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Effect of potassium chloride on black cotton soil

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ABSTRACT

Expansive soil is spread over more than twenty percentage area of India. Soils containing montmorillonite clay minerals are susceptible to volumetric changes. Change in the volume happens due to variation in the moisture content of soil. Expansive soils swell and shrink respectively, with the increase and decrease in the moisture content in the soil mass. Suitable remedial measures are to be taken before construction on expansive soil. There are various solutions available to decrease the swelling and shrinkage potential of an expansive soil and mixing of electrolytes with soil is a good alternative. Potassium chloride was used as an additive to modify the soil characteristic. Effect of potassium chloride on the unconfined compressive strength, Atterberg limits and compaction parameters are presented in this paper. Shrinkage limit, dry density and unconfined compressive strength increased with addition of potassium chloride in soil. Plasticity index and liquid limit decreased with addition of potassium chloride. Moisture content initially decrease with increase in the amount of added potassium chloride but adding potassium chloride more than 10% causes an increase in the OMC of soil. Plastic limit increases with increase in the amount of potassium chloride. The optimal quantity of KCl is about 7% weight of soil mass.

Keywords: potassium chloride, expansive soil, UCS, OMC, maximum dry density

1. INTRODUCTION

The expansive soil is spread over a large part of India and it covers Gujrat, Madhya Pradesh, Maharashtra Andhra Pradesh, Tamilnadu, Karnataka and some portion of other states. Expansive soil is spread over more than twenty percentage area of India [1-2]. It is popularly called as black cotton soil due to its black colour and its suitability to grow cotton. Expansive soils shrink and swell, respectively, with the decrease and increase in the moisture content of soil and it is primarily due to montmorillonite minerals present in the soil mass [3].

Suitable remedial measures are to be taken before construction in the expansive soils. There are numerous solutions available to minimize the swelling characteristic of soil, for example, maintaining water table well below the foundation, removal of the soil up to a specific depth, reinforcement of the soil, construction of under reamed foundation or modification of the soil characteristics through some additives. Modification of soil characteristic by mixing of chemical admixture in soil is a very popular technique in the stabilization of expansive soils. Chemical stabilization causes decrease in the shrinkage and swelling characteristic of expansive soil. Electrolytes like ferric chloride, lime, potassium chloride calcium chloride or sea water were used in various studies [4-11]. Non-uniform mixing is a main problem in the use of electrolytes and non-uniform mixing may lead to erratic outcomes. Katti R. K. et al. (1966) [6] used various types of additives such as KCl, $MgCl_2$, NaCl, BaCl2, and CaCl2 to stabilize the expansive soil and found that potassium chloride KCl is more effective as compared to other additives. Reference [7] found that potassium chloride reduced the activity of soil by a significant amount. Reference [8] found that the KCl has reduced the plasticity index, liquid limit, OMC and free swell of soil. Literature review confirms that only a few studies were conducted on expansive soil with potassium chloride (KCl) as additive to modify the soil properties. In present study, effect of potassium chloride (KCl) on compaction parameters, Atterberg limit, and unconfined compressive strength are determined.

2. MATERIALS USED IN STUDY

Soil samples were collected from different palaces of Dumehar village, Shimla, Himanchal Pradesh. The properties of soil are shown in Table 1. As per [13-15], this soil can be classified as medium swelling potential soil. The relative density of used potassium (KCl) is nearly 1.988 and its melting point is 7710°C. Figure 1 shows potassium chloride used in study. Used KCL have 99.3% purity.

Table 1 Properties of soil used in present study

Soil Properties	Value	Soil Properties	Value
Clay + silt	80-84 %	Plasticity index	36-38%
Sand	16-20	OMC	18-20%
Liquid limit	16-20%	Maximum dry density	15.6-15.8 kN/m3
Plastic limit	62-66%	Soil Classification	CI
Shrinkage limit	12-13%	Free swell	Intermediate

3. METHOLOGY

Atterberg limits, unconfined compressive strength and compaction parameters of virgin soil were determined as per Indian standards. Different content of KCl (ranging from 5-15% by weight) were thoroughly mixed with the soil and the shrinkage limit, and plastic limit, and liquid limit were determined as per [16-17]. The plastic limit were determined by thread rolling method and liquid limit were determined by Casagrande percussion method.

Compaction parameters of the expansive soil were determined as per procedure given in IS code [18]. Potassium chloride was mixed thoroughly with soil and then the mixture was compacted in the proctor mould. Soil was compacted in three layers of equal height. After compaction, soil was removed from the mould. Three soil samples, from top, middle and bottom were collected in each test to determine the moisture content of soil. Average of three samples were considered as OMC of soil. This entire process was repeated for 5, 10 and 15% of added potassium chloride. After calculation of water content, dry density was determined for each samples and graph was plotted for water content and dry density of soil. Unconfined compressive strength (UCS) tests were conducted as per instruction given in [19]. A metallic split sampler, having height of 76 mm height and diameter of 38mm was used to prepare the samples for UCS testing. Initially, tests were conducted for soil, and later tests were repeated for 5, 10 and 15% of added potassium chloride.

4. RESULT AND DISCUSSION

Tests were performed on virgin expansive soil and potassium chloride mixed soil. Amount of potassium chloride were varied from 0 to 15%. Effect of potassium chloride on Atterberg limits, namely, liquid limit, plastic limit and shrinkage limit are shown in figure 1. Addition of potassium chloride in expansive soil caused a reduction in the liquid limit of soil. Reduction in the liquid limit is more substantial at 5-7% of potassium chloride and mixing of additional amount leads to decrease in the efficiency of potassium chloride. Change in the plastic limit of potassium chloride added soil is insignificantly up to 5% of KCl, but further more addition KCl caused an increase in the plastic limit.

Shrinkage limit is increased with increase in the amount of added potassium chloride. The increase in the shrinkage limit is significant up to 10 % of potassium chloride, beyond 10%, rate of increase in the shrinkage limit becomes insignificant. This is a favourable change in expansive soil. Shrinkage limit increases from 13.1 % to 15.90%, this indicates that soil volume cannot be reduced even after water decreased below 15.90%. Shearing resistant between soil particles improved due to the decrease in the thickness of the double layer water [7-8, 11]. This enhancement in the shearing resistance between soil particles had decreased the plasticity index and liquid limit of soil.

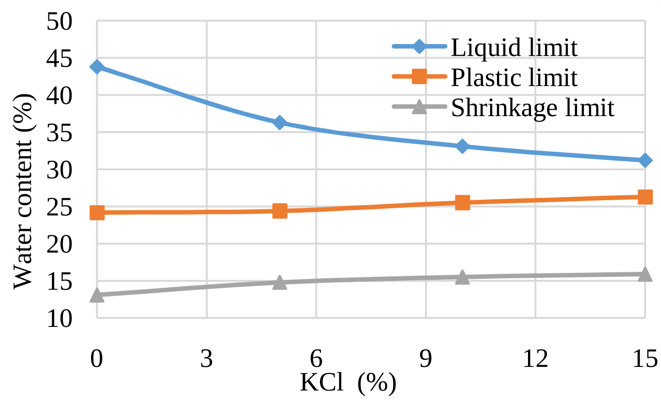

Figure 1 Variation in the Atterberg limit of soil for different amount of KCl

Variation in OMC and maximum dry density are shown separately in figure 2 (a) and (b) respectively. Adding KCl in expansive soil increased the dry density of soil. Change in density of soil is significant up to 6-7% of KCl but after this density is increased with very slow rate. Optimum moisture content (OMC) is reducing with increase in the quantity of added potassium chloride up to 10% but mixing more KCl leads to an increase in the OMC of soil. This increase in the density and decrease in the OMC is result if reduction in the thickness of diffuse double layer due to addition of potassium chloride. Similar result was reported in [8, 11].

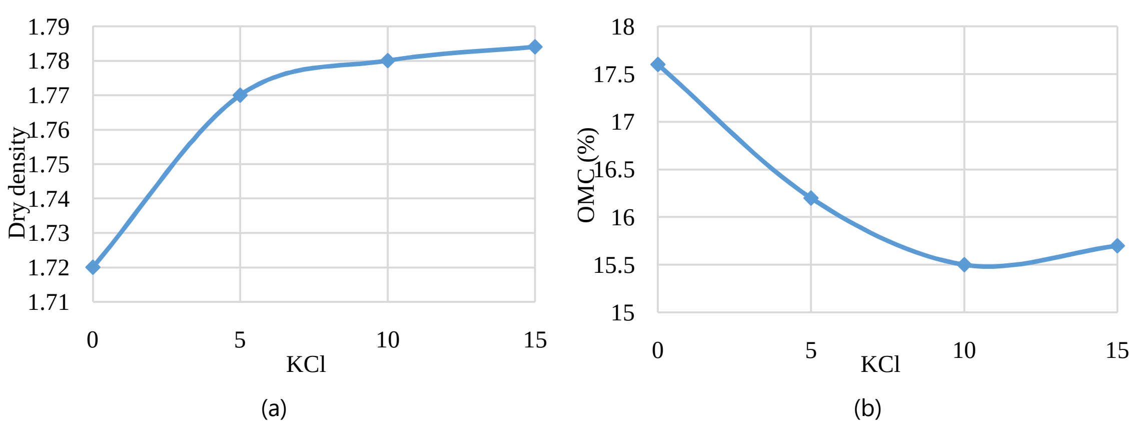

Figure 2 Effect of KCl on compaction parameters of KCl mixed expansive soil (a) on maximum dry density, (b) on optimum moisture content

Reference [9] found that repulsive force were devolved due to mixing a large amount of KCl. Large quantity of potassium chloride can increase the cations in soil mix and these additional cations can also leads to reverse action and consequently it decrease and increases the dry density and optimum moisture content (OMC) of soil respectively.

Figure 3 shows the change in the unconfined compressive strength (UCS) of soil for different amount of KCl. It shows that UCS is increased with increase in the potassium chloride. Its efficiency is decreasing when KCl is more than 7-8% of soil weight. It is accredited due to the fact that at higher amount of added KCl, soil absorbs more water and causes the reduction in its efficiency.

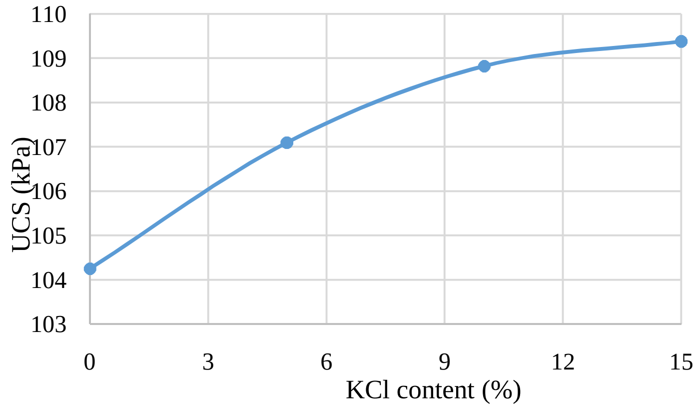

Figure 3 Effect of potassium chloride on UCS

Amount of KCl is approximately 7%. For studies [7, 8 and 9], optimum amount was found to be 5.5%, 6% and 5% respectively. Variation in the optimum amount of potassium chloride is ascribed due to variation in the KCl purity, soil characteristics and water characteristic.

Classification of soil changed due to addition of KCl in soil. As per Unified Soil Classification System and Indian classification system, virgin soil was classified as intermediate plasticity (CI), but after addition of potassium chloride it changed to clay of low plasticity (CL).

5. CONCLUSION

Atterberg limit tests, unconfined compressive strength tests and compaction tests were conducted as per Indian standards. Mixing of KCl caused to substantial reduction in the OMC, plasticity index and liquid limit of black cotton soil. Shrinkage limit, maximum dry density and unconfined compressive strength are increased with addition of KCl. Mixing excessive amount of potassium chloride has adverse effect on soil characteristics. Excessive amount not only reduced the cations exchange capacity but also increased the water absorption, and consequently it reduced the efficiency of potassium chloride. Earlier studies found that optimum quantity of KCl were varying between 5 to 6%, but in present study it is approximately 7.0%. It is advised that optimum amount of KCl is to be determined before using it for ground improvement in expansive soil.

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REFERENCE

1. Nicholas Wallis, J. A. (1977) "Intensified Systems of Farming in the Tropics and Subtropics," World Bank Discussion Paper No.364. The International Bank for Reconstruction and Development, Washington, D.C., U.S.A.
2. Ranjan, G and Rao, A.S.R. (2005), "Basic and applied soil mechanics", New Age International (P) Ltd, New Delhi.
3. Chen, F.H. (1988). "Foundations on Expansive Soils." Elsevier Scientific Publishing Co., Amsterdam.
4. Ramana Sastry, M.V.B., Srinivasulu Reddy, M. and Gangaraju, Ch.P. (1986). Comparitive Study of the effect of addition of Rice-Husk-Ash and Cinder-Ash to Soil-Lime mixtures, Indian Highways, Vol. 14, No. 8, pp 5-14.
5. Prasada Raju, G.V.R. (2001). Evaluation of flexible pavement performance with reinforced and chemical stabilization of expansive soil subgrades, Ph.D thesis, Kakatiya University, REC, Warangal.
6. Katti R. K., Kulkarni R. R. and Radhakrishnan (1966) "Research on Expansive soils without and with Inorganic Additives" IRC Road Research Bulletin No. 10. PP 1-97.
7. Frydman, S., Ravina, I., and Ehrenreich, T. (1977). "Stabilization of heavy clay with potassium chloride." Geotechnical Engineering, Southeast Asian Society of Soil

Engineering, 8, 95–108.

8. Al-Omari, Raid R., Saad F. Ibrahim, Ishraq K. Al-Bayati (2010) Effect of potassium chloride on cyclic behavior of expansive clays. International Journal of Geotechnical Engineering 4, 231-239.
9. Al-Ashou, O., and Al-Khashab, M. N. (1993). "Treatment of expansive clay soil with potassium chloride." Al-Rafidian Engineering Journal, 1(2), 17–31.
10. Al-Omari, R. R., and Oraibi, W. K. (2000). "Cyclic behavior of reinforced expansive clay." Soils and Foundations, 40(2), 1–8.
11. Shukla, R.P, Parihar, N., Tiwari, R.P., Agrawal, B.K. (2014), Black Cotton Soil Modification using Sea Salt. Electronic Journal of Geotechnical Engineering, Vol. 19, Bundle Y, pp 8807-8816. 9, Bundle Y, pp 8807-8816.
12. STM D4943-08 (2008). Standard test method for shrinkage factors of soils by the wax method. Annual book of ASTM standards, West Conshohocken, PA.
13. Holtz, W. G. and Gibbs, H. J. (1956) "Engineering properties of expansive clays," Transactions, American Society of Civil Engineers, vol. 121, pp. 641-677.
14. Seed, H. B., Mitchell, J. K. and Chan, C. K. (1960) the Strength of Compacted Cohesive Soils. Proc., ASCE Research Conference on Cohesive soils, Boulder, American Society of Civil Engineers, New York, 877-964.
15. Snethen, D.R. (1980), "Characterization of expansive soil using soil suction data", Proc. 4th Int. Conf. on Expansive Soils, Vol.1, pp 54-75.
16. IS: 2720, Part V: 1985, Indian Standard, "Determination of Liquid Limit, Plastic Limit and Plasticity Index", (1985).
17. IS: 2720, Part VI: 1985, Indian Standard, "Determination of shrinkage factors", (1972)
18. IS: 2720, Part VII: 1985, Indian Standard, "Determination of water content-dry dinsity relation using. Light compaction", (1980)
19. IS: 2720, Part X: 1991, Indian Standard, "Determination Of Unconfined Compressive Strength" (2006)