Feasibility of lime stabilized black cotton soil in flexible Pavements

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Abstract: *This study aims at understanding the strength of subgrade in terms of CBR values subjected to different days of soaking and the corresponding variation in moisture content. Initially all basic Geotechnical properties like Specific Gravity, liquid limit, plastic limit, Plasticity index, Shrinkage limit, Free Swell Index, Grain Size Distribution of Black Cotton Soil were determined. In the later stages CBR tests were performed on various proportions of lime stabilized soil mixes such as 2, 5, 8 and 10(%by weight) percentages. Maximum strengths were obtained at 28 days curing period for all proportions of mixes so that this period is decided as optimum curing period. Eventually this research facilitates an economical, strong and durable construction material for the construction of Flexible Pavements.*

Keywords: *cotton soil , flexible*

I. Introduction:

Flexible Pavement consists of a layer system of materials which distribute the wheel loads to the subgrade. The thickness of individual layer must be such as to distribute the loads without deformation of the material, thereby presenting an uneven running surface. Flexible pavement may be constructed in a number of layers and the top layer has to be of best quality to sustain maximum compressive stress, in addition to wear and tear. Flexible pavement layers reflect the deformation of the lower layers on to the surface layer (e.g., if there is any undulation in sub-grade then it will be transferred to the surface layer). In the case of flexible pavement, the design is based on overall performance of flexible pavement,

and the stresses produced should be kept well below the allowable stresses of each pavement layer. The main objective of this research work is to provide strong and durable material for Flexible pavements. (Holtz & Gibbs, 1956) has discussed wetting and drying process causes vertical movement in the soil mass which leads to failure of a pavement, in the form of settlement, heavy depression, cracking and unevenness. Balasubramaniam, (et. al, 1989) was discussed Black Cotton soil has a high percentage of clay, which is predominantly montmorillonite in structure and black or blackish grey in colour. Bell, (1993) was discussed the black cotton soils possess low strength and undergo excessive volume changes, making their use in

the constructions very difficult. Akawwi and Al-Kharabsheh (2002) were expressed the swelling and shrinkage potential of soils are affected by mineralogical constituents and surrounding environment and recorded best result when 3.5 – 5 % quicklime by dry weight of soil was used to improve and stabilize expansive soils in Amman, Jordan. Dobrowolski (1998); Malhotra and Mehta (1996); Cokca (2001) was discussed by Using industrial by-products such as fly ash, blast furnace slag, cement kiln dust, and limestone dust, among many others, as additives to civil engineering construction materials helps arrest their hazardous effects on the environment and reduce construction costs.

II. Testing materials

Black cotton soil (BCS): Black cotton soil (BC soil) is a highly clayey soil. The black colour in soil (BC soil) is due to the presence of titanium oxide in small concentration. Cotton grows well in the black colour soil and hence it is named a Black Cotton Soil. The soil sample for the present research work was collected from Tolusurupalle which is located nearby Tekkali in Srikakulam Dist.

Lime: It is a hydraulic lime $Ca(OH)_2$ for the stabilization of soil which was brought from locally available local chemical laboratory.

iii. Results and discussions: A detailed experimental work was carried out on black cotton soil and lime stabilized black cotton soil mixes. The experimental results are as follows: The Geotechnical properties of Black cotton soil are as shown below:

Table .1 Represents the Properties of Black cotton soil.

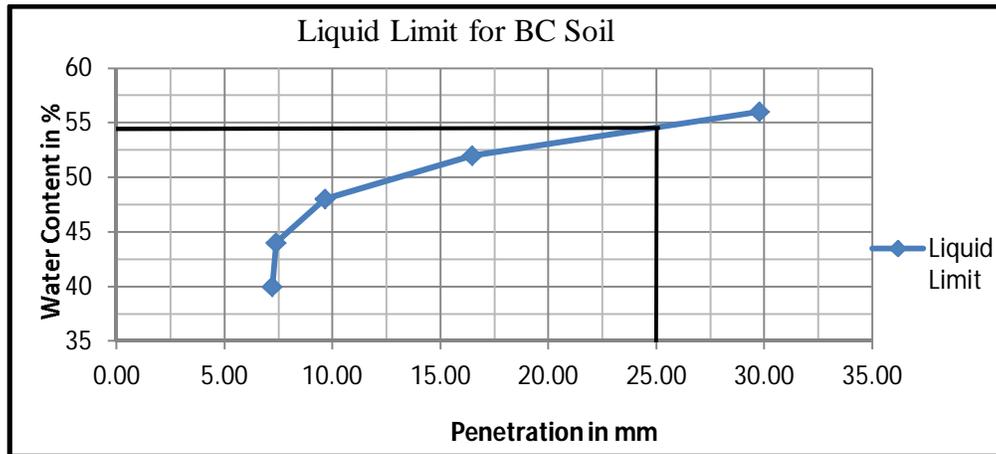| Property	Value
Color	Dark Grey to Black
Free Swell Index (%)	56
Specific Gravity	2.80
Liquid limit (%)	54.5
Plastic limit (%)	20
Plasticity index	34.5
Shrinkage limit(%)	16
OMC(%)	17.5
MDD(g/cc)	1.83
CBR (%)	3.9
P^H	8.9

Fig.No.1 Shows the Liquid limit for Black cotton soil at 25mm penetration

The liquid Limit of the sample was determined using Digital cone penetrometer apparatus i.e Uppal's Method the curve is as shown in the Figure No.1

Table 2 The Geotechnical Properties of Black cotton Soil stabilization with Lime.

Property	Value
Free Swell Index(%)	20
Specific Gravity	2.68
OMC(8%)	23
MDD(g/cc)	1.72
CBR(8%)	18
P^H	11.90

Sieve Analysis:
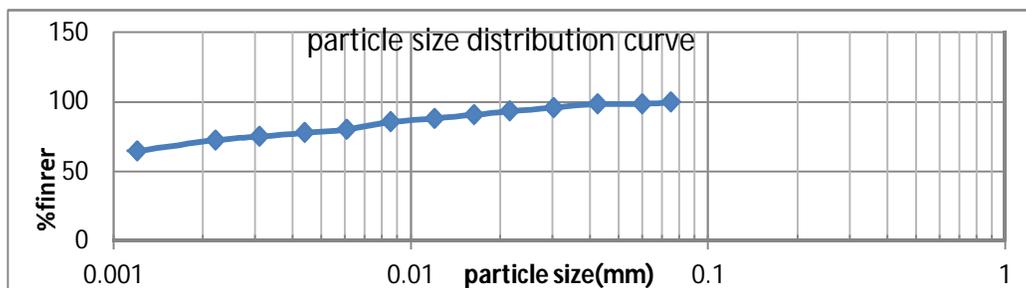
Fig no: 2 shows that black cotton soil consists of 65% of clay which

pH:

The pH was tested for various percentages of lime i.e., 2, 5, 8 and 10 by dry weight of soil mass. pH for lime-stabilized soils are in the range

causes more swelling and shrinkage behaviour.

of 10-12. For Black cotton soil pH value is 8.90. The pH varies by adding of lime percentages as shown in below Table no.3

Table .3 shows the variation of pH for different % of lime

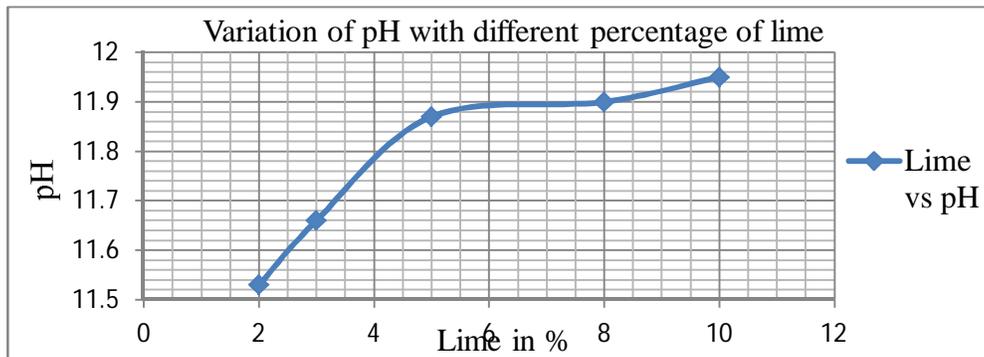| LIME (%)	pH
0	8.50
2	11.53
5	11.87
8	11.90
10	11.95

Fig..3 shows the variation of %pH for different % of lime

From observed that Table no. 3 and Fig no. 3 shows the variation of pH values of Black cotton soil and Lime mixes. As % of lime increases an increase in pH was observed. The increase in pH is due to high lime content.

Free Swell Index:

Free swell Index was tested for all proportions of mixes. The values are as shown below.

Table.4 Shows the Variation of Free Swell Index with changing % of Lime

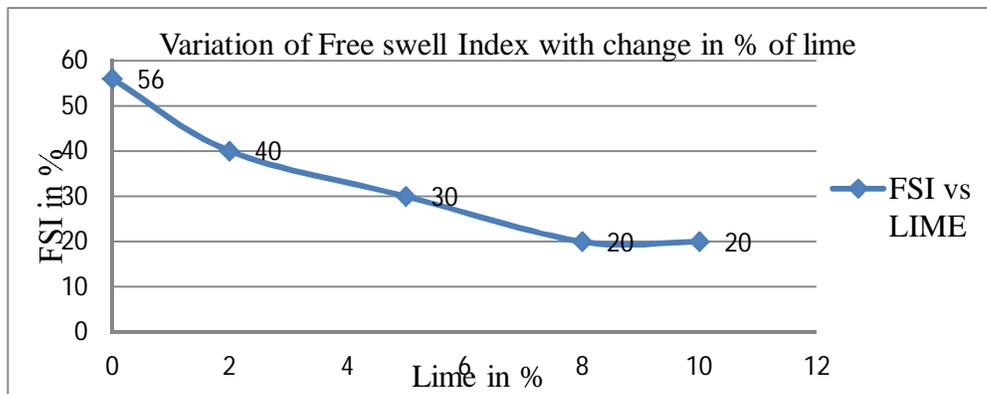| MIX (%)	free swell index in %
BCS+0%lime	56
BCS+2%lime	40
BCS+5%Lime	30
BCS+8%Lime	20
BCS+10%Lime	20

Fig 4. Shows the variation of swelling index values

Table 4 and Fig 4. Shows the variation of swelling index values. The main cause for swelling is the presence of Montmorillonite in major percentage. It is observed from the above figure that there is a reduction in swelling with increase in percentage of lime. The addition of lime helpful in controlling the swelling behaviour of black cotton soil. The variation is remarkable upto 8% addition of lime later on no considerable change was observed. It is concluded from the fig no 4 that more dosage of lime beyond 8% becomes waste in the mix which is not involved in reactions.

Compaction Characteristics: Compaction characteristics like OMC (optimum moisture contents), MDD (maximum dry densities) were tested for various percentages of lime i.e., 2, 5, 8 and 10 by dry weight of soil mass as per IS: 2720 (part VII) - 1980.

Table .5 Variation of OMC and MDD with changing % of LIME

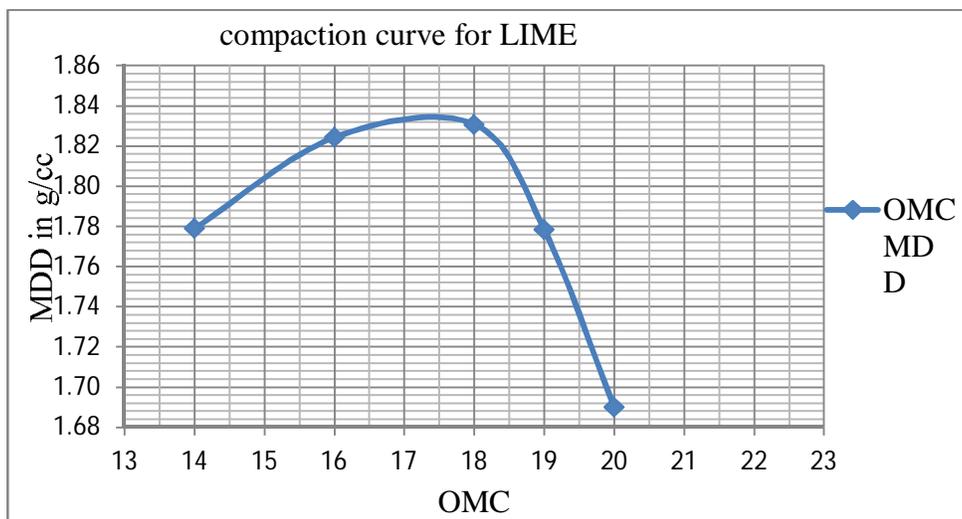| % of lime	OMC (%)	MDD (g/cc)
0	17.5	1.84
2	19.5	1.77
5	21	1.73
8	23	1.72
10	25	1.78

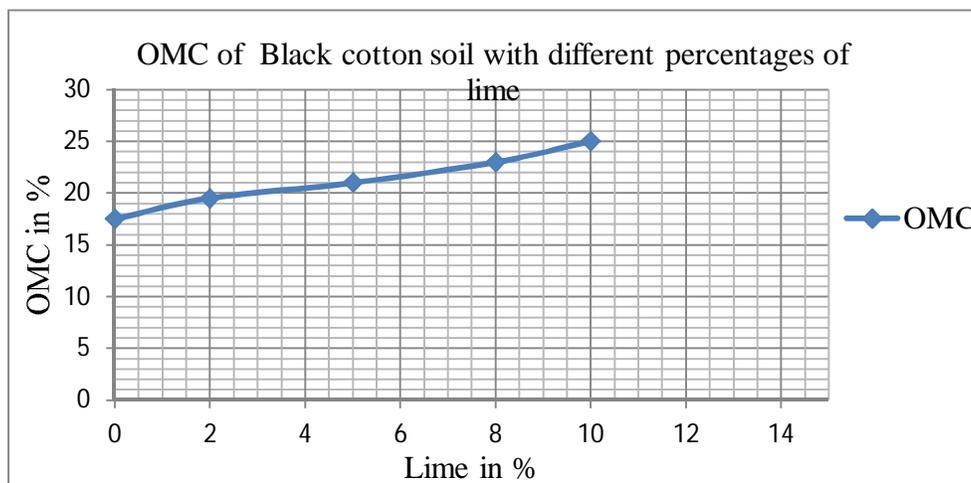Fig.5 Shows the OMC and MDD for Black cotton soils

Fig.6 Shows the Variation of OMC with changing % of LIME

Fig's 5, 6 show the variation of optimum moisture content values of Black cotton soil and lime mixes. As % of lime increases an increase in OMC was observed. The increase in OMC is due to high water content needed for effective mobility of particles under flocculation condition. This increase in OMC values was observed and this increase is up to 10% addition of lime.
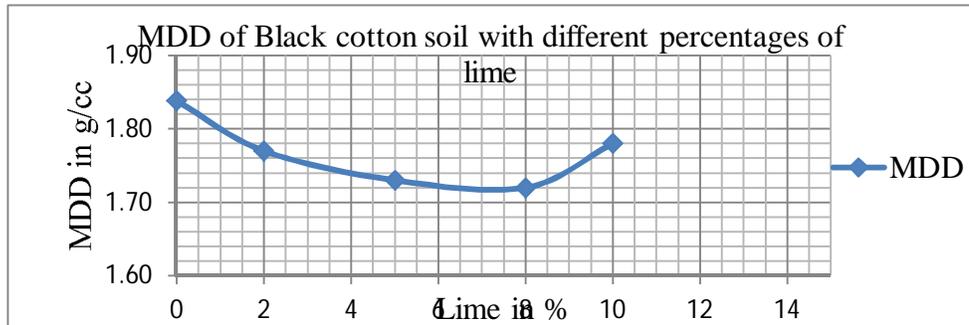

Fig.No.7 Shows the Variation of MDD with changing % of LIME

Table   5 and Fig   7 shows the variation of maximum dry density values of Black cotton Soil and lime mixes. As % of lime increases a decrease in MDD was observed. The decrease in MDD is due to flocculation of soil particles when lime added to it, the more dosage of lime leads to the increase in void ratio, because of the formation of more voids a decreased trend was observed in MDD values.   This decrease in MDD is effective up to 10% lime beyond that no much variation was observed.

California Bearing Ratio (CBR):

The sample of nearly 4.5 to 5 kg was compacted in a mould of volume 2250cc with 5 layers and 56 blows were given for each layer. All the prepared samples were cured for 7 days and 28 days by maintaining 100% humidity. The sample is loaded until splitting / failure load takes after completion of their curing period at a strain rate of 1.25 mm/min. this test was conducted as per IS 2720 part 16.

Table 6 CBR % for Soaked and Unsoaked conditions for different % of lime

% of Lime	Soaked Condition		Unsoaked Condition	
	7days	28days	7days	28days
0	2	2.3	2.7	3.9
2	2.4	2.5	3.2	5
5	3.1	4.5	6.2	12
8	5.8	10	12.2	18
10	5.6	9.8	11.4	17

The increase in CBR is due to effective hydration that took place in the lime soil mixes. The curing period helped in occurrence of agglomeration in the mixes. Consequently the strengths have been increased. The dosage of 8% lime was decided as optimum which has shown higher CBR values and the 28 days was decided as optimum curing period which has given maximum strengths. This is because of increase in calcium oxide content in the mixes which is predominant in enhancing the CBR values.   It is observed from the experimental findings that there is an increase of % in CBR values up to optimum percentage addition i.e. 8%lime, later on no much variation was observed in increase of strengths of the mixes so that this percentage addition was decided as optimum percentage.
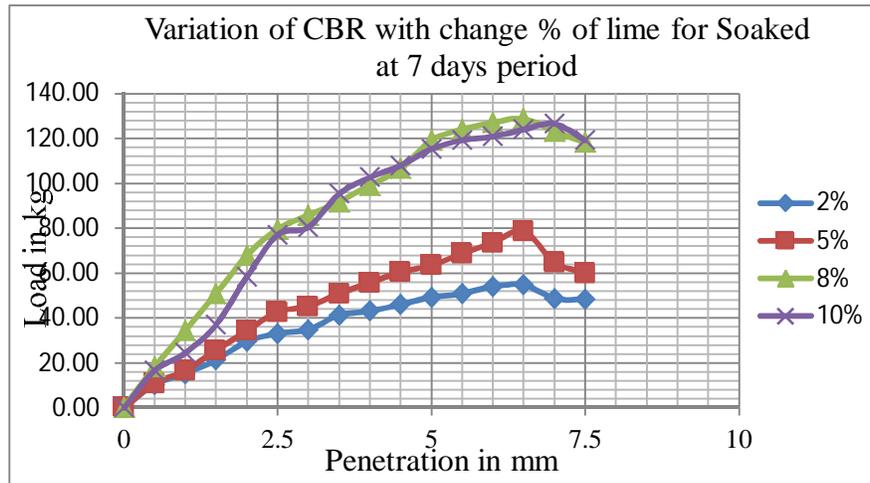

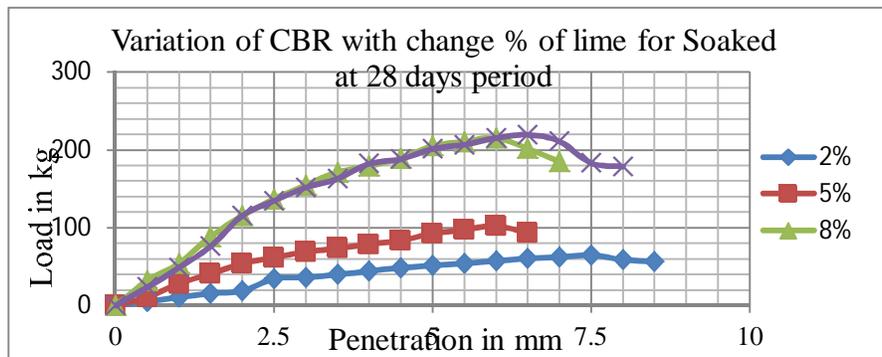Fig.8 CBR% for soaked condition with changing % of Lime at 7days period

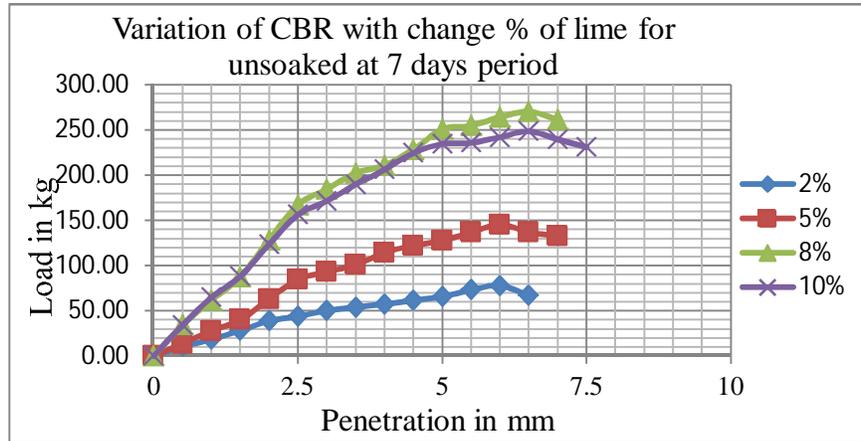Fig.9 CBR% for soaked condition with changing % of Lime at 28 days period

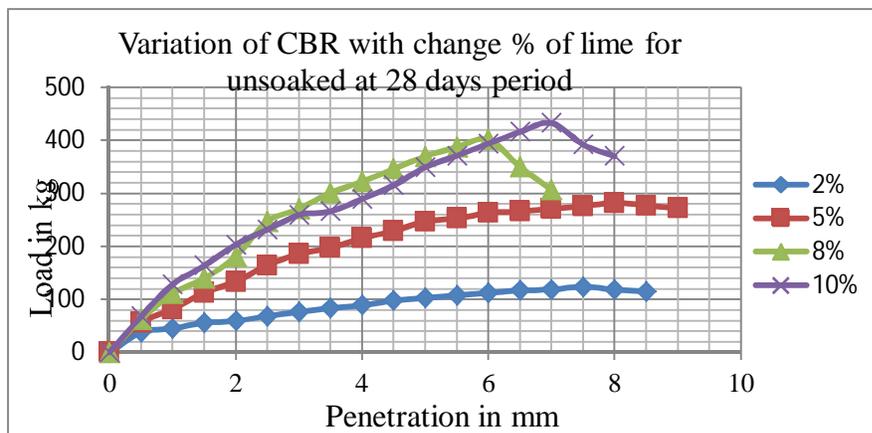Fig.No. 10 CBR% for unsoaked condition with changing % of Lime at 7days period

Fig.11 CBR% for unsoaked condition with changing % of Lime at 28 days period

From observed that Fig.No.11 represents the variation of CBR values for every percentage of lime at both conditions of Soaked and Unsoaked at 7 days and 28 days period.

As lime increases CBR values are increasing for all percentages of lime and for all conditions. At 8% lime dosage the CBR values for 7days and 28 days for unsoaked conditions are 12.2% and 17% respectively. The values were increased upto 8% lime addition this is due to increase in percentage of Calcium oxide and effective flocculation. The formation of flocs developed the strong bonds among the particles. From the test data it was observed that the addition of lime more than 8% did not show
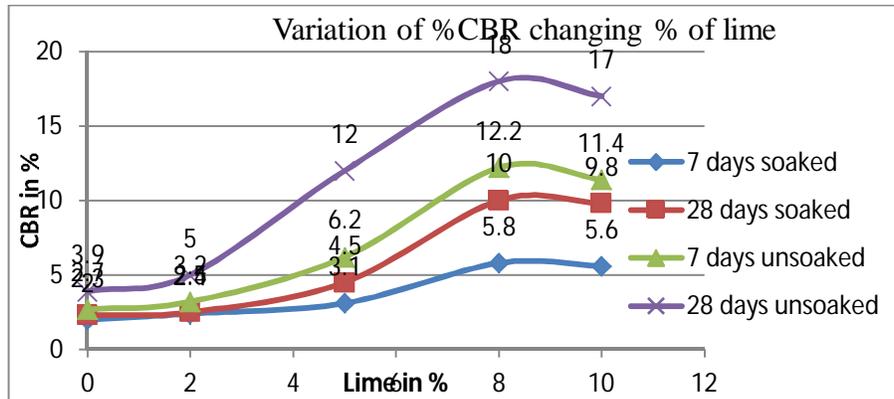
any considerable variation in the   CBR values.

Fig.12 shows the variation of %CBR for different % of lime

IV. Conclusion:

➢ The percentage increase in lime decreases the maximum dry density(MDD) and increases the optimum moisture content(OMC)

➢ Optimum values are attained at 8% of lime for all the proportions.

➢ It is observed from all experimental results that the certain proportions of Lime added to the soil improved the CBR values.

➢ The optimum content of the lime was 8% for the soil at both Un soaked & soaked conditions for 7 and 28 days.

➢ Maximum strengths were obtained at 28 days curing period for all proportions of mixes so that this period is decided as optimum curing period.

➢ The values obtained in Unsoaked condition are greater than soaked condition for all proportions of mixes and for all curing periods.

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