A Laboratory Investigation on The Efficacy of Portland Slag Cement And Lime on Improving Properties of Expansive Soil As Foundation Bed Under Static Pressure

Dr.D.Koteswara Rao[1], Md. Sajida Sulthana[2], P.Rajesh Babu[3]
[1, 2, 3] Dept of Civil Engineering
[1, 2, 3] JNTUK Kakinada, Andhra Pradesh, India

Abstract- *India has large tracts of expansive soils commonly known as black cotton soils which covers approximately 20% of the total land area of our country. These soils experience large volume changes on exposure to climates with alternate wetting and drying. Several innovative foundation techniques have been suggested to overcome the problem of expansive soils. Those techniques include sand cushion technique, cohesive non-swelling (CNS) layer technique and under reamed piles. Stabilization of expansive soil with various types of additives is the most commonly used technique. Stabilization is process of fundamentally changing the chemical properties of soft soils by adding stabilizers or binders, either in wet or dry conditions to increase the strength and stiffness of the naturally weak soils. In present investigation, the aim is to reduce swelling and shrinkage behaviour of expansive soil by improving strength and engineering properties of soil. Also, the industrial Material Port Land Slag Cement is utilised for stabilisation so as to solve the problem of indiscriminate disposal. The other additive used in this study is Lime. Various tests are conducted with varying proportions and results are reported.*

Keywords- Expansivesoil (ES), lime, Portland Slag Cement (PSC),CBR.

I. INTRODUCTION

Due to land limitations and increase in population, people are utilizing every land available for construction. The behavior of soil at any location is not same due to anisotropic nature. When a project is to be carried out in difficult foundation condition, the possible alternate solutions are, avoid the particular sites, design the plan structure accordingly, use pile foundation which transmits the total load to hard strata, remove and replace the foundation soil and attempt to modify the existing ground i.e. Soil stabilization which is commonly used. Soil stabilization is a process of improving the engineering properties of soil. It is extremely cost-effective method of converting poor quality soil into hard impermeable medium.

In present study, Portland Slag Cement and Lime are added to expansive soil to evaluate the performance through laboratory tests such as consistency limits, modified proctor test and California bearing ratio strength test.

II. LITERATUREREVIEW

Dr. D. Koteswara Rao et al., (2012) studied the properties of expansive soil before and after treated with rice husk ash and potassium chloride.

Geethu Saji (2016) has studied the effect of Egg Shell Powder (ESP) and Quarry Dust (QD) on the properties of clayey soil.

Butt etal., (2016) conducted extensive experimental demonstrate the soil improvement prospective of saw dust ash (SDA) by performing California bearing ratio (CBR) and unconfined compression strength tests.

Dharmend rasahu has investigated the effects of NaoH on mixing with the black cotton soil as a stabilizing material.C. Neeladharan (2017) studied about the stabilization of expansive soil using tile waste with sodium hydroxide as a binder.

M. Vignesh (2019) studied about the stabilisation of clay soil using polypropylene and sawdust ash.

III. METHODOLOGY, EXPERIMENTAL STUDY ANDRESULT

The study is carried out on Expansive soil, Expansive soil blended with Portland Slag Cement and Expansive Soil with optimum percentage of Portland Slag Cement with Lime

in the following percentages. Portland Slag Cement was varied in percentages of 5%,10%, and 15% by weight of Expansive soil throughout the experiments. To increase the CBR of Portland Slag Cement treated Expansive soil, Lime was added in percentages of .2%, 4%, 6%, 8% and 10%.

3.1 Soil properties: The soil used for current study has been taken from Turpulanka village near Amalapuram area of East Godavari district, AP, India. It is collected from a depth of 1.50 m. Tests are conducted to determine the Index properties, Engineering properties as per Indian standard (IS 2720). The Soil properties are given in Table 1:

S.No	Property	Symbol	Untreated Expansiveso il
1	LiquidLimit(%)	W_L	75
2	PlasticLimit (%)	W_P	35.5
3	PlasticityIndex(%)	I_P	39.5
4	SoilClassification	--	CH
5	SpecificGravity	G	2.66
6	FreeSwell(%)	FS	130
7	OptimumMoisture Content(%)	OMC	27.20
8	Maximum Dry Density(g/cc)	MDD	1.54
9	CBR (%)	--	1.12

3.2 Portland Slag Cement: Cement is an oldest binding agent since the invention of soil stabilization technology in 1960's. It may be considered as primary stabilizing agent or hydraulic binder because it can be used alone to bring about the stabilizing action required. Cement is used to stabilize a wide range of soil. Numerous types of cements are available in the market such as ordinary Portland cement, blast furnace cement, sulfate resistant cement and high alumina cement. Usually, the choice of cement depends on type of soil to be treated and desired final strength. Cement can be used to modify and improve the quality of the soil or to transform the soil into a cemented mass with increased strength and durability and improve engineering properties of soil and further improved cation exchange of clay

Table 2:Chemical composition of Portland Slag Cement

Chemical composition	Percentage (%)
SiO_2	12
$Al2O_3$	26
$Fe2O_3$	12
CaO	43
MgO	7

(Source: data collected from https://www.civilgiant.com/portland-slag-cement)

3.3 Quick Lime: Main constituent of lime is calcium carbonate (CaCO3), It is available in nature in the form of limestone. Limestone from stone hills is main source of lime and Shells of sea animals are its purest form.

Quick lime: When limestone is burnt CO2 is given out and quick lime is obtained.

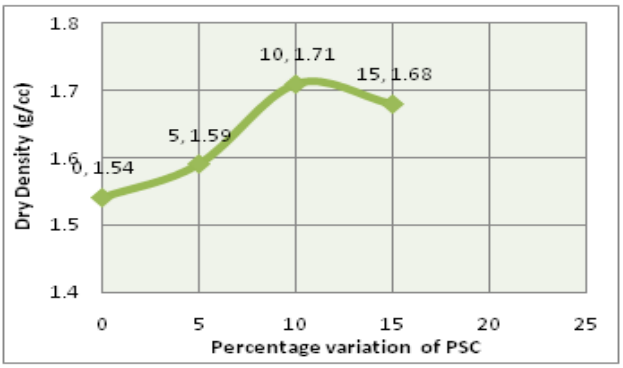
Slaked lime: Water should be added on quick lime to turn it into calcium

Hydroxide, the process is known as slaked lime.

CaO+H2O ------>Ca(OH)2

Table: 3 Compaction Characteristics of Expansive soil treated with percentage of Portland Slag Cement (PSC)

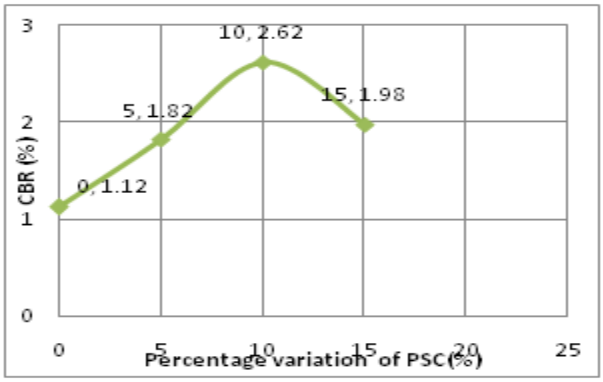
MixProportion	Water Content(%)	DryDensity(g/cc)
ES + 0% PSC	27.20	1.54
ES+5%PSC	25.63	1.591
ES+10%PSC	**25.82**	**1.71**
ES+15%PSC	25.18	1.68



Graph 1: Shows the Variation of MDD (g/cc) w.r.t various percentage of PSC

Table 4 CBR Values of Expansive soil treated with Percentage Variations of PSC

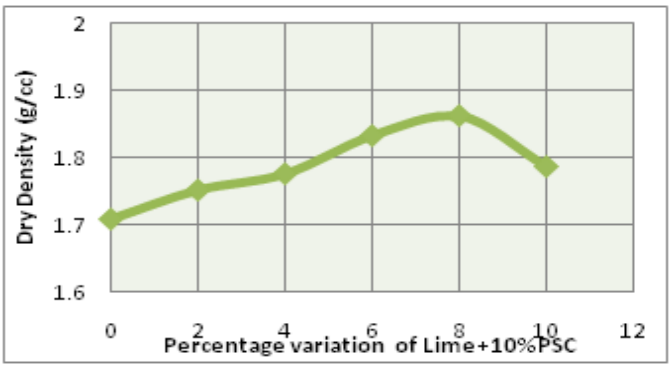
MixProportions	CBR(%)
ES+0% PSC	1.12
ES+5% PSC	1.82
ES+10%PSC	**2.62**
ES+15%PSC	1.98



Graph.2: Shows the variation of CBR w.r.t Different percentages of PSC.

Table 5 OMC and MDD Values of the Expansive soil with 10% of Portland Slag Cement and different percentages of Lime

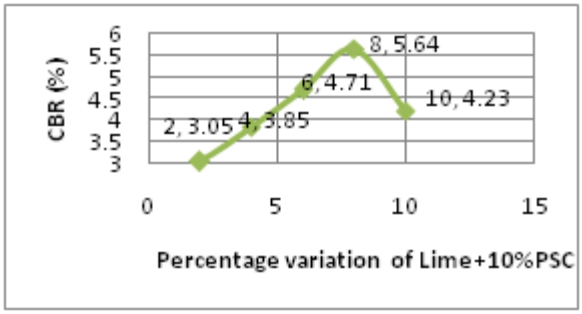
S.No	Mixproportion	Optimum MoistureContent (%)	MaximumDry Density(g/cc)
1	ES+10% PSC+0%Lime	25.82	1.71
2	ES+10% PSC +2%Lime	25.35	1.75
3	ES+10% PSC+4%Lime	24.89	1.776
4	ES+10% PSC +6%Lime	24.05	1.833
5	**ES+10% PSC +8%Lime**	**23.24**	**1.862**
4	ES+10% PSC+10%Lime	23.18	1.788



Graph 3: OMC and MDD values of Expansive soil with 10% of PSC with various percentages of Lime

Table 6 CBR Values of 10% PSC Treated Expansive soil with Various Percentages of Lime

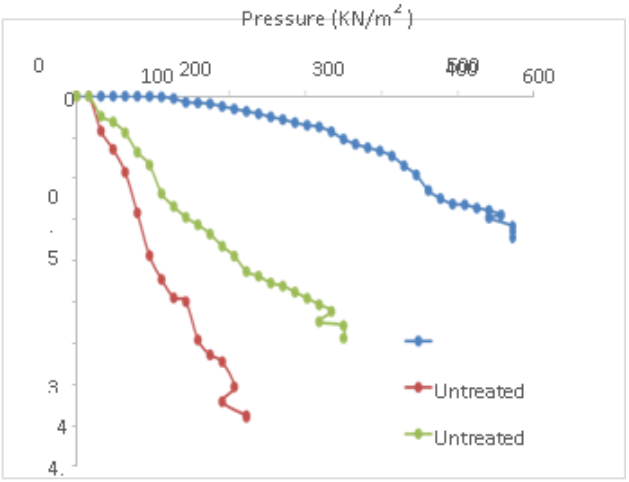
S.No	MixProportions	CBR (%)
1	100%Expansivesoil	1.12
2	ES+10%PSC	2.62
3	ES+10% PSC + 2% Lime	3.05
4	ES+10% PSC + 4% Lime	3.85
5	ES+10% PSC + 6% Lime	4.71
6	**ES+10% PSC + 8% Lime**	**5.64**
7	ES+10% PSC + 10% Lime	4.23



Graph 4: Shows the Graph Variation of Soaked CBR values withExpansivesoil+10% PSC+different% Lime

Table7:Variation of LL,PL,PI for Expansive soil treated with percentage of PSC and Lime

Expansive soil treated with percentage of PSC and Lime	LiquidLimit(%)	PlasticLimit(%)	PlasticityIndex(PI)
100% ES	75	35.5	39.5
ES+10%PSC	55.23	24.52	30.71
ES+10%PSC+8% Lime	46.46	21.36	25.1



Graph 5: Laboratory Static Plate Load Test results of Expansive soil treated with 10% PSC + 8% Lime

IV. CONCLUSIONS

- It is observed from the laboratory test results, that the liquid limit of treated Expansive Soil has been decreased by 26.36% on addition of 10% PSC and it has been further decreased by 38.05% on addition of 8% of lime as an optimum compared with the Untreated Expansive Soil.
- It is observed from the laboratory test results, that the plastic limit of treated Expansive Soil has been decreased by 30.92% on addition of 10% PSC and it has been further decreased by 39.83% on addition of 8% of Lime as an optimum compared with the Untreated Expansive Soil
- It is observed from the laboratory test results, that the plasticity index of treated Expansive Soil has been decreased by 22.25% on addition of 10% PSC and it has been further decreased by 36.45% on addition of 8% of Lime as an optimum compared with the Untreated Expansive Soil.
- It is observed from the laboratory test results, that the specific gravity of treated Expansive Soil has been increased by 2.63% on addition of 10% PSC and it has been further increased by 10.31% on addition of 8% of lime as an optimum compared with the Untreated Expansive Soil.

- It is observed from the laboratory test results, that the Differential free swell of treated Expansive Soil has been decreased by 53.84% on addition of 10% PSC and it has been further decreased by 76.92% on addition of 8% of lime as an optimum compared with the Untreated Expansive Soil.
- It is found that the Optimum Moisture Content (OMC) of treated Expansive Soil has been decreased by 5.10% on addition of 10% PSC and it has been further decreased by 14.59% on addition of 8% of lime as an optimum compared with the Untreated Expansive Soil.
- It is found that the Maximum Dry Density (MDD) of treated Expansive Soil has been increased by 11.03% on addition of 10% PSC and it has been further increased by 20.78% on addition of 8% of lime as an optimum compared with the Untreated Expansive Soil.
- It is noticed that the CBR value of treated Expansive Soil has been improved by 133.92% on addition of 10% PSC and it has been further improved by 403.57% on addition of 8% of Lime as an optimum compared with the Untreated Expansive Soil.
- It is observed from the laboratory test results, that the cohesion value of treated Expansive Soil has been decreased by 11.52% on addition of 10% PSC and it has been further decreased by 35.13% on addition of 8% of Lime as an optimum compared with the Untreated Expansive Soil.
- It is observed from the laboratory test results, that the angle of internal friction of treated Expansive Soil has been improved by 63.57% on addition of 10% PSCand it has been further improved by 171.78% on addition of 8% of Lime as an optimum compared with the Untreated Expansive Soil.
- It is observed from the laboratory test results, Static Plate Load test results of Expansive Soils treated with optimum of 10PSCand 8% Lime foundation bed treated with gravel cushion which has exhibited the ultimate Static Plate Load of 556.828 KN/m2 with the deformation of 1.45 mm at OMC.

REFERENCES

[1] Wajid Ali Butt, Karan Gupta and K.N Jha (2016). "Strength behaviour of clayey soil stabilized with saw dust ash", International Journal of Geo-Engineering. DOI 10.1186/s40703-016-0032-9.

[2] Koteswara Rao. D, M.Anusha, P.R.T. Pranav, G.Venkatesh(2012). "A Laboratory Study On the Stabilization of Marine Clay Using Saw Dust and Lime", International Journal Of Engineering Science & Advanced Technology. Volume-2, Issue-4, 851 – 862.

[3] IS: 2720(Part 5)-1985- Methods of test for soils: Determination of liquid and plastic limit.

[4] IS: 2720(Part 7)-1980- Methods of test for soils: Determination of water content-dry density relation using light compaction

[5] Improvement of Mechanical Properties by Waste Sawdust Ash Addition into Soil by Shaheer Khan volume 20 2015 EJGE and Haziq khan

[6] Pallavi, Pradeep Tiwari, Dr P D Poorey (2016), "Stabilization of Black Cotton Soil using Fly Ash and Nylon Fibre", "International Research Journal of Engineering and Technology (IRJET)", e-ISSN: 2395 - 0056 Volume: 03 Issue: 11 | Nov -2016 p-ISSN: 2395-0072.

[7] "Zuhaib Zahoor Shawl, Er. Ved Parkash, Er. Vishal Kumar" (2017), "Use of Lime and Saw Dust Ash in Soil Stablization", Vol. 6, Issue 2, February 2017.

[8] A Venkatesh and Dr, Srinivasa Reddy (2016). "Effect of Waste Saw Dust Ash On Compaction and Permeability Properties of Black Cotton Soil", International Journal of Civil Engineering Research. ISSN 2278-3652 Volume 7, Number 1 (2016), pp. 27-32

[9] ASTM Standards on Soil Stabilization with Admixtures, 2nd edition. 1992. 126 pp.

[10] ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

[11] Akshaya Kumar Sabat "Stabilization of expansive soil using waste ceramic dust". Electronic journal of Geotechnical Engineering (EJGE), vol.17, pp 3915-3925, January 2012.

[12] Olaniyan O.S,olaoye.R.A "Soil stabilization techniques using sodium hydroxide additives". International Journal of Civil and Environmental Engineering (IJCEEIJENS) Vol.11, pp 19-22, December 2011

[13] . Punmia B.C. (2007), "Soil Mechanics & Foundations", Laxmi Publications.

[14] E. Kufre, C. Chijioke, E. Edidiong, and C. Imoh, "Influence of Sawdust Disposal on the Geotechnical Properties of Soil," Electron. J. Geotech. Eng., vol. 22 (12), pp. 4769-4780, 2017

[15] H. I. Owamah, E. Atikpo, O. E. Oluwatuyi, and A. M. Oluwatomisin, "Geotechnical Properties of Clayey Soil Stabilized with Cement-Sawdust Ash for Highway Construction," J. Appl. Sci. Environ. Manag., vol. 21, no. 7, pp. 1378–1381, 2017.

[16] S. M. Al-zaidyeen, and A. N. S. Al-qadi, "Effect of Phosphogypsum As a Waste Material in Soil Stabilization of Pavement Layers," Jordan J. Civ. Eng., vol. 9 (1), pp. 1-7, 2015.

[17] Ikeagwuani, C. C., "Stabilisation of black cotton soil with sawdust ash and lime for subgrade," MS thesis,

Department of Civil Eng., Univ. of Nigeria, Nsukka, Enugu, 2013.

[18] Osinubi, K. J., Ijimdiya, T. S. and Nmadu, I. "Lime stabilisation of black cotton soil using bagasse ash as admixture," Advances in materials and systems technologies II, vol. 62, no. 64, pp. 3-10, 2009

[19] T.Geeta Rani "Strength behaviour of expansive soil treated with tiles waste",International Journal of Engineering Research and Development, Vol.10, Issue 12, pp 52-57, December 2014.

[20] H.Bairagi, R.Yadav, R.Jain, Effect of Jute Fibers on Engineering characteristics of Black Cotton Soil, Ratio, 15, 20 International Journal of Engineering Science and Research Technology, 2014, ISSN:2277-9655.

BIOGRAPHIES

Author 1

- Dr. D. Koteswara Rao is working as OSD to Honorable Vice Chancellor and Professor of Civil Engineering, Department of Civil Engineering, University College of Engineering, Jawaharlal Nehru Technological University Kakinada, Kakinada.

- He is the "Triple Hat-Trick Best Teacher Awardee" from the Department of Civil Engineering, University College of Engineering, JNTUK Kakinada.

- He was awarded "The University Meritorious Teacher Award-2013" by the University Authorities.

- He was received "The National Award-2013 for Teaching Excellence in Civil Engineering".

- Recently he has received "The State Best Teacher Award-2017" by the Government of Andhra Pradesh, India.

- He has published Number of research and review papers in various international journals and conferences. He has guided about 65 post graduate projects and also 6 research scholars are working under his guidance. He is a leading consulting member in the fields of Surveying, Transportation and Geotechnical Engineering

Dr. D. Koteswara Rao, Professor of Civil Engineering, University College of Engineering, JNTUK, Kakinada, East Godavari District-533003, Andhra Pradesh, India.

Author 2

Smt.Md. Sajida Sulthana, Assistant Professor (C) in Civil Engineering, University College of Engineering, JNTUK, Kakinada, East Godavari District-533003, Andhra Pradesh, India.

Author 3

Pinisetti Rajesh Babu Roll No18021D1921, PG student, Soil Mechanics and Foundation Engineering, Department Civil Engineering, University College of Engineering, JNTUK, Kakinada, East Godavari District-533003, Andhra Pradesh, India.