IMPROVEMENT OF CBR VALUE OF EXPANSIVE SOIL WITH INDUSTRIAL WASTE

Manpreet Kaur
Assistant professor
Department of Civil Engineering
Baba Banda Singh Bahadur Engineering College, Fatehgarh Sahib, Punjab, India.

Abstract**:** In India, the expansive soil is one of the major soil deposits. They exhibit high swelling and shrinking when exposed to changes in moisture content and hence have been found to be most troublesome from engineering considerations. It is also known as "Black cotton soil". Because of its high swelling and shrinkage characteristics, the Black Cotton soil has been a challenge to geotechnical and highway engineers. Geotechnical engineer recommend a verity of preventative techniques for soil to control of expansive soil. Recently many researchers used industrial waste in soil stabilization as low cost materials and to save the environment. Foundry sand is basically fine aggregate. This includes many civil engineering applications such as embankments and Portland cement concrete. Foundry sands have also been used in agriculture as topsoil. The largest volume of foundry sand is used in geotechnical applications such as embankments, site development fills and road bases. This paper brings out the results of experimental program carried out in the laboratory to evaluate the effect of mixing different proportions of foundry sand with clayey soil on compaction and California bearing ratio. Results show that addition of foundry sand reduces the swelling, plasticity index and increases the CBR value of soil.

Index Terms– **Expansive soil, Foundry sand, Free swell index, CBR.**

I. INTRODUCTION

Expansive soils of Central India, commonly known as Black Cotton soils, cover approximately one-sixth of the total area of our country. These soils cover the Deccan plateau covering entire Maharashtra state, South Gujarat, central and western Madhya Pradesh, Southern part of Andhra and Orissa states. Black soils also occur in a smaller area of Rajasthan, Uttar Pradesh and Tamilnadu. In terms of geotechnical Engineering, Black Cotton soil is one which when associated with as engineering structure and in presence of water will show a tendency to swell or shrink causing the structure to experience moments which are largely unrelated to the direct effect of loading by the structure. Black cotton soil is not suitable for the construction work on account of its volumetric changes. It swells and shrinks excessively with change of water content. Such tendency of soil is due to the presence of fine clay particles which swell, when they come in contact with water, resulting in alternate swelling and shrinking of soil due to which differential settlement of structure takes place. With development in soil improvement procedures, many constructions over BCS have been possible.

Various innovative techniques such as special foundations that include belled pier, drilled pier, and friction piers have been developed to mitigate the problems posed by expansive soil (e.g., Chen 1975). Apart from these techniques, stabilization of expansive soil with various industrial waste including foundry sand, fly ash ,lime, cement also met with considerable success .stabilization of expansive soil with admixtures controls the potential of soil for a change in volume.

Metal foundries use large amount of sand as part of the metal casting process. Foundries successfully recycle and reuse the sand many times in foundry. When the sand is no longer reused and removes from foundry it is called foundry sand. It is a waste product but beneficial applications to other industries. Foundry sand is high quality silica and with uniform physical characteristics. This note presents the results of an experimental investigation carried out to study the effect of foundry sand on engineering properties of expansive soils including the free swell index.

1.2 OBJECTIVES

1) To provide a solution for waste industrial waste of foundry soil as disposal in a sustainable manner
2) To minimize the problems associated with Expansive soil for the land development of roads in rural areas.
3) To check the characteristics such as free swell, plasticity index, compaction, CBR of modified soil.

II. MATERIALS AND METHODOLOGY

2.1 SOIL

The soil was collected from "Dhamani" in Sangli district, Maharashtra state in India .The expansive soil was collected by method of disturbed sampling after removing the top soil at 150 mm depth and transported in sacks to the laboratory.

2.2 SOIL SAMPLING

Soil sampling was done by quartering method- (1). Sample was mixed thoroughly. (2)Foreign materials like roots, Stones, pebbles & gravels were removed. (3)Quartering is done by dividing the thoroughly mixed sample into four equal parts. (4) Two opposite quarter's are mixed. (5)Sample was collected inbags.

The expansive soil index properties are summarized in table 1. Based on the index properties and grain –size distribution soil is classified as a CH.

Table 1: Geotechnical Properties of soil

Laboratory Experimentation	Value
Specific gravity	2.62
Grain size distribution	
Clay (%)	62
Silt (%)	35
Sand (%)	3
Atterberg's limits	
Liquid limit (%)	71
Plastic limit (%)	25
Plasticity Index (%)	46
Compaction characteristics	
Optimum moisture content (%)	21
Maximum dry density (KN/m^3)	14.75
Differential Free swell (%)	127.27
CBR value	
CBR –unsoaked	4.03
CBR –soaked	1.20

Table 2 Chemical Composition of Expansive soil (Rao 2000)

Chemical Composition	Quantity
Silica (Sio_2)	63.17
Alumina (Al_2o_3)	19.36
Ferric (Fe_2o_3)	4.32
Potassium(K_2o)	1.73
Sodium (Na_2O)	8.73
Magnesium (Mgo)	1.79
Calcium(Cao)	0.67

2.3 FOUNDARY SAND

Foundry sand from industry, named oceans pumps, Mandi Gobindgarh. The physical properties of foundry sand also shown in table no. 2 .Foundry sand are non-plastic material. The chemical composition is shown in table no. 3. The effect of foundry sand on liquid limit, plastic limit, compaction chacteristics, free swell of the expansive soil were evaluated.

.

Table 3: Physical Properties of Foundry sand

Property	Results
Specific Gravity	2.39
Bulk Relative Density, Kg/m^3	2575
Moisture Content %	0.1- 9.11
Plastic Limit/ Plastic Index	Non-plastic

Table 4 Chemical Composition of Foundry sand

Chemical Composition	Quantity
Silica (Sio_2)	87.91
Alumina (Al_2o_3)	4.70
Ferric (Fe_2o_3)	0.94
Potassium(K_2o)	0.25
Sodium (Na_2O)	0.19
Magnesium (Mgo)	0.30
Calcium(Cao)	0.14

Table 5 sieve analysis of foundry sand

Sieve size	Weight retained(gm)	% weight retained	Cumulative % weight
4.75mm	10	1	1
2.36mm	5	0.5	1.5
1.18mm	6	0.6	2.1
600µ	5	0.5	2.6
300µ	40.5	4.05	6.65
150µ	712.5	71.25	77.9
Pan	221	22.1	100

Fineness modulus of foundry sand $=\sum F/100=191.75/100=1.91$

III. RESULTS AND DISCUSSION

3.1 Differential Free swell test: As per Indian standard code of practice (I.S.2911-Part III, 1973 Appendix A) two samples of oven dried soil passing 425 micron sieve and weighing 10 gm each are used. One sample is poured slowly in 50 ml graduated glass cylinder filled with kerosene (a non-polar liquid). The other sample is poured in another 50 ml graduated cylinder filled with distilled water. Both the cylinders are left for 24 hours and the respective volumes are noted. The DFS is calculated as below.

Fig.1-Differential free swell test (DFS test)

$$S_f = (V_w-V_k) \times 100/V_k \ \%$$

Where Vw and V_k are final volumes of Soil in water and kerosene respectively

Where V_f and V_i are final and initial volumes respectively.
FREE SWELL INDEX OF EXPANSIVE SOIL = 127.27%

3.2 Colloid content, plasticity index

The colloid content of soil is fraction finer than 0.001 mm to be determined from sedimentation analysis (Hydrometer or pipette method), and is the most active part of any soil, causing swelling. The expansiveness is proportional to colloid content present in soil. The high plasticity index (PI) is indicative of the capacity of soil to absorb higher amount of water when changing from plastic to liquid state.

3.3 Compaction Behaviour &California Bearing Ratio (CBR) Test:

Compaction tests were conducted on soil with varying percentages of foundry sand from 10% to 50% and optimum mixes were obtained. After obtaining optimum mix proportion varying percentages of foundry sand is added with expansive soil. Foundry sand mix from 10% to 40% in increments of 10%.Then appropriate mix of soil-foundry-sand is chosen for compaction. The

California bearing ratio tests were performed in laboratory in accordance with IS: 2720 (Part 16) 1987. The sizes of samples were of 150mm diameter and 127mm height. Soaked CBR tests were conducted in standard mould for samples compacted statically at maximum dry MDD and OMC. Surcharge weight of 50N was used during the testing. A metal penetration plunger of diameter 50 mm and 100 mm long was used to penetrate the samples at the rate of 1.25 mm/minute using computerized CBR testing machine.

Table-6 Effect of Foundry sand on index properties, swelling, compaction and CBR value

Property	Foundry sand content				
	0	10	20	30	40
Liquid limit (%)	71	68	66	64	60
Plastic Limit (%)	25	28	31	35	40
Free swell index	127.27	100	80	68	55
Optimum moisture content (%)	21	19	17	15	13
Maximum dry density (KN/m^3)	14.75	14.91	15.05	15.19	15.30
CBR	1.20	4.6	6.7	9.8	12.6

IV. CONCLUSIONS

Following conclusions can be drawn from the present investigation

1. Insertion of foundry sand within the expansive soil sub grade is found to effective in controlling the swelling significantly. The percentage reduction in swelling however depends on percentage of foundry sand used.
2. The highest value of maximum dry density is achieved for clay-foundry sand mix of 60:40. This occurs due to the reason that the voids between the foundry sand particles are occupied by the clay particles when the sand content is less but larger sand content segregates the particles and the maximum dry density decreases.
3. The CBR value of the soil improve significantly with foundry sand The improvement in CBR value may be attributed to better compaction and packing of the mix particles with addition of foundry sand. The California bearing ratio provides a basis of designing the sub-grades of flexible pavements. Usually, a value of CBR more than 5.0 is considered to be satisfactory for the design of flexible pavements with traffic intensity of 1 to 10 million standard axles (msa). Thus, the expansive soil blended with foundry sand can be effectively used in the construction of sub-grades of roads with low traffic volume.

REFERENCES

[1] A. K. Sabat, “Stabilization of Expansive Soil Using Waste Ceramic Dust”, Electronic Journal of Geotechnical Engineering, Vol.17, Bund. Z, 2012.
[2] ASTM D422-63, “Standard test methods for hydro meter analysis of soils,” American Society for Testing of Materials, Pennsylvania, Pa, USA.
[3] ASTM D698-07e1, “Standard test methods for laboratory compaction characteristics of soil using standard effort,” American Society for Testing of Materials, Pennsylvania, Pa, USA.
[4] ASTM D854-10, “Standard test methods for specific gravity of soil,” American Society for Testing of Materials, Pennsylvania, Pa, USA.
[5] ASTM D1883-05, “Standard test methods for California bearing ratio test for soils,” American Society for Testing of Materials, Pennsylvania, Pa, USA.
[6] ASTM D2487-11, “Standard practice for classification of soils for engineering purposes (unified soil classification system),” American Society for Testing of Materials, Pennsylvania, Pa, USA.
[7] ASTM D4318-10, “Standard test methods for liquid limit, plastic limit, and plasticity index of soils,” American Society for Testing of Materials, Pennsylvania, Pa, USA.
[8] ASTM D5239-2004, “Standard practice for characterizing fly ash for use in soil stabilization,” American Society for Testing of Materials, West Conshohocken, PA, USA.
[9] ASTM D6913-04, “standard test methods for particle size distribution of soils,” American Society for Testing of Materials, Pennsylvania, Pa, USA.
[10] B. Bose, “Geo engineering properties of expansive soil stabilized with fly ash,” Electronic Journal of Geotechnical Engineering, Vol. 17, Bund. J, 2012.
[11] Dr. N. K. Ameta, Dr. A. S. Wayal, P. Hiranandani , “Stabilization of Dune Sand with Ceramic Tile Waste as Admixture” , American Journal of Engineering Research, Volume-02, Issue-09, 2013, pp-133-139.
[12] D.S. Leidel, M. Novakowski, D. Pohlman, Z. D. MacRunnels, and M. H. MacKay. "External Beneficial Reuse of Spent Foundry Sand," AFS Transactions, Volume 102. American Foundrymen's Society, 1994.
[13] J.R. Kleven, T.B Edil, & C. H. Benson“Evaluation of excess foundry system sands for use as sub-base material,” Proceedings of the 79th Annual Meeting, Transportation Research Board, Washington, DC, 2000.
[14] L.N. Reddi, G.P. Rieck, A.P. Schwab, S.T. Chou, & L.T. Fan, “Stabilization of Phenolics in Foundry Waste using Cementitious Materials,” Journal of Hazardous Materials 4 (2–3), 1996, 89–106.
[15] M. Goodhue, T.B. Edil, & C.H. Benson, “Interaction of Foundry Sand with Geo-synthetics,” Journal of Geotechnical and Geo-environmental Engineering, 127 (4), 2001, 353–362.
[16] M. B. Rajgor, J. Pitroda , “A Study of Utilization Aspect of Stone Waste in Indian Context” Global Research Analysis ,Volume 2, Issue 1-January-2013.
[17] M.S. Chauhan, S. Mittal, and B. Mohanty, “Performance evaluation of silty sand sub-grade reinforced with fly ash and fiber,” Geotextiles and Geomembranes, Vol. 26, Issue 5, 2008, 429-435.

[18] P.B. Kirk, "Field demonstration of highway embankment constructed using waste foundry sand," Ph.D. Dissertation, Purdue University, West Lafayette, IN, 1998, 202 p.
[19] S.T. Bhat, & C.W. Lovell, "Use of Coal Combustion Residues and Waste Foundry Sands in Flowable Fill", Purdue University-Joint Highway Research Project Report, Federal Highway Administration, Washington, DC, 240 ,1996.
[20] S. Bhuvaneshwari, R.G. Robinson, and S.R. Gandhi, "Stabilization of expansive soils using fly ash,"Fly Ash India, Fly Ash Utilization Programme (FAUP), TIFAC, DST, New Delhi, 2005.
[21] T.Abichou, C.H. Benson, T.B. Edil, & B.W.Freber, "Using Waste Foundry Sand for Hydraulic Barriers," In: Vipulanandan, C., Elton, D. (Eds.), Recycled Materials in Geotechnical Applications, Geotechnical Special Publication 79. ASCE, Boston, MA, 1998,86–99.
[22] T.B. Edil, H.A. Acosta, and C.H. Benson, "Stabilizing soft fine grained soils with fly ash", Journal of Materials in Civil Engineering, ASCE 18(2), 2006, 283-294.