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Strength and Compressibility Characteristics of An Expansive Soil with addition of GGBS and Alkali Activated Slag

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Abstract: The phenomenal development in civil engineering infrastructure in developing countries like India, soil stabilization has emerged as à key problem in the engineering industry. Engineers have been attempting to enhance the engineering properties of low-quality soil due to their negative impact on project performance. With increasing awareness of environmental issues, there has been a remarkable shift towards green and sustainable technologies. Reuse of waste materials have been advocated for quite a while to improve the properties of poor soils open up to new avenue and double advantage of waste management. In the project investigation an attempt to evacuate the Plasticity characteristics, Strength characteristics and Compressibility characteristics were conducted on selected soil as per Indian Standards using GGBS and Alkali Activated Solution (AAS) with different percentages and curing for 0,3,7,14, and 28 days to analyze the variation of engineering properties. From the results combination of (GGBS + AAS) proved to increase of strength and reduce compressibility characteristics. The combination of GGBS + AAS is cost effective, non-destructive, low energy demanding and ecofriendly than GGBS to the selected expansive soil.

Index Terms: GGBS, AAS, Shear Strength, Compressive strength, Molarity.

I. INTRODUCTION

The civil engineers are the forerunners of all development activities that the environment is consciously given due to consideration while embarking on development activities, which are essential to meet the aspiration of people especially in developing countries, like India. Engineers are often faced with the problem of constructing facilities on or with soils which do not possess sufficient strength to support the loads imposed upon them either during construction or during the service life of the structure .Many areas of India consists of soils with high silt contents, low strengths and poor bearing capacities .The poor engineering performance of such soils has forced Engineers to attempt to improve the engineering properties of poor quality soils .There are various methods that could be used to improve the performance of poor quality soils. The choice of a particular method depends mainly on the type of soil to be improved, its characteristics and the type and degree of improvement desired in a particular application. Stabilization of soils is an effective method for improving the properties of soil. Every year, millions of tons of various industrial wastes are created as undesirable by-products of thermal power plants and manufacturing companies in India and throughout the world. Utilisation of industrial waste materials in the improvement of problematic soils is a cost efficient and environmental friendly method. It helps in reducing disposal problems caused by the various industrial wastes. Using stabilizing substances to improve the geotechnical properties of weak soils such as compressibility, strength, permeability, and durability, is known as soil stabilization. Increased soil unit weight, a lower soil void ratio, and less soil plasticity are all achieved by soil stabilization . Reduction of excavation, import of new materials, and export of inappropriate material . Dayalan (2016) studied the different amount of fly ash and GGBS are mixed separately, i.e., 5%, 10%, 15% and 20% by dry weight of soil and conducted various physical and strength performance tests like specific gravity, Atterberg limits, standard proctor test and CBR tests. From the results, it was found that optimum value of fly ash is 15% and GGBS is 20% for stabilization of given soil based on CBR value, and with the increases of fly ash and GGBS percentage, OMC goes on decreasing while maximum dry density goes on increasing, hence compact ability of soil increases and making the soil more dense and hard.. V. Gokul , D. Anolin Steffi, R. Kaviya, C.V. Harni, S.M.A. Dharani (2020):An experiment is conducted to increase the stability of clayey soil using Ground Granulated Blast Furnace Slag (GGBS) and 12 M Sodium Hydroxide (NaOH). The alkali to binder ratio (A/B) remains between 0.40 and 0.60.

The percentages of GGBS applied to the soil are 6%, 12%, 18%, and 24%. Soil strength is measured using the Unconfined Compressive Strength Test on days 7, 14, and 28. The strength at the 28th day for the Alkali to Binder ratio (A/B) of 0.60 for various percentages of GGBS is 580 kPa, 1880 kPa, 2803 kPa, and 4062 kPa. The addition of NaOH and GGBS to clayey soil gave rise to benefits. The Unconfined Compressive Strength (UCS) of the stabilized soil improved with the proportion of GGBS. Soil's Unconfined Compressive Strength (UCS) increases with longer curing time. In this investigation it is observed that with addition of GGBS the maximum strength characteristics are obtained at 15 % of GGBS. With this optimum GGBS and AAS is mixed, where strength increases up to 1M .Series of Tests are conducted to arrive the comparison of compressibility and strength characteristics of GGBS and (GGBS + Alkali Activated Slag) in combination

II. MATERIALS AND METHODS

Soil: Clay soil, GGBS, AAS were used as the materials for this investigation. The soil used in this study have been obtained from Veldurthi, Kurnool district which is having Liquid Limit of 56. The area is largely covered by clayey soil. The required amount of soil is collected from trial pits at a depth of 2 m below the ground level, since the topsoil is likely to contain organic matter and samples are homogenous. After collecting soil from the field, it is stored in polythene bags where it is crushed using a wooden mallet and then sieved using a 4.75 mm sieve (both air and oven dried). According to IS classification (IS: 1498-1970), the soil has a "CH" classification, indicating that it is an inorganic clay with high plasticity.

Table 1: Properties of clay soil

PROPERTY	VALUES
Gravel	0
Sand (%)	8.7
(Silt + Clay) (%)	91.3
Liquid Limit (%)	56
Plastic Limit (%)	17.7
Free Swell Index (%)	120
I.S Classification	CH

A. GGBS

Blast furnace slag is produced as a byproduct during the manufacture of iron in a blast furnace. Molten blast furnace slag has a temperature of 1300- 1600^{o}C and is chilled very rapidly to prevent crystallization. The granulated material thus produced is known as Granulated Blast Furnace Slag. GGBS is collected from Astra Chemicals, Chennai. The glassy structure and chemical composition make it reactive when mixed with water and cementitious materials.. It contributes to the development of additional hydration products, enhancing the strength ,durability and reducing compressibility of soil. It can be mixed with soils to improve the engineering properties. GGBS contributes to the development of calcium silicate hydrate ,a special compound which is binding agent that improves the strength of soil. This leads to increased bearing capacity and improved load bearing characteristics. The composition of GGBS (provided by supplier) are Silicon Dioxide(SiO_2) - 35.43, Calcium Oxide(CaO) - 25.6, Magnesium Oxide(MgO) - 8.00, Iron(FeO or Fe_2O_3) - 0.37,Manganese Oxide – (MnO)-0.55, Sulphur(S) -1.4.

B. Alkali Activated Solution (AAS)

Sodium hydroxide and Sodium silicate are procured from ASTRA Chemicals, Chennai. Where Sodium Hydroxide are in the form of pellets are used to make solution of required amount in water ,producing an alkaline solution . Sodium hydroxide (NaOH) is a highly caustic, alkaline compound commonly known as caustic soda. It is an inorganic compound and is typically available in the form of white, translucent pellets or flakes. Sodium Hydroxide is a highly caustic base and alkali that decomposes proteins at ordinary ambient temperatures and may cause severe chemical burns. It is soluble water, and absorbs moisture. The sodium silicate was originally in liquid form and having a molecular weight of 284.20 g/mole and specific gravity of 1.5. The sodium silicate composed of 18.7% of Na_2O , 41.7% of SiO_2 and 39.6% of water. Whereas the sodium Hydroxide was originally in flake form having a molecular weight of 40 g/mole having a specific gravity of 2.13 at 20°C and 95–99% purity. The ratio of Sodium Silicate to Sodium Hydroxide solution by mass was kept constant at 1:2.

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Fig 1: Materials used in this study GGBS – Sodium Hydroxide Pellets - Sodium Silicate

III. LABORATORY EXPERIMENTATION

Laboratory tests were conducted for finding the index and engineering properties of the soils used during the study. Atterberg limits, Compaction, Unconfined Compressive Strength, Triaxial and. Consolidation tests were conducted by using different percentages of GGBS, AAS and Bacteria mixed with black cotton soil materials for finding optimum percentages.

A. Atterberg Limits

Atterberg limit of blended soil were determined as per IS:2720 (part-5)- 1985. Consistency is a term which used to describe the degree of fineness of a soil is in a qualitative manner by using descriptions such as soft, medium, firm, stiff or hard. It indicates the relative is with which a soil can be deformed generally the properties of consistency associated only with fine grained soil especially clay. The four phases of consistency—liquid, plastic, semi-solid, and solid—are used to characterize the engineering qualities of clay soils, and the quantity of water contained in them greatly influences those properties.

a) Liquid Limit Test: The liquid limit is the water content at which the soil changes from the liquid state to the plastic state. The liquid limit of soil depends upon the clay mineral present. The stronger the surface charge and the thinner the particle the greater will be the amount of absorbed water and therefore the higher will be the liquid limit.

b) Plastic Limit Test: Plastic limit is the water content below which the soil stops behaving as a plastic material. He plastic limit of tested soil alone and with addition admixtures, it can be observed that plastic limit increases with increase of admixtures.

B. Compaction Properties

To identify the optimum percentages for mixing black cotton soil with varying amounts of GGBS, an IS light compaction test was conducted in accordance with IS: 2720 (Part VIII). The test yielded the maximum dry density and optimal moisture content.

C. Shear Strength of Soil

The shear strength of soil is the resistance to deformation by continuous shear displacement of soil particles or on masses upon the action of a shear stress. To find the shear strength of soil the Triaxial Test can be done in A remould sample may be made by mixing soil that is 4.75 mm in diameter, compacting it into a mould with three layers, and then pushing a thin-walled tube with the same internal diameter into the mould. Pushing from the cutting-edge side of the tube, the sample should be extruded. After cutting the specimen's ends flat and aligning them with its axis, the split mould must be lightly oiled from the inside. After that, the specimen is cautiously removed from the split mould to ensure that its diameter and length remain unchanged. Next, place the specimen on one end cap, and place the other end cap on top of the specimen. The rubber membrane is then placed around the specimen above and below so that water is not affect the specimen. The specimen is ready to use for the calculation of dial gauge and proving ring reading.

D. Consolidation Test

The consolidation test is used to determine the rate and magnitude of settlement in soils. The settlement values obtained by this test are due to primary consolidation test are very much helpful in the design of foundations.

IV. RESULTS AND DISCUSSIONS

Tests are conducted as per IS code provisions and the test results are furnished below with a view to determine the optimum percentages. To investigate the effect of GGBS on soils samples laboratory tests were carried on natural soils and blended samples which include. Atterberg limit, Free Swell Index, Standard Proctor test, Triaxial Shear Test and Consolidation test, Compaction test conducted in the present study is light compaction test. For conducting compaction, Triaxial and consolidation test the soil samples were prepared for adding various percentages of GGBS and GGBS + AAS.

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A. *Effect of Admixtures on the Atterberg limits*

Atterberg limit of blended soil were determined as per IS:2720 (part-5)- 1985. The liquid limit & plasticity index decreases, and the plastic limit of soil increases with increase of percentage of Ground Granulated blast furnace slag. The liquid limit is found to decrease for all the admixtures used in the soil which is very nominal compared to the original soil value. this may be attributed to decrement in repulsive forces and lubrication effect development leading to decrement in diffusion double layer thickness and on further curing improvement in the bonding.

B. *Effect of GGBS on Compaction test*

The test was conducted according to IS: 2720 (part 7)-1980. The process of densification of the soil by reducing air voids is called compaction. The degree of compaction of a given soil was measured in terms of dry density. It is a laboratory method to determine the optimal moisture content for which the selected soil will become dense and achieve its maximum dry density. The Optimum moisture content (OMC) decreased significantly while the maximum dry density (MDD) increased with the addition of GGBS at 15% to expansive soil and MDD decreases with further addition.

Table 2: Compaction of Soil + %GGBS

S.No	Soil+ % GGBS	Compaction	
		OMC (%)	MDD(g/cc)
1	100%+0%	16.9	1.70
2	100%+5%	16.5	1.71
3	100%+10%	15.8	1.72
4	100%+15%	15.3	1.77
5	100%+20%	15.9	1.69

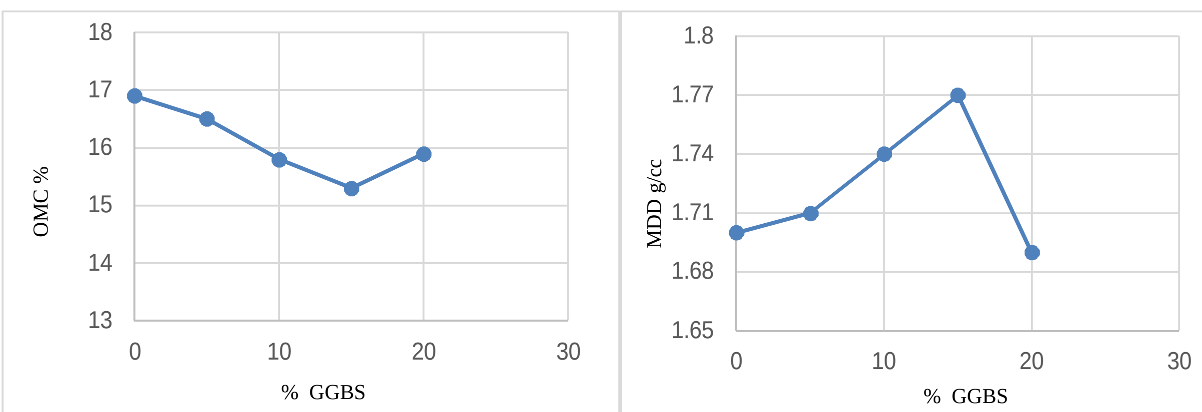


Fig 2 : Effect of GGBS on OMC and MDD

C. *Effect of Admixtures on Shear Strength Test*

Effect of GGBS on Shear Strength test at OMC is conducted as per IS: 2720 (part-X). Triaxial compressive test was conducted at different curing periods for different percentages of GGBS 5%, 10 %, 15%, and 20% blended in black cotton soil and cured for 3, 7, 14 and 28 days and the shear strength values are 179kPa , 186kPa , 214kPa , 221.8kPa respectively at 15% Ground Granulated Blast Furnace Slag(GGBS) .After finding the optimum percentage of GGBS , adding different percentages of AAS 0.2M ,0.4M , 0.6M , 0.8M and1M blended in black cotton soil and cured for 0,3, 7, 14, and 28 days and the triaxial compressive strength values are 194kPa , 201kPa , 210kPa , 211kPa , 220kPa respectively at 1M AAS .The strength increases when GGBS added with Alkali Activated Slag to the selected soil.

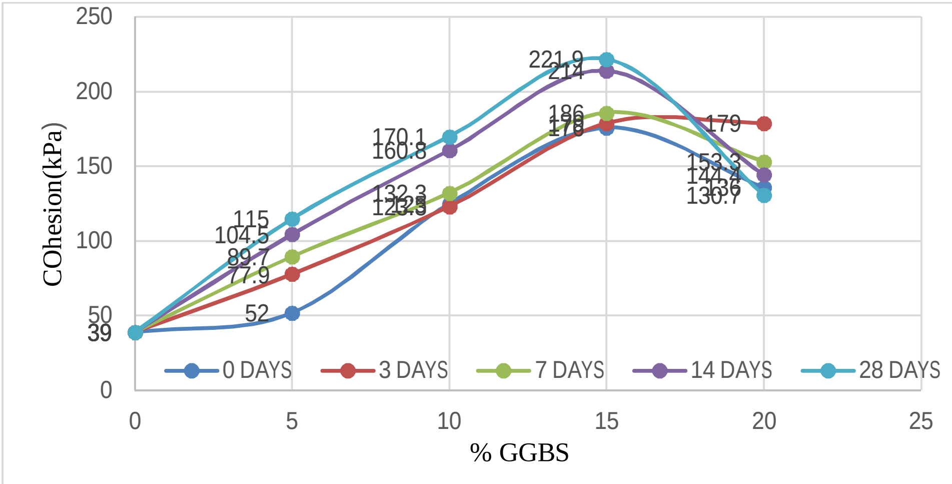


Fig 3: Variation of cohesion of soil with addition of GGBS at different curing periods

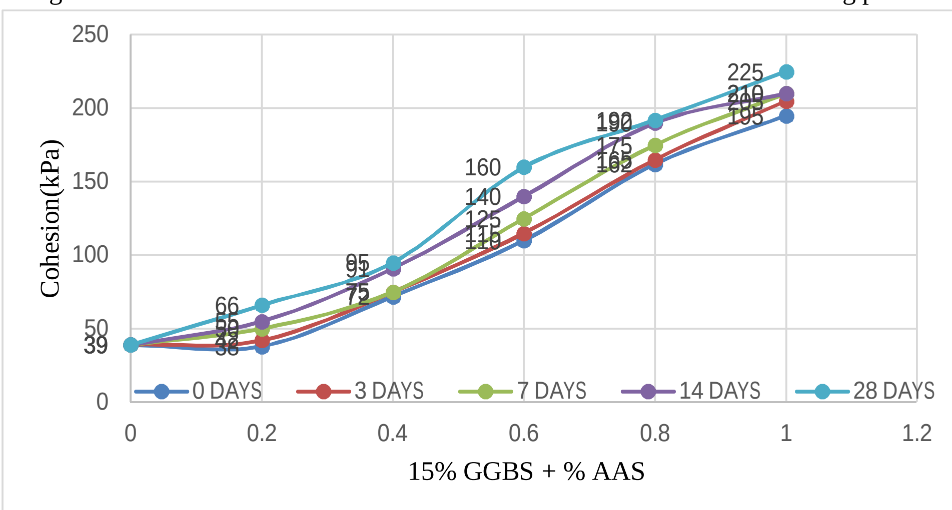


Fig 4: Variation of cohesion of soil with addition of 15 % GGBS + % AAS at different curing periods

D. Effect of Admixtures on Compressibility Characteristics

In consolidation test , The settlement values obtained by this test are due to primary consolidation only which is 90% of the total consolidation. The results of the consolidation test are very much helpful in the design of foundations . The tests were conducted for soil addition of GGBS and (GGBS + AAS) and curing for 0 and 28 days curing.

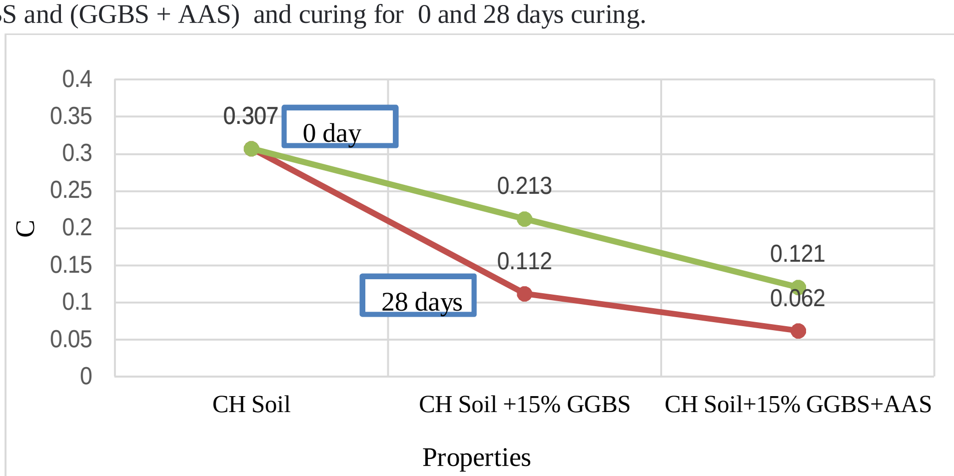


Fig 5: Variation of Compression Index of soil with addition of admixtures

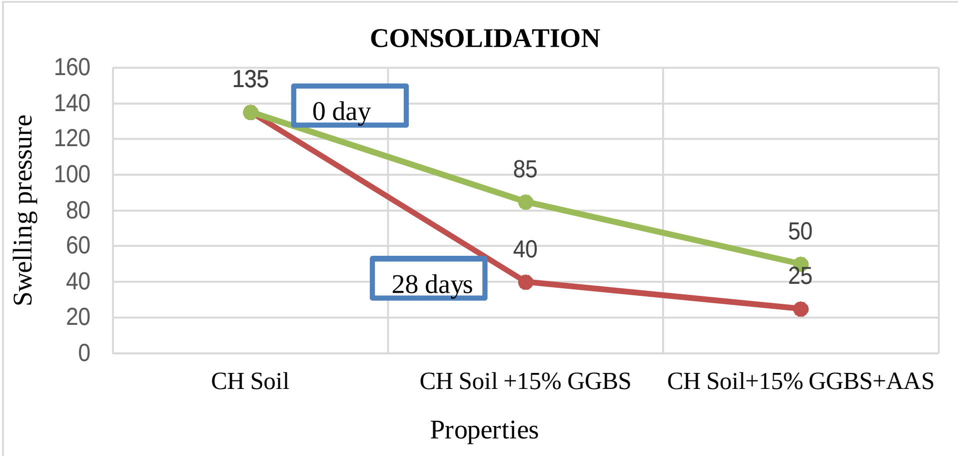


Fig 6: Variation of Swelling Pressure of soil with addition of admixtures

V. CONCLUSION

The Strength Characteristics and Compressibility Characteristics of a selected expansive soil with addition of GGBS and AAS are studied in this investigation. Based on the test results, Liquid Limit and Plasticity Index decreased whereas Plastic limit increases with the addition of GGBS, Alkali Activated Solution and (GGBS + Alkali Activated Slag) in combination. The MDD value has been increased with increasing the Ground Granulated Blast Furnace Slag (GGBS) up to 15 % to the expansive soil and it's decreases with further addition. Cohesion value increased up to 5 times with addition of GGBS,6 times with addition of (GGBS+AAS), Swelling Pressure reduced by 37.1% and 62.9%. Compression Index reduced by 30.7% and 60.5 % with addition of GGBS and (GGBS+ AAS) in combination. The Investigation confirms that addition of GGBS and (GGBS +Alkali Activated Slag) in combination improved cohesion and reduced Swelling Pressure. Admixtures used in this work are from industrial waste and eco-friendly which doesn't cause harm to environment. It creates new idea for expanding engineering applications of expansive soil improvement. But the combination of GGBS+AAS is cost effective, non-destructive, low energy demanding and eco-friendly than GGBS.

REFERENCES

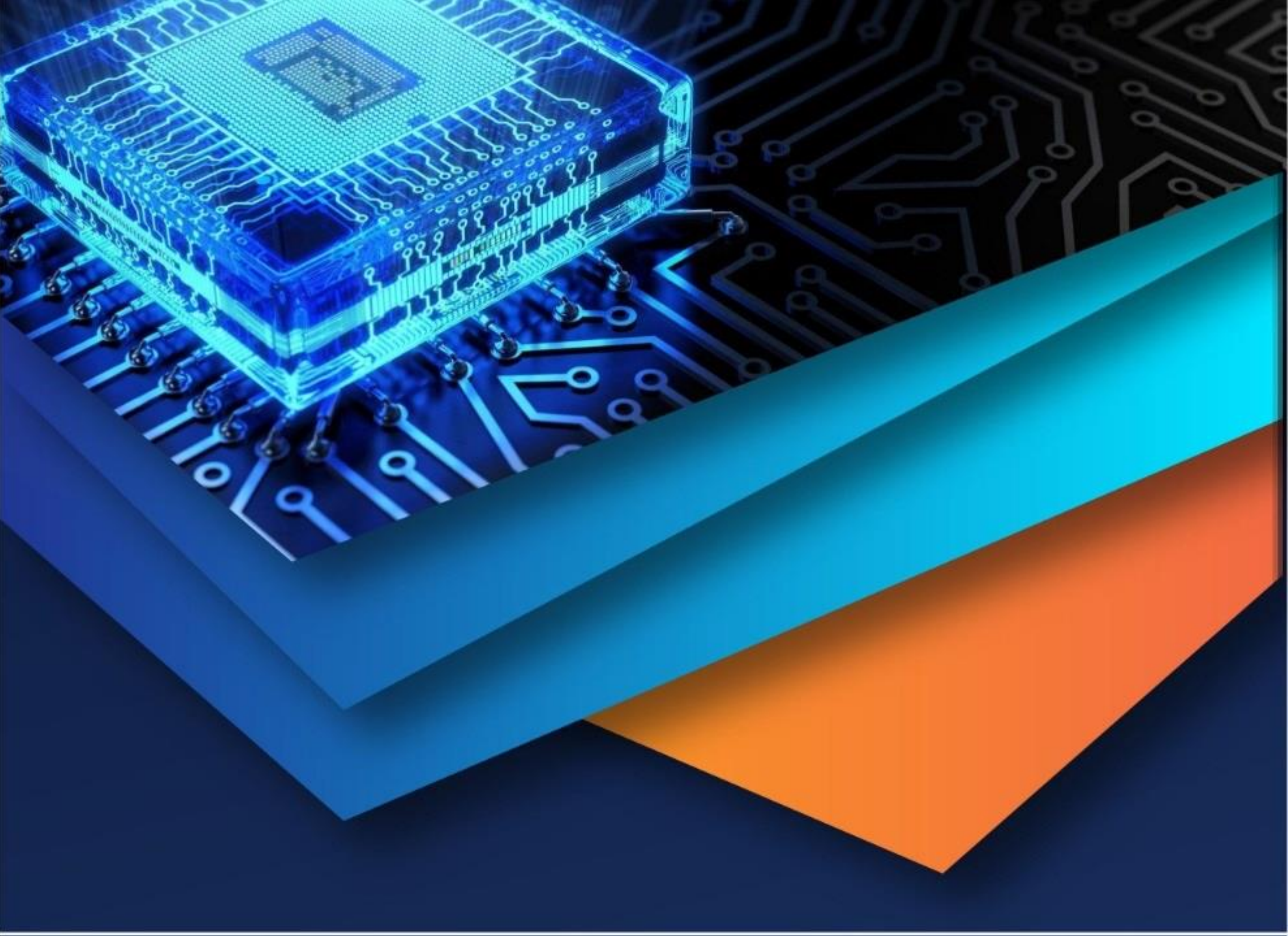
[1] Dayalan J. (2016), "Comparative Study on Stabilization of Soil with Ground Granulated Blast Furnace Slag (GGBS) and Fly Ash", International Journal of Engineering and Technology (IRJET). 2016; Volume- 03, Issue-05, pp.2198–2204Pathak, A.K., et al., 2014. Soil stabilization using ground granulated blast furnace slag. Int. Journal of Engineering Research and Applications, 4 (5), 164–117

[2] Ashish Kumar Pathak, Dr. v. Pandey, Krishna Murari, j.p. singh (2014), "soil stabilization using ground granulated blast furnace slag" Int. Journal of engineering research and application, ISSN: 2248-9622. Vol. 4, issue 5(version 2), pp. 164-171.

[3] 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 Jour., v.25(2), pp.199-209

[4] Cokca, E., Y azici, V ., and Ozaydin, V . (2009) Stabilization of expansive clays using Granulated Blast Furnace Slag (GBFS) and GBFS-Cement, Geotechnical and Geological Engineering, v.27, pp.489-499

[5] Laxmikanth yadu and Dr. R. Tripathi (2013). "Effects of Granulated blast furnace slag in the engineering behaviour of stabilized soil" procedia Engineering 51, 125- 131, DOI: 10.1016/j. proeng.2013.01.019.



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