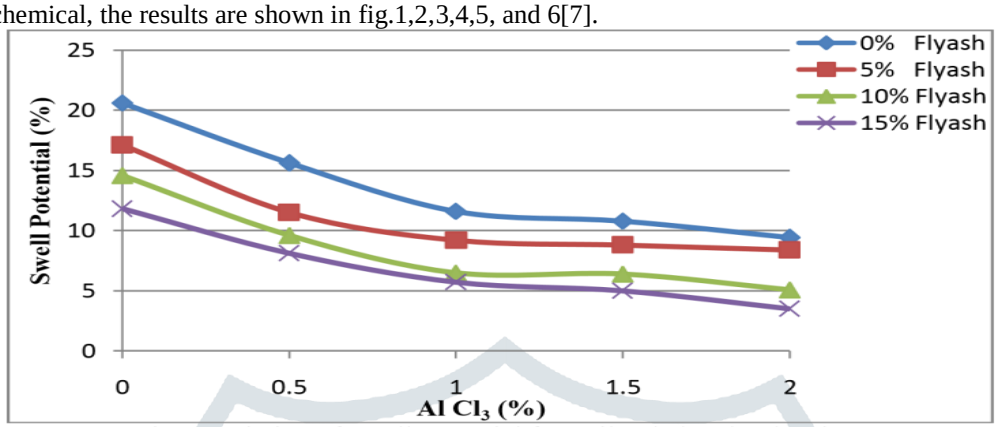

Fig.4 Variation of Swell Potential for Soil+$AlCl_3$+Flyash Mixes

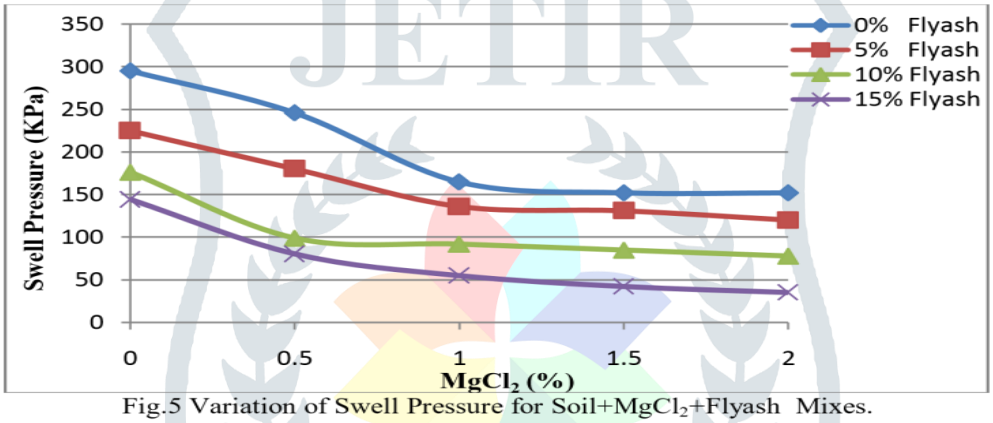

Fig.5 Variation of Swell Pressure for Soil+$MgCl_2$+Flyash Mixes.

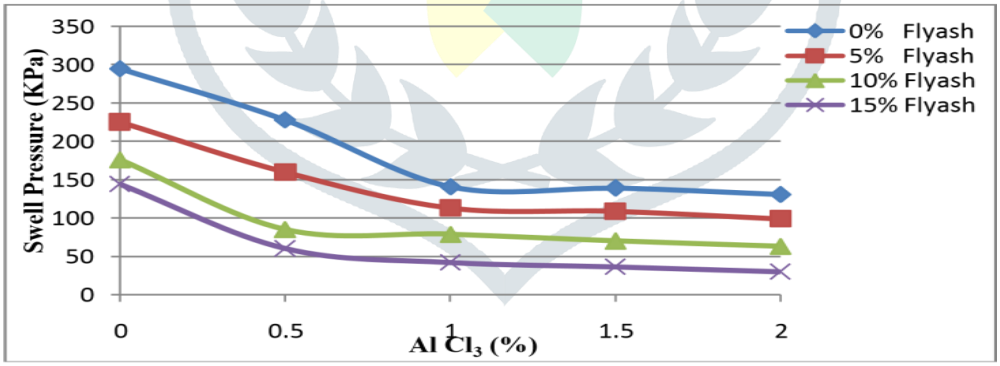

Fig.6 Variation of Swell Pressure for Soil+$AlCl_3$+Flyash Mixes

Fig. 8 Variation of swelling pressure for different chemicals

The reduction in the value of DFS at 1% chemical and 0% flyash are of the order of 54% and 46% for $AlCl_3$, $MgCl_2$ respectively. Whereas the reduction in the values of DFS at 1% chemical+10% flyash are of the order of 64% and 54% for $AlCl_3$ and $MgCl_2$ treatments respectively[7].

Untreated sample is having a swell potential of 20.6% and is gradually reduced to 9.4% and 10.5% with the addition of 2% $AlCl_3$, $MgCl_2$ respectively. And addition of flyash has its effect in reducing the swell potential. Addition of 1% chemical and 10% flyash is considered as optimum and the swell potential reduced to 6.5% and 7.6% for $AlCl_3$, $MgCl_2$ respectively[7].
The researcher are concluded that the swell pressure values are reduce by 44% and 52% with the treatment of 1% $MgCl_2$, and $AlCl_3$ respectively. Similarly these values reduced to 69% and 73% with addition of 1% chemical and 10% flyash for $MgCl_2$ and $AlCl_3$ respectively and are considered as the most approving combination.

The reduction in swell potential and swell pressure is significant upto the addition of 1% chemical and 10% flyash. The percentage reduction in swell potential is 63%, 68% and swell pressure is 69%, 73% respectively for $MgCl_2$, $AlCl_3$ chemicals with flyash. Finally a conclusion can be made that the selected chemical and flyash combination is very effective in reducing the swell pressure, swell potential of the expansive soil considered.

III CONCLUSION

From this review paper it can noticed that, when chemical admixture is added in soil, it could be react with soil and reduced the swelling and shrinkage characteristics of the soil, from this paper, we areconcluded that the using CEC value method, it can be easily found out the chemical admixture which are used in soil. Here, different types chemical are used for reduced the swell and shrink properties of the soil.

1. The CAPB chemical is more effective than the BKC and CTAB chemical. The chemical are chosen based on the CEC value.
2. The chemical is effective in reducing the swelling characteristics in the tested range and sodium carbonate is slightly better than the calcium carbonate. Here not mentioned the any type of CEC value.
3. Using chloride salts are generally reduced the swell and shrink properties of the soil, NH_4Cl more effective than the $AlCl_3$ and $FeCl_3$.
4. The swelling nature of the expansive soil is reduced considerably with the addition of the selected chloride chemicals. For an optimum value of chemical contents the percentage decrease in the swelling pressure are 26% and 35% for $CaCl_2$ and $FeCl_3$ treatments respectively.
5. The selected chemical that $AlCl_3$, $MgCl_2$ and flyash combination is very effective in reducing the swell pressure, swell potential of the expansive soil co

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