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Evaluating the Chemical Stabilization of Soil Pavement and Its Molecular Spectra

Ankit Patel[1], Prof. C. B. Mishra[2]
[1]M. Tech Transportation Engineering Student, BVM Engineering College, V.V. Nagar, Anand, India
[2]Associate Professor Civil Engineering Department, BVM Engineering College, V.V. Nagar, Anand, India

Abstract: ***In India, the increment in populace combined with substantially loaded heaps of vehicles passing on heavier stresses focuses particularly on roads running in clayey soil zones which make critical issues for pavements and consequently should be balanced out. The augmentation in movement action close by the heavier size of wheel burdens causes quick failure in pavements worked over such soils. At first the examination of typical soil is done to survey the physical and designing properties as demonstrated by Indian Standard (1498 – 1970) by organizing investigation center tests and to assess the change in properties by the using sea shell powder of 15% and nano chemical terrasil stabilizer of 0.021% percent measurement as stabilizers to be utilized as a piece of the pavement setup for the economy at 28 days curing. In this review, the movements in sub-review quality, the right layout frameworks of the black-top layers in view of the sub review quality can be worked out using IRC code and similar sparing expense per km. Likewise, utilizing field emission microscopy (FESEM) and an energy dispersive x-beam spectrometry (EDAX) strategy on ordinary soil balanced out with 15 % sea shell powder and 0.021% nano-substance terrasil to have a superior comprehension of changes in atomic structure contributing towards upgraded quality.***

Keywords: ***Soil Stabilization, Clay Soil, Seashell Powder, Terrasil, OMC-MDD, UCS, CBR, FE-SEM, EDAX.***

I. INTRODUCTION

India is a developing nation and may confront different difficulties to manage huge highway ventures for short conceivable time. Roads going through extensive soil areas are subjected to serious pain bringing about poor execution and expanded upkeep cost. Fast populace development and industrialization created the utilization of transportation office to convey heavy commercial vehicle loads and repetitive applications of it thereby producing heavier stresses on sub-grade soil exposed to the regular evolving environment. India is faced with saving and redesigning the pavement system, these require the enthusiasm of utilizing waste material for improving the security of soils. In this review, a basic stride is being taken to finish financial usage of waste materials utilizing sea shell powder and nano chemical terrasil stabilizer of 0.021% percent dose by enhancing the properties as per requirements of pavement design from its arranged use meeting the standards of the code. Also, an experimental study is focused on investigating the changes in the structure utilizing field emission microscopy (FESEM) and an energy dispersive x-beam spectrometry (EDAX).

II. LITERATURE REVIEWS

A. Karthika Prasad (June 2016) [15]
had found that the increase in unconfined compressive strength of kuttanad clay, by testing it after placing the sample for a curing period of 0, 4,7 days. Also, the Geotechnical properties and volumetric shrinkage strain of Kuttanad clay were tested in this study. The eggshell powder can be used to considerably improve the strength of soil. The result of the unconfined compressive test with eggshell as a stabilizing agent at varying percentage (10%, 15%, 20%) after 0, 4, 7 days each showed that the strength increases at 15% after 7 days curing which is the optimum value and reduces by 20%. For each value of optimum moisture content determined from the standard proctor test, a sample was prepared using the same proctor mold consolidating each layer, after which it was extruded out of this mold and its dimensions were calculated. The change in the dimensions was noted after a period of 4, 7 days. Minimum volume change was observed at 15%, which is found to be the optimum percentage.

B. Nandan A. Patel, Prof.C. B. Mishra, Mr. Vasu V. Pancholi (2015) [19]
had found that the responsibility of the road authorities to use the local material and correct the soil properties using additives enhancing the strength of soil and make the road-durable. The examination was completed to focus first soil engineering properties (with and without stabilizer), standard compaction; four days soaked California Bearing Ratio (CBR), permeability test and cyclic

loading test according to codal procurement. A concoction named Terrasil was utilized as a stabilizer and it was utilized for altered measurement i.e. 0.041% by dry aggregate weight of soil test according to the convention of Zydex Industries, Vadodara. Test outcome demonstrates that designing properties got modified and CBR on stabilized clayey samples increased considerably, which reflects the lower thickness in correlation with natural characteristic soil properties. Additionally, the expense is diminishing which advantages the road builders, engineers, policy makers and pavement designers as well.

C. Swathy M Muraleedharan, Niranjana K (March 2015) [14]
had found that the results of experiments conducted on clay of high plasticity treated with an organic, non-toxic, eco-friendly bio-enzyme stabilizer (TerraZyme) to improve the engineering and index properties of soils. The effect of the enzyme on the soil in terms of Plasticity Index, Compaction, Unconfined Compressive Strength (UCS), and California Bearing Ratio (CBR) are studied. The dosage of bio-enzyme added to the soil was 0ml, 0.1ml, 0.2ml, 0.3ml and 0.4ml per kg soil. It has been observed that the enzyme-treated soil showed significant improvement in index and engineering properties of soil.

D. K. Mounika (Nov 2014) [6]
uncovered that the CBR value increments by including the sea shell powder as an admixture at an extent of 5% to 45%. It achieves a most extreme CBR estimation of 7.8% at 20%, concerning original soil without including the admixture accomplishes an estimation of 1.0%.

E. Maheshwari G. Bisanal (July 2015) [9]
had described that black cotton soil has a large tendency to swell and shrink with respect to variation in moisture content, thus causing serious problem to the structures build on that. The most common methods for stabilizing black cotton soil are using lime, cement, kiln dust, iron slag, cattle waste ash, industrial wastes and sea shell powder which cause problems in disposal and create environmental pollution

F. B M Lekha S Goutham, A U Ravi Shankar – (2013) [2]
had described that the behaviour of Black Cotton (BC) soil with and without stabilization, a chemical named Terrasil was used as a stabilizer and it was used for different dosages and cured for 7-28 days. Due to the chemical reaction, the soil mass densifies by minimizing the voids between particles and it makes the soil surface impervious. The important geotechnical properties of soil were determined in the laboratory. It is noted that CBR values increase with the increase in the percentage of the stabilizer. Permeability is found to be nil for treated soil. It makes the soil impermeable completely. The XRD and SEM analysis conducted for the soil samples were not able to justify the improvement for stabilized soil.

III.EXPERIMENTAL MATERIALS

The materials which are to be used in this study as follows

A. Clay Soil
The Soil is collected from the Valsad city near NH-48 at 2 m depth. The experiments are conducted in NKPC-Geotechnical laboratory, Valsad, Gujarat. The soil used is the extracted waste soil, which on the visual test and by laboratory test known to be clay soil. The soil is intermediate plastic clayey soil, i.e. CI soil. Test according to Indian Standards are performed on the soil to check the properties of untreated and treated the soil with stabilizer. Properties of clay soil are shown in table 1.

Table 1 Properties of clay soil

Sr. No.	Property	Value
1	Specific Gravity	2.42
2	Liquid Limit	41.75%
3	Plastic Limit	25.28%
4	Plasticity Index	16.67%
5	Free Swell Index	60.04%
6	Optimum Moisture Content	17.70%

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7	Maximum Dry Density	1.7360 g/cc
8	Unconfined Compressive Strength	51.66 KPa
9	California Bearing Ratio	2.48%

B. Seashell Powder

The seashell is a waste material obtained near the seashore area is made in powdery form as per the code for the work. Seashell containing the 90% of calcium carbonate, remaining 10% it contains dust and impurities.

C. Terrasil

Terrasil is a nanotechnology based product produced by Zydex Industries Ltd., Gujarat. Terrasil is water soluble, ultraviolet and heat stable, reactive soil modifier. It improves the frictional value, reduces water permeability and maintains breathability of the soil layer. The composition of terrasil is as shown in Table 2.

Table 2 Composition of Terrasil

Chemical Compound	Value in range, %
Hydroxyalkyl-alkoxy-alkylsil	65 – 70 %
Benzyl alcohol	25 – 27 %
Ethylene glycol	3 – 5 %

IV. EXPERIMENTAL MATERIALS

A. Properties of Clayey Soil with and without Additive

Comparative Graph for CI Soil and Seashell Powder (15%) + Terrasil (0.021%):

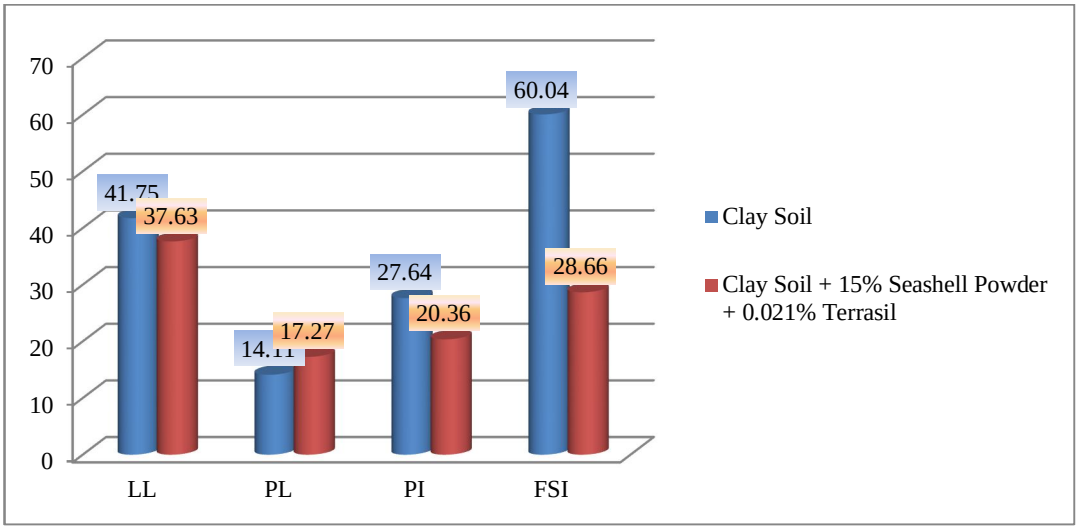

Fig. 1 Comparative Graph for CI Soil and Seashell Powder (15%) + Terrasil (0.021%)

B. Results of OMC and MDD for Clay soil stabilized with Seashell Powder + Terrasil

The OMC and MDD of the soil samples for 15% seashell powder + 0.021% of terrasil stabilizer were determined by performing the Standard proctor test. The dry density was resolute and plotted against the corresponding water content to ascertain OMC and MDD. The 15% seashell powder + 0.021% Terrasil are tabulated in table 3.

Table 3 OMC-MDD of the Samples

% Replacement	Clay Soil + Seashell Powder + Terrasil	
	OMC (%)	MDD (g/cc)
0	17.70	1.7360
Seashell Powder (15%) + Terrasil (0.021%)	16.48	1.8049

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C. Results of California Bearing Ratio (CBR) test for Clay soil stabilized with Seashell Powder + Terrasil

The CBR test is carried out as per the IS code 2720 part 16, 1987 on the soil containing seashell powder (15%) + Terrasil (0.021%) (fig 1) and the 4-day outcome is as shown in table 4.

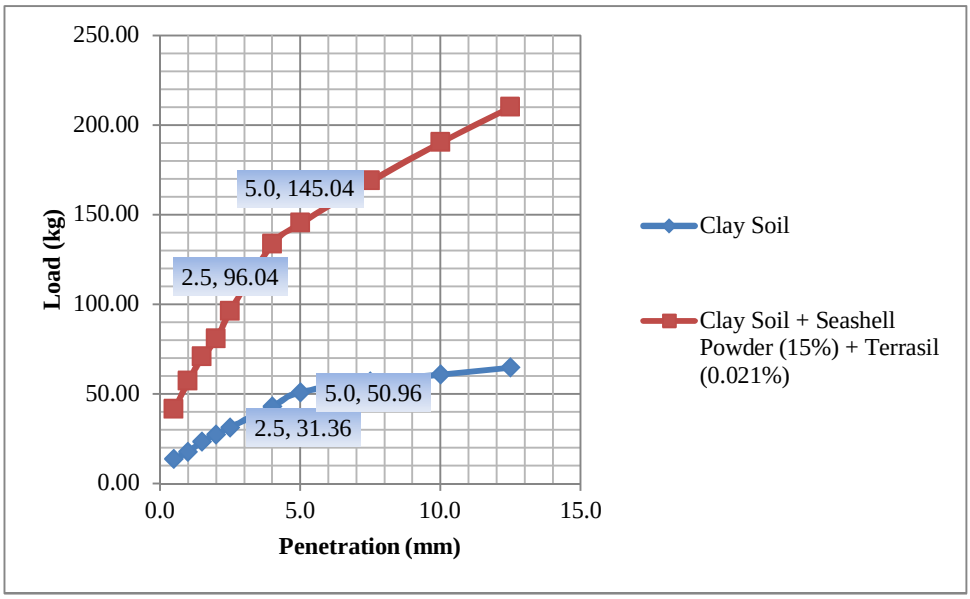

Fig. 2 Penetration vs Load

Table 4 CBR Value

CBR Value at St. Penetration 2.5 mm and St. load 1370 Kg		
Sample	CL Soil	Soil + Seashell Powder (15%) Terrasil (0.021%)
Load at 2.5 mm	31.36	96.04
CBR Value	2.29	7.01
CBR Value at St. Penetration 5 mm and St. load 2055 Kg		
Sample	CL Soil	Soil + Seashell Powder (15%) Terrasil (0.021%)
Load at 5 mm	50.96	145.04
CBR Value	2.48	7.06

The outcomes of CBR of 5 mm penetration CI soil are 2.48% and CI Soil + Seashell powder + Terrasil are 7.06%. CBR of 5 mm penetration quality is taken for design as results are reiterated. It is evident that CI soil treated with Seashell powder + Terrasil upgraded thickness values by lessening the void extents. This penchant may be a direct result of practical alert exchange process which all things considered takes longer period without such stabilizers. The low CBR of the CI soil is credited to its innate low quality which is because of the strength of the clay fraction.

D. Thickness Design of Flexible Pavement as per IRC: 37 – 2012

The traffic taken into consideration is 26 msa (Million Standard Axle) accordingly the thickness design is calculated as per IRC: 37 – 2012 for materials. Generally, the construction cost is based on tender pricing. It is assumed that the initial cost reflects the correct design and the best workmanship of required quality.

Now, for 2% CBR and 26 msa traffic, thickness design is calculated as per IRC: 37 – 2012, pg.26. After interpretation of 26 msa traffic Pavement composition is shown in fig. 3.

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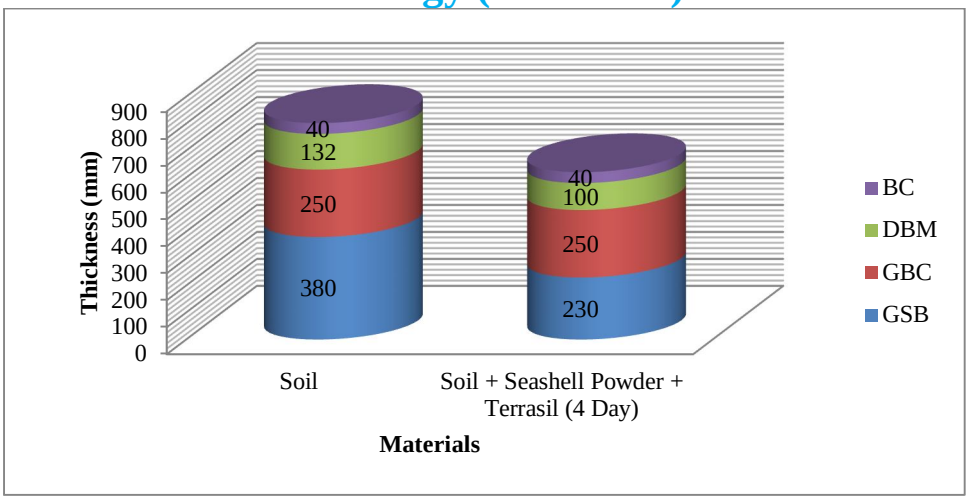

Fig. 3 Comparison of Thickness layers with and without additives

E. Construction Cost

Here the rate is taken from NH Standard Data Book (Road & Bridge) 29/01/2013 for calculating the total cost of construction.

Table 5 Summary of Cost Analysis (1 km) for 10.5 m width of road

Sr. No.	Materials	Cost (Rs.)
1	Clay Soil	21,239,673.00
2	Clay Soil + Seashell Powder + Terrasil (4 Day)	17,196,270.00

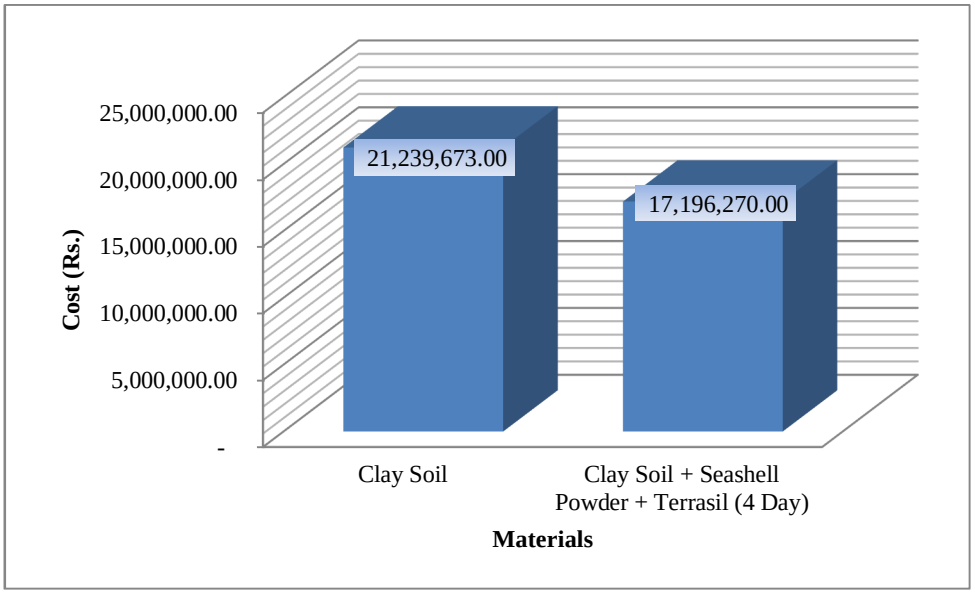

Fig. 4 Summary of Cost Analysis (1 km) for 10.5 m width of road

F. FE-SEM and EDAX

The Field emission microscopy (FEM) is an analytical technique used in materials science to investigate molecular surface structures and their electronic properties. In FEM, the phenomenon of field electron emission was used to obtain an image on the detector on the basis of the difference in work function of the various crystallographic planes on the surface. EDAX is a more sophisticated approach regarding the surface composition of particles at different intervals. Also, the intensity of peaks reveals the relative elemental changes induced by the stabilizers.

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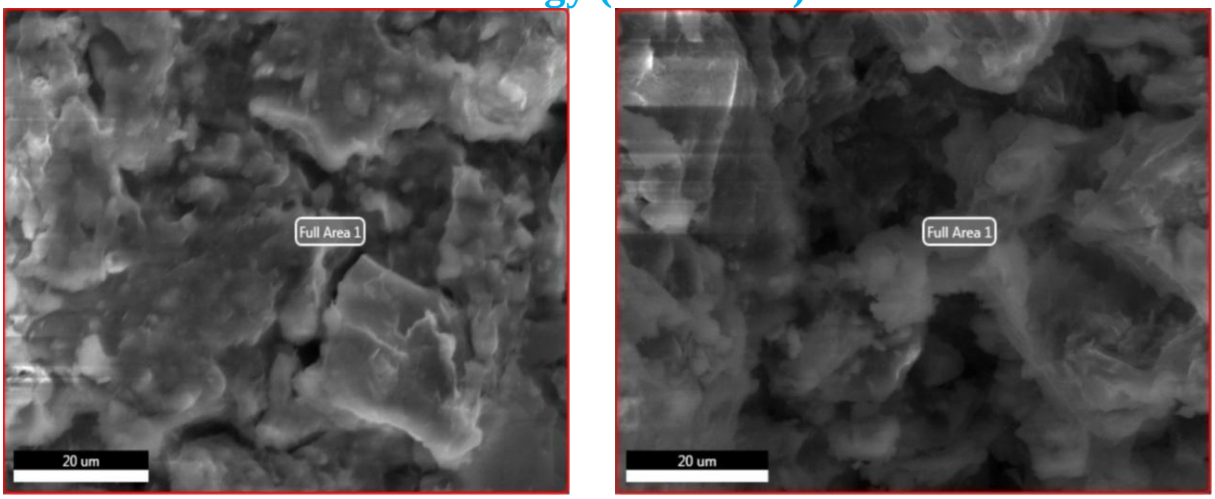

Fig. 5 Images of FE-SEM: CI soil and CI soil + Seashell Powder + Terrasil

From the images of FESEM, it is evident that there is the formation of layers and clusters of soil particles in samples having Seashell powder and Terrasil, which does not appear in the images of Clay soil sample.

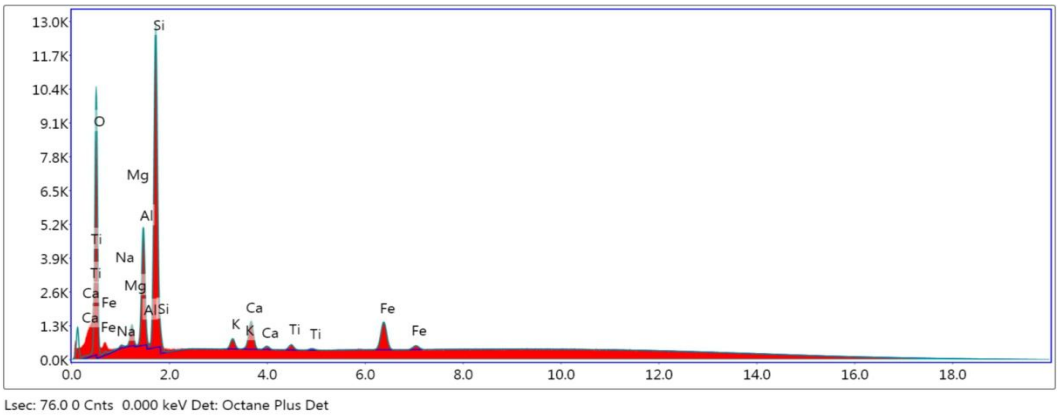

Fig. 6 EDAX Graph of Clay soil

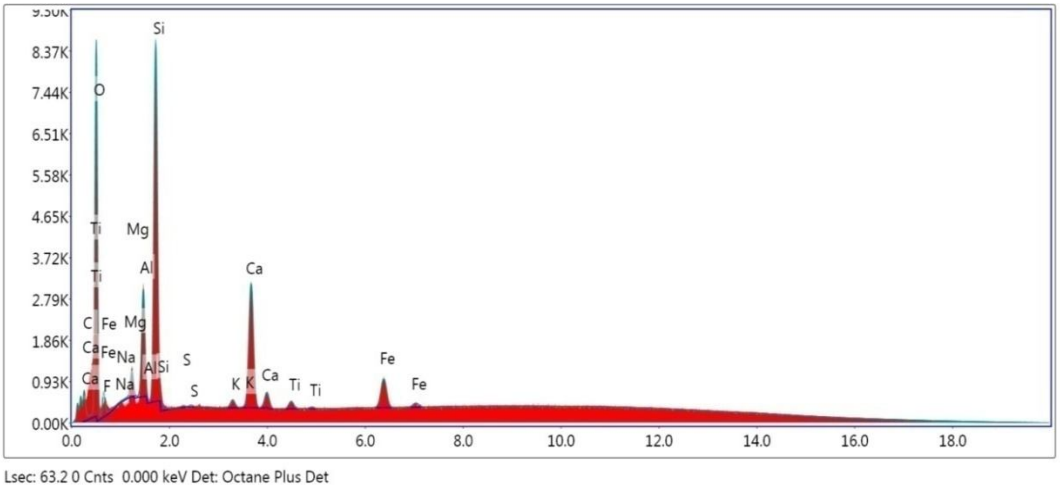

Fig. 7 EDAX Graph of Clay soil + 15% Seashell powder + Terrasil 0.021%

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Table 6 EDAX Results

Soil	Elements	Amount %
CI	C	6.3
	Na	1.43
	Si	24.11
	Ca	4.25
CI + S + T	C	4.19
	Na	1.47
	Si	16.25
	Ca	10.81

As the table of EDAX results shows that the amount of calcium (Ca) is increased after addition of seashell powder and terrasil, which is lower in CI soil sample.

V. CONCLUSIONS

A. The liquid limit and plastic limit of the soils decrease with the addition of seashell powder and terrasil to the soil in a proper proportion. The CBR value of soil gets increased with the addition of seashell powder + terrasil. The increase in CBR of stabilized soil noted is 2.28 times that of ordinary soil.

B. The images of FESEM it is evident that there is the formation of layers and clusters of soil particles in samples having seashell powder, terrasil, which does not appear in the images of BC soil sample. The behavior of treated soils shown by the SEM-micrographs indicated the formation of the flaky texture of cementations form. This flaky texture which confirms the formation of needle-like crystalline formations in the soil sample were shown in the micrographs of the treated soil samples due to reactions which contributed to the increase of the strength of stabilized soil samples.

C. The graph of EDAX shows the chemical species present in the soil having higher peaks in a spectrum represent a higher concentration of the elements specially, increase in calcium amount in the samples having seashell powder and terrasil is noted. Calcium is responsible for the increase in the strength of soil due to the formation of layers and clusters in the soil particles.

D. The cost of untreated soil per km comes out to be Rs. 21,239,673.00 while soil treated with 15% of seashell powder + 0.021% of terrasil per km comes out to be Rs. 17,196,270.00. Also, the cost reduces to Rs. 4,043,403 per km when treated with Seashell Powder (15%) + Terrasil (0.021%).

E. The highway contractors and pavement designers can avail the usage of Seashell Powder (15%) + Terrasil (0.021%) with ordinary soil, as it is alluring and backings the supportable improvement in road development.

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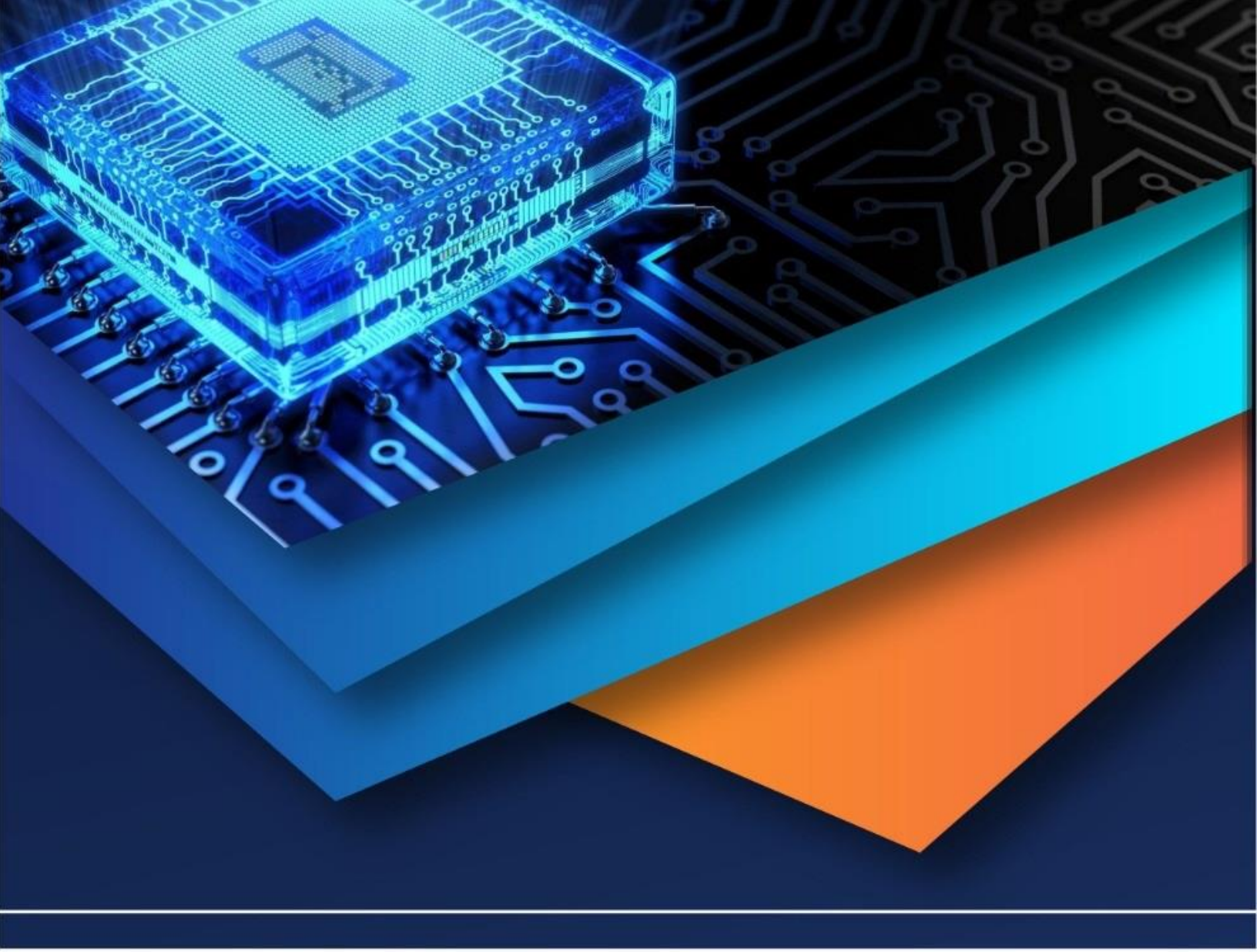

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