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# Laboratory Investigations on Stabilization of Soil with Fly-ash

Harpreet Singh[1], S.N.Sachdeva[2], Rakesh Manocha[3]

[1] *M.Tech student, Department of Civil Engineering, National Institute of Technology Kurukshetra, Haryana-136119,*
[2] *Professor, Department of Civil Engineering, National Institute of Technology, Kurukshetra, Haryana-136119, India,*
[3]*Engineer-In-Chief, PWD B&R , Haryana, Chandigarh*

***Abstract— Fly ash is a waste by-product of the thermal power plants. Its disposal is not only problematic but also environmentally hazardous to the nearby habitations. Some fine grained soils are problematic due to their settlement, swelling and strength issues when used in road subgrade / embankment. High strength soil in subgrade is recommended by IRC:37-2012, the code for design of flexible pavement. It recommends the use of selected soil of minimum CBR 8% in the subgrade where the traffic is more than or equal to 450 Commercial Vehicle Per Day (CPVD) . Quite often, large areas are covered with highly plastic and expansive soil, which is not suitable for subgrade / embankment and the idea of replacing the whole soil is very uneconomical. As fly ash is freely available, for projects in the vicinity of a thermal power plants, it can be used for stabilization of fine grained soils for various uses. This paper brings forth the work of various studies carried out for the improvements in the properties of such soils with fly ash in varying proportions (10%, 20%, 30%) and its combined effect with cement (1%).***

***Keywords— California bearing ratio (CBR); modified proctor test; Fly-Ash; Cement.***

## I. INTRODUCTION

In engineering practice, the earth construction requires compaction of existing sub grade by improving the density & strength of the strata. All types of earth structures i.e. highways, pavements etc. rest directly on the soil beneath them. The safety of these entities depends upon the strength/bearing capacity of the soil over which these are constructed. Therefore, a proper analysis of the soil properties and the design of their compression parameter become necessary to ensure that these structures remain stable and are safe against unequal settlements[4]. To determine the suitability of any soil type for use as sub grade, sub base or base material, one of the parameter generally used is the California bearing ratio (CBR). In order to attain the safety and stability requirements, the engineering properties of the soil beneath the structure must be identified. Soil compaction and California bearing ratio are the most commonly used properties in engineering projects such as highways, railways and pavements. The rapid urban and industrial developments pose an increasing demand for the construction of highways, embankments and many other civil engineering structures. Hence barren lands, problematic soils, waterlogged areas, landfills and damping yards are to be brought to use for construction activities . The low strength soils need to be treated by means of a soil stabilization technique, which is the process of altering some soil properties by different methods, mechanical or chemical, in order to produce an improved soil material which has the desired engineering properties. Soils are generally stabilized to increase their strength and durability or to prevent soil erosion . The properties of soil varies from one place to other, also in certain cases for a particular place variation in behaviour of stabilized soil can be easily detected which consequently depends on soil testing. The strength of the sub-grade is expressed in terms of CBR value.

## II. IMPORTANCE OF STUDY

The topic "Laboratory Investigations on Stabilization of Soil with Fly-Ash" has been selected to determine the effect on California Bearing Ratio of subgrade soil with some variation of soil stabilizing materials. Clayey soil being expansive in nature has low CBR value resulting in poor strength of soil due to which usually replacement of soil is opted to overcome this problem. Stabilization improve the strength of soil and helps to reduce soil volume change due to temperature or moisture and Improves soil workability and this improved subgrade soil with higher CBR value reduces the pavement crust requirements.

## III. MATERIALS USED METHODOLOGY

Laboratory tests such as Sieve analysis, Liquid limit, Plastic limit, Modified proctor test and C.B.R. test (Un-soaked and Soaked condition) are performed on untreated soil samples and chemically stabilised mixes of soil is made by mixing with Flyash (10%, 20% and 30% by dry weight of soil), cement (1% by dry weight of soil) and in mixed proportion (20% Flyash + 1% cement ) have been carried out..

Modified proctor test has been performed for determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC). California bearing ratio tests were performed on untreated soil and stabilized mixes in un-soaked and soaked conditions using the standard method.

**Materials Used**

**Sub-grade soil**
A road stretch of 21 km in Kurukshetra (Haryana) has been selected for sampling of soil for the work to be carried out.

**Fly-ash**
Class C fly-ash manufactured from Rajiv Gandhi Thermal Power Plant at Khedar in Hisar ,Haryana is made available by the civil deptt. authorities of NIT, Kurukshetra.

**Cement**
Ordinary Portland cement (43 grade); manufactured by Birla Cement is used in the present study as one of the stabilizer is obtained from local market of Kurukshetra.

## IV. RESULTS AND DISCUSSION

The experimental results of untreated soil types are summarized in Table-1

**Table I:** Properties of untreated soil types

| S. N | Weight retained (gm) on IS sieve | | | | Atterberg limits (%) | | MDD (g/cc) | OMC (%) | CBR (%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 10mm | 4.75mm | .425mm | .075mm | LL | PI | | | Un-soaked | Soaked |
| 1. | 0 | 2.35 | 8.92 | 12.19 | 25.2 | 4.1 | 1.94 | 13.3 | 12.3 | 4.2 |
| 2. | 0 | 1.42 | 17.62 | 64.53 | 19.8 | 2.4 | 1.95 | 12.4 | 13.6 | 6.0 |
| 3. | 0 | 12.13 | 14.34 | 22.81 | 24.2 | 6.6 | 1.94 | 12.2 | 3.4 | 2.0 |

Table 1 indicates that all the samples selected for the study has 4 days soaked CBR value less than 8 % requiring suitable stabilization to increase their strength so as to make the subgrade suitable for high volume traffic road.

The typical results of experiments conducted on treated soil samples are shown in Table II, III&IV and in fig 1,2&3. .

**Table II :** Test results of treated soil type 1

| S.N. | Properties | Untreated | Flyash | | | Cement | Proportion |
|---|---|---|---|---|---|---|---|
| | | | 10% | 20% | 30% | 1% | 20%F.A+ 1%Cement |
| 1 | MDD (g/cc) | 1.94 | 1.95 | 1.96 | 1.96 | 1.93 | 1.92 |
| 2 | OMC (%) | 13.3 | 12.7 | 12.2 | 11.8 | 13.5 | 13.8 |
| 3 | CBR%(unsoaked) | 12.33 | 12.7 | 13.9 | 14.6 | 13.1 | 15.8 |
| | CBR % (Soaked) | 4.27 | 6.2 | 6.8 | 8.9 | 6.9 | 9.8 |

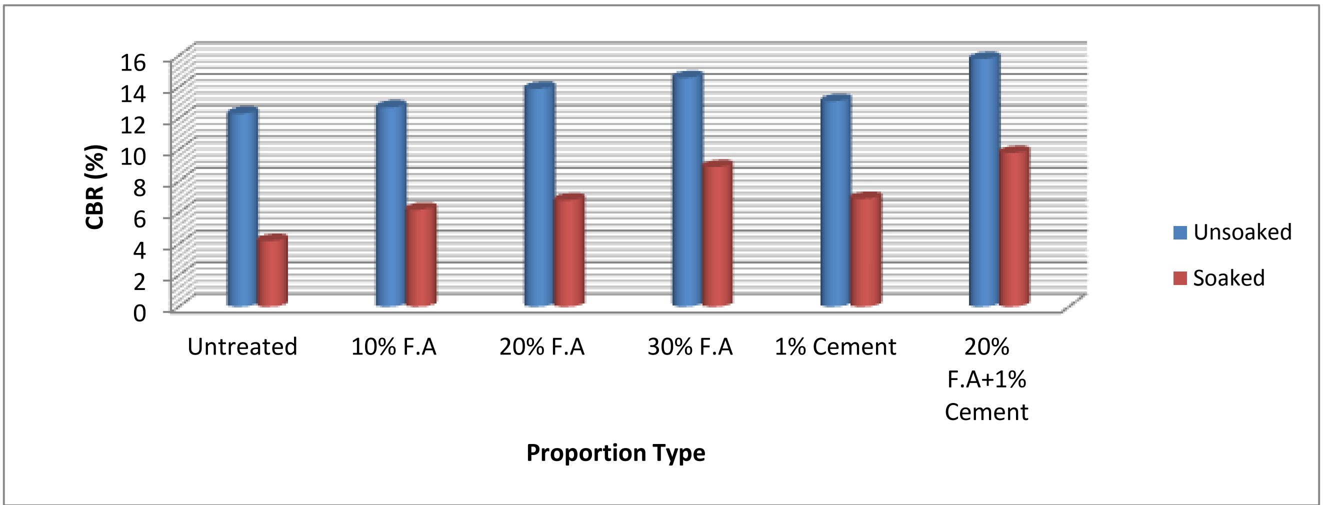


**Fig1:** CBR results of soil type 1 in unsoaked and soaked condition

**Table III:** Test results of treated soil type 2

| S.N. | Properties | Untreated | Fly-ash | | | Cement | Proportion |
|---|---|---|---|---|---|---|---|
| | | | 10% | 20% | 30% | 1% | 20%F.A + 1%Cement |
| 1 | MDD (g/cc) | 1.95 | 1.96 | 1.98 | 1.99 | 1.94 | 1.92 |
| 2 | OMC (%) | 12.4 | 12.1 | 11.8 | 11.4 | 12.7 | 13.2 |
| 3 | CBR%(unsoaked) | 9.6 | 10.5 | 12.2 | 15.8 | 11.7 | 16.3 |
| | CBR % (Soaked) | 5.9 | 7.2 | 9.6 | 10.4 | 7.8 | 10.8 |

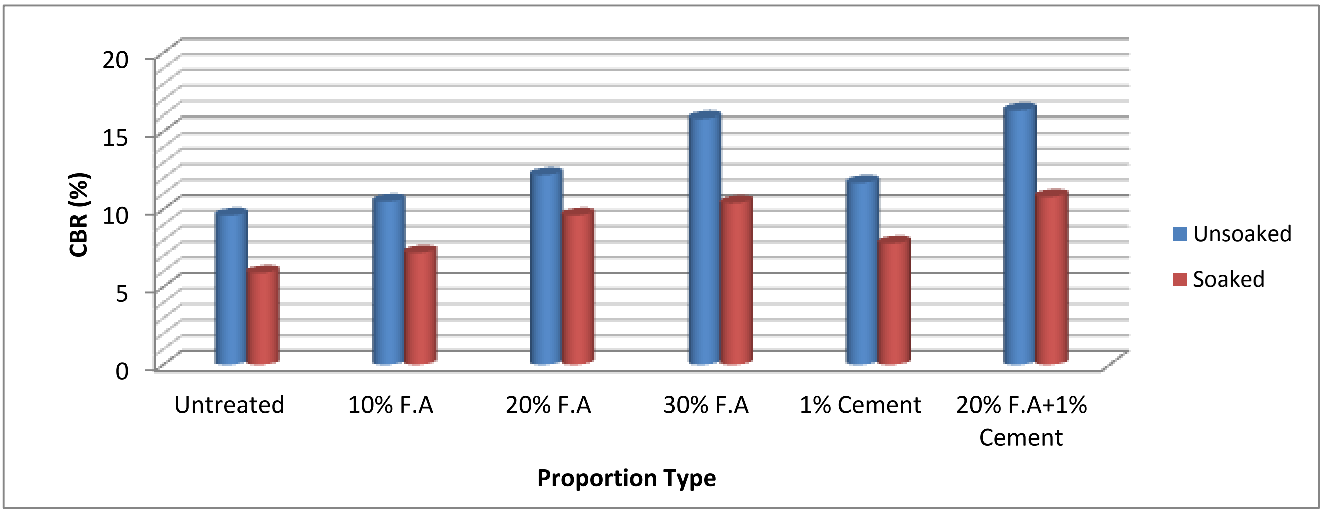


**Fig2:** CBR results of soil type 2 in unsoaked and soaked condition

**Table IV:** Test results of treated soil type 3

| S.N. | Properties | Untreated | Flyash | | | Cement | Proportion |
|---|---|---|---|---|---|---|---|
| | | | 10% | 20% | 30% | 1% | 20%F.A + 1%Cement |
| 1 | MDD (g/cc) | 1.94 | 1.95 | 1.96 | 1.98 | 1.94 | 1.92 |
| 2 | OMC (%) | 12.2 | 11.9 | 11.5 | 11.2 | 12.3 | 12.6 |
| 3 | CBR%(unsoaked) | 3.45 | 6.4 | 7.1 | 9.5 | 7.6 | 12.8 |
| | CBR % (Soaked) | 2 | 3.4 | 3.9 | 5.1 | 4.8 | 8.3 |

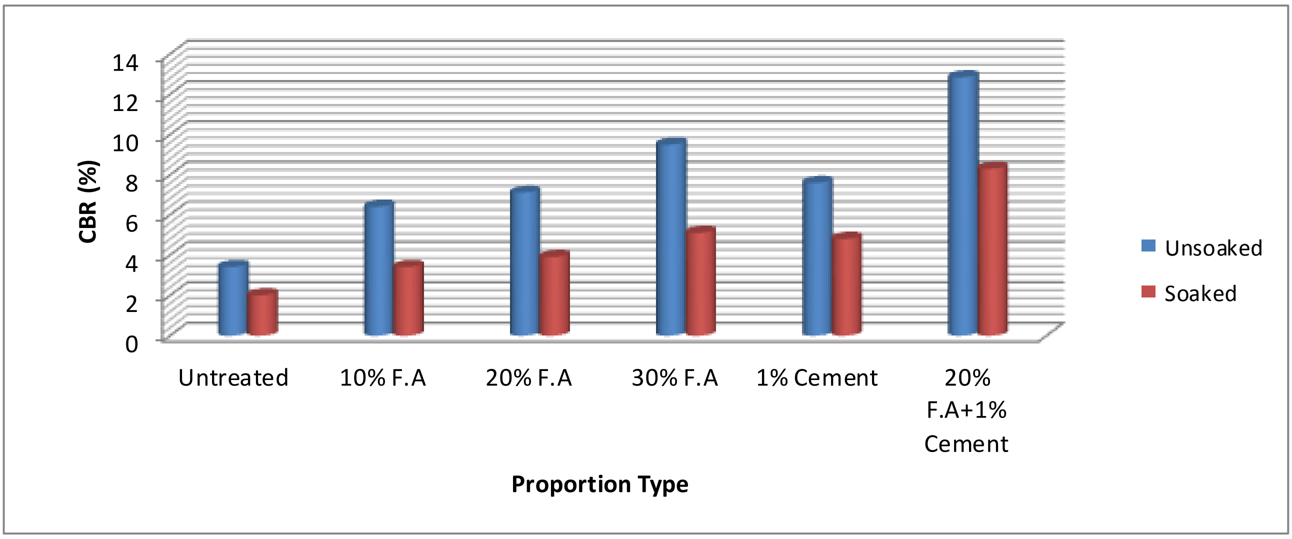


**Fig3:** CBR results of soil type 3 in Un-soaked and soaked condition

It is observed from Table II to IV and fig. 1 to 3 that CBR value under both un-soaked and soaked condition increases with addition of fly-ash and cement in various proportions. The MDD value is found to increase with the addition of fly-ash but decreases with the addition of cement.

## V. CONCLUSION

The experiments conducted show favorable results as the CBR of soil is enhanced by the inclusion of fly-ash and cement. The following conclusions are made from this study:

1. The MDD value of the soil types tested in the study is found to increase with the addition of fly-ash but decrease with the addition of cement.
2. Chemical stabilizers in the form of fly-ash (10%, 20% and 30% by dry weight of soil), cement (1% by dry weight of soil) and in mix proportion (20% fly-ash + 1% cement), increases the CBR value of the soil types considered in the study.
3. On adding cement, it increases the cementitious properties of fly-ash thereby increasing the CBR value to a great extent.

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