STABILIZATION OF EXPANSIVE SOIL USING COPPER SLAG

Dhokariya Miten, Patel Parth, Mistry Sanjay, Patel Mihir
Civil department, IIET- dharmaj, Anand, India

Abstract: Black cotton soil is one of the major regional soil deposits in India, covering an area of about 3.0 lakh sq.km. Infrastructure projects such as highways, railways, water detention structures, foundation of structure , etc. requires earth material in very large quantity. Black cotton soils or the expansive soils in India are highly problematic, as they swell on absorption of water and shrink on evaporation and also low soil bearing capacity thereof. Because of this alternate swell and shrinkage, distress is caused to the foundations of structures laid on such soils. Expansive soils are problematic soils because of their inherent potential to undergo volume changes corresponding to changes in the moisture regime. Because of this alternate swelling and shrinkage, structures founded on them are severally damaged. Utilization of industrial wastes like fly ash, quarry dust, silica fume, copper slag, tannery sludge, etc. in the geotechnical engineering field will solve the problem of disposal of these wastes.

Index Terms **– Copper slag, black cotton soil, utilization.**

I. INTRODUCTION

Site feasibility study for geotechnical projects is of far most beneficial before a project can take off. Site survey usually takes place before the design process begins in order to understand the characteristics of subsoil upon which the decision on location of the project can be made. The following geotechnical design criteria have to be considered during site selection.

- Design load and function of the structure.
- Type of foundation to be used.
- Bearing capacity of subsoil.

In the past, the third bullet played a major in decision making on site selection. Once the bearing capacity of the soil was poor, the following were options:

- Change the design to suit site condition.
- Remove and replace the in situ soil.
- Abandon the site.

Abandoned sites due to undesirable soil bearing capacities dramatically increased, and the outcome of this was the scarcity of land and increased demand for natural resources. Affected areas include those which were susceptible to liquefaction and those covered with soft clay and organic soils. Other areas were those in a landslide and contaminated land. However, in most geotechnical projects, it is not possible to obtain a construction site that will meet the design requirements without ground modification. The current practice is to modify the engineering properties of the native problematic soils to meet the design specifications. Nowadays, soils such as, soft clays and organic soils can be improved to the civil engineering requirements. This state of the art review focuses on soil stabilization method which is one of the several methods of soil improvement.

II. RESEARCH METHODOLOGY

- Grain Size Analysis
- Atterberg Limit
- Free Swell test
- California bearing ratio test
- Triaxial shear test
- Unconfined compressive strength

4.2.1 Grain Size Analysis (IS: 2720 Part IV):-The sieve analysis is carried out in accordance with IS 2720 Part IV.

THE TEST PROCEDURE IS AS FOLLOWS: a) The riffled and weighed fraction shall be spread out in the large tray or bucket and covered with water. b) Two grams of sodium hexametaphosphate per litre of water used should then be added to the soil. c) The mix should be thoroughly stirred and left for soaking. d) The soaked soil specimen may be washed on the 75-micron IS Sieve until the water passing the sieve is substantially clean. e) The fraction retained on the sieve should be tipped without loss of material in a tray, dried in the oven and sieved through the nest of sieves 4.75mm, 2mm, 425micron and 75micron either by hand. f) The fraction retained on each sieve should be weighed separately and the masses recorded.

4.2.2 Atterberg's Limit:- Liquid limit and Plastic limits are carried out for the determination of different characteristic of soil. The tests performed in accordance with I.S.2720 P-5-1985 by using cone penetrometer. Liquid limit and plastic limit of soils are both depend up on the amount and type of clay in a soil and form the +basis for the soil classification system for cohesive soils based on the Plasticity index. The liquid limit of the soil with corresponds to the moisture content of a paste which would give 20mm penetration of the cone is determined by using following formula.

Wl = Wx / (0.65+0.0175*X).

Where,

X = Penetration of cone in the sample

Wx = Moisture Content of the soil sample at the respective penetration

4.2.3 Free Swell test (IS: 2720, P-40, 41): -In order to determine the swelling characteristics of the soil, differential free swell test is carried out. An oven dried soil sample, 10 gm passing through 425 micron is poured in two 100 ml graduated cylinder. One cylinder was filled with distilled water and in kerosene up to 100 ml mark. After the removal of entrapped air, sample was allowed sufficient time to attain equilibrium state of volume. The final volume of soil in each cylinder was recorded. Sp = Free swell

$$Sp = \frac{\text{Soil volume in water} - \text{Soil volume in kerosene}}{\text{Soil volume in kerosene}}$$

4.2.4Triaxial Shear Test (IS: 2720 P-11):- Triaxial shear (Quick) tests are conducted to determine the shear parameters of clayey samples. The shear tests are carried out in accordance with IS: 2720 (part X, XI, XII & XIII).

THE TEST PROCEDURE IS AS FOLLOWS:

For unconsolidated undrained (Quick) Triaxial compression test, the specimen having dia 38mm and height to diameter ration of 2 is prepared and placed on the pedestal of the triaxial cell after enclosing it in rubber membrane. The cell is then assembled with the loading ram and then placed in the loading machine. The fluid is admitted to the cell and the pressure is raised to the desired value.

4.2.5 California Bearing Ration (CBR) Test:California bearing ratio is the ratio of force per unit area required to penetrate into a soil mass with a circular plunger of 50mm diameter at the rate of 1.25mm /min. As perIS: 2720 (Part 16) 1979.

TEST PROCEDURE IS AS FOLLOW:

1) Take the soil sample which passes through 20 mm IS sieve, but it is retained on 4.75 mm IS sieve. 2) Take about 4.5 to 5.5 kg of material, and mix it with optimum water content which is found by light compaction. Sample is to be compacted at optimum water content corresponding dry density. 3) Fix the extension collar to the mould. Also fix the base plate to the bottom. 4) Insert the disc over the base with the central hole of the disc at the lower face. Place coarse filter paper disc on the top of the displacer disc. 5) Take the soil sample in the mould. Compact it using either the light compaction rammer.

III. RESULTS AND DISCUSSION

SOIL CLASSIFICATION:

TABLE 1 RESULTS OF SIEVE ANALYSIS AND ATTERBERG'S LIMIT

Sr. No.	ID	Grain Size Distribution				Atterberg's Limit			IS Classi-fication
		Course Soil	Medium Soil	Fine Soil	Soil + Clay	LL %	PL %	PI%	
1	Black Cotton Soil	00	00	01	99	58	26	32	**CH**
2	Soil+35% Copper Slag	04	13	09	74	41	24	17	**CI**
3	Soil+40% Copper Slag	04	18	07	71	37	22	15	**CI**
4	Soil+45% Copper Slag	05	23	07	65	35	21	14	**CI**

Based on test results only soil is classify as inorganic clays of high plasticity and combination of soil and copper slag are classify as inorganic clays of medium plasticity.

From above graph liquid limit for combination of 35% copper slag with 65% soil (41)sharply decrease in case of only soil(58),than the value of LL gradually decrease in small percentage for other combination

.5.2 FREE SWELL TEST RESULT

SR.NO	ID	FREE SWELL
1	Black Cotton Soil	52
2	Soil + 35%Copper Slag	39
3	Soil + 40%Copper Slag	27
4	Soil + 45%Copper Slag	22

TABLE 5 RESULTOF FREE SWEEL TEST

IV. CONCLUSION

Graphical representation of the test results are presented in Chapter 5 above with varying percentage of copper slag . Based on the test result following conclusions are established

- From % copper slag v/s Liquid Limit, it can be concluded that with increase incopper slag content, the liquid limit decreases.
- From% copper slag v/s Plastic Limit, it can be concluded that with increase in copper slag content, the Plastic limit decreases.

From the above detailed investigation carried out on the copper slag, it has the potential to use as admixture to improve the properties of problematic soil. Copper slag with 35% to 45% can be mix with problematic soil to improve or modify the soil characteristics. copper slag can be recommended for sub-grade, sub base. engineering behaviour of expensive soil cab be improve by utilizing the copper slag. For embankment construction, land reclamation and for improving sub-grade soil condition, also it is easily available in huge quantity so, it is economical to use as stabilizing agent in the stabilization of expiation soil.

REFERENCES

1.Hartlen, J., Carling, M &Nagasaka, Y. (1997) Recycling or reuse of waste materials in geotechnical applications, Proceedings of the second InternationalCongress on Environmental Geotechnics, Osaka, Japan, pp 1493-1513.

2. Kamon, M. (1997) Geotechnical utilization of industrial wastes, Proceedings of the second International Congress on Environmental Geotechnics, Osaka, Japan, pp 1293-1309.

3. Kamon, M. & Katsumi, T. (1994) Civil Engineering use of industrial waste in Japan, Proceedings of theInternational Symposium on Developments inGeotechnical Engineering, Bangkok, Thailand, pp 265- 278.

4. Sarsby, R. (2000) Environmental Geotechnics, Thomas Telford Ltd., London, UK.

5. Vazquez, E., Roca, A., Lopez-soler, A., Fernandez- Turiel, J.L., Querol, X &Felipo, M.T. (1991) Physico- Chemical and mineralogy characterization of mining wastes used in construction, Waste materials in construction, Proceedings of the InternationalConference on Environmental Implications ofConstruction with Waste Materials, Maastricht, The Netherlands, pp 215-223.

6. Comans, R.N.J., van detSloot, H.A., Hoede, D. &Bonouvrie, P.A. (1991) Chemical Processes at a redox/pH interface arising from the use of steel slag in the aquatic environment, Waste materials in construction, Proceedings of the InternationalConference on Environmental Implications ofConstruction with Waste Materials, Maastricht, The Netherlands, pp 243-254.

7. Chu, S.C. and Kao, H.S. (1993) A study of Engineering Properties of a clay modified by Fly ash and Slag, Proceedings, Fly ash for Soil Improvement, American Society of Civil Engineers, GeotechnicalSpecial Publication, No. 36, pp 89 – 99.

8. Mclaren, R.J. and A.M.Digionia, (1987) The typical engineering properties of fly ash, Proceedings ofConference on Geotechnical Practice for WasteDisposal, Geotechnical Special Publication NO 13, ASCE, R.D.Woods (ed.), pp 683-697.

9. Martin, P.J., R.A.Collins, J.S.Browning and J.F.Biehl, (1990) Properties and use of fly ashes for embankments, Journal of Energy Engineering, ASCE, 116(2), pp 71-86.

10. Vasant G. Havanagi, SudhirMathur, P.S.Prasad, C. Kamaraj, Feasibility of Copper slag – fly ash - soil mixas a Road construction material, CRRI, Delhi.

11. Use of waste materials and by-products inroad construction (1977) Organization for economiccooperation and development (O.E.C.D.), pp 68-69.

12. Mroueh, U. M., Laine-Ylijoki, J &Eskola, P. (2000), Life-Cycle impacts of the use of industrial by-products in road and earth construction, Waste Materials in Construction, WASCON 2000, Proceedings of theInternational Conference

on the Science andEngineering of Recycling for EnvironmentalProtection, Pergamon Press, Harrogate, England, Vol 1, pp 438-448.

13. Sh. Binod Kumar, Utilization of Copper Slag as Fine Aggregate in Cement Concrete, CRRI.

14. Central Electro Chemical Research Institute (CECRI) (2004) Corrosion and leaching studies on blendedcopper slag in concrete, A report to Sterlite industries, Tuticorin, India.

15. Transportation Research Board of Washington (TRBW) (1994) Recycling and use of waste materials and by-products in Highway Construction, A NationalCooperative Highway Research Programme.

16. K.S.Al-Jabri, R.A.Taha, Al-Hasmi, A.S.Al-Harthy,(2006) Effect of copper slag and cement by-pass dust 447 C.Lavanya, Dr.A.SreeramaRao&Dr.N.DargaKumaraddition on mechanical properties of concrete, Construction & Building Materials, 20, pp 322-331.

17. Toshiki A, Osama K, Kenji S, (2000) Concrete with Copper Slag as fine aggregate, J Soc Mater SciJapan,pp 1097-1202.

18. Alpa I, Devecia H and u¨ ng ¨unb H S (2008), "Utilization of flotation Wastes of Copper Slag as Raw Material in Cement Production", Karadeniz Technical University, Department of Mining Engineering, 61080 Trabzon, Turkey.

19. Al-Rawas A A, Taha R, Nelson J D, Al- Shab T B and Al-Siyabi H (2002), "A Comparative Evaluation of Various Additives Used in the Stabilization of Expansive Soils", Geotechnical Testing Journal, Vol. 25, No. 2, pp. 199-209.

20. BipraGorai and Jana R K Premchand (2003), "Characteristics and Utilization of Copper Slag: A Review", Resources,Conservation and Recycling, Vol. 39, pp. 299-313.

21. Brindha D, Baskaran T and Nagan S (2010), "Assessment of Corrosion and Durability Characteristics of Copper Slag Admixed Concrete", International Journalof civil and structural Engineering.

22. BlessenSkariah Thomas, Anoop S and Sathish Kumar V (2012), "Utilization of Solid Waste Particles as Aggregates in Concrete", in Procedia Engineering, Elsevier, Vol. 38, pp. 3789-3796.

23. Chaudhary R and Rachanan M (2006), "Factors Affecting Hazardous Waste solidification/stabilization: A Review", in Journal of Hazardous Materials, Vol. B137, pp. 267-276.

24. DayanandThagriya (2011), M.Tech. Thesis Entitled "Use of copper Tailing for clay soil stabilization" Submitted to Malaviya National Institution of Technology, Jaipur, India.