

CBR Values of Black Cotton Soil and Fly Ash Blend in Soaked and Unsoaked Conditions for Road Pavements

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Abstract: The experimental research work brings out the effect of Raichur Fly Ash (RFA) and Nyveli Fly Ash (NFA) on California Bearing Ratio (CBR) of Black Cotton soil. For road construction this blend is useful. CBR of soil fly ash mixtures are calculated in compacted status and making blend subjected to soaking condition. In unsoaked conditions they show better readings because of extra added resistance from forces due to capillary action, for instance when 20% of RFA is blended along with B C soil under unsoaked condition, CBR found to be 10.38%. In presence of water, fly ashes capillary action reduces and gives lower CBR and CBR of 4.56% for addition of same quantity of RFA is revealed. Fly ash with mineral calcium, they can generate cementitious gel and adds strength to complex mix. By mixing of cement to RFA and calcium to NFA, the strengths of blends increases. CBR of soils with RFA shows peaks at fly ash doses of 20% and 80%. The CBR of soil by adding NFA, increases due to soaking. CBR of soil with NFA addition increases continuously with fly ash content. It is observed that when 20% NFA is mixed to soil, the CBR in unsoaked status is 11.46%, but for soaked condition it is seen that as 23.62%.

Keywords: Black cotton soil, Calcium, California bearing ratio (CBR), Capillary forces, Fly ash, Soaked, Unsoaked.

I. INTRODUCTION

Inadequate strength of soils is a serious constraint to take up any development activity. Before starting main projects, these soils are expected to be evaluated and assure proper alterations by one or the other means, so that soil can be made stable one in construction area. It is aware that the engineering property of soil improves notably by mixing of fly to soils, which depends on the amount of fly ash and time of curing period. CBR of

soil fly ash mixtures attain notable importance in their utility for pavements and road works. CBR can be modified depending on the soaking condition of mix. Thus CBR of soil fly ash blends are determined as compacted and also in soaked status.

II. MATERIALS AND METHODS

A. Black Cotton Soil

Available black cotton soil containing montmorillonite as key clay mineral is used. Soil is a residual one and was gathered from an open well, at a depth of one meter below ground level. The soil was dried and made to pass through IS sieve 425 microns before using in this work. The physical properties of the black cotton soil are shown in Table I and the chemical compositions are in Table II.

TABLE I: SHOWS PHYSICAL PROPERTIES OF BLACK COTTON SOIL

Property	Value
Colour	Black
Specific gravity	2.37
Atterberg's limits	
a) Liquid limit (%)	55
b) Plastic limit (%)	38
c) Plasticity index (%)	17
Compaction characteristics:	
a) Optimum moisture content (%)	34
b) Maximum dry density (kN/m ³)	13.65
Unconfined compressive strength (kN/m ²)	310
Permeability (cm/sec)	1.796x10 ⁻⁷
Consolidation characteristics:	
Coefficient of consolidation, <i>c_v</i> (mm ² /sec)	1.2
Compression index	0.21

TABLE II: SHOWS CHEMICAL PROPERTIES OF BLACK COTTON SOIL

Chemical composition	Percentage
Silica, (SiO ₂)	52.85
Alumina, (Al ₂ O ₃)	12.24
Ferric Oxide, (Fe ₂ O ₃)	8.04
Calcium Oxide, (CaO)	6.01
Magnesium Oxide, (MgO)	2.94
Titanium Oxide, (TiO ₂)	0.24
Potassium Oxide, (K ₂ O)	0.48
Sodium Oxide, (Na ₂ O)	0.26
Loss of ignition	16.18

B. Fly Ashes Used

a. Raichur Fly Ash (RFA)

Raichur fly ash is procured from Raichur Thermal Power plant station, of Karnataka state. RFA is having specific gravity of 2.02. Chemical analysis shows that the soluble silica and free lime content in fly ash are considerably low.

b. Neyveli Fly Ash (NFA)

Neyveli fly ash is procured from Neyveli Thermal Power station, of Chennai, Tamilnadu. NFA has non-plastic property showing a specific gravity 2.0. Chemical analysis reveals that base soluble silica content of 5.61% and free lime content of 3.92% are available. CBR of fly ashes under un-soaked conditions shows higher readings because of extra resistance from capillary action. In presence of water fly ashes loses all capillary forces and arrives at lesser value of CBR. In cases of fly ash with calcium, they form cementitious gel and add strength to mix, which increases the CBR also in soaked status. Addition of cement to RFA and lime to NFA, the resistance of blends improves.

III. METHODOLOGY

According to IS 2720 part XVI, CBR tests were carried out in the laboratory to determine the CBR values of Fly ash and Fly ash – Soil mixtures.

$$\text{CBR Percent} = \left(\frac{\text{Unit Load Carried by sample at defined penetration}}{\text{Unit Load Carried by standard Crushed stones at above penetration}} \right) \times 100$$

The CBR values are considered at 2.5 mm penetration for both samples and standard crushed stones.

IV. RESULTS AND DISCUSSIONS

A. Effect of RFA on CBR of B C Soil

Table III and Fig. 1 shows the variation of CBR both soaked and unsoaked conditions of B C soil and RFA mixtures. The CBR of B C soil in unsoaked condition is 3.86% and 1.71% in soaked condition. For RFA CBR is 6.54% in unsoaked condition and

3.14% in soaked condition. The reduce in CBR of RFA upon soaking is due to less cementing property of their particles. The CBR of B C soil increases considerably by the mixing of 10% of RFA. Also increases further with increase in fly ash adding up to mix 20% and reaches 10.38% in un-soaked status. It is interesting to note CBR of soil fly ash mixture is higher than fly ash values.

However the CBR of soil fly ash mixture reduces with further additions of fly ash beyond 20% and up to 60%. However, the CBR again changes with change in fly ash amount. One more peak is also observed by addition of 80% of RFA to BC soil. Hence two peaks of CBR are seen at 20% and 80%. The peak with 20% is greater than the reading at 80% fly ash. Similar behaviour of soil fly ash mixture giving two peaks was explained by Prof. Sridharan et al., (1997) for unconfined compressive strength values. Soil and fly ash mixture with the skeleton of soil fly ash particles are controlled by either soil or fly ash which gives more strength.

TABLE III: SHOWS CBR BOTH SOAKED AND UNSOAKED CONDITIONS OF B C SOIL AND RFA

RFA, %	CBR, Unsoaked, %	CBR, Soaked, %
0	3.86	1.71
10	9.31	3.78
20	10.38	4.56
30	7.84	3.64
40	6.79	3.14
50	5.32	2.8
60	5.02	2.61
70	7.59	3.77
80	8.13	4.12
90	6.93	3.71
100	6.54	3.14

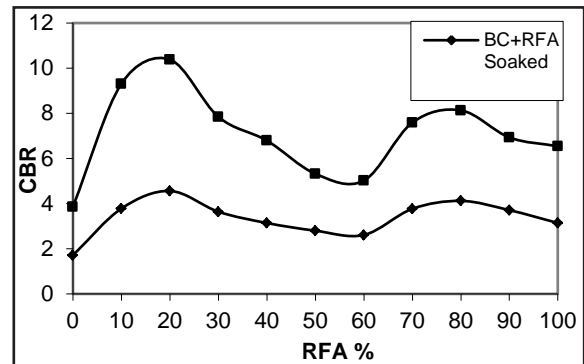


Fig. 1: Shows CBR of B C soil and RFA mixtures

The CBR of soil in soaked condition also improve with addition of fly ash up to 20% and then decreases. The CBR of any soil fly ash mixture decreases considerably by soaking. The highest CBR in soaked condition is 4.56% with 20% fly ash. With further addition of RFA, the CBR decreases again up to 60%

addition of fly ash. When fly ash content is increased the CBR in soaked condition increases and reaches another peak when RFA addition percentage is 80%. Thus 80% addition of RFA gives second peak values for CBR 8.13% in unsoaked condition and 4.12% in soaked condition.

TABLE IV: SHOWS C B R OF B C SOIL AND NFA MIXTURES

NFA, %	CBR, Unsoaked, %	CBR, Soaked, %
0	3.86	1.71
10	8.34	10.13
20	11.46	23.62
30	12.02	32.74
40	15.24	47.69
50	19.23	68.42
60	21.37	80.27
70	24.64	94.93
80	27.38	99.66
90	29.23	110.72
100	33.24	119.7

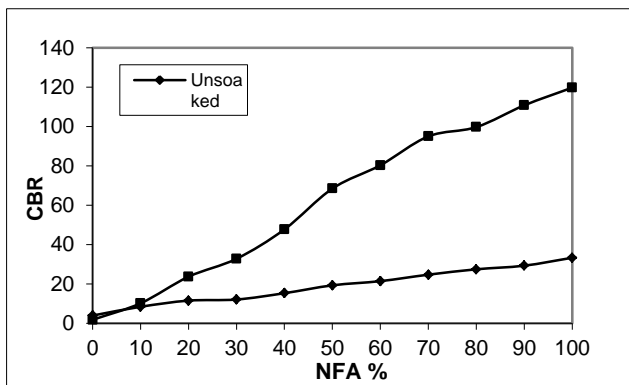


FIG. 2: SHOWS VARIATION OF CBR OF B C SOIL AND NFA MIXTURES

The CBR of B C soil continuously increases with increasing additions of NFA. For 20% addition of NFA, the CBR is 11.46% in unsoaked condition and 23.62% in soaked condition. At 80% addition of NFA, the CBR is 27.38% in unsoaked condition and 99.66% in soaked condition.

B. Effect of NFA on CBR of B C Soil

Table IV and Fig. 2 show the variation of CBR of soil with NFA under soaked and unsoaked condition. The CBR of NFA alone in unsoaked condition is 33.24% and in soaked condition it is 119.7%. The high increase in CBR is due to pozzolanic reactivity of NFA, which produces cementitious compounds when soaked with water. It was also shown that NFA gives high unconfined strength with curing. NFA gives very high CBR even without specific curing period because of sufficient

strength that is lapsed in testing. Also the CBR of NFA increases with curing unlike in RFA, where the CBR decreased upon soaking. This further supports the high pozzolanic reactivity of NFA. Since NFA has got more calcium compared to RFA, it generates cementitious gel in soaked condition and imparts strength, thereby increasing CBR values of blends.

V. CONCLUSION

- The CBR of soil improve marginally with less pozzolanic RFA compared to pozzolanic NFA.
- The CBR of soil with RFA decrease considerably on soaking. CBR of soils with RFA exhibits pronounced peaks at fly ash contents of 20% and 80%. This is due to predominance of skeleton of soil and fly ash respectively.
- NFA increases steeply the CBR of soils. The CBR of soils with NFA further increase with soaking. CBR of soils with NFA increase continuously with fly ash content.

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