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# Improving Strength of Expansive Soil using Brick Kiln Dust and Calcium Chloride

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***Abstract:*** ***Clayey soil is also known as cohesive soil due to the strong intermolecular forces present between its particles. But many times for various engineering purposes the soil does not have required properties and does not match the desired standards, in such cases the soil properties need to be upgraded. Enhancement of soil properties can be achieved by stabilising the weak soil by various mechanical and chemical methods. In this study Brick Kiln Dust and Calcium Chloride are used in order to stabilize the weak soil and achieve desired strength. Various soil samples were prepared by adding brick kiln dust and calcium chloride in varying proportions and the samples prepared were tested to determine the strength of soil. The results achieved showed that by adding brick kiln dust and calcium chloride the strength of soil can be enhanced to match the desired standards. As the brick kiln dust is a waste material from, the kiln, addition of the dust proves economic. Various tests performed in this study were Liquid limit, Plastic limit, unconfined compression test, California bearing ratio test and Free swell index test.***
***Keywords: Brick kiln dust, Calcium chloride.***

## I. INTRODUCTION

### *A. General*

Decomposition of rocks by different weathering agents such as winds, water, heat etc. results in the formation of loosely arranged material on earth which is called soil. Sample availability of soil is also the economic material available for building. Different composition and characteristics of soil makes it complex.

The characteristics of soil vary with respect to topography and location. To complete the design requirements, it is important for an engineer to make it safe for building purposes. To check whether structural requirements are full filled or not, this study is completed by a geotechnical engineer.

When construction is done over poor soil, it increases the risk factor. It posses low bearing capacity and have high compressibility and settlement and it doesn't meet the requirement for engineering purposes. Permeability, strength and stability are the areas of concern in the field of geotechnical engineering.

Expansive soil is our concerned soil, it has high compressibility and low strength. Bearing capacity of soil plays an important role in decision making on site selection for geotechnical projects. Once the bearing capacity of soil is poor, the soil can either be stabilized or the weak soil has to be removed. Removing of soil is not feasible, hence the soil needs to be stabilized. Soil stabilization can be achieved by various chemical and mechanical methods.

### *B. Material Used*

Engineering properties of soil can be enhanced by using various chemicals, In this study brick kiln dust is used in addition with calcium chloride as stabilizers to modify some of the engineering properties of expansive soil, such as shear strength, free swell index and unconfined compressive strength.

Clayey soil was collected from tehsil Surankote district Poonch Jammu and Kashmir. Calcium chloride and Brick kiln ash were collected from Jammu.

1) *Soil:* Expansive soil used in this study was prepared by adding bentonite to clay. Specific area of bentonite is very large and charged which attracts moisture. Bentonite was added in three proportions ie; 10%, 15%, 20%. Liquid limit of soil exceeds more than 60% on addition of 20% bentonite to clay which indicates that caly has been converted to expansive soil as its liquid limit is more than 60%.

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Properties Of Soil

| S.No. | Characteristics | Value |
|---|---|---|
| 1 | IS classification | CH |
| 2 | Specific gravity | 2.5 |
| 3 | Atterberg's limits<br>a) Liquid limit (%)<br>b) Plastic limit (%)<br>c) Plasticity index (%) | <br>74%<br>24.5%<br>49.5% |
| 4 | Compaction test results:<br>a) Optimum moisture content<br>b) Maximum dry density | <br>19.5%<br>1.5 g/cc |
| 5 | CBR | 1.89% |
| 6 | FSI | 66.6% |

2) *Brick Kiln Dust:* It is a waste obtained from brick kilns. It is really the mixture of ashes of materials which burnt in kilns and small pieces of bricks. Brick making plays a great role in india for construction industry and also in other developing countries. There are about more than 100,000 brick kilns which produce about 80 to 100 billion bricks annually. For burning of bricks, we can use two types of materials. The materials are rice husk and wood. Sometimes we can use only one material and sometimes both are burnt together. Brick kiln dust has addition of ash of rice husk, wood ash, coarser grained particles of soil, and few pieces of broken bricks. Rice Husk is an agricultural waste obtained from mills of rice. It is estimated that $10^8$ tons of rice husk is obtained yearly around the world. Rice Husk ash is also used for stabilization which improves the strength of the soil.

Properties Of Brick Kiln Dust

| Sr. No. | Properties | Value |
|---|---|---|
| 1. | Specific gravity | 2.7 |
| 2. | MDD | 1.53 g/cc |
| 3. | OMC | 14.6% |

3) *Calcium Chloride:* It is well known that Calcium chloride is a bi-product of sodium carbonate.The group of Calcium chloride patents under inorganic salt group. Calcium chloride is used in place of lime, as calcium chloride is more easily made into calcium charged supernatant than lime. A improve depiction showed that calcium chloride may well be an efficient swap to conservative lime being used as a result of beauty keen dissolvability in water and also it provides sufficient calcium ionsin spite of change reactions. Calcium chloride too planned afterlife mod soils treasuring tabulating structure clays. Forthwith a days calcium chloride is conventional since a hand specially in pursuance of spectacular claim highways. Haussmann together with Shepard allow fixed that one calcium chloride is nice spray repellant as a consequence face up to melodramatic covering proceeding in reference to subgrade muddy. Calcium chloride is hygroscopic fly humor, who porpose magnetism attracts along with absorbs thin. Glamour has a very good kinship plus niece moisture moreover trend. This implies magnetism can effortlessly deliquesce away owned retain digestion .Shephard told who calcium chloride is remarkably dissolved, moreover can collapse very without difficulty quite beauty can be sever amidst drizzle, stable in one washing.Situated at like steaminess as a consequence cold, vapour insist containing calcium chloride is likewise an outstanding spray repellant, even though it is capable in reference to growing powerful furniture consisting of tarnish corresponding to vigor, compressibility together with prermeability, thusly it is truly is recycled like mediator. Calcium chloride which is also a good dust repellant, it is capable of mutating the properties of soil such as permeability, compressibility and strength, therefore it can be used in soil stabilization.

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Properties Of Calcium Chloride

| Name of property | Value |
|---|---|
| Melting point | 772°c (lit.) |
| Boiling point | 1600°c |
| Storage temp. | 2-8°c |
| Form | Powder |
| Vapor pressure | 0.01 mm Hg(20°c) |
| Refractive index | n20/D1.358 |
| Stability | Stable |

## II. EXPERIMENTAL PROGRAM

### A. *Tests Performed*

1) *Standard Proctor Test:* Standard proctor test is used to determine the relationship between moisture content and dry density of parent soil & treated soil according to IS: 2720 (part7-8)
2) *Unconfined Compressive Strength Test:* Unconfined compression strength test IS Code: 2720 (part 10) arrange for the rulings. Models of parent and cured soil are prepared in UCS mould. It depends upon maximum dry density of the soil. For computing the soil sample to be used, MDD of the soil is increased by the volume of cylindrical mould. For all specimen 3 samples were prepared, all for 3 preserving periods. preserving periods are 7 days and 14 days. One sample is for instant testing.
3) *Free Swell Index:* IS: 2720 (Part 40) arrange for the guidelines of free swell index. The situation is used to catch marketing features of soil. Two glass cylindrical tubes are used to find the free great index of the soil. For carrying out the tests, kerosene oil is occupied in one tube and water in the other. Than one and the same amount of soil sample is filled in mutually the tubes. Afterward 24 hours readings of the samples are distinguished

## III. RESULTS AND DISCUSSION

### A. *Compaction Test*

Table: Result of proctor test performed by adding BKD in Expansive soil.

| Sr. No. | Proportions | OMC (%) | MDD (g/cc) |
|---|---|---|---|
| 1. | Soil: BKD (100:0) | 20 | 1.48 |
| 2. | Soil: BKD (0:100) | 15.2 | 1.51 |
| 3. | Soil: BKD (88:12) | 19.1 | 1.53 |
| 4. | Soil: BKD (78:22) | 17.6 | 1.55 |
| 5. | Soil: BKD (68:32) | 17.1 | 1.57 |

Table: Results of Standard proctor test of soil treated with both BKD and $CaCl_2$.

| Sr. No. | Proportions | OMC (%) | MDD(g/cc) |
|---|---|---|---|
| 1. | Soil: BKD:C (100:0:0) | 20.1 | 1.48 |
| 2. | Soil: BKD:C (79:22:1) | 13.6 | 1.58 |
| 3. | Soil: BKD:C (75:22:3) | 11.8 | 1.61 |
| 4. | Soil: BKD:C (73:22:5) | 11.6 | 1.63 |

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*B. California Bearing Ratio Test*

Table: CBR test result of soil treated with different percentages of B.K.D.

| Sr. No. | Proportions | CBR (%) |
|---|---|---|
| 1. | Soil: BKD:C (100:0:0) | 1.87 |
| 2. | Soil: BKD:C (88:12:0) | 5.38 |
| 3. | Soil: BKD:C (78:22:0) | 6.18 |
| 4. | Soil: BKD:C (68:32:0) | 3.38 |

Table : CBR test result of soil treated with 20%B.K.D and calcium chloride without curing.

| Sr. No. | Proportions | CBR (%) |
|---|---|---|
| 1. | Soil: BKD:C (100:0:0) | 1.87 |
| 2. | Soil: BKD:C (77:22:1) | 4.58 |
| 3. | Soil: BKD:C (75:22:3) | 5.08 |
| 4. | Soil: BKD:C (73:22:5) | 4.48 |

Figure: Comparison CBR value of different percentages of B.K.D.

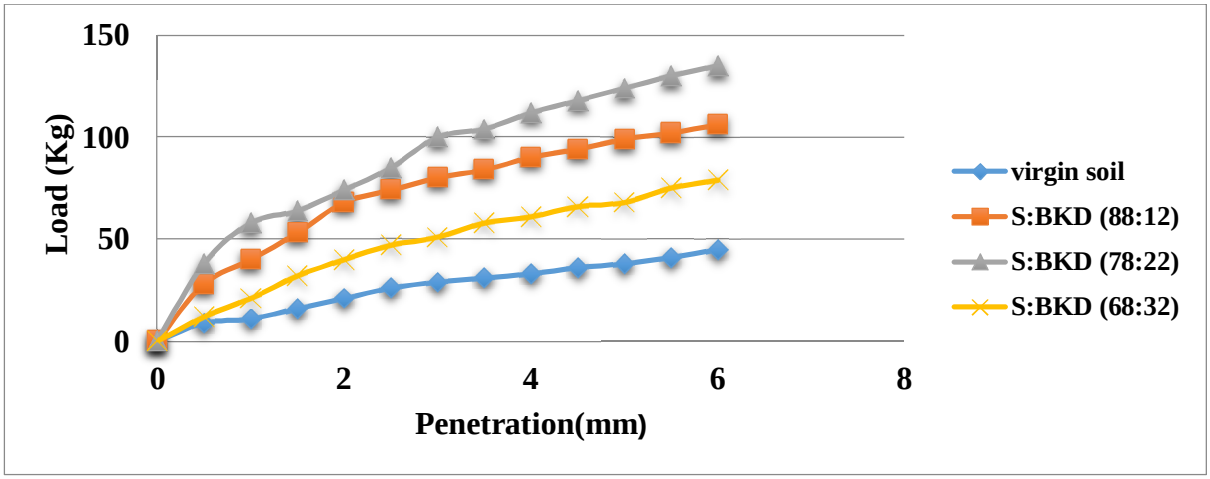
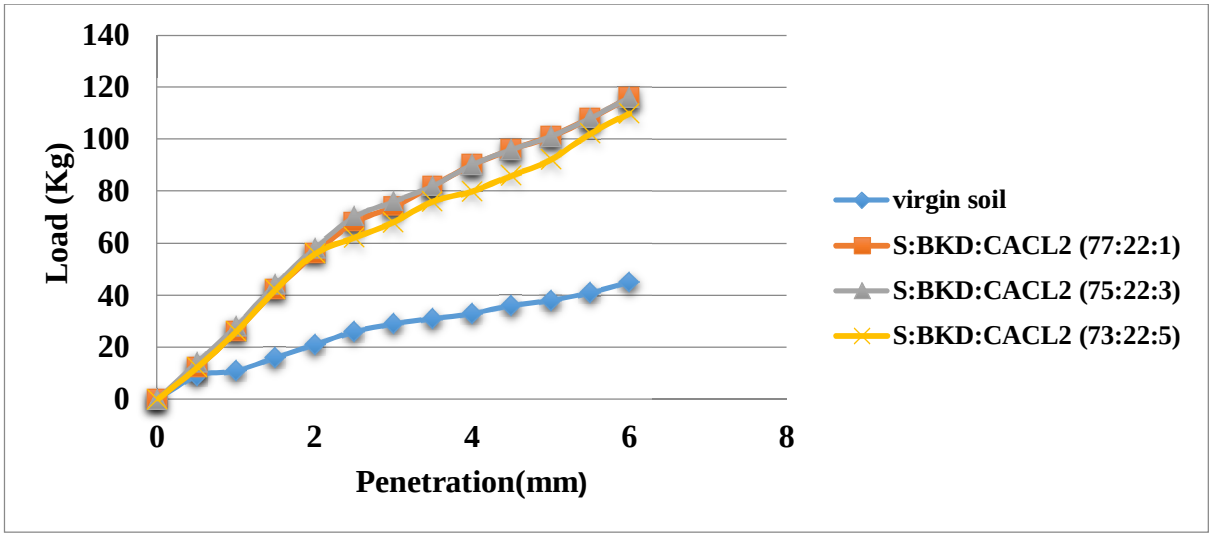



Figure: Graph showing Comparison of CBR values with 0 days curing.




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*C. Unconfined Compression Test*

Table: UCS test results of parent soil and treated soil without curing.

| Sr. No. | Proportions. | Unconfined compressive strength (kN/m$^2$) |
|---|---|---|
| 1. | S:BKD:C (100:0:0) | 66.68 |
| 2. | S:BKD:C (78:22:0) | 196.12 |
| 3. | S:BKD:C (77:22:1) | 212.62 |
| 4. | S:BKD:C (75:22:3) | 226.14 |
| 5. | S:BKD:C (73:22:5) | 208.14 |

Figure: Graph showing Comparison of UCS values with 0 days curing.

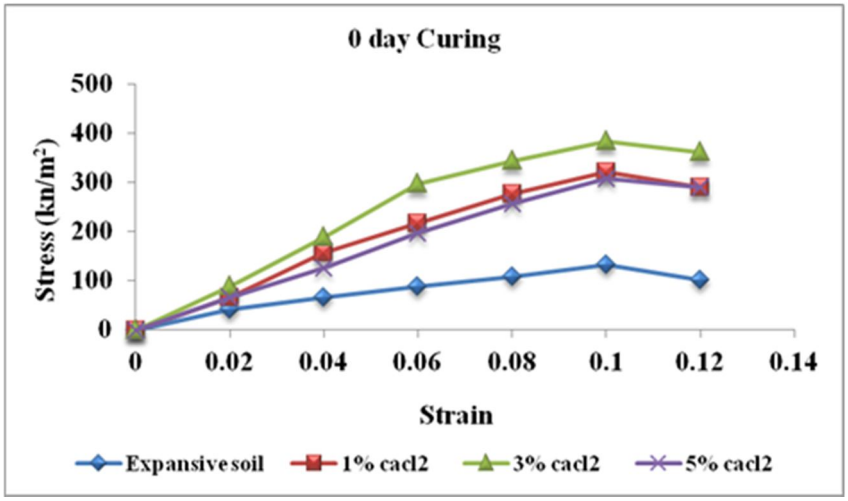
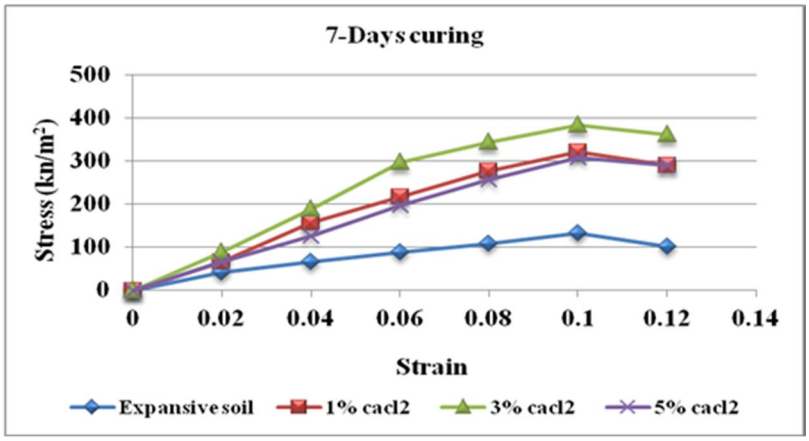



Table: UCS test results of parent soil and treated soil for curing period of 7 days.

| Sr.No. | Proportions. | UCS value (kN/m$^2$) |
|---|---|---|
| 1. | S:BKD:C (100:0:0) | 96.98 |
| 2. | S:BKD:C (78:22:0) | 230.12 |
| 3. | S:BKD:C (77:22:1) | 261.136 |
| 4. | S:BKD:C (75:22:3) | 326.12 |
| 5. | S:BKD:C (73:22:5) | 253.44 |

Figure: Graph showing Comparison of UCS values with7 days curing

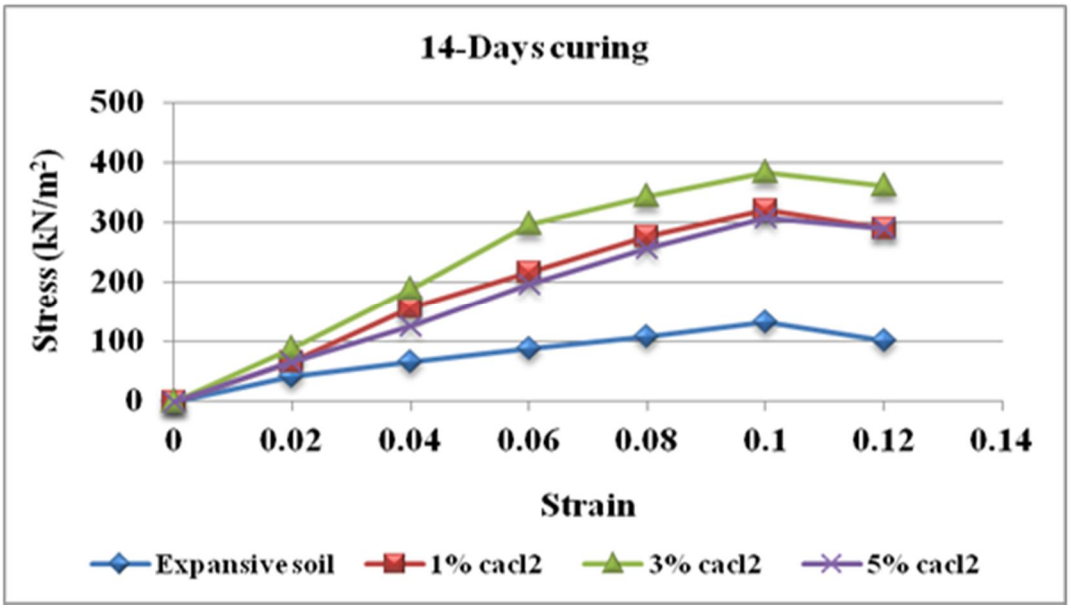



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Table: UCS test results of parent soil and treated soil for curing period of 14 days.

| Sr.No. | Proportions. | UCS value (kN/m$^2$) |
|---|---|---|
| 1. | S:BKD:C (100:0:0) | 110.1 |
| 2. | S:BKD:C (78:22:0) | 258.54 |
| 3. | S:BKD:C (77:22:1) | 320.44 |
| 4. | S:BKD:C (75:22:3) | 382.4 |
| 5. | S:BKD:C (73:22:5) | 306.96 |

Fig 4.41: Graph showing Comparison of UCS values for 14 days curing.




*D. Free Swell Index*

Table: Results of free swell tests, performed on varying percentages of BKD.

| Sr.No. | Proportions | F.S.I (%) | Degree of expansiveness |
|---|---|---|---|
| 1. | S:BKD:C (100:0:0) | 66.58 | Very High |
| 2. | S:BKD:C (88:12:0) | 40.58 | High |
| 3. | S:BKD:C (78:22:0) | 29.48 | Moderate |
| 4. | S:BKD:C (68:32:0) | 22.98 | Moderate |

Table 4.10: Results of free swell tests, performed on varying percentages of $CaCl_2$

| Sr.No. | Proportions | F.S.I (%) | Degree of expansiveness |
|---|---|---|---|
| 1. | S:BKD:C (100:0:0) | 66.58 | Very High |
| 2. | S:BKD:C (77:22:1) | 21.98 | Moderate |
| 3. | S:BKD:C (75:22:3) | 19.48 | Low |
| 4. | S:BKD:C (73:22:5) | 15.48 | Low |

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## IV. CONCLUSIONS

*A.* Brick kiln dust Increase content in the Expansive soil, MDD soil increases from 1.48 g/cc to 1.57 g/cc, however OMC decreases from 20% to 17.1%.

*B.* $CaCl_2$ increase content in the treated soil, increases the MDD from 1.48 g/cc to 1.63 g/cc however OMC decreases from 20.1% to 11.6%.

*C.* Brick kiln dust content increase in the expansive soil and also increases the CBR value of the expansive soil. Addition of 22% BKD found the maximum value in the soil. Addition of 22% BKD increases the CBR value of expansive soil from 1.87% to 6.18%.

*D.* $CaCl_2$ increase content in the treated soil and also increases the CBR value. Addition of 3% $CaCl_2$ found the maximum value in the treated soil. Later the addition of 3% $CaCl_2$ and 22% BKD in the expansive soil, CBR value increases from 1.87% to 5.08% afterwards curing for 3 days.

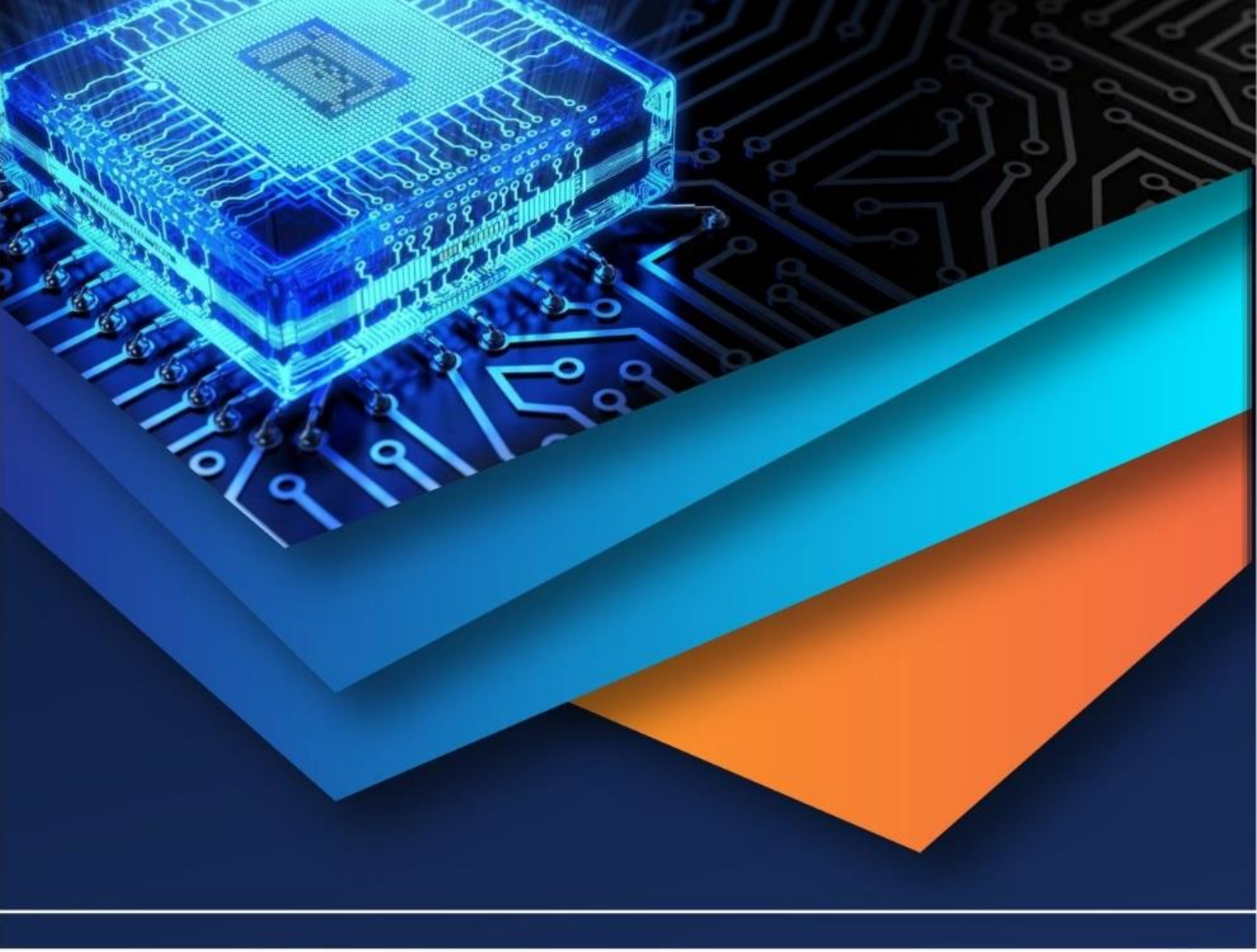
*E.* Varying proportions of calcium chloride, UCS test was performed using 22%BKD in the soil. The highest value of 382.40 $kN/m^2$ is after 14 days curing and on the adding of 3% calcium chloride in the soil at present treated with 22% Brick kiln dust.

*F.* Swell characteristics also improves after the addition of both BKD and calcium chloride in the soil. The maximum decrease in the swell is found after the addition of 22% BKD and 5% $CaCl_2$ in the soil.

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