iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH
IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 Issue: XI Month of publication: November 2022

DOI: https://doi.org/10.22214/ijraset.2022.47340

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue XI Nov 2022- Available at www.ijraset.com

An Experimental Study on Stabilization of Expansive Soil by Copper Slag

K. Venkata Surya Sandeep[1], Ch. Sivanarayana[2]

[1]*PG Student, Department of Civil Engineering, B V C Engineering College, Odalarevu, East Godavari District, Andhra Pradesh, India*

[2]*Assistant Professor & Principal, Department of Civil Engineering, B V C Engineering College, Odalarevu, EastGodavari District, Andhra Pradesh, India*

Abstract: Stability of any structure depends on strength properties of underground soil on which it is constructed. Structures basically transfer all the loads come on itself directly to the ground. If the underlying soil is not stable enough to support transferred loads then various types of failure occur such as settlement of the structure, cracks and so on. To solve this issue, soil improvement is necessary because it not only lowers the construction cost but also cuts the risk of any damage of structure later on. Numerous improvement methods can be adopted to make ordinary soil stable enough to support the structural loads. In this research work a number of tests may conduct using both ordinary soil and stabilised soil. The stabilising agents are using in this study is Copper Powder. The varying percentage of 5%, 10%, 15%, 20% and 25% added to the expansive soil. It binds the soil particles together and helps in reduction of rapid change in volumetric properties. The tests may conduct on un-stabilised and stabilised expansive soil is CBR, UCS and tri-axial test.The test may conducted on untreated and treated expansive soil i.e. index properties (liquid limit, plastic limit), compaction test, California bearing ratio (CBR), unconfined compressive test (UCS), Triaxial test

Keywords: Expansive Soils, Copper Powder (CP), Shear Strength Paramaters.

I. INTRODUCTION

A. General

Expansive soils are a worldwide problem that poses several challenges for civil engineers. They are considered a potential natural hazard, which can cause extensive damage to structures, if not adequately treated. Such soils swell when given an access to water and shrink when they dry out (Al-Rawas et al. 2002). In general, expansive soils have high plasticity, and are relatively stiff or dense. The expansive nature of soil is most obvious near the ground surface where the profile is subjected to seasonal, environmental changes. The pore water pressure is initially negative and the deposit is generally unsaturated.

These soils often have some montmorillonite clay mineral present. The higher the amount of monovalent cations absorbed to the clay mineral (e.g. sodium), the more severe the expansive soil problem (Fredlund and Rahardjo, 1993). Expansive soils have been reported from many parts of the world, mainly in the arid or semi-arid regions of the tropical and temperate zones like Africa, Australia, India, South America, United States, and some regions in Canada. This never means that expansive soils do not exist elsewhere, because they can be found almost everywhere. However, in the humid regions water tables are generally at shallow depth and moisture changes, which are responsible for volume changes in soils, are minimal excepting under extended drought conditions (Arnold, 1984; Shuai and Fredlund, 1998; Wayne et al. 1984). The problems with foundations on expansive soils have included heaving, cracking and break-up of pavements, roadways, building foundations, slab-on-grade members, channel and reservoir linings, irrigation systems, water lines, and sewer lines. In INDIA, these soils are generally called as black cotton soils and cover about 20% of the total land area. They are found in the states of Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra and Tamilnadu.

For a long time, we are facing problems like failures of small and big structures. The biggest problem behind this is swelling soil. This is very unstable soil. Its property varies from hard to soft and dry to wet. It exhibits swelling and shrinkage with different water content. As a result the many structures usually face excessive settlement and differential movements, which results in damage to foundation systems and structural elements. We are aware about this situation for a long time, but unable to make improvements due to absence of technologies till now. So now our main aim is to improve the properties of swelling soils.

II. REVIEW OF LITERATURE

Changes in the moisture content of clay soil are generally accompanied by volume changes. On moisture uptake there is generally a volume increase and moisture loss is accompanied by shrinkage. Expansive soils swell when given access to water and shrink when they dry out. Soils containing the clay mineral montmorillonite (a smectite) generally exhibit high swelling properties (Wayne, 1984; komine and ogata 1996).The basic units of which the clay is made are silica (SiO2) tetrahedral sheets and Aluminum (Al) or Magnesium (Mg) Oxide octahedral sheets. These were shown in Figures 1 and 2 (Mitchell and Soga, 2005Improving an on-site soil's engineering properties is referred to as either "soil modification" or "soil stabilization" Ramanatha Ayyar, et al. (2002) carried out tests on coir fiber reinforced clay and found that the discrete fibers of small diameter randomly distributedin soil offer a greater resistance to swelling than the larger pieces placed similarly. Mandal and Vishwamohan have carried out performance studies of expansive clay for three types of clays by conducting California bearing ratio test made use of coir fiber and jute fiber as geo-fabrics placed in layers.

Havanagi et al. (2006) had mixed Copper slag (a waste generated during the manufacture of copper) with fly ash and expansive soils in different proportions and their suitability in embankment, sub base and base were investigated. The selected mixes were also stabilized at 3%, 6% and 9% of cement to make it suitable for base course.

Akshaya Kumar Sabat and Subasis Pati says that Expansive soil is a problematic soil for civil engineers because of its low strength and cyclic swellshrink behaviour. Stabilization using solid wastes like copper slag, blast furnace slag, mines waste etc., is one of the different methods of treatment, to improve the engineering properties and make it suitable for construction. The beneficial effects of some prominent solid wastes as obtained in laboratory studies, in stabilization of expansive soils.

R C Gupta, Blessen Skariah Thomas, Prachi Gupta, Lintu Rajan and Dayanand Thagriya studied that Copper Slag is one of the waste byproduct produced by 'Hindustan Copper limited', Khetri, Rajasthan, India. The production of Copper Slag is 120-130 lakh ton per annum. Expansive soils are a worldwide problem that creates challenges for Civil Engineers. They are considered as potential natural hazard, which can cause extensive damage to structures if not adequately treated. The disadvantages of clay can be overcome by stabilizing with suitable material. This research was done on the engineering behavior of Clay when stabilized with Copper Slag.

Prof. Jinka Chandrshekhar and Timir A Chokshi discussed that Copper slag is one of the waste materials that are being used extensively in the civil engineering construction industry. Copper producing units in India leave thousands of tonnes of copper slag as waste every day. Large quantities of the accumulated slag is dumped and left on costly land, causing wastage of good cultivable land. Based on U.S. environmental protection agency regulations, governing solid waste characteristics, copper slag can be classified as a non-hazardous material. Granulated copper slag is more porous and, therefore, has particle size equal to that of coarse sand. In this paper, a review of the previous research studies carried out by various researchers on utilization of copper slag in geotechnical applications is discussed and presented.

Isaac Ibukun Akinwumi discussed that Elemental and chemical analysis of the steel slag was determined using x-ray fluorescence spectroscopy. Tests were carried out to determine the index properties, compaction characteristics (maximum dry density, MDD and optimum moisture content, OMC), strength characteristics (California bearing ratio, CBR and unconfined compressive strength, UCS) and permeability of the natural and treated soil. Test results show that Atterberg limits (liquid limit, plastic limit and plasticity index) generally decreased, while specific gravity of soil – steel slag mixtures increased with higher steel slag content; MDD and OMC increased and decreased, respectively, with higher steel slag content. Generally, CBR and UCS increased up to 8% steel slag treatment of the soil. Permeability of soil – steel slag mixtures increased with higher steel slag content. Based on laboratory test results, an 8 % optimal stabilization of the A 7-6 soil with steel slag satisfactorily meets the Federal Republic of Nigerian General Specifications (Roads and Bridges) requirement for subgrade materials.

Mitchell (1981) described a variety of ground improvement technologies under six categories based on principles. It is more appropriate to classify ground improvement techniques under the following headings viz. replacement, densification, consolidation / dewatering, grouting, admixture stabilization, thermal stabilization, reinforcement and miscellaneous methods (Terashi and Juran, 2000).

Central Electricity Authority (2011) With industrialization, another major problem that came to the fore was pollution and solid waste production. With rising turnover, industrial solid wastes produced soon blew up to huge proportions. To cite an example, the flyash production in India was 131.09 million tons in the year 2010-11 With research, one of the avenues for the utilization of these waste materials came out to be their use in soil improvement. The utilization of several waste materials have improved over the years, the total utilization of flyash produced in India stands at 73.13 million tons which is 55.79% of the total production in the country.

(Kavak et al. 2011, Guleria and Dutta, 2011, Ramirez et al. 2012, Okonkwo et al. 2012, Rahmat and Ismail, 2011) These industrial by-products produce even better results when combined with other materials like lime and cement that have been used in soil improvement for long time Ordinary Portland cement is one of the most commonly used stabilizers for soil stabilization.

Al Rawas et al. (2002) The addition of cement to a material, in the present case soil, produces hydrated calcium silicate and aluminate gels in the presence of moisture, which crystallise and bond the soil particles together. Most of the strength of a cement-stabilised soil comes from the physical strength of the matrix of hydrated cement.

Fang (1991) Cement stabilized soils can be classified into three types, Soil Cement, Cement Bound Material (CBM) and Lean Concrete (TRL, 2003). Soil cement usually contains less than 5% cement (Lay 1986). CBM uses granular material like crushed rock or gravel instead of soil (Croney, 1988). Lean concrete has higher cement content when compared to CBM and is more like concrete rather than CBM (TRL, 2003). Lime stabilization has been extensively studied by earlier researchers. Lime basically reacts with medium, moderately fine, and fine-grained soils to produce reduced elasticity and swell and increased workability and strength. Such improvement in soil properties are the result of three basic chemical reactions: 1. Ion exchange and flocculation; 2. Pozzolanic reaction; and 3. Carbonation.

III. METHODOLOGY

In this portion, a brief description of the experimental procedures adopted in this investigation and the methodology adopted during the course of study are presented.

IV. MATERIALS USED AND THEIR PROPERTIES

The details of the various materials used in the laboratory experimentation are reported in the following sections.

Expansive Soil

The soil used was a typical black cotton soil collected from muramalla East Godavari District, Andhra Pradesh State, India. The properties of soil are presented in the Table All the tests carried on the soil are as per IS specifications. Table 3.1 shows the Properties of Expansive Soil.

Properties of Expansive Soil

S no	Properties	Value		
1	Grain Size Distribution	Sand Size Particles 8%	Silt Particles 15%	Clay particles 77%
2	Specific gravity	2.64		
3	Differential free swell	125		
4	Atterberg's Limits	Liquid Limit 80.35%	Plastic Limit 32.25%	Plasticity Index 48.10%
5	IS soil classification	CH		
6	Compaction Properties	Optimum Moisture Content 27.26%	Max. Dry Density 1.35g/cc	
7	California Bearing Ratio(CBR)	Un soaked C.B.R 2.77%	Soaked C.B.R 1.78%	
8	Shear Strength Parameters	Cohesion 0.40kPa	Angle of Internal Friction 0.1 Deg	

A. Copper Powder

Physical properties Value obtained Test sample Value

1) Particle shape: Irregular
2) Appearance: Black & glassy
3) Type: Air cooled
4) Specific gravity: 2.99
5) Percentage of voids: 45%
6) Bulk density: 2.08 g/cc
7) Fineness modulus: 3.86
8) Angle of internal friction: 20^{0}
9) Water absorption: 0.4%
10) Moisture content: 0.1%

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue XI Nov 2022- Available at www.ijraset.com

Chemical composition of copper slag:
Silica (SiO_2) 32%
Alumina (Al_2O_3) 4%
Iron oxide (Fe_2O_3) 41%
Calcium oxide(CaO) 1.5%
Magnesium oxide(MgO) 1.35%

B. Laboratory Experimentation

Tests were conducted in the laboratory on the expansive soil to study the behaviour of expansive soil, when it is treated with the materials given in the above sections.

The following tests were conducted as per IS codes of practice.
1) *Index Properties:* Liquid limit, Plastic limit, Shrinkage limit.
2) *Compaction Properties:* Optimum moisture content, maximum dry density.
3) *Strength Tests:* Tri-axial test, California bearing ratio and Unconfined
Compressive Strength Test
All the above tests were conducted on the various combinations, as listed in the table.

C. List Of Tests Conducted

- Specific gravity,
- Free swell index,
- Plastic limit,
- Liquid limit,
- Compaction,
- C.B.R,
- Unconfined Compressive Strength Test

1) Specific Gravity (IS: 2720-II)

Specific gravity of a substance is defined as the ratio of its mass in air to the mass of an equal volume of water at 4 ^{o}C.

Procedure
a) A pycnometer or constant volume method has been found to be the most reliable for the determination of specific gravity.
b) Commonly 200gms of dry mass of sample, a 500 cc constant volume bottle, and distilled water are used.
The pictorial representation of the procedure is given below.
Specific gravity of solids (G) = (M2-M1)/[(M4-M1)-(M3-M2)]

2) Free Swell Index [IS: 2720(part 40)]

This is the direct method for finding the swell of the soil.

Procedure
a) We took 10 gms (V_i) of oven dry soil passing through IS Sieve of 425 µ .
b) Then it is poured into a 100 cm^3 graduated cylinder containing distilled water.
c) The cylinder is kept un disturbed for 24 hours, and then final volume(V_f) of the settled soil is measured

$$\text{Free swell} = [(V_f - V_i)/ V_i]\text{x}100$$

3) Plastic Limit [IS: 2720(part-V)]

Plastic limit is the water content below which the soil stops behaving like a plastic material.

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue XI Nov 2022- Available at www.ijraset.com

Procedure

a) For determination of plastic limit of a soil, the soil is air-dried and sieved through a 425µ IS sieve.
b) We took about 30gms of soil in an evaporating dish. It is mixed thoroughly with distilled water till it become plastic and can be easily moulded with fingers.
c) Then, 10gms of plastic soil 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.
d) The water content at which the soil can be rolled into a thread of 3mm diameter without crumbling is known as plastic limit.

4) *Liquid Limit [IS: 2720(part-V)]*

The liquid limit is the water content at which soil changes from liquid state to plastic state.

Procedure

a) For determination of liquid limit of a soil, it is air-dried and sieve through a 425µ IS sieve.
b) Here we took 120gms of soil and mixed with a distilled water to form a uniform paste.
c) A portion of paste is placed in cup of liquid limit device, and surface is smoothened and levelled with spatula to a maximum depth of 1cm.
d) Then by using Casagrande tool a groove is cut through the sample along the symmetrical axis of cup.
e) After that, the handle is turned at a rate of 2 revolutions per second until the two parts of the soil sample come into contact at the bottom of the groove.
f) We took the soil from that paste for water content determination.

5) *Proctor's Compaction Test [IS: 2720(Part-VII)]*

Compaction means pressing of the soil particles close to each other by mechanical methods. Air, during compaction is expelled from the void space in the soil mass and, therefore, the mass density is increase.

Procedure

a) We took about 20kg of air dried soil, sieved through 4.75mm IS sieve.
b) The proctor mould is cleaned, dried and greased lightly.
c) Then, we took about 2.5kg of soil and 8% water by weight of soil is added.
d) The sample is mixed thoroughly and left for maturing for some time.
e) Now, the soil is placed in three layers in the mould, each layer is compacted with 25 blows.
f) The compacted soil up to the collar is removed, and the weight of the soil with mould is noted.
g) A small sample is taken from compacted specimen for water content determination.
h) Similarly, the procedure is repeated for water contents of 14%, 20%, 26%, and 32%.
i) From the water content and mass of soil, dry density is found.
j) Now, the graph is drawn between water content and dry density.

Bulk density (ρ) = mass/volume
Dry density (γ_d) = $\rho/(1+w_c)$
w_c................ Water content

6) *California Bearing Ratio Test [IS: 2720(part-31)]*

The California bearing ratio test is conducted for evaluating the suitability of the sub grade and the materials used in sub-base and base of a flexible pavement.
The plunger in the CBR test penetrates the specimen in the mould at the rate of 1.25mm per minute.

Procedure

a) We sieve the sample through 20mm IS sieve.
b) From that we took 4.5 kg of soil as passed through 20mm sieve and retained in 4.75mm IS sieve.
c) The CBR mould is cleaned, dried and greased lightly.
d) The sample is mixed with water of quantity O.M.C thoroughly and left for maturing for some time.

e) Now, the soil is placed in five layers in the mould, each layer is compacted with 56 blows.
f) The compacted soil up to the collar is removed, and the weight of the soil with mould is noted.
g) Place the mould containing the specimen, with base plate in CBR machine, turned on.
h) Apply the load on the plunger. Keep the rate of penetration as 1.25mm/min.

7) Triaxial Shear Test

The Triaxial compression test is used for determination of shear characteristics off all types of soils under different drainage conditions.

Procedure

a) We calculate the volume of the Triaxial sample mould, multiply it with MDD and took that amount of soil.
b) Mixed it with water of OMC and mixed thoroughly and left for 2 hours for getting maturing.
c) Now, the soil is placed in three equal height of layers in the mould, each layer is compacted thoroughly.
d) Remove that sample from mould and repeat same procedure to get 3 or more number of samples.
e) Then we took one sample and placed it in the Triaxial machine for testing.
f) For the cell pressure values of 50kpa, 100kpa, 150kpa the samples have tested.

Corrected area = A/(1-t),
Load = division x proovingring constant,
Stress = load/corrected area.

V. SAMPLE PREPARATION

The soil was initially air dried, pulverized and then was sieved through 4.75mm sieve, prior to the testing. The samples were prepared by mixing the pulverized and sieved soil with the needed stabilizing agents in dry condition and then required amount of water is added to make a consistent mix by thorough mixing. The following tests were conducted as per IS Codes of practice to assess the influence of Quarry Dust (QD), Lime and Discrete Reinforcing Waste Plastic Inclusions (DRWPI) on the problematic expansive soil.

1) Differential Free Swell Index
2) Atterberg's Limits
3) Compaction test
4) Strength test- Unconfined Compressive Strength Test (UCS)
5) Penetration test- California Bearing Ratio Test (CBR).

The following table 3.3 lists the different variables and their respective contents used in the present study.

VI. DISCUSSION AND RESULTS

In this portion, a detailed discussion on the results obtained from various laboratory tests is presented.

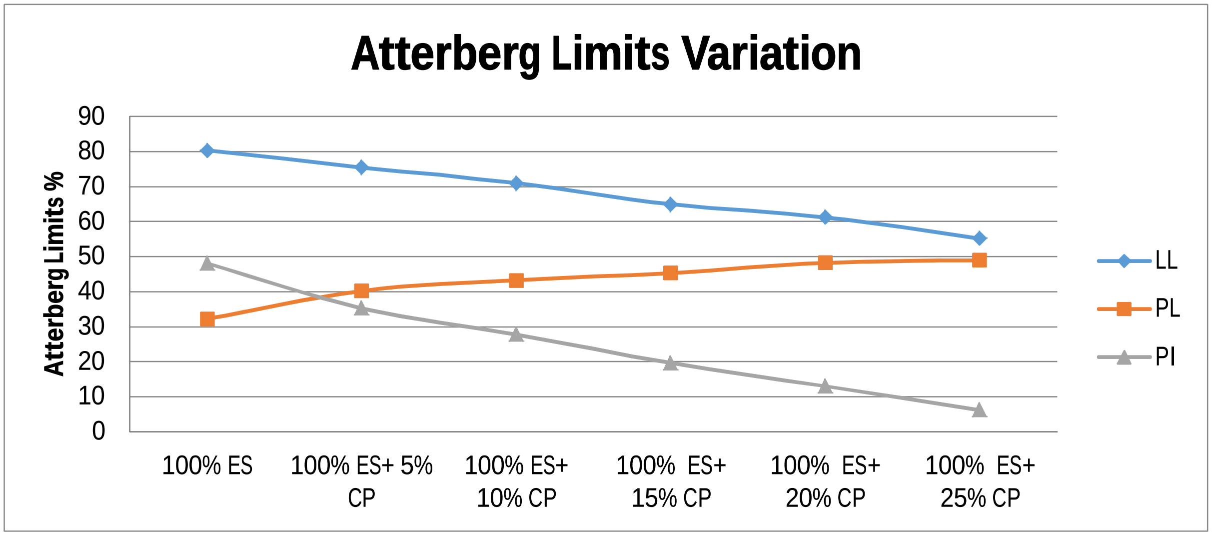
A. Index Properties

Standard procedures recommended in the respective I.S. Codes of practice [IS:2720 (Part-5)-1985; IS:2720 (Part-6)-1972], were followed while finding the Index properties viz. Liquid Limit and Plastic Limit of the samples tried in this investigation.

Table : Variation of Index Properties of Expansive soil with % of CP

S.No.	Samples	Liquid Limit	Plastic Limit	Plasticity Index
1	100% ES	80.35	32.25	48.1
2	95% ES+ 5% CP	75.52	40.23	35.29
3	90% ES+ 10% CP	71	43.25	27.75
4	85% ES+ 15% CP	65	45.36	19.64
5	80% ES+ 20% CP	61.25	48.23	13.02
6	75% ES+ 25% CP	55.2	49	6.2

Figure : Variation of Atterberg Limits of ES with different % of CP



B. Compaction Test Results

IS Modified Proctor compaction tests were conducted as per IS: 2720 (Part VIII).

S.No.	Sample	OMC (%)	MDD (g/cc)
1	100% ES	27.26	1.35
2	95 ES + 5% CP	24.32	1.38
3	90% ES + 10% CP	22.32	1.43
4	85% ES + 15% CP	20.23	1.48
5	80% ES + 20% CP	18.65	1.52
6	75% ES + 25% CP	16.33	1.5

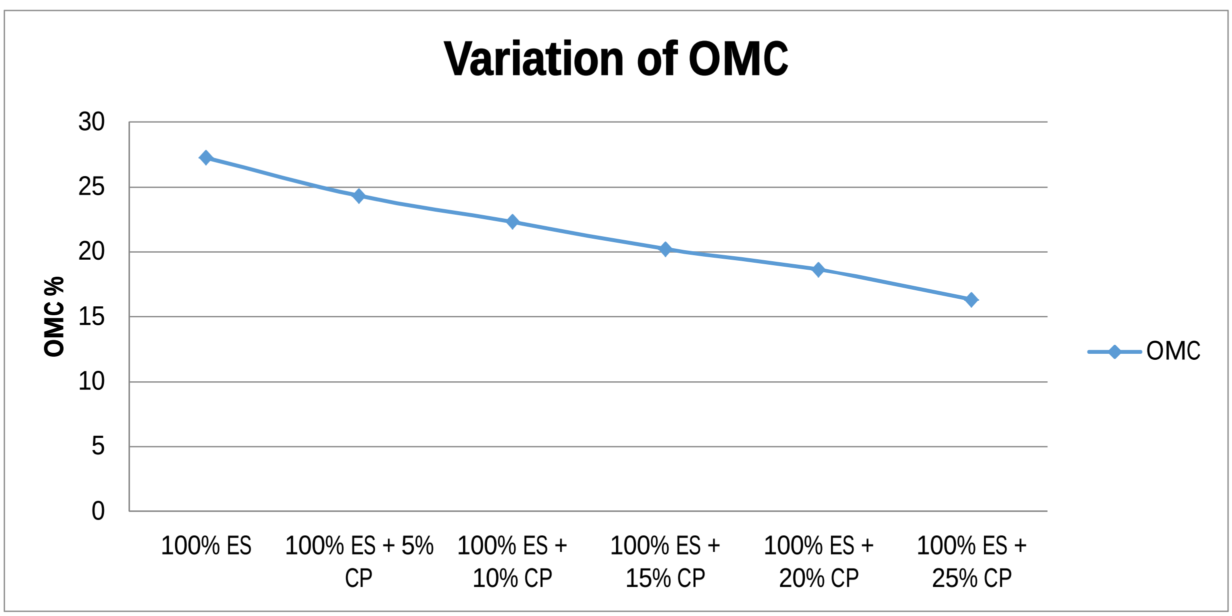


Figure .: Variations of Water Content with addition of CP

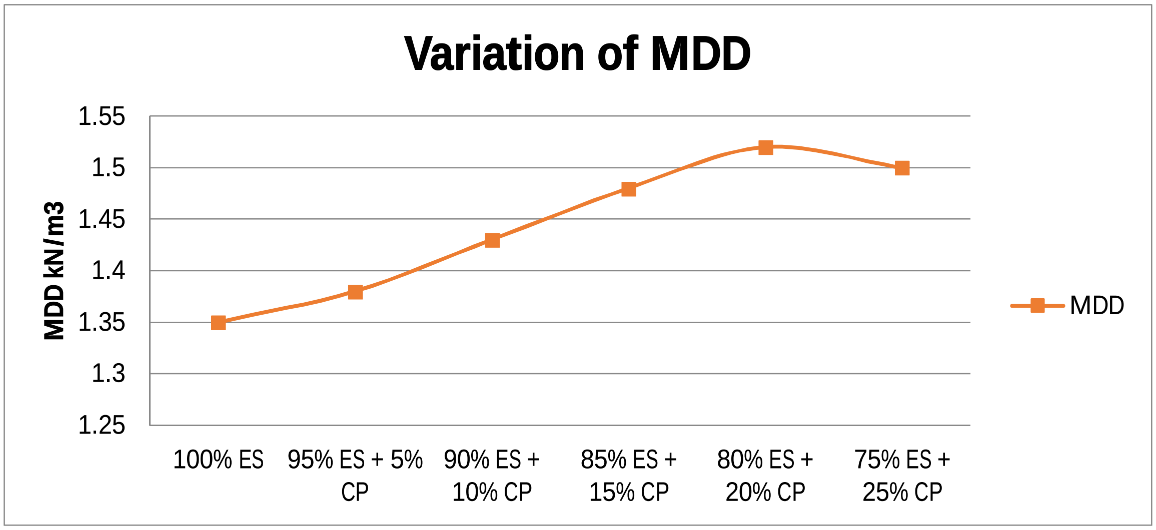


Figure: Variations of Dry Density with addition of CP

C. Differential Free Swell Index (DFS)

S.No.	Particulars	DFS %
1	100% ES	125
2	95% ES + 5% CP	107
3	90% ES + 10% CP	98
4	85% ES + 15% CP	88
5	80% ES + 20% CP	83
6	75% ES + 25% CP	74

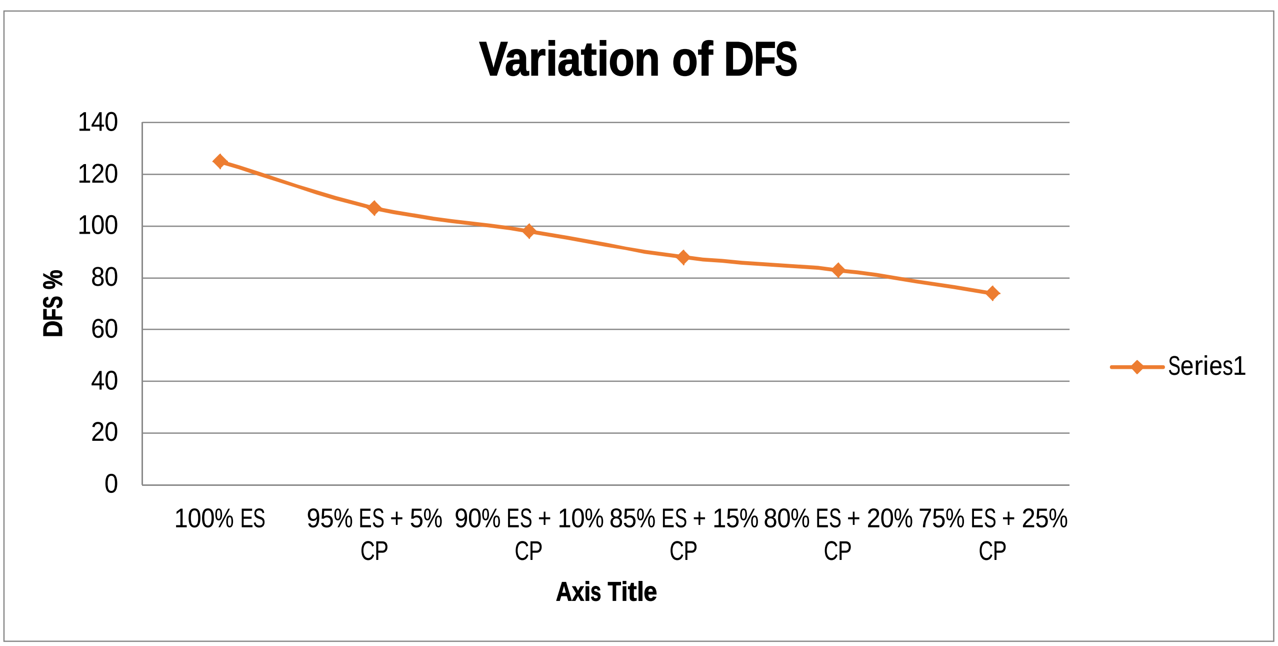
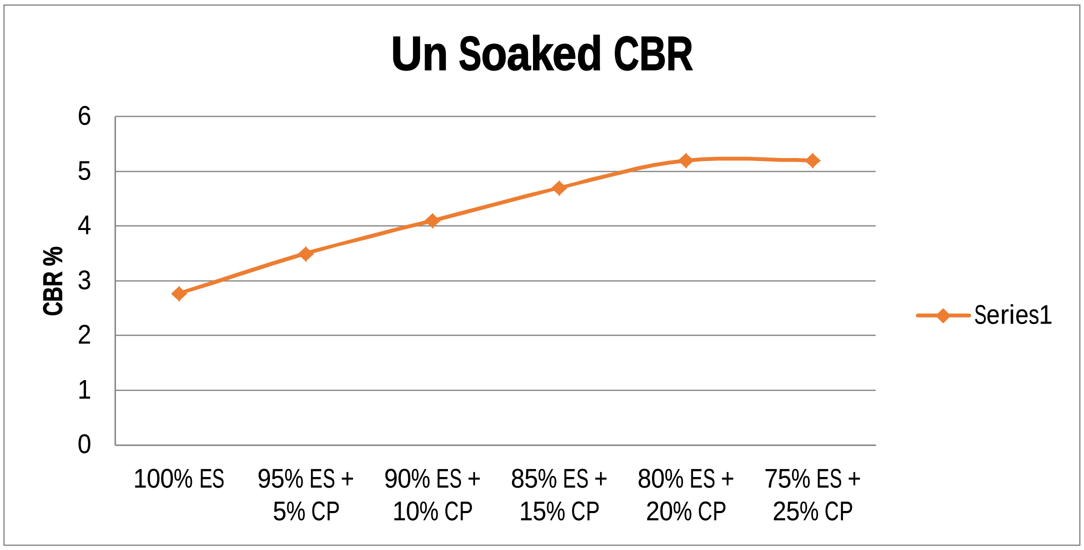


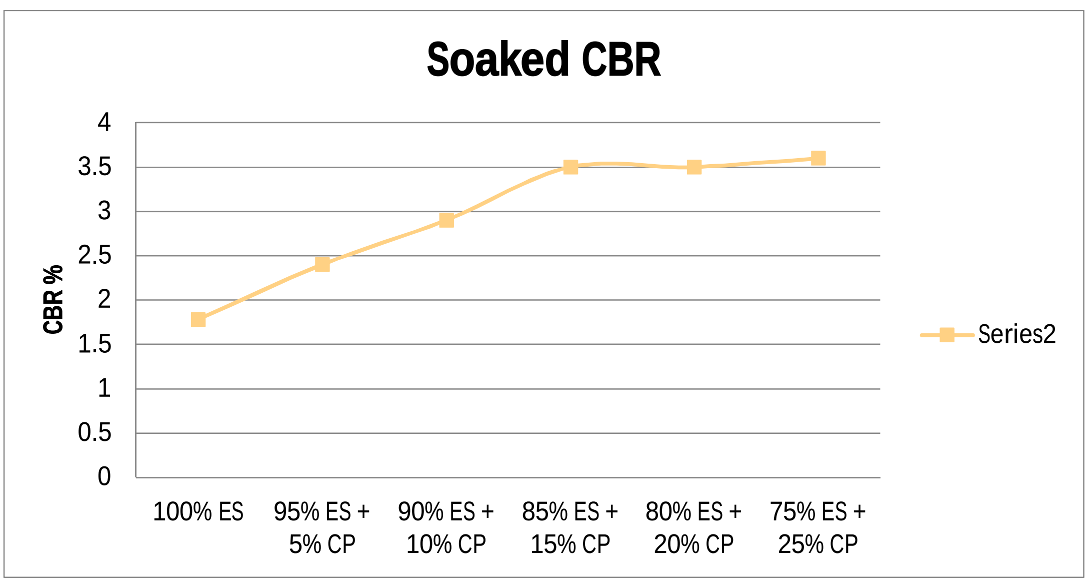
Figure Shows: Variation of DFS with addition of expansive soil and CP

D. California Bearing Ratio (CBR) Test Results

The CBR tests were conducted in the laboratory for all the expansive soil samples treated with different percentages of CP.

S.No.	Particulars	CBR % (UnSoaked)	CBR % (Soaked)
1	100% ES	2.77	1.78
2	95% ES + 5% CP	3.5	2.4
3	90% ES + 10% CP	4.1	2.9
4	85% ES + 15% CP	4.7	3.5
5	80% ES + 20% CP	5.2	3.5
6	75% ES + 25% CP	5.2	3.5





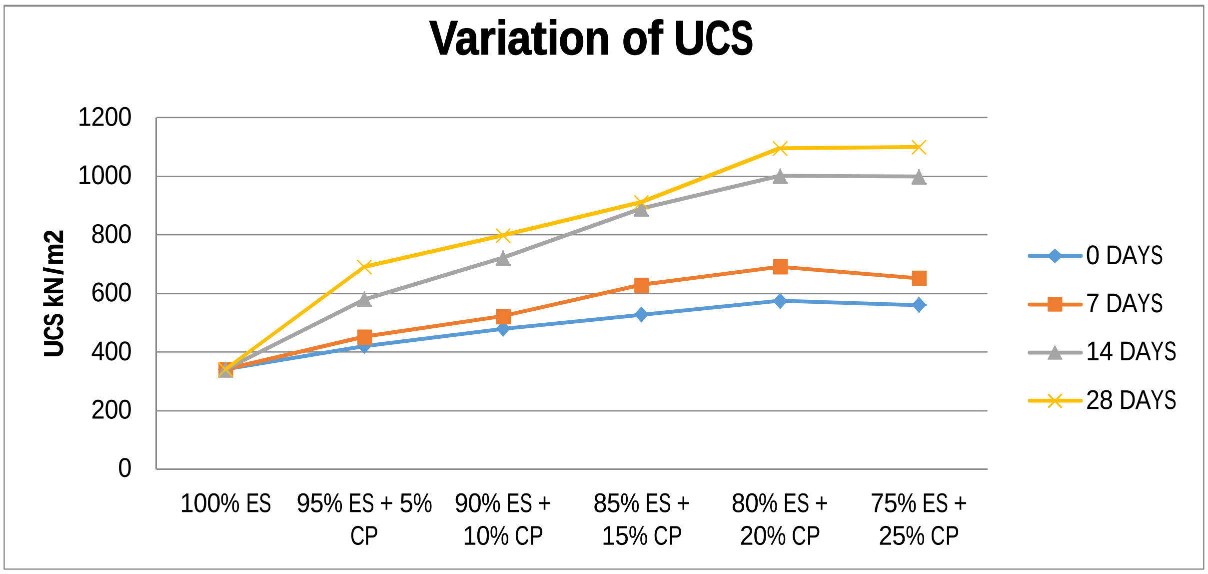
Explanation: The results of Soaked and Un-soaked CBR tests on expansive soil treated with increase in percentage of CP on increasing up to the optimum percentages of additives and the results are presented above.

ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue XI Nov 2022- Available at www.ijraset.com

E. Unconfined Compressive Strength Test Result

The unconfined compressive strength testing machine is used to conduct the tests in accordance with IS 2720-part X.

S No	Particulars	Days UCS(kN/m2)			
		0	7	14	28
1	100% ES	341	341	341	341
2	95% ES + 5% CP	421	452	580	691
3	90% ES + 10% CP	480	522	721	798
4	85% ES + 15% CP	528	630	890	912
5	80% ES + 20% CP	575	692	1001	1095
6	75% ES + 25% CP	561	652	999	1100

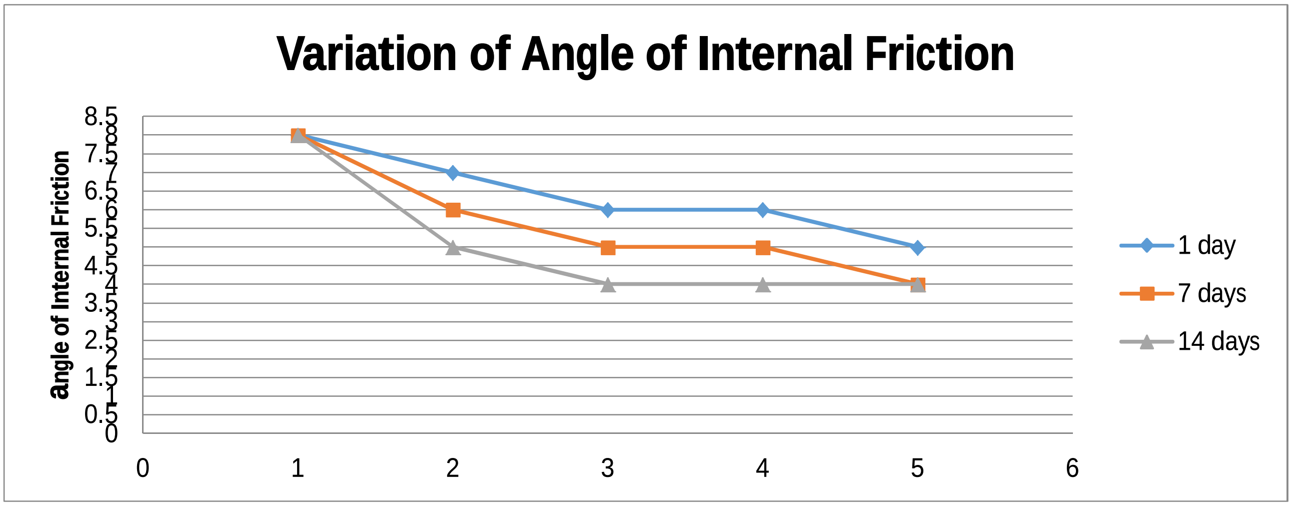


F. Tri-Axial Test Result

The tri-axial test strength testing machine is used to conduct the tests in accordance with IS 2720-part X.

Particulars	Shear Strength Properties					
	1 day		7 days		14days	
	Cohesion, C_u (kg/cm^2)	Angle of internal friction, □, (Deg.)	Cohesion, C_u (kg/cm^2)	Angle of internal friction, □, (Deg.)	Cohesion, C_u (kg/cm^2)	Angle of internal friction, □, (Deg.)
100% ES	0.85	8	0.85	8	0.85	8
95% ES+ 5% CP	0.9	7	0.88	6	0.85	5
90% ES+ 10% CP	0.95	6	0.9	5	0.88	4
85% ES+ 15% CP	0.76	6	0.73	5	0.7	4
80% ES+ 20% CP	0.7	5	0.68	4	0.65	4
75%ES + 25% CP	0.9	3	0.9	2	1	2

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue XI Nov 2022- Available at www.ijraset.com



VII. DISCUSSIONS

Details of the laboratory experimentation carried-out on Expansive Soil stabilised with different materials have been discussed in the previous chapter. In this chapter a detailed discussion on the results obtained from various laboratory tests done on untreated and treated expansive soil are presented.

VIII. CONCLUSIONS

Based on the received results and discussion thereof below conclusions are made:

1) Optimum percentage of CP obtained at exact 20%.
2) The results of Liquid Limit tests on expansive soil treated with different percentages of CP can be seen that with increase in percentage of CP the liquid limit of soil goes on decreasing from 80.35% to 55.20% when CP is increased from 0 to 25%.
3) The results of plastic Limit tests on expansive soil treated with different percentages of GGBS can be seen that with increase in percentage of GGBS the plastic limit of soil goes on decreasing from 32.25% to 49% when CT is increased from 0to 25%.
4) The results of Plasticity Index of expansive soil treated with different percentages of CP, it can be seen that with increase in percentage of CP the plasticity Index of soil goes on decreasing from 48.10% to 6.20% when CP is increased from 0 to 25%.
5) The overall increase of plastic limit, decrease of Liquid Limit due to the depress diffuse double layer.
6) The results of Compaction tests on expansive soil treated with different percentages of CP can be seen that with increasing of MDD with the increasing addition of CP, while the other side of OMC decreasing. The MDD of soil goes on increasing from 1.35 g/cc to 1.5g/cc when CP added at 20%.
7) The results of Compaction tests on expansive soil treated with different percentages of CP can be seen that with increase of MDD with the increasing addition of CP, while the other side of OMC increasing. The OMC of soil goes on decreasing when CP added at 25%.
8) The reason for decreasing OMC due to the effect of absorbing the moisture content by soil and dust particles whereas the MDD increasing because of escaping of soil particles from the Compaction Mould.
9) The results of DFS tests on expansive soil treated with different percentages of CP can be observed that the Decrease of DFS with the increasing addition of CP. The DFS of soil goes on decreasing from 125% to 55% at added 25% CP.
10) The results of CBR tests on expansive soil treated with different percentages of CP can be seen that with increase of un-Soaked CBR with the increasing addition of GGBS. The Un-Soaked CBR of soil goes on increasing from 2.2% to 5.7% by adding 20% CP.
11) The results of CBR tests on expansive soil treated with different percentages of CP can be seen that with increase of Soaked CBR with the increasing addition of CP. The Soaked CBR of soil goes on increasing from 1.78% to 3.5% when CP added at 20%.
12) The increase CBR due to the reason of formation of silicate zell.
13) The results of UCS tests on expansive soil treated with different percentages of CP can be seen that the increase of UCS with the increasing addition of CP. The UCS of soil goes on increasing from 0 to 341kN/Sq.m for 0 days, 341kN/Sq.m to 561 kN/Sq.m for 7 days, 341kN/Sq.m to 1001 kN/Sq.m for 14 days and 341 kN/Sq.m to 1100 kN/Sq.m for 28days by adding 20% CP.

REFERENCES

[1] Ramesh, H.N., K.V. Manoj Krishna and H.V. Mamatha (2010) “Compaction and strength behaviour of ESP-coir fiber treated black cotton soil”, geomechanics and Engineering, Vol. 2., No. 1 19-28

[2] Kaniraj, S.R. and Vasant, G.H. (2001), “Behavior of cement-stabilized fiber reinforced fly ash soil mixture”,Geotech. Geoenviron. Eng. J, 574-584

[3] Kaniraj, S.R. and Gayathri, V. (2003), “Geotechnical Behavior of fly ash mixed with randomly oriented fiber inclusions”, Geotext. Geomembranes, 21, 123-149

[4] Nagu, P.S., Chandrakaran, S. and Sankar, N. (2008), “Behaviour of ESP stabilized clayey soil reinforced with Nylon fibers”, Proceedings of ’08 International Conference on Geotechnical and Highway Engineering, Geotropika, Kuala Lumpar, Malaysia, May.

[5] Kavitha. S and Dr. T. Felix Kala, “ESP Analysis by Scanning Electron Microscope Study”. International Journal of Civil Engineering and Technology (IJCIET), 7(4), 2016, pp.234–241.

[6] Jamei M., Villard P. and Guiras H.,(2013), “ Shear Failure Criterion Based on Experimental and Modeling Results for Fiber-Reinforced Clay”, Int. J. Geomech.,(ASCE), 13(6): 882-893

[7] Jiang H., Cai Y. and Liu J, (2010) “Engineering Properties of Soils Reinforced by Short Discrete Polypropylene Fiber”, J. Mater. Civ. Eng., (ASCE), 22(12): 1315-1322

[8] Sabat A.K., (2012), “A Study on Some Geotechnical Properties of ESP Stabilised Expansive Soil –Quarry Dust Mixes”, International Journal of Emerging trends in Engineering and Development, Issue 2, Vol.1, 42-49

[9] Venkateswarlu H., Prasad A.C.S.V., Prasad D.S.V. & Raju G.V.R.P., (2015) “ Study on Behavior of Expansive Soil Treated With Quarry Dust”, International Journal of Engineering and Innovative Technology (IJEIT) Volume 4, Issue 10, 193-196.

[10] V Paul John and M Antony Rachel Sneha, “Effect of Random of ESPs on Strength Behaviour of FlyAsh Treated Black Cotton Soil,”International Journal of Civil Engineering and Technology (IJCIET),Volume 7, Issue 5,pg. 153–160 September-October 2016

[11] Hussain, M. and Dash, S. K. (2009), “Influence of ESP on Compaction Behaviour of Soils”, Geotides, Indian Geotechnical Conference, Guntur, India, IGC-2009.

[12] B.R. Phanikumar,C. Amshumalini and R. Karthika(2009)”Effect of ESP on Engineering Behavior of Expansive Clays”, IGC- 2009,Guntur,pp.80-82.

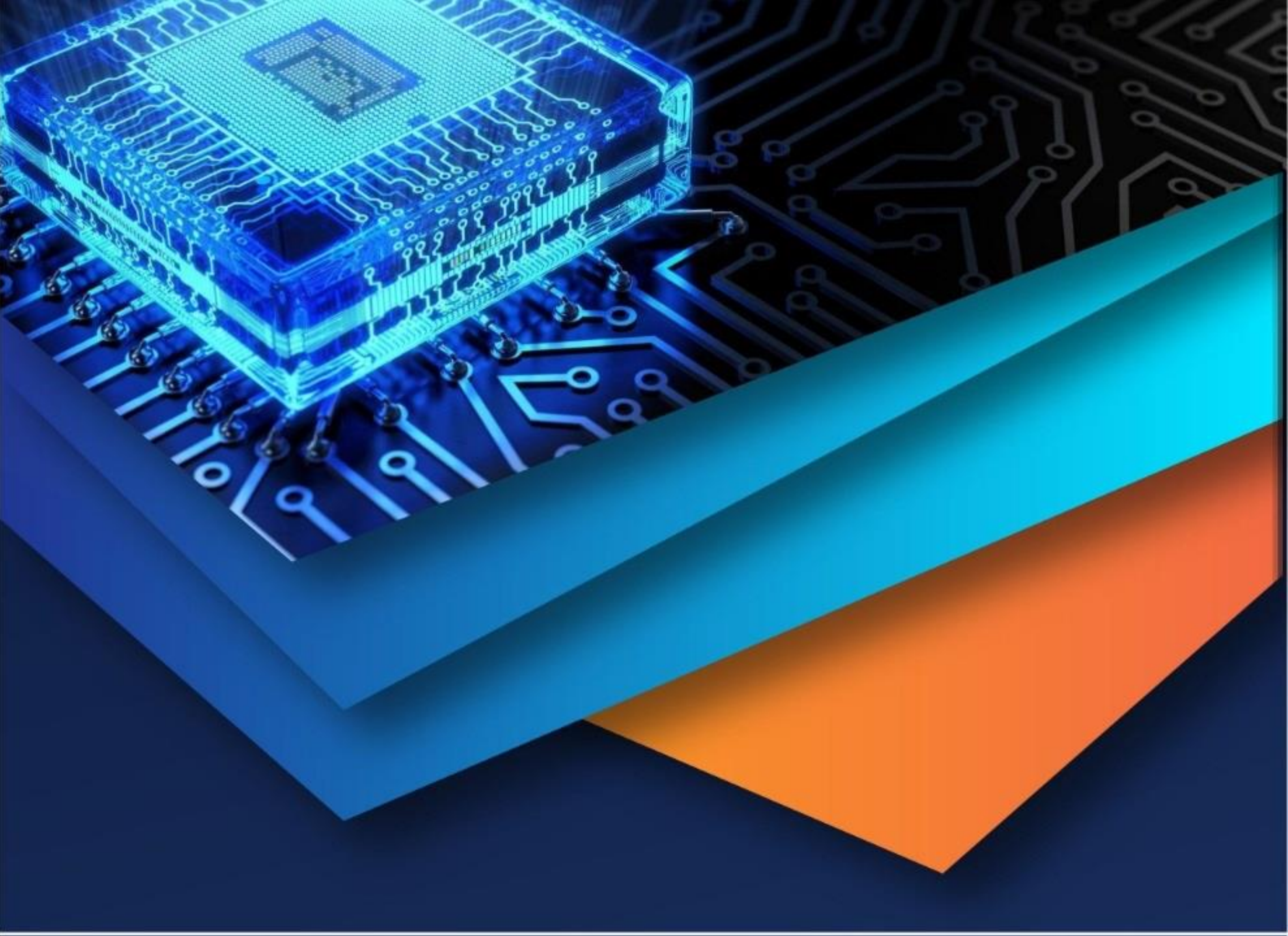
[13] Siddique, A. M. and Hossain, A. (2011), “Effects of ESP Stabilization on Engineering Properties of an Expansive Soil for Use in Road Construction.” Journal of Society for Transportation and Traffic Studies, 2(4).

[14] Pankaj R. Modak, Prakash B. Nangare, Sanjay D. Nagrale, Ravindra D. Nalawade, Vivek S. Chavhan(2012), “Stabilization of black cotton soil using admixtures” International Journal of Engineering and Innovative Technology (IJEIT) Volume 1, Issue

[15] Akshaya Kumar Sabat (2012), “A Study on Some Geotechnical Properties of ESP Stabilised Expansive Soil –Quarry Dust Mixes”. International Journal of Emerging trends in Engineering and Development, Issue 2, Vol.1.

[16] P.V.Koteswara Rao, K.Satish Kumar and T.Blessingstone, (2012),”Performance of Recron-3s Fiber with Cement Kiln Dust in Expansive Soils”, International Journal of Engineering Science and Technology (IJEST), Vol. 4 No.04, pp.1361-1366.

[17] Monica Malhotra and Sanjeev Naval (2013), “Stabilization of Expansive Soils Using Low Cost Materials” International Journal of Engineering and Innovative Technology (IJEIT) Volume 2, Issue 11, May 2013,pp.181-184.



10.22214/IJRASET

INDEX COPERNICUS
45.98

IMPACT FACTOR:
7.129

TOGETHER WE REACH THE GOAL

IMPACT FACTOR:
7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY