International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 11 | Nov 2019 www.irjet.net p-ISSN: 2395-0072

AMENDMENT OF GEOTECHNICAL PROPERTIES OF CLAYEY SOIL USING BRICK KILN DUST AND ALCCOFINE 1101

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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 Liquid limit test, plastic limit test, standard proctor test 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.*

Key Words: Alccofine 1101, Brick kiln dust, Stabilizer, Clayey soil, Atterberg limits, Compaction test.

1. 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 cementious 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 cementious 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

1.1 LITERATURE REVIEW

Abhineet Godayal et al. (2018) The use of alccofine alone as a stabilizer shows little improvement in the CBR value of clayey soil.. The dosage of 4.5% lime and 2.5% alccofine by weight of soil can be taken as optimum to stabilize the soil. There is increase in compressive strength of soil from 2.65kg/cm^2 for virgin soil up to 7.55 kg/cm^2 (without curing) and 16.10kg/cm^2 (14 days curing) for 4.5% lime and 2.5 % alccofine, Results show that there is 65% increment in UCS without curing and UCS value increased by 83.5% after 14 days curing. With the increase in amount of alccofine there was decrease in liquid limit and plastic limit that leads to decrease in plasticity index of soil.

Amit Talgotra et al. (2017). The alccofine percentage being kept 2.5% and varying CKD %age as 10,15,20% respectively giving out various conclusions.. There was a sharp increase in UCS with addition of alccofine at all ages indicating the abnormal

and high strength behavior of alccofine. The specific gravity was found to increase with addition of CKD and increases further with addition of alccofine. The amount of CKD and alccofine added did not cause significant changes in the maximum dry density as well as optimum moisture content.. The compressive strength was found to be maximum at 28 days with 15% CKD and 2.5% alccofine indicating the optimum percentage of both alccofine and cement kiln dust. There were increases in the values of CBR with higher additive contents at higher compactive efforts with a peak value of 22.57% recorded at 15% CKD (10% of sand weight): 2.5% alccofine.

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/m^2 to 180 kN/m^2 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.

Mohd Khaliq Ahmed et al. (2016) The practice involves adding three proportions 30%, 40%, and 50% of BKD with expansive soil. With increasing amount of stabilizer swelling decreases. Maximum decrement in swelling has been noted in 50% of replacement of soil by brick dust. Also by increasing stabilizing content linear shrinkage reduces. Maximum decrement in shrinkage has been noted in 50% replacement of soil by stabilizer. MDD of soil is improving and OMC is decreasing with increasing BKD. For increasing content of stabilizing agent brick dust atterberg's limit values are also decreasing.

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%.

Sachin N. Bhavsar et al. (2014) The study involves combination of Black cotton soil with 30%, 40%, and 50% brick dust. It has been observed great decrement in swelling and shrinkage of soil. The liquid limit values for 30% replacement are nearly equal to 33 which 22% less than the black cotton soil value, As same for 40% replacement liquid limits value decrease by 24.41% and for 50% brick dust it reduced by 31.86%. Reduction in plastic limit value for 30, 40, 50 % burnt brick dust are respectively 23.29, 24.42, & 32.35 %. Reduction in plasticity index for 30, 40, 50 % brick dust are respectively 21.34, 24.44, & 31.57 %. For replacement of soil MDD is increasing by 5.84%, 9.64%, & 13.27% for 30%, 40%, & 50% brick dust respectively. And OMC for the same is decreasing by 13.99%, 20.90%, & 35.34% than the black cotton soil.

1.2 MATERIALS USED AND METHODOLOGY

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

Fig 1. Clayey soil

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.

Fig 2. Brick Kiln dust

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.

- Alccofine 1101: **-** It contains high calcium silicate. It is a micro finer cementious 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.

Fig 3. Alccofine 1101

2. Tests Involved

The main aim and objectives of the requisite work is to amend the various geotechnical properties of clayey soil using BKD and Alccofine 1101, To attain those objectives of the requisite work, following tests ought to be performed as per Indian standard codal provision:

- Atterberg's limits test (IS: 2720, Part-V),
- Compaction characteristics test (IS: 2720, Part-VII)

Atterberg's limit test is done to evaluate the condition of soil in which it exists. Atterberg's limit test gives an idea about, the classification and compressibility behavior of the soil, with the help of which it is found that if soil is highly compressible or least compressible. The compressibility behavior can be checked with the help of liquid limit and plasticity index value in the Plasticity chart. The following Atterberg's limits were determined:

- Liquid limit
- Plastic limit
- Plasticity index

As the water is added to the dry soil it helps in getting the soil particles near to each other by engulfing them with a thin cover of water. When the water content is low, the behavior of soil is stiff and is difficult to get them closer to each other. But as soon as the water content is increased the stiff soil particles start to get packed under a given compactive effort and try to obtain least space, thereby increasing the dry density. At a particular instant after increasing further water content in soil, the volume of soil reduces to minimum, thus the dry density at this stage shifts to maximum value called as maximum dry density & the water content at this stage is called as optimum water content. If water is increased beyond optimum water content the dry density starts decreasing. So apart from obtaining the values of liquid limit, plastic limit and plasticity index of the soil admixture, we need to examine the soil for compaction characteristics. For that purpose we need conduct compaction characteristic test. The test evaluates the soil for the calculation of two important characteristics:

- Maximum dry density (MDD)
- Optimum moisture content (OMC)

3. RESULTS AND DISCUSSIONS

3.1 ATTERBERG LIMITS:

Table 1: Variation of LL, PL and PI for Various Proportions Of Soil, BKD And Alccofine 1101

Soil: BKD: ALCCOFINE1101	Liquid limit (LL)%	Plastic Limit (PL)%	Plasticity index (PI)%
100:00:00	51.6	26.5	25.1
87 : 10 : 3	49.2	27.2	22
82: 15 : 3	48.2	27.5	20.7

77 : 20 : 3	47.5	27.9	19.6
72 : 25 : 3	46.7	28.2	18.5
84 : 10: 6	46	28.8	17.2
79 : 15 : 6	45.4	29.4	16
74 : 20 : 6	**43.5**	**30.3**	**13.2**
69 : 25 : 6	44.1	29	15.1
81 : 10: 9	45.3	28.5	16.8
76: 15 : 9	46.7	27.3	19.4
71 : 20 : 9	47.2	26.7	20.5
66 : 25 : 9	48.5	25.8	22.7

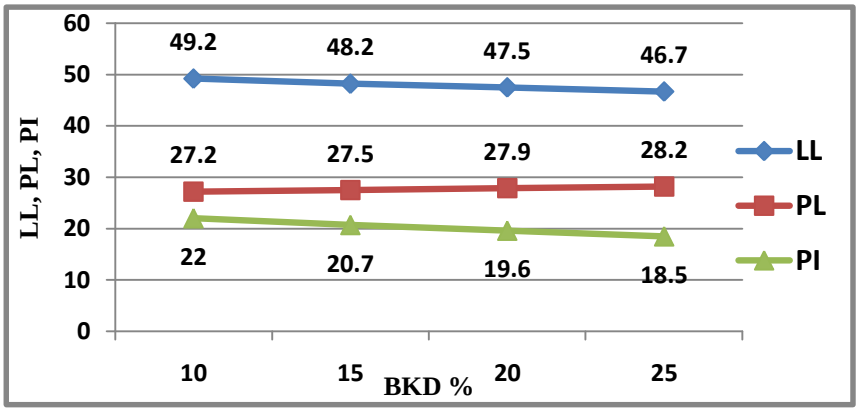

Fig. 3.1 BKD% vs consistency limits of mixture for 3% Alccofine 1101

Figure 3.1 shows the consistency limits i.e. liquid limit, plastic limit and plasticity index of the clay mixed with 3% of Alccofine 1101 with 10 %, 15 %, 20 %, and 25% of brick kiln dust. It shows that at 3% Alccofine the liquid limit of the mix decreases as the content of BKD increases. In case of plastic limit the effect is opposite i.e. PL increases. The plasticity index curve shows same results as liquid limit.

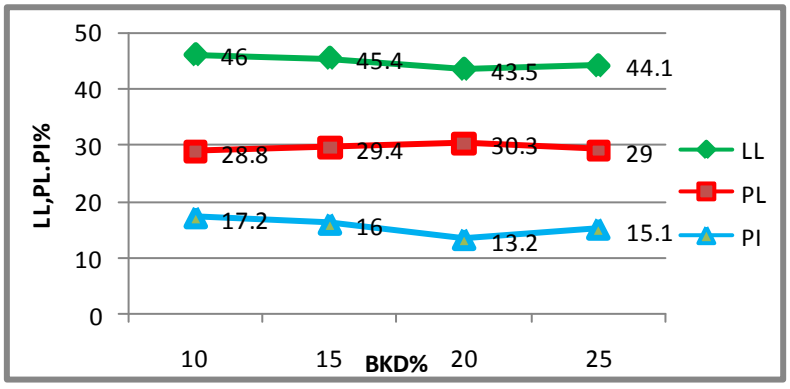

Fig. 3.2 BKD% vs consistency limits at 6% Alccofine 1101

Figure 3.2 shows the consistency limits of the clay mixed with 6% of Alccofine with 10%, 15 %, 20%, and 25% of BKD. It shows that at the 6% of Alccofine liquid limit of the mix decreases as the content of BKD increases at 20% BKD after that liquid limit increases. In case of plastic limit there is increase in the value with increase in BKD content at 20 % after that it decreases. The plasticity index curve shows same results of liquid limit.

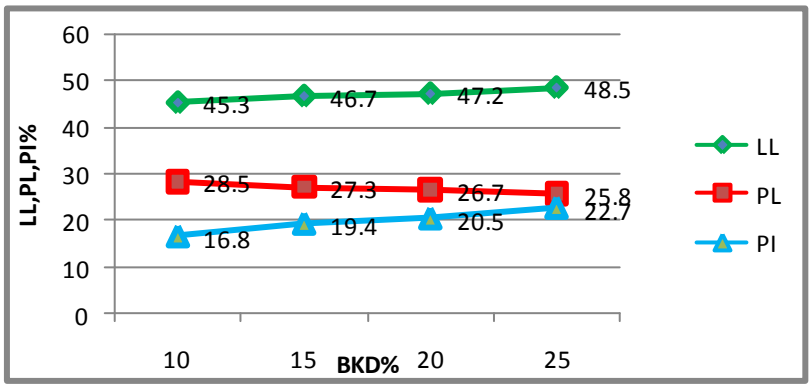

Fig. 3.3 BKD% vs consistency limits at 9% Alccofine

Figure 3.3 shows the consistency limits of the clay mixed with 9% of Alccofine with 10%, 15 %, 20 %, and 25% of BKD. It shows that at 9% of Alccofine the liquid limit of the mix increases as the content of BKD increases. In case of plastic limit there is decrease in the value with increase in BKD. The plasticity index curve shows increment in the results of plastic limit after 20% of BKD.

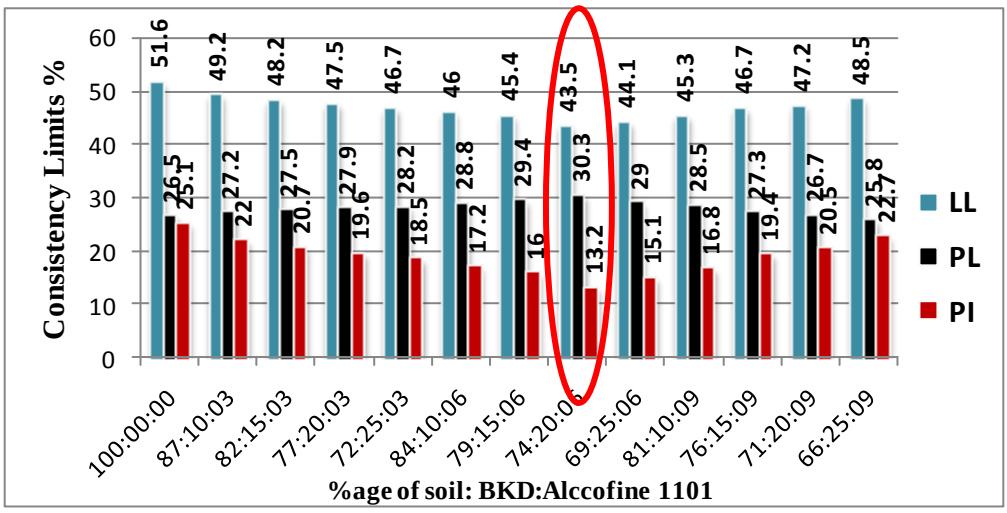

Fig. 3.4 %age of BKD: Alccofine vs consistency limits

Fig 3.4 shows variation of consistency limits with various mixtures of soil, BKD & Alccofine 1101. It can be clearly observed that the liquid limit decrease gradually up to mix 74:20:06 reaching minimum value i.e. LL=43.5 and then increases, while as plastic limit increases up to the same mix and becomes PL=30.3, and finally the plasticity index shows same behaviour as that of LL and its value at optimum mix becomes PI=13.2 and then increasing.

3.2 COMPACTION CHARACTERISTICS

Table 2: Variation Of MDD And OMC For Various Proportions Of Soil, BKD And Alccofine 1101

SOIL: BKD: ALCCOFINE 1101	MDD (g/cc)	OMC(%)
100:00:00	1.52	23.52
87 : 10 : 3	1.59	22.50
82: 15 : 3	1.65	21.22
77 : 20 : 3	1.71	19
72 : 25 : 3	1.74	18.4
84 : 10: 6	1.79	17.95

79 : 15 : 6	1.83	17.20
74 : 20 : 6	**1.88**	**16.28**
69 : 25 : 6	1.82	17.56
81 : 10: 9	1.76	18.75
76: 15 : 9	1.73	19.27
71 : 20 : 9	1.69	20
66 : 25 : 9	1.61	21.6

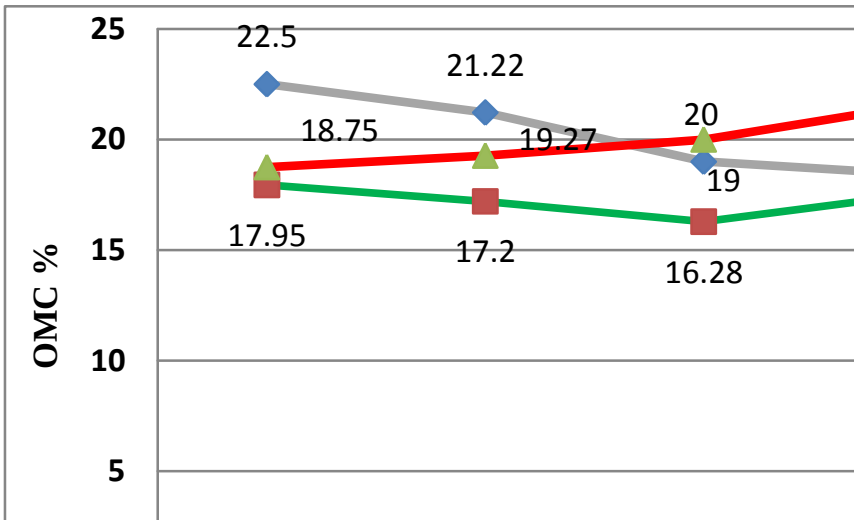

Fig. 3.5 BKD vs OMC for 3%, 6%, 9% Alccofine 1101

Figure 3.5 shows the optimum moisture content of 3%, 6% and 9% Alccofine 1101 at different proportions of brick kiln dust i.e. 10 %, 15 %, 20 %, 25%. As per the graph of 3% ALCCOFINE the OMC value decreases. In the 6% graph, value decreases upto 20%, then increases. In the case of 9 % addition of Alccofine value increases.

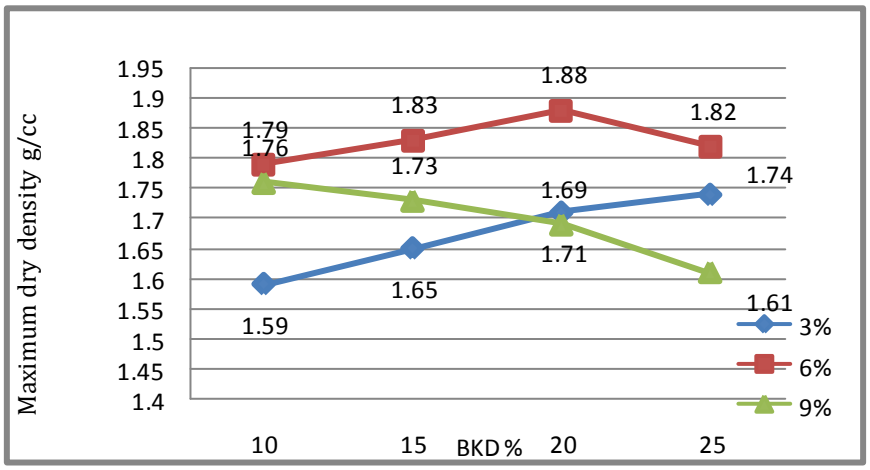

Fig. 3.6 BKD% vs MDD (g/cc) for 3%, 6%, 9% Alccofine 1101

Figure 3.6 shows the maximum dry density of 3%, 6%, and 9% Alccofine at different proportions of BKD i.e. 10 %, 15 %, 20 % & 25%. As per the graph of 3% Alccofine1101 the MDD value goes on increasing. In the 6% graph values increase upto 20 %, after that decreases. In the case of 9% addition of Alccofine values show gradual decrease till 20 % after that it shows a steep decrease.

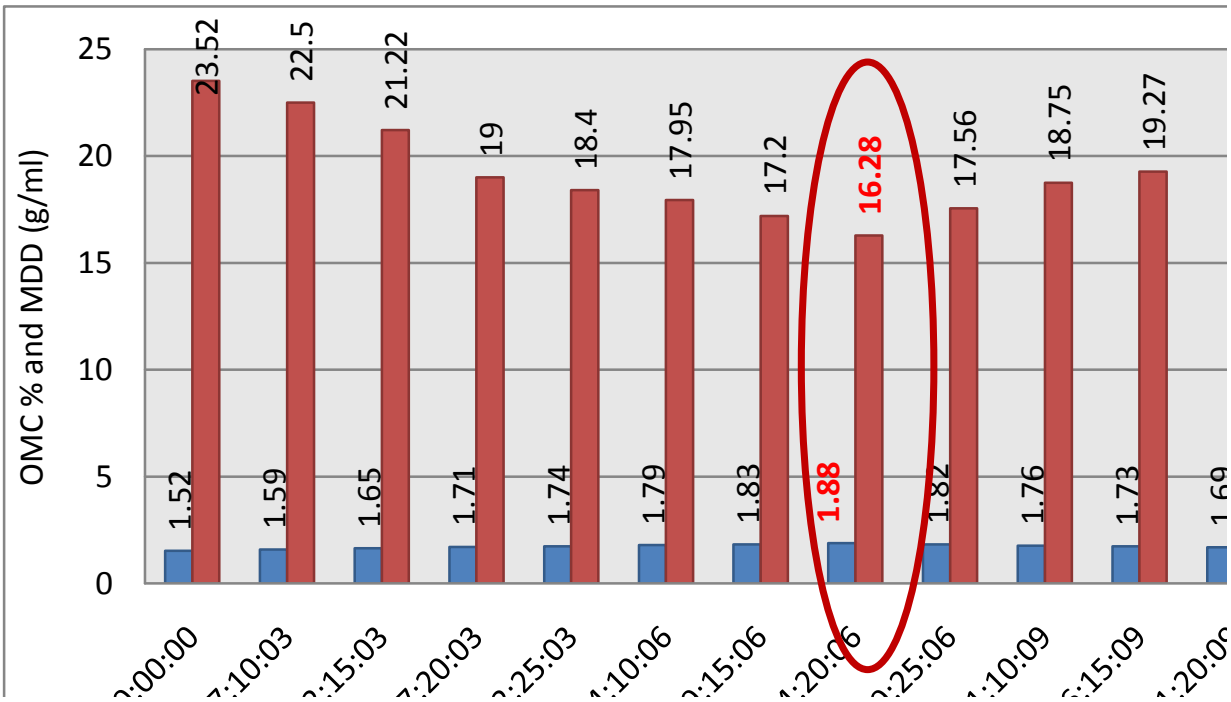

Fig. 3.7 soil mixture vs OMC % & MDD (g/cc)

From Fig 3.7 it can be clearly depicted that as we go on increasing the %age of BKD and Alccofine 1101 in soil, the value of MDD also keeps on increasing and reaches a maximum value of 1.88 g/cc at a mix of 74:20:06. On the contrary the value of optimum moisture content (OMC) goes on decreasing and reaches minimum value of 16.28 for the same mix. Thereby indicating the optimum mix as 74:20:06.

3. CONCLUSIONS

1. The optimum mix is found to be 74% soil, 20% BKD and 6% Alccofine 1101 on the basis of consistency limit test and compaction test.

2. Liquid limit starts decreasing as we increase the %age of BKD and Alccofine 1101 in the mixture upto optimum mix, same pattern is observed for the case of plasticity index, however on increasing the %age of BKD and Alccofine 1101 the value of plastic limit goes on increasing upto optimum mix.

3. The values of consistency limits for optimum mix (74:20:6) are found to be as follows, LL=41, PL=25, PI=13.2.

4. The MDD increases from 1.52 to 1.88 and OMC decreases from 23.52 to 16.28 upto optimum mix (74:20:06) with increase in percentage of Alccofine 1101 and Brick Kiln Dust into the soil.

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