

Effect of Brick Kiln Dust & Alccofine 1101 on UCS & CBR Values of Clayey Soil

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ABSTRACT: Keeping in consideration the importance of soil as one of the most valuable materials used in different construction projects so it is of utmost importance to increase the engineering properties of soil using various techniques, methods and materials. Stabilizing soil may not prove to be economical, so every time we intend to increase the strength of soil we need to keep in consideration the economic feasibility. Stabilization needs to be carried out using better material, otherwise the soil is treated with a pre defined stabilizer. Soil sample containing Brick Kiln Dust had a comparatively higher strength, lower value plasticity index than original soil. The addition of Brick Kiln Dust (BKD) in the clayey soil gave large increase in strength and reduced swelling properties. For doing various tests, the expansive soil was mixed with Brick Kiln Dust (BKD) from 10% to 25% at an increment of 5%. Another material Alccofine 1101 was mixed with expansive soil from 3% to 9% at an increment of 3%. The Unconfined compression test (UCS), California bearing ratio (CBR) tests were done on clayey soil in accordance with Indian standard (IS) codes. The organizations which are involved in the construction of roads, highway pavements, railways, bridges, building foundations and other civil engineering structures can use these results in the field of soil stabilization with advantage.

KEYWORDS: Alccofine 1101, Brick kiln dust, Stabilizer, Clayey soil, UCS, CBR

I. INTRODUCTION

The topmost solid material of the earth constitutes soil. Its origin is due to the disintegration of rocks due to naturally occurring weathering conditions such as wind, rain, snow, heat, etc. It is largely available and is the cheapest construction material. Soil is a complex material because of its highly variable composition and properties. The characteristics of soil change according to topography and its location. For safer construction the properties of soil should match with the design requirements of an engineering structure. Geotechnical engineer plays a vital role in this work for checking whether the requirements of the structure are fulfilled by the soil or not. Construction on weak soils is dangerous, these soils show settlements, low shear strength and high compressibility. So in order to overcome these problems and defects geotechnical engineers adopt the method of soil stabilization using different techniques and materials. Now in order to strengthen the clayey soils we can use two kind of materials, one is to replace soil with a good cementitious stabilizing material and second one to be used should be an industrial waste. So we could replace soil by Brick Kiln Dust (BKD) and ALCCOFINE 1101 for stabilization process of clayey soil. Burnt Kiln Dust is a waste powder generated from the burning of bricks has great ability to reduce swelling and shrinkage characteristics of expansive soils, but apart from that we need to impart strength to the soil so we would use another cementitious stabilizing material available i.e Alccofine 1101. It is a micro finer cementitious grouting material for soil stabilization and rock anchoring. The performance of Alccofine is superior to all other admixtures used in India. BKD was obtained from a Brick Kiln at Budgam J&k, while as Alccofine 1101 was bought from a registered supplier at Jammu. The sample of clayey soil was collected from Jammu. The collected samples of clayey soil were mixed with various proportions of BKD and Alccofine 1101.

International Journal of Innovative Research in Science, Engineering and Technology

(A High Impact Factor, Monthly, Peer Reviewed Journal)

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Vol. 8, Issue 12, December 2019

II. LITERATURE REVIEW

Jeevan Singh et al. (2018) From the laboratory investigations the following conclusions were made keeping %age of silica fume as 20% and varying alccofine %age from 0%,5%,7%,10% respectively.

- 1) The addition of mixture to the RED soil increases the optimum moisture content and decreases the maximum dry density with the increase in mixture content.
- 2) The addition of mixture to the RED soil improves the soaked CBR considerably. The addition of 20% silica fume and 10% Alccofine to the RED soil increases the CBR strength by 70% approximately.
- 3) The UCS of stabilized samples significantly increases from 160.0 kN/m² to 180 kN/m² i.e. approximately 18% increase.

Lovedeep Singh Sambyal et al. (2018) studied characteristics of clay soil Utilizing Fly Ash and Alccofine for Efficient Soil Stabilization.

In case of clay soil the liquid limit increased from a value of 45 % to 88 %. The decrease in the free swell Index was from 20 % to 9.5 %. The shrinkage limit of soil increased to 18 % and 28 % respectively for clay soil from 9 % initially for virgin soil. The MDD increased from 19KN/m³ to 21.5kN/m³ in case of addition of % mixture to the soil. The OMC decreased steeply with % mixture 14% to 7%. The undrained cohesion value of soil mixed with soil increase from 30 kN/m² to 35.5 kN/m². The unsoaked CBR value of the soil increased from 3% to 8% whereas soaked CBR value from 4% to 8% only in the case of addition of mixture to clay soil.

Neha Pundir et al. (2017). In this study, the soil is replaced with burnt brick dust of different percentages (10%, 20%, 30%, 40% and 50%) and tests are performed after seven days of curing. Test results are as:

increase in the percentage of burnt brick dust in clayey soil decrease the swelling of soil, the OMC decreases and MDD increases. The OMC and MDD at 50% replacement of soil with burnt brick dust is 11.9% and 19.64 KN/m³. On increasing the percentage of burnt brick dust CBR value also increases. At 50% replacement of soil the CBR value is 10.72 percent.

Nikhil Tiwari et al. (2018), An analysis examination is done to think about the impact of over burnt brick powder on building properties of the black cotton soils. It is discovered that the properties of expansive soil blended with Burnt Brick powder and lime are enhanced. Liquid limit of black cotton reduces to almost 29%. with increasing percentage of brick dust from 10 to 50 %. Plastic limit decreases to 11% from 17%. Plasticity index reduces with increasing percentage of brick dust it almost lessen up to 17 % to 26%. There is a decrement of 18.8 to 11.1% in moisture content and increment 1.7 to 1.9 % in dry density.. The CBR values increases up to 8%.

III. MATERIALS & METHODOLOGY

1.MATERIALS

A . Clayey Soil :

Clayey soil is one of the types of soil composed of very small particles, and usually it contains silicates of aluminum and/or iron and magnesium. The flow of water impedes by clayey soil, means it slowly absorbs water and then retains it for a long time. Clayey soil swells in wet condition and shrinks in dry condition.

Clay soils feel very sticky and roll like plastic in when wet. They can hold more total water than most other soil types and, although only about half of this is available to plants, crops seldom suffer from drought. They swell when wetted and shrink when dried.

They are very late in warming up in the spring because water heats up more slowly than mineral matter. They are normally fairly rich in potash, but are deficient in phosphates. Clay soils usually need large infrequent dressings of lime. Over liming will not cause any troubles such as deficiency. The clayey soils being expansive in nature need to be stabilized in order to improve its various geotechnical parameters like strength, settlement control, shrinkage , swelling

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Vol. 8, Issue 12, December 2019

etc which can be done by numerous ways and here I would be discussing the strength improvement by brick kiln dust and alccofine 1101



B. BRICK KILN DUST

Burnt Kiln Dust is a waste powder generated from the burning of bricks with the soil covered by surroundings. Due to burning of soil bricks it hardened and at the time of removal the set up we get the powder form of brick. It has red colour and fine in nature. It has great ability to reduce the swelling potential of black cotton soil.



C. ALCCOFINE

Alccofine is a new generation, micro fine material of particle size much finer than other hydraulic materials like cement, fly ash, etc. being manufactured in India. Alccofine has unique characteristics to enhance 'performance of concrete' in fresh and hardened stages due to its optimized particle size distribution. It can be used as practical substitute for Silica Fume as it has optimum particle size distribution not too coarse, not too finer. Alccofine 1203 and Alccofine 1101 are two types of Alccofine with low calcium silicate and high calcium silicate respectively.

1. Alccofine 1101: - It contains high calcium silicate. It is a micro finer cementitious grouting material for soil stabilization and rock anchoring. The performance of Alccofine is superior to all other admixtures used in India. Due to high calcium oxide (Cao) content . Due to its extreme fineness, the product has extremely good penetration in voids of soil.



International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 8, Issue 12, December 2019

2. Tests Involved

In order to check the effect on the characteristic properties of the soil admixture after being admixed with BKD and Alccofine 1101 following tests were performed as per Indian standard codal provision:

1. Unconfined Compressive Strength test (IS: 2720, Part-X),

The resistance of underlying soil to the shearing deformation and compressibility is its compressive strength. If there is no lateral support, it is unconfined compressive strength. This test consists of a cylinder of soil with no lateral support & soil sample is tested to failure in simple compression at a constant rate of strain.

2. California Bearing Ratio test (IS: 2720 Part-VI).

The California bearing ratio test is penetration test required for the calculation of sub-grade strength of road pavements. The values calculated by these tests are used with the empirical curves to calculate the thickness of pavement and its component layers. This is the most common and widely used method for the design of flexible pavement. The calculation of C.B.R. values are usually done for penetration of 2.5 mm and 5 mm. Generally the C.B.R. value at 2.5 mm will be greater than that at 5 mm and in such a case the former shall be taken as C.B.R. for design purpose. If C.B.R. for 5 mm is more than that for 2.5 mm, the test should be repeated. If identical results follow, the C.B.R. corresponding to 5 mm penetration should be taken for design.

$$\text{C.B.R} [\%] = [\text{Test load} / \text{Standard load}] \times 100$$

IV. RESULTS & DISCUSSIONS

UNCONFINED COMPRESSIVE STRENGTH

The value of unconfined compressive strength for original soil and soil with various mix proportions of BKD and Alccofine 1101 calculated from UCS test is given in table 4.8 as below:

Table 1 UCS Values Of Various Mix Proportion At Different Curing Periods

Soil : BKD: ALCCOFINE 1101	UCS (kPa) 3 days curing	UCS (kPa) 7days curing	UCS (kPa) 28 days curing
100 : 0 : 0	91	91	91
87 : 10 : 3	84	124	187
82: 15 : 3	124	170	278
77 : 20 : 3	163	250	395
72 : 25 : 3	259	345	480
84 : 10: 6	291	390	510
79 : 15 : 6	398	505	635

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 8, Issue 12, December 2019

74 : 20 : 6	560	630	755
69 : 25 : 6	410	530	655
81 : 10 : 9	375	415	535
76 : 15 : 9	315	380	410
71 : 20 : 9	280	310	340
66 : 25 : 9	205	275	310

The optimum mix having highest UCS values for the different curing periods i.e 3, 7, 28 days. The compressive strength of treated soil is greater than untreated soil. For different curing periods, the strength of the stabilized soil increases with increase in curing periods. The UCS value of the stabilized mix increases from 91 kPa to 755 kPa at 28 days curing for 20% of BKD and 6% of ALCCOFINE 1101 with 74 % of soil. Typically, for 74: 20: 06 (Soil: BKD: ALCCOFINE1101) mix, the UCS value increases from 91 to 510 kPa, 630 kPa and 755 kPa for 3, 7 and 28 days of curing periods, respectively. The increase in compressive strength is due to pozzolanic reaction.

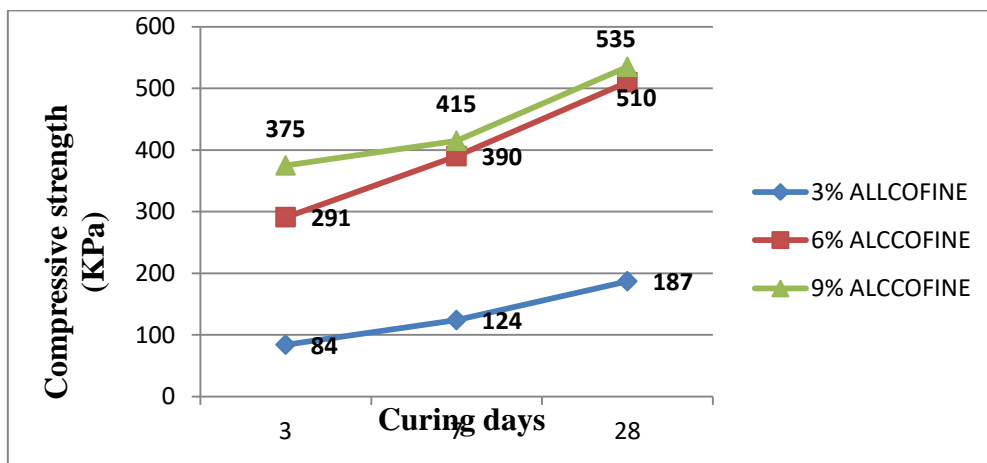


Fig. 4.1 Compressive strength v/s curing days of 10 % BKD with 3%, 6%, 9% of Alccofine 1101 with various proportions of Soil

Figure 4.1 shows the graph of compressive strength of mix having 10 % BKD with 3%, 6%, 9% of Alccofine 1101 for different curing periods of 3 days, 7 days and 28 days. The 3% graph shows that there is little increase in the compressive strength as the days of curing increases. The 6% addition of Alccofine 1101 shows very much increase in the values as compared to 3% addition of Alccofine 1101. The best result has given by 9% addition of Alccofine 1101. In 6% addition there is increase in the compressive strength as the curing days increase but it is less than addition of 9% of addition of Alccofine 1101. From the graphs it is found that there is increase in the compressive strength of the sample kept for 28 days curing.

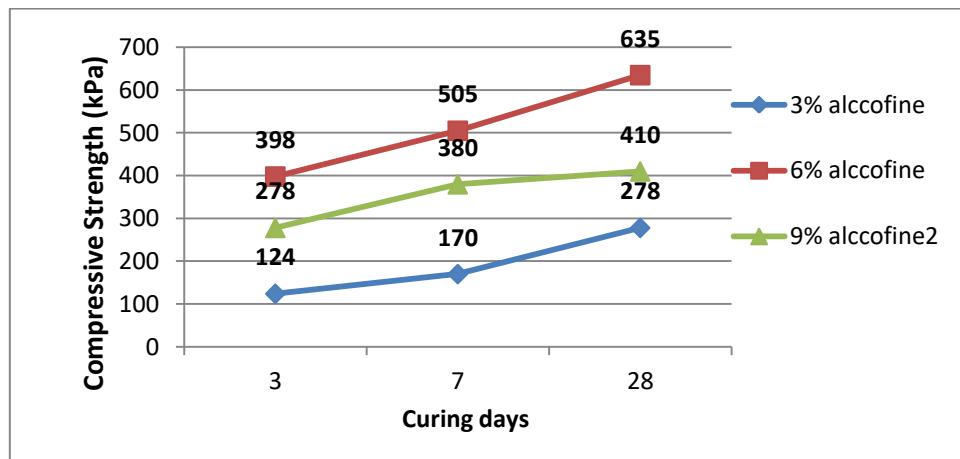


Fig. 4.2 Compressive strength v/s curing days of 15 % BKD with 3%, 6%, 9% of Alccofine 1101 with various proportions of Soil

Figure 4.2 shows the compressive strength of mix having 15 % BKD with 3%, 6%, 9% of Alccofine 1101 for different curing periods of 3 days, 7 days and 28 days. The 3% curve shows that there is little increase in the compressive strength as the days of curing increases. The 6% of Alccofine 1101 shows much increase in the values as compared to 3% addition of Alccofine 1101. The best result has given by 6% addition of Alccofine. In 9% addition there is increase in the compressive strength as the curing days increase but it is less than addition of 6% of Alccofine 1101.

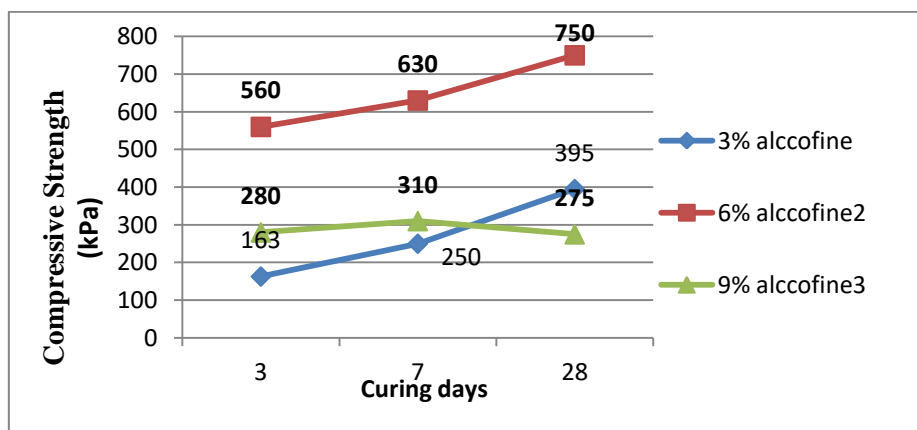


Fig. 4.3 Compressive strength v/s curing days of 20 % BKD with 3%, 6%, 9% of Alccofine 1101 with various proportions of Soil

Figure 4.3 shows the compressive strength of mix having 20 % BKD with 3%, 6%, 9% of Alccofine 1101 for different curing periods of 3 days, 7 days and 28 days. The 3% curve shows that there is increase in the compressive strength as the days of curing increases. The 6% of Alccofine 1101 shows very much increase in the values as compared to 3% of Alccofine 1101. The best result has given by 6% of Alccofine 1101. The 9% of Alccofine 1101 leads to less increase in the compressive strength as the curing days as compared to 3% and 6% addition of RBI Alccofine 1101.

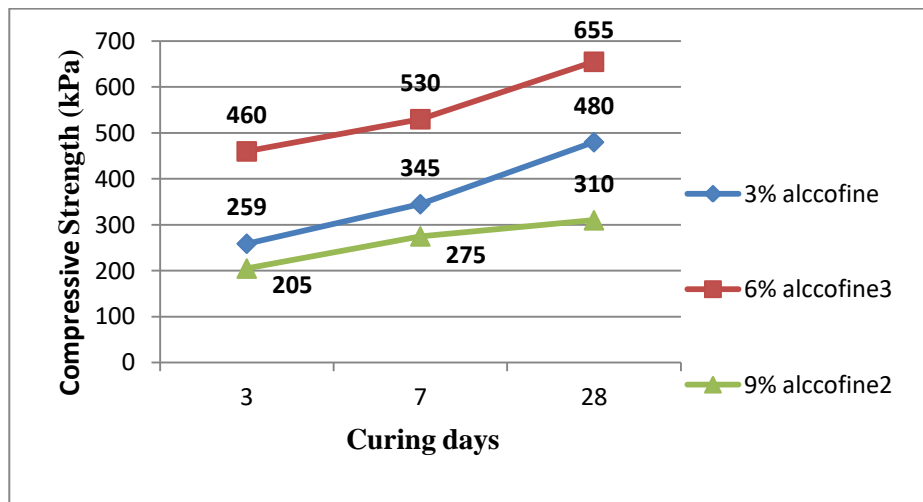


Fig. 4.4 Compressive strength v/s curing days of 25 % BKD with 3%, 6%, 9% of Alccofine 1101 with various proportions of Soil

Figure 4.4 shows the compressive strength of mix having 2 % BKD with 3%, 6%, 9% of Alccofine 1101 for different curing periods of 3 days, 7 days and 28 days. The 3% curve shows that there is increase in the compressive strength as the days of curing increases. The 6% of Alccofine 1101 shows very less increase in the values as compared to 3% of Alccofine 1101. The 9% of Alccofine 1101 leads to less increase in the compressive strength as the curing days as compared to 3% and 6% addition of RBI Alccofine 11011.

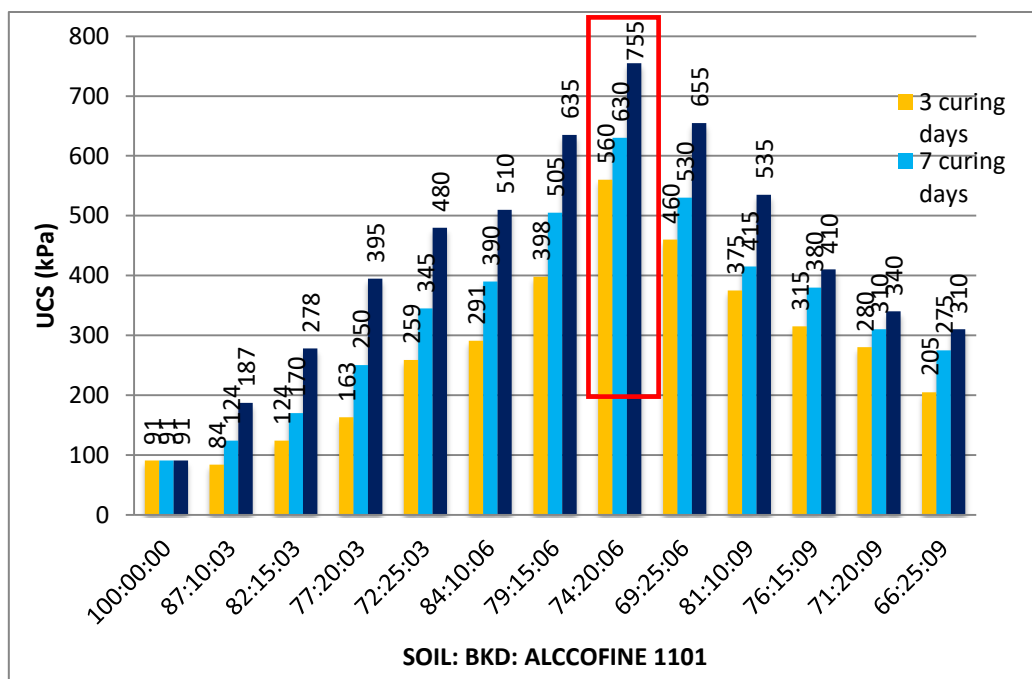


Fig. 4.5 UCS values with various proportions of soil, BKD and Alccofine 1101 at 3,7,28 curing days

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Vol. 8, Issue 12, December 2019

From Fig 4.5 it is observed that as we go on increasing the %age of BKD and Alccofine 1101 in soil, the value of UCS also keeps on increasing and reaches a maximum value of 755 kPa for 28 curing days at a mix of 74:20:06.

CALIFORNIA BEARING RATIO

California bearing ratio (CBR) value of a soil or stabilized soil is a crucial parameter in depicting the viability of the soil for engineering use. It gives us an idea about the strength and bearing ability of the soil.

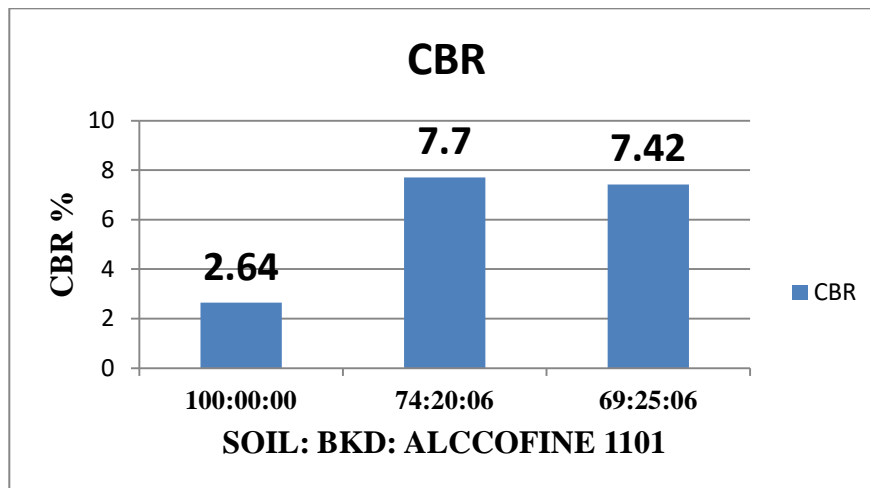
The variation of the CBR of soil mixtures with BKD and Alccofine1101 contents are given in Fig. 4.9 The CBR gave a peak value at 74:20:6 (SOIL: BKD: ALCCOFINE 1101).

It was noticed that, though, the value of the CBR showed increment with higher additive contents at higher compactive efforts, the compactive efforts do not have appreciable effect on the values of the CBR.

TABLE 2 CALIFORNIA BEARING RATIO TEST RESULTS FOR SOIL: BKD: ALCCOFINE 1101 MIXES

SOIL: BKD: ALCCOFINE 1101	CBR
100:00:00	2.64
74:20:06	7.7
79:25:06	7.42

Figure 4.14 CBR value for different mixes



V. CONCLUSION

- Optimum mix as per UCS test is found to be 74:20:06 i.e soil: BKD: Alccofine1101
- The compressive strength of soil from UCS test increases from 91 kPa(3days) with the addition of BKD and Alccofine 1101 till it becomes maximum i.e 560 kPa (3day) for optimum mix (74:20:6) and then goes on decreasing. The same increasing pattern is observed for 7 and 28 curing days.
- The unconfined compressive strength also increases with the increase in curing days of optimum mix
- The increase in compressive strength is due to pozzolanic reaction taking place between lime and silica in presence of moisture.

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Vol. 8, Issue 12, December 2019

- The CBR value is also found to increase from 2.64 with increase in percentage value of BKD and Alccofine 1101 till it attains maximum value i.e 7.7 For optimum mix (74:20:6) & the increase in CBR is due to pozzolonic reaction.

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