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INFLUENCE OF FLY ASH AND POLYPROPYLENE FIBRE ON THE CALIFORNIA BEARING RATIO OF FINE-GRAINED SOIL

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ABSTRACT

Soil stabilization is the most common ground improvement technique adopted to improve soil properties. Day by day soft ground creates problems in construction of structures due to its low shear strength and high compressibility. The valuable structures are sometimes collapsed due to excessive settlement while constructed on soft ground without adopting proper foundation system.

Soil improvement refers to the technique of improving soil by mixing some admixtures with soil to improve its shear strength behavior. This study went through a series of laboratory test of CBR of stabilized soil using fly ash and polypropylene fiber. Fly ash is industrial wastes left after the cement production while polypropylene fiber is made of plastic or polypropylene in using the production cement bag. In order to investigate the influence of fly ash in engineering properties of soil, varying proportion of fly ash 0 to 30% at an increment of 5% were added to soil. In the time of polypropylene fiber the fiber was added 0 to 5% at an increment of 1.5% were added to soil. In both of the case the soils were cured up to 4 days.

The Results have been shown that Maximum Dry Density increased with the increase of Admixture content while Optimum Moisture content decreased. CBR % increased up to 30% for fly-ash and for polypropylene fiber CBR increased from 0 to 3.5% and again decreased for 5% polypropylene fiber mixed with soil. So Shear strength increased for stabilized soil.

The findings of the test results identified that fly ash and polypropylene fiber mixed with soil increases the successive CBR value than normal soil. It can noted that soils stabilized with fly ash and polypropylene fiber will give much higher strength. Moreover Stabilized soils with fly-ash showed comparatively higher CBR value than that of stabilized soils with polypropylene fiber.

Keyword: *Fly-ash, Polypropylene Fibre, OMC, MDD and CBR.*

1. INTRODUCTION

Construction of residential buildings and other civil engineering structures on normal soil is highly risky. The average annual cost of damage to structures due to shrinkage and swelling is estimated about £400 million in the UK, $15 billion in the USA, and many billions of dollars worldwide (Jones, 2012). The strength of the underlying soil to be used as a subgrade material of highway and foundation is assessed from its CBR (California Bearing Ratio) value. Moreover for the foundation of civil infrastructure a civil engineer needs to ensure bearing capacity of underlying soil. This type of soil also shows low California bearing ratio (CBR) (Akshaya, 2014). To overcome this situation soil stabilization technique is necessary. Soil stabilization may be defined as any process by which a soil material is improved bearing capacity, increase in soil strength and durability under adverse moisture and stress conditions (Joel, 2011). Soil stabilization a general term for any physical, chemical, mechanical, biological or combined method of changing a natural soil to meet an engineering purpose. (Pamukcu, 1991). Before selecting stabilization techniques, the engineer must be aware of the potential problems of stabilization as well as it advantages. (Hicks, 2002). Successful stabilization has to depend on the proper selection of binder and amount of binder added. (S.a., 1999). Stabilization of soils with Portland cement will increase the service life of motor roads in areas where marl is used as a local road construction material. (Piskunov, 2017) The simplest stabilization processes are compaction and drainage (if water drains out of wet soil it becomes stronger). The other process is by improving gradation of particle size and further improvement can be achieved by adding binders to the weak soil. (Rogers, 1993). The components of stabilization technology include soils and or soil minerals and stabilizing agent or binders (cementitious materials) (Al Tabbaa, 2005). Presence of organic matters, sulphates, sulphides and carbon dioxide in the stabilized soils may contribute to undesirable strength of stabilized materials. (NETTERBERG, 1984), (Sherwood, 1993). Moreover stabilized soils with PVC and HDPE increases the CBR and MDD value. (S. Rehab Bekkouche, 2016) In this study CBR value is computed of different Soil samples mixed with the admixtures fly-ash and polypropylene fibre. At first we have computed the CBR value of normal soil. Than Fly-ash with the percentage of 0-30 % at an increment of 5% mixed with the soil and successive CBR values were computed. Similarly 0-5 % polypropylene fibre at an increment of 1.5% mixed with the soil and CBR values were computed. The optimum moisture content increases with increasing binders. (Sherwood, 1993) The variation of the value of different admixture mixed with soil was compared. By this study we will able to evaluate and provide information for adequate and economical design during stabilization procedures. Stabilize soil through fly-ash and polypropylene fibre will also help for increasing the shear strength and bearing capacity of the soil.

2. METHODOLOGY

2.1 Collection of Soil Samples

The disturbed soil sample used in this study was collected from the KUET campus at a depth of 5 feet from the ground surface. The site of the soil sample was beside the Lake of IT Park which is situated in the KUET campus, Bangladesh. It was easily accessible and proper care was taken so that no loose soil was taken. About 40 kg soil was collected for conducting this study.

2.2 Laboratory Investigations

For proper characterization of soil samples different physical properties were measured through ASTM standard test methods. At first moisture content was determined of the soil and the soil was air dried. Than the soil sample was classified according to the different properties. However the soil which is collected was inorganic clays with low plasticity. The various soil tests were done following the ASTM test procedures. The physical and index properties of soil is depicted in Table 1.

Table 1: Physical and index properties of soil used in this study

Properties	Results
Liquid limit, LL (%)	34
Plastic limit, PL (%)	23.24
Shrinkage limit, SL (%)	18.37
Specific gravity, Gs	2.73
Moisture content, w (%)	33.19
Sand: silt: clay (%)	16.2:70.5:13.3
Optimum Moisture Content, OMC (%)	15.89
Maximum Dry Density, MDD (gm./cc)	1.55

Properties	Results
California Bearing Ratio, CBR (%)	4.52
Soil Type	ML

2.3 Preparation of Samples for Compaction

The samples were prepared by OMC at different percent of fly-ash. While mixing the soil fly- ash with water, was taken care to mix properly and also it was checked carefully that till any amount of lamb present in the soil. The mold use in the experiment has a diameter of 6 inch and height 7 inch. At first the soil sample was prepared without mixing any fly-ash and polypropylene fibre except water with same quantity of OMC. The sample was then compact by standard proctor of 10 lb weight and 12 inch height of fall. The method was applied as the ASTM D698. At first the spacer disk was placed on the base plate and the top of the plate was placed a filter paper. Then the mold placed over the spacer disk and the sample was then poured into the mold by three layers and the Compaction conducted per layer was 56. After compacting three layers the mold was levelled its surface and the mold was clamped with base plate. But after the 0% fly-ash and polypropylene fibre the samples were prepared with the soil by the proportion of 0% fibre with 5,10,15,20,25,30% fly-ash were mixed. Again with 0% fly-ash 0.5, 2, 3.5, 5% polypropylene fibre were prepared and taken for 0 day cure and 4 days soaking. A sample of soil mixed with 0.5% polypropylene fibre is given in Figure 1.

Figure 1: Preparation of sample

2.4 Curing of the Samples

After the preparation of compacted samples for 0 day curing the samples were placed in the water for wet curing and the molds were sinks in the water (Figure 2). The water used in the curing was as the room temperature. The water temperature varies from 32 to 35 degree centigrade. The sample is cured up to 4 days and the figure is given bellow in Figure 2.

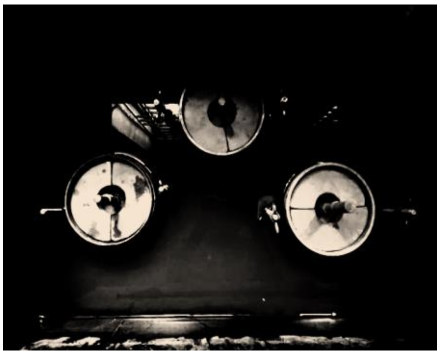


Figure 2: Curing of Samples

2.5 Testing of the Samples

CBR machine is a gradual loading machine which measures load with respect to deformation. The molds were placed in the machine by removing surcharge and by wooden pieces the samples were tighten hardly. Then a collar and surcharge placed over the mold. A deformation meter was attached with the machine. By making the loading gauge as zero, the load was gradually applied. The deformation was conducted for 0, 0.25, 0.50, 1.0, 1.25, 1.50, 2.0, 2.5, 3.0, 3.5, 3.75, 4.0, 4.5, 5.0, 6.0, 7.5, 10 and 12.5 mm respectively. Also at the same time, the corresponding load value was recorded. A CBR test conducting with CBR mold is shown below in Figure 3.

Figure 3: Testing of Samples

3. RESULTS AND DISCUSSIONS

To investigate the effect of the mixing amount of admixtures on fine-grained soils, the compaction properties and CBR of stabilized soils were analysed and hence discussed in the following articles.

3.1 Compaction properties

The maximum dry density (MDD) and optimum moisture content (OMC) of stabilized soils with admixtures were measured and hence discussed in the following articles:-

3.1.1 Compaction Properties of stabilized soils with Fly-ash

Compaction test was done for different fly-ash (0-30) % at an increment of 5% mixed samples with soil. For different samples different moisture content (%) and corresponding Dry density (kN/m^3) were found. The variation of MDD with OMC of different percentage of Fly-ash mixed soil is shown in figure 4. For the different soil samples different value of dry density and moisture content has been plotted on a graph. Maximum value of dry density which was found in graph has been taken as MDD (kN/m^3) and maximum value of moisture content has been taken as Optimum moisture content OMC (%). For 0% fly-ash mixed soil MDD was found 1674.91 kg/m^3 and OMC 15.90%. For 5% fly-ash mixed soil MDD was found 1695.3 kg/m^3 and OMC 15.41%. For 10% fly-ash mixed soil MDD was found 1744.1 kg/m^3 and OMC 15.37%. For 15% fly-ash mixed soil MDD was found 1784.2 kg/m^3 and OMC 14.87%. For 20% fly-ash mixed soil MDD was found 1850.19 kg/m^3 and OMC 14.43%. For 25% fly-ash mixed soil MDD was found 1874.23 kg/m^3 and OMC 14.29%. For30% fly-ash mixed soil

MDD was found 1891.3 kg/m^3 and OMC 14.1%. By this result we have found that MDD increased for different percentage of fly-ash mixed soils and OMC decreased for fly-ash stabilized soils.

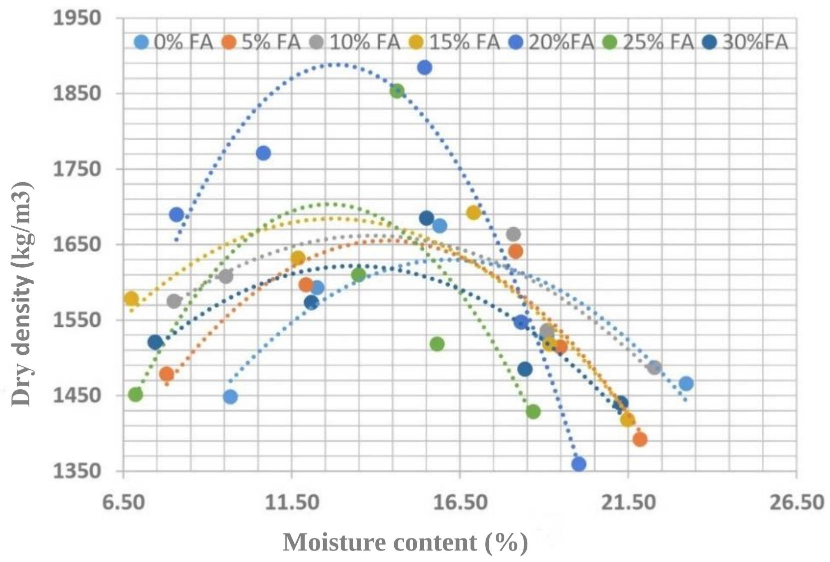


Figure 4: Variation of moisture content with dry density for fly-ash

3.1.2 Compaction Properties of Stabilized soils with Polypropylene Fibre

Compaction test was also done for different polypropylene fibre (0-5) % at an increment of 1.5% mixed samples with soil. For different samples different moisture content (%) and corresponding MDD (kN/m^3) were found. The variation of MDD with OMC of different percentage of polypropylene fibre mixed soil is shown in figure 5. For the different soil samples different value of dry density and moisture content has been plotted on a graph. Maximum value of dry density which was found in graph has been taken as MDD (kN/m^3) and maximum value of moisture content has been taken as Optimum moisture content OMC (%). For 0.5% fibre mixed soil MDD was found 1744.2 kg/m^3 and OMC 15.35%. For 2% fibre mixed soil MDD was found 1744.2 kg/m^3 and OMC 15.03%%. For 3.5% fibre mixed soil MDD was found 1897.5 kg/m^3 and OMC 14.23%. For 5% fibre mixed soil MDD was found 1784.5 kg/m^3 and OMC 14.59%. Based on this results MDD (kg/m^3) increased up to 3.5% fibre mixed soil and started to decrease again OMC (%) decrease up to 3.5 % and started to increase for polypropylene fibre mixed soils.

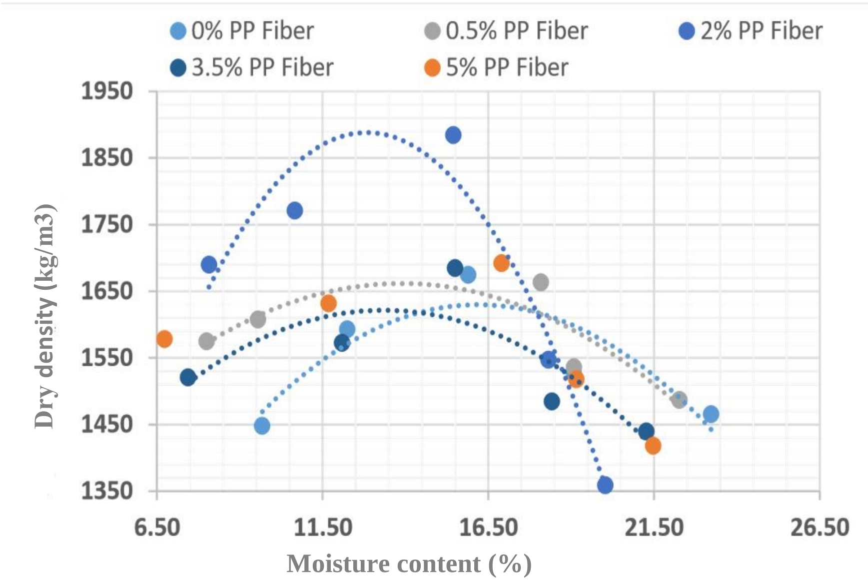
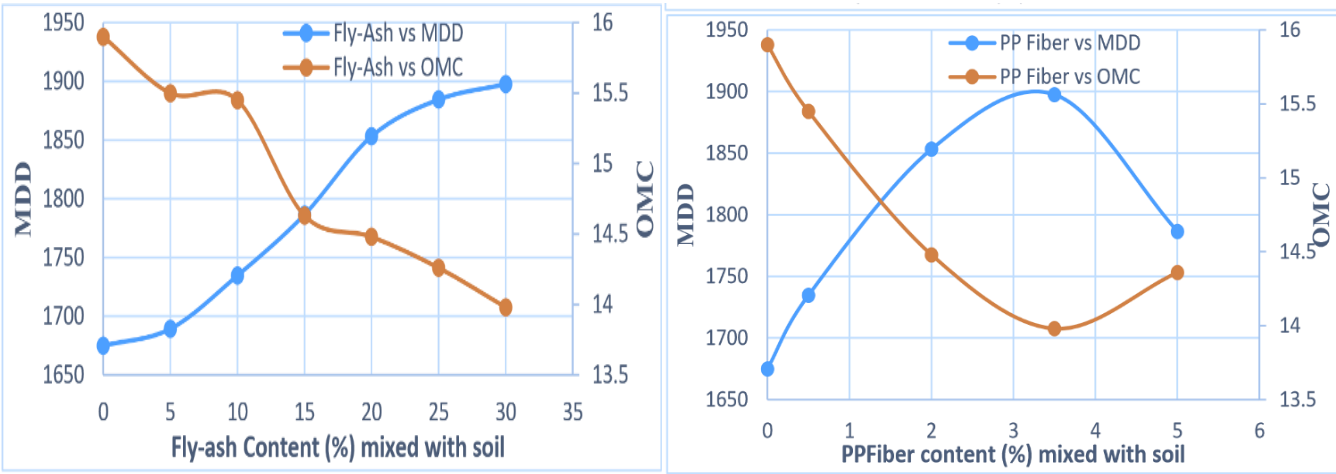


Figure 5: Variation of moisture content with dry density for Polypropylene Fibre

3.1.3 Variation of Compaction Properties of Stabilized Soils with Admixtures

The variation of MDD and OMC of stabilized soils with fly-ash and polypropylene fibre is shown in Figure 6(a) and 6(b) respectively. Figure reveals that with increasing % of fly-ash OMC decreases and MDD increases. For polypropylene fiber OMC decreases upto 3.5% and further increases and MDD increases upto 3.5% and further decreases. Due to the increasing % of admixtures the materials to absorbed water other than the soil increases and OMC (%) decreases. The reason behind the increase of MDD was the admixtures with soil densely compacted and it strengthened the stress strain behaviour of the soil.



(a) (b)

Figure 6: Variation MDD and OMC of stabilized soils (a) fly-ash (b) polypropylene fibre

3.2 CBR Results

The laboratory test method in ASTM **D1883** and AASHTO **T 193** for the CBR test is a simple empirical method, comparing resistance to penetration of the test specimen to that of a "standard" sample of well-graded crushed stone material using a standard-sized piston. The CBR is generally calculated for the deformation of 2.5 mm and 5 mm penetration. In case of deformation of both the CBR is calculated which is greater in value. In this test two values has been taken and greater value becomes accumulated CBR.

3.2.1 CBR of Stabilized Soils

In the laboratory stabilized soils went through successive CBR test. For different soil samples individual test was done. In the case of fly-ash was seen that the percentage of CBR has been increased. For the case of polypropylene fibre CBR percentage increased up to 3.5% fibre mixing proportion for 5% fibre in soil CBR value decreased. The list of data for CBR results of different stabilized soils depicted in Table 2.

Table 2: Results of Stabilized soils with fly-ash and polypropylene fibre.

Fly-ash		**Polypropylene fibre**	
Mixing proportion (%)	**CBR (%)**	**Mixing proportion (%)**	**CBR (%)**
0	4.52	0	4.52

5	5.43	0.5	5.74
10	7.35	2	7.17
15	8.59	3.5	8.24
20	8.85	5	7.49
25	9.84		
30	10.24		

3.2.2 Variation of CBR Results of Fly-Ash

The variation of CBR results shows how fly-ash and changes its CBR results with its different mixing proportions. The results shows that for 5% fly-ash mixed soil CBR% has been found as 5.43. For 10% fly-ash mixed soil CBR% has been found as 7.35. For 15% fly-ash mixed soil CBR% has been found as 8.59. For 30% fly-ash mixed soil CBR% has been found as 10.24. The normal soil CBR is 4.52. So a successive increasing CBR% has been found for fly-ash mixed stabilized soils. We know that CBR ranges from 5-15 will have good bearing capacity and shear strength so stabilized soil with fly-ash has given a good percentage of CBR. The relation between CBR percent with mixing proportion of fly-ash % is given in Figure 7.

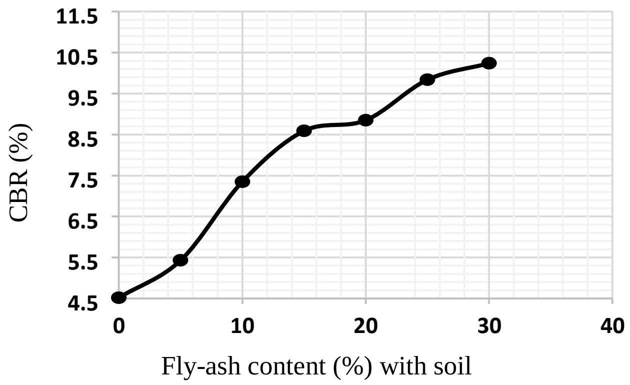


Figure 7 Variation of CBR vs. mixing percentage of fly-ash

3.2.3 Variation of CBR Results of Polypropylene Fibre

The variation of CBR results shows polypropylene fibre changes its CBR results with its different mixing proportions. We see for the polypropylene fibre CBR increases from 5.42 to 8.24 for 0.5% to 3.5%. For 5% fibre the CBR value decreases. So we can come to a discussion that CBR increases from 0.5% to 3.5%. After that CBR value will decrease due to the increase of void in soil. The normal soil CBR is 4.52. We know that CBR ranges from 5-15 will have good bearing capacity and shear strength so stabilized soil with polypropylene fibre has given a good percentage of CBR. The relation between CBR percent with mixing proportion of polypropylene fibre % is given in Figure 8.

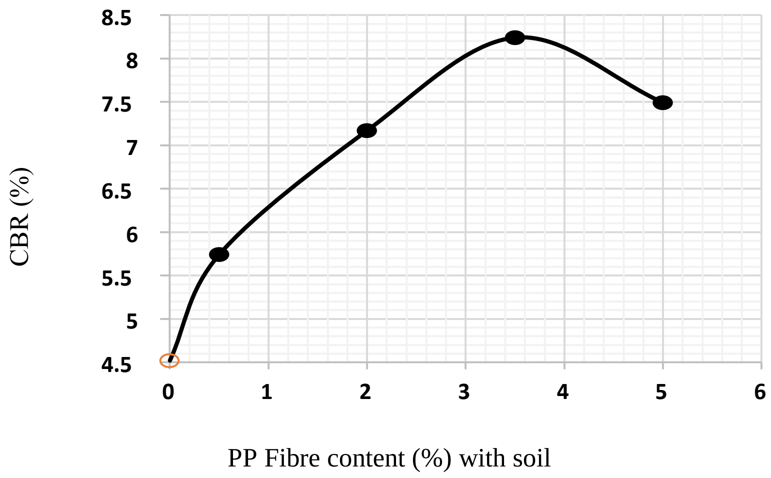


Figure 8: Variation of CBR vs. mixing percentage of polypropylene fibre

3.3 Comparison with the previous Study

The variation of present study and previous study where ML soil is mixed with (0-30) % fly-ash is shown in figure 9. In the previous study normal soil has shown CBR value of 4.1 whereas the present study has shown 4.52 as CBR value. The soil mixed with 30% fly-ash has the CBR value of 11.35 in the previous study where in the present study the value of is 10.24.

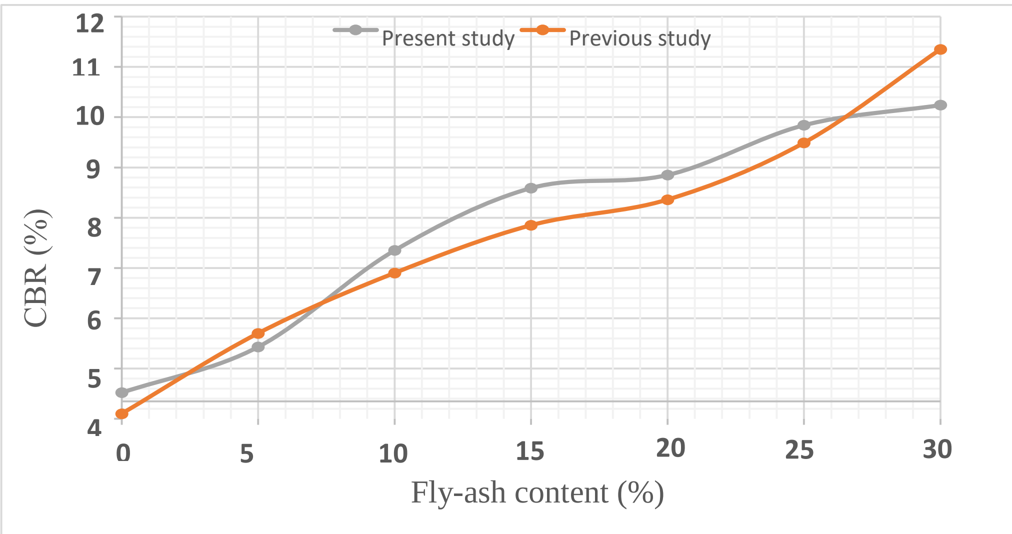


Figure 9: Variation of present study with previous study for different mixing proportion of fly-ash.

4. CONCLUSIONS

1. Based on results the value of MDD increased for stabilized soils while OMC decreased with the increase of fly-ash and polypropylene fibre.
2. CBR values increased up to 30% of fly-ash and 3.5% of polypropylene fibre content mixed with soil.
3. Normally 3-5% CBR results shows “Normal” subgrade strength and 5%-15% CBR results shows “Good” subgrade strength. For Stabilized soil with 30% fly-ash the CBR result found as 10.24 and for 5% polypropylene fibre it was 7.49 indicate good ranges.

4. In this study stabilized soils with fly-Ash showed comparatively higher CBR than that of with polypropylene fibre.

5. Soil shows higher resistance to penetration when it is stabilized than that of normal soil.

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