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STABILIZATION OF BLACK COTTON SOIL BY REPLACING COPPER SLAG- FLY ASH AND RICE HUSK ASH MIX

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Abstract:

Industrial wastes such as copper slag and fly ash are being generated in tons every year and disposed mainly by land fillings, resulting in wastage of useful land. Copper slag in itself is a granular cohesionless sand-like material, while fly ash is highly pozzolanic. – Different trial mixes of copper slag fly ash & Rice Husk Ash were tested for obtaining the optimum mix having maximum dry density. Cylindrical specimens were prepared using optimum mix with different proportion of cement and cured for period of 7, 14 and 28 days in desiccator. Several tests such as proctor test, unconfined compressive strength test, splitting tensile strength test and soaked CBR test were carried out. The purpose of this paper is to investigate copper slag, fly ash and Rice husk ash mixes with cement as stabilizer for their proper use in road construction. In the present study, using fly ash obtained from Thermal power plant, Rice Husk Ash & Cooper Slag for stabilization of soil obtained from Hyderabad is attempted. With various proportions of this additive, expansive soils are stabilized. Owing to the fact that fly ash possesses no plastic property, plasticity index (P.I.) of clay-fly ash mixes show a decrease in value with increasing fly ash content. In conclusion, addition of fly ash results in decrease in plasticity of the expansive soil, and increase in workability by changing its grain size and colloidal reaction. Tested under both soaked and un-soaked conditions, the CBR values of clay with fly ash mixes were observed. Analysis of the formerly found result exposes the potential of fly ash as an additive that could be used for improving the engineering properties of expansive soils.

Keywords: Fly ash, Copper slag, Rice Husk Ash, Flexible pavement, Modified proctor test, unconfined compressive strength, CBR and Triaxial shear test.

INTRODUCTION:

The use of waste materials in the road construction industry is gradually gaining significance in India, considering disposal and environmental problems and the gradual depletion of natural resources. The copper unit located at Dahej, Gujarat, India, produces 1,200 to 1,500 tons of copper slag per day. The large quantity of accumulated slag is dumped and left for the most part unused on costly land within the plant premises. Also, 50 to 100 tons of fly ash are produced per day from the existing captive thermal power plant. The potential use of these materials in road construction was studied initially by evaluating the materials for their physical and chemical characteristics. The waste materials were mixed with local soils in the range of 25% to 75%, and their geotechnical characteristics were investigated. The feasibility of using these mixes in the base course of road pavement was investigated by adopting stabilization techniques. The potential of copper slag as a replacement for fine aggregates in bituminous mixes was also investigated. It was concluded that a mixture of copper slag, fly ash, and soil has the potential for use in embankment, subbase, base, and wearing courses of road pavement. The results of laboratory tests and typical technical design specifications indicating the utility of copper slag, fly ash, and soil in different layers of road pavement are discussed. Most of the roads in India are being constructed on the problematic soils, due to which many problems regarding the stability and the characteristics strength are faced. Problematic soils cause some engineering problems like differential settlement and failures under load. The amount of industrial wastes such as copper slag, fly ash and rice husk (rice husk ash) goes on increasing day-by-day, and the main problem is their disposal. Some major applications, where copper slag-fly ash and rice husk has already been recognized worldwide, are cement and concrete manufacturing, road and river embankment, pavement blocks. In recent years, there has been a growing emphasis all over the world towards promoting the use of marginal materials in road construction in order to affect cost saving, reduce pressure on good quality aggregates and also to protect environment. Copper slag-fly ash and Rice husk mixture can be used as an embankment and subbase material for road construction. Recycling and re-use of these materials can decrease the environmental impacts from the excavation and treatment of raw material.

General :Copper is one of the basic chemical elements which are a soft and ductile metal, known for its high thermal and electrical conductivity and has a reddish-orange surface in its pure state. It is commonly used in electrical, construction and transportation industries. Pure copper is rarely found in nature, but is usually combined with other chemicals in the form of copper ores.

The process of extracting copper from copper ore varies according to the type of ore and the desired purity of the final product. Each process consists of several steps in which unwanted materials are physically or chemically removed, and the concentration of copper is progressively increased. the construction engineer is concerned are volume, strength, permeability and durability

Fig 1.Black cotton soil

OBJECTIVES

- Strengthening of soil, and its bearing capacity.
- To decrease the index properties like Liquid limit, Plasticity index, swelling potential and to increasing of engineering properties like UCS value and also increases Soil Bearing Capacity.

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- To make the use of inferior quality of local materials.
- To enhance the unfavorable soil properties such as excessive swelling or shrinkage, high plasticity so on.
- The main objective of stabilization is to rise soil strength and soil stability by use of the locally accessible materials.
- To know the properties of subgrade by conducting the tests like Atterberg limits, UCS, CBR and Triaxial test.

The second objective of the present investigation is to study the possibility of using Fly ash for mechanical stabilization of expansive soil. It is intended to obtain Optimum fly ash from view point of compaction characteristics, strength and deformation characteristics.The third objective is to determine optimum Rice husk, copper slag and fly ash content for treated expansive soils.

METHODOLOGY:

Brief Steps Involved In the Experiments

Sieve analysis

Sieve analysis is the name given to the operation of dividing a sample of aggregate into various fractions each consisting of particles of the same size. The sieve analysis is conducted to determine the particle size distribution in a sample of aggregate, which we call gradation.The sieve analysis gives us a detailed idea regarding the type, consistency and components of the soil.

Atterberg Limits

Liquid Limit:

It is the water content of the soil between the liquid state and plastic state of the soil. It can be defined as the minimum water content at which the soil, though in liquid state, shows small shearing strength against flowing. It is measured by the Casagrande's apparatus and is denoted by *wL*.

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Plastic Limit:

This limit lies between the plastic and semi-solid state of the soil. It is determined by rolling out a thread of the soil on a flat surface which is non- porous. It is the minimum water content at which the soil just begins to crumble while rolling into a thread of approximately 3mm diameter. Plastic limit is denoted by wP.

Particle size distribution:

Soil at any place is composed of particles of a variety of sizes and shapes, sizes ranging from a few microns to a few centimeters are present sometimes in the same soil sample. The distribution of particles of different sizes determines many physical properties of the soil such as its strength, permeability, density etc. Particle size distribution is found out by two methods, first is sieve analysis which is done for coarse grained soils only and the other method is sedimentation analysis used for fine grained soil sample. Both are followed by plotting the results on a semi-log graph. The percentage finer N as the ordinate and the particle diameter i.e., sieve size as the abscissa on a logarithmic scale. The curve generated from the result gives us an idea of the type and gradation of the soil. If the curve is higher up or is more towards the left, it means that the soil has more representation from the finer particles; if it is towards the right, we can deduce that the soil has more of the coarse-grained particles.The soil may be of two types- well graded or poorly graded (uniformly graded). Well graded soils have particles from all the size ranges in a good amount. On the other hand, it is said to be poorly or uniformly graded if it has particles of some sizes in excess and deficiency of particles of other sizes. Sometimes the curve has a flat portion also which means there is an absence of particles of intermediate size, these soils are also known as gap graded or skip graded.For analysis of the particle distribution, we sometimes use D_{10}, D_{30}, and D_{60} etc. terms which represents a size in mm such that 10%, 30% and 60% of particles respectively are finer than that size. The size of D_{10} also called the effective size or diameter is a very useful data. There is a term called uniformity coefficient C_u which comes from the ratio of D_{60} and D_{10}, it gives a measure of the range of the particle size of the soil sample.

Specific gravity:

Specific gravity of a substance denotes the number of times that substance is heavier than water. In simpler words we can define it as the ratio between the mass of any substance of a definite volume divided by mass of equal volume of water. In case of soils, specific gravity is the number of times the soil solids are heavier than equal volume of water. Different types of soil have different specific gravities, general range for specific gravity of soils:

Table : Specific Gravity Classification

1.	Sand	2.63 - 2.67
2.	Silt	2.65 - 2.7
3.	Clay and Silty clay	2.67 - 2.9
4.	Organic soil	<2.0

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Test Procedures

Liquid limit

The Casagrande's tool cuts a groove of size 2mm wide at the bottom and 11 mm wide at the top and 8 mm high. The number of blows used for the two soil samples to come in contact is noted down. Graph is plotted taking number of blows on a logarithmic scale on the abscissa and water content on the ordinate. Liquid limit corresponds to 25 blows from the graph.

FIG:-2

Plastic limit

Air-dried soil samples have been used for this test. The soil fraction passing the 425µ sieve is taken for the test. About 30gm of soil is taken in an evaporating dish and thoroughly mixed with distilled water till it becomes plastic and it becomes easily moulded with fingers. About 10gm of the plastic soil mass is taken in one hand and a ball is formed. The ball is rolled with fingers on a glass plate to form a soil thread of uniform diameter of about 3mm approximately without crumbling. The rate of rolling is kept about 80 to 90 strokes / min. The test is repeated taking a fresh sample each time. The plastic limit is taken as the average of three values.

FIG:-3

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RESULTS:

Moisture Content of Soil:

Table Moisture content observations

Specific Gravity:

S.No	Observation number	1	2	3
1	W1- Weight of bottle (gms)	28.19	28.19	28.19
2	W2- Weight of bottle + Dry soil (gms)	79.2	78.19	78.06
3	W3- Weight of bottle + Soil + Water (gms)	110.68	110.8	110.54
4	W4- Weight of bottle + Water (gms)	80.05	80.07	80.05
5	Specific gravity G= (w2-w1)/[(w2-w1)-(w3-w4)]	2.59	2.60	2.57
5	Avg specific gravity		2.58	

Table 4.3 Grain size analysis observations

I.S Sieve no (mm)	wt. retained on each sieve (gms)	Percentage on each sieve	Cumulative % retained on each sieve	% finer
4.75	220	22	22	78
2.36	210	21	43	57
1.18	190	19	62	38
0.6	121	12.1	74.1	25.9
0.425	80	8	82.1	17.9
0.3	50.75	5.075	87.175	12.825
0.15	95	9.5	96.675	3.325
0.075	20.95	2.09	96.77	1.23
pan	12.3	1.23	100	0

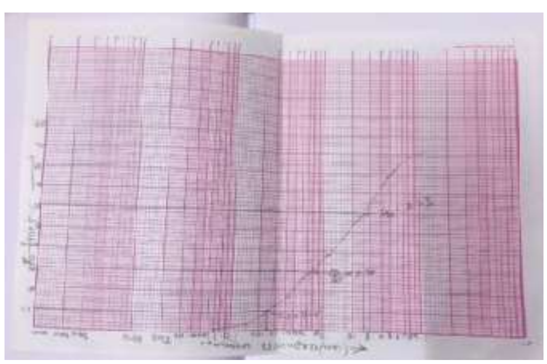

Fig Liquid limit

From the graph

D10 = 0.25, D30 = 0.76, D60 = 2.63

Uniformly coefficient (Cu) = D10/D60

= 2.63/0.25

= 10.52

Coefficient of curvature (Cc) = $D^2$30/D60xD10

= 0.76^2/2.63x0.25

= 0.87

- By observing the above observations and trails, it is clear that the table 4.11 (Fig 4.8) shows that the maximum dry density is increased compared to trail 1 (table 4.9) and conventional soil (table 4.7). It also found that table 4.11 (trail 2) shows the optimum moisture content.
- The optimum value of MDD and OMC is obtained as 1.86 gm/cc and 13.6%

CONCLUSION:

The Black cotton soil collected from the local village Gundla pochampally, Telangana. Based upon the results obtained from the study, the following conclusions are drawn;

1.The maximum dry density and optimum moisture content for conventional soil is obtained as 1.78 gm/cc and 13.05%.

2.The maximum dry density and optimum moisture content for partial replaced soil (copper slag 30% + fly ash 14% + Rice husk ash 10%) is obtained as 1.86 gm/cc and 13.6%.

3.The C.B.R of conventional soil is obtained as 4.69%

4.The C.B.R of optimum mix (copper slag 30% + fly ash 14% + Rice husk ash 10%) is obtained as 6.65%. The C.B.R at 2.5mm > C.B.R at 5mm. Hence the C.B.R value can be used for the design purpose.

5.The shear strength of optimum (copper slag 30% + fly ash 14% + Rice husk ash 10%) was 0.0935 N/mm^2

6.Use of waste materials as stabilizers gives economic and ecological solutions for stabilization of subgrade of road embankment.

7.The combination of copper slag, fly ash and rice husk ash is proved advantageous in stabilizing the black cotton soils and the method adopted is cost effective. In the process, we will be helping the industries to dispense with this waste generated and saving the space occupied by the waste.

REFERENCES:

1.Prasanna S. Utilization of waste plastic shreds for stabilization of soil. In Geotech Transp Infrastruct Conf. 2004.

2.Prabakar J, Dendorkar N, Morchhale RK. Influence of fly ash on strength behavior of typical soils. Constr Build Mater. 2004;18(4):263- 267.

3.Mallikarjuna Rao K, Rama Subbarao GV. Optimum fly ash for mechanical stabilization of expansive soils using 22 factorial experimental design. Nat Hazards. 2012;60(2):703-713.

4.Chebet FC, Kalumba D. Laboratory investigation on re-using polyethylene (plastic) bag waste material for soil reinforcement in geotechnical engineering. Int J Civ Eng Urban Plan. 2014;1(1):67-82.
5.Prasanna S, Kumar P. Soil reinforcement using coconut shell ash: A case study of Indian soil. J Civ Eng Constr. 2017;6(2):73-78.
6.Gupta D, Kumar A. Stabilized soil incorporating combinations of rice husk ash, pond ash and cement. Geomech Eng. 2017;12(1):85-109.
7.Prasanna S. Utilization of waste plastic shreds for stabilization of soil. In Geotech Transp Infrastruct Conf. 2019;619-628.
8.Abdullah. Effect of soil stabilization on subgrade soil using cement, lime and fly ash. Eurasian J Sci Eng. 2020;6(2):39-52.
9.Havanagi, V. G., Sinha, A. K., Mathur, S., and Prasad, P., "Experimental study on the use of copper slag wastes in embankment and pavement construction." Proc., Symposium on Engineering of Ground and Environmental Geotechnics, Hyderabad, 2008, pp.259-264.
10.Sant Hitesh et.al,(2016) "Stabilization of black cotton soil with bagasse ash", International Journal Of Engineering Research And Technology(IJERT), Vol: 4 - Issue 23, 2016, pp.2278-0181
11 Das, S., Nayak, J., Nayak, S., Dey, S., 2022, Prediction of Life Insurance Premium during Pre-and Post-Covid-19: A Higher-Order Neural Network Approach, Journal of The Institution of Engineers (India): Series B, 10.1007/s40031-022-00771-1
12 Pittala, C.S., Vallabhuni, R.R., Vijay, V., Anam, U.R., Chaitanya, K., 2022, Numerical analysis of various plasmonic MIM/MDM slot waveguide structures, International Journal of System Assurance Engineering and Management, 10.1007/s13198-022-01664-8
13 Ahmad, N., Yadav, K.S., Ahmed, M., Hussain Laskar, R., Hossain, A., 2022, An integrated approach for eye centre localization using deep networks and rectangular-intensity-gradient technique, Journal of King Saud University - Computer and Information Sciences, 10.1016/j.jksuci.2022.02.015
14 Velliangiri, S., Pandiaraj, S., Iwin Thanakumar Joseph, S., Muthubalaji, S., 2022, Multiclass recognition of AD neurological diseases using a bag of deep reduced features coupled with gradient descent optimized twin support vector machine classifier for early diagnosis, Concurrency and Computation: Practice and Experience, 10.1002/cpe.7099
15 Muthubalaji, S., Devadasu, G., Srinivasan, S., Soundiraraj, N., 2022, Development and validation of enhanced fuzzy logic controller and boost converter topologies for a single phase grid system, Electrical Engineering and Electromechanics, 10.20998/2074-272X.2022.5.10