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# An Experimental Analysis of Fly Ash and Sand Mixture on Variation of their Physiochemical Properties

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## INTRODUCTION

Indeed India is rich and abundant in natural resources like coal, which was in current scenario and because of heavy electricity demand become the 60% power generation resources. Now a days thousands of coal based thermal power plant station were run continuously to generate the electricity for meeting the consumption demand of various industries and urbanisation. Beside of the heavy exploitation of the natural resources of the coal beds these thermal power plants also face the problem of disposing their residual material like fly ashes. As a record now India is facing the problem of managing 130 million tonnes of fly ash production by the thermal power plants. Regardless of such a huge amount of fly ash production only 3% of their were utilised initially as cementing material.

Coal on burning in thermal plants generate the electricity will generate the 80% fly ash and 20% bottom ash as residual. But as to follow the basic sustainable development principle of 3-R Recycle Reuse and Reduce, Now the day’s fly ashes become the headache for the various environmental protecting agencies all over the world because of these increasing production and their impeccable role in global warming. Along with the other green house gases fly ashes also pays significant role in global warming.

Beyond the Indian scenario if we just consider the problem of fly ash in Utter Pradesh we will found that due to rapid industrialisations in the state leads to the rapid increase in the power requirement which indeed pressure the thermal power plant to fulfil their requirement and as a result being the cheapest raw material available and also convenient raw material in the state the problem of the fly ash management indeed rises abruptly.

As the India is a conjugate country of various developing states with more promising technology and more urbanisation, which indeed create a huge need of the power generation to run the whole states progress unfluctuationally. If this is a scenario of a single state of India then what will be the whole scenario when all the states in India were competent to each other for power generation to meet their developmental requirement. Here i provide a list of thermal power plant currently run with full bloom in India.

**Objective of the study:**

- Implementation of the fly ash as mixing component in road construction with soil.
- The change in mechanical property of the various mixtures of soil and fly ash.
- Various mixtures of soil and fly ash along with soil had different properties which were use as a definite material for different construction.

**Limitation of the study**

The fly ashes produced by the thermal power plants were very difficult in storage and transportation as they were very fine in shape and structure but highly reactive with soil as they easily leached out with water and dissolve in ground water lavel. So the accidents during the transportation were leads difficult situation.

**Future perspective of the study:**

The fly ashes with mixture of soil provides various different characteristic property with increasing soil content in fly ash mixture. These different characterstic of different mixture were used in the road construction industry in various stages of road empavements.

## LITERATURE REVIEW

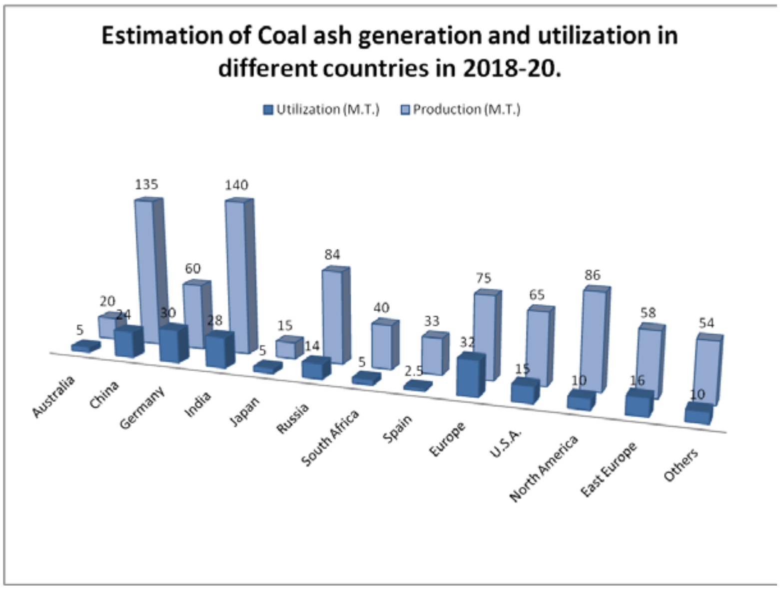
Fly ash consists of predominantly small spherical particle, which differs in shape and size due to its difference in degree of pulverization of coal and efficiency of collecting system. One of the foremost aspect obstruct the consumption and oparation of fly ash has been an financially viable system for gathering and assortment, beside these handling and transportation of fly ash at thermal power station and smooth the progress of for handling and storage at the user end and its economics. But as their efficiency in the road embankment is increased there were more technology developed for their transportation easily.

Here we provide an approx estimation of the coal ash generation and utilization across the world. From the chart we can roughly estimated that the coal ash generation is highest in India and followed by the china.

**Estimation of Coal ash generation and utilization in different countries in 2018-20.**

| S No. | Country | Production (M.T.) | Utilization (M.T.) |
|---|---|---|---|
| **1.** | Australia | 20 | < 5 |
| **2.** | China | > 135 | 24 |
| **3.** | Germany | 60 | 30 |
| **4.** | India | > 140 | 28 |
| **5.** | Japan | 15 | 5 |
| **6.** | Russia | 84 | 14 |
| **7.** | South Africa | 40 | 05 |
| **8.** | Spain | 33 | 2.5 |
| **9.** | Europe | 75 | 32 |

| | | | |
|---|---|---|---|
| **10.** | U.S.A. | 65 | 15 |
| **11.** | North America | 86 | 10 |
| **12.** | East Europe | 58 | 16 |
| **13.** | Others | 54 | 10 |




## STUDY AREA

**Fly ash use in Delhi NCR NHAI Projects:**

Delhi is surrounded by the 2 highly active industrial areas of Uttar Pradesh and Haryana. Fly ash, the key component for fly ash bricks, is mainly sourced from thermal power plants. In some places, it is also obtained from other factories. In Haryana, units get fly ash from power plants such as CLP's Mahatma Gandhi Super Thermal Power Project at Jhajjar; NTPC, Jharli; NTPC Badarpur; Panipat Thermal power plant and other factories. In Uttar Pradesh, the only source of fly ash is NTPC, Dadri thermal power plant. For Delhi and Rajasthan, the source of fly ash is NTPC, Badarpur. The characteristics of fly ash may vary depending on the source and may play an important role in the quality of bricks. Unfortunately, the fact that all kinds of fly ash are not same is generally unrecognized, even by the thermal power plants.

## MATERIALS AND METHODS

This study is based on the fly ash produced by the various TPPs, so we used the fly ash produced by various TPPs near the study are delhi NCR. We used the fly ashes in dry condition so fine powders were oven dried at 110 $^{o}$C–160 $^{o}$C and kept in air tight bottle for later use. This experiment used with the mixture of fly ashes with sand so we had first identified the various parameter like composition of fly ashes and sand. Fly Ash for the most part consists of Silica ($SiO_2$), Alumina ($Al_2O_3$), Calcium Oxide (CaO), and Iron Oxide ($Fe_2O_3$).The chemical composition of Fly ash is tabulated below in Table.

**Compositional Analysis of Fly Ash.**

| Compounds | Composition(%) fly ash | Sand |
|---|---|---|
| $SiO_2$ | 54.5 | 98.2 |
| $Al_2O_3$ | 26.5 | 0.28 |
| CaO | 2.1 | 0.28 |
| MgO | 0.57 | 0.03 |
| P2O5 | 0.6 | - |
| $Fe_2O_3$ | - | 0.1 |
| $SO_3$ | - | 0.07 |
| $K_2O$ | - | 0.01 |
| LOI (Loss on ignition) | 14.18 | 0.18 |

### Experimental setup

For the experimental study of the fly ashes in the embankment in road construction. We consider the basic and most natural way of using the fly ash as a mixture with the sand. Most probably with the characteristics of the fly ashes the different concentration of the sand and fly ashes along with sand has different properties which were used in different prospective of using the mixture in road pavement. We will use the fly ash obtained by NTPC Dadri, and common soil used in experiment. Also the mixture ratio is the standard ratio as per used with cement and sand mixture

### Mixture

The following procedure was adopted for preparation of fly ash and Sand mixtures in all tests. The materials were first dried for 24 hrs and brought to room temperature. Fly ash and Sand were then mixed together in the required proportions (by dry weight) in dry form. Different proportions of NTPC Dadri fly ash and Sand and their mixed designation are given in table.

### Fly Ash and Sand Mix Designation

For the experiment we mix the fly ash and soil in different proportion and these were 0:100, 20:80, 40:60, 60:40, 80:20, 100:0 which were represented in the table below.

| Mix Designation | % of Fly Ash + % Sand |
|---|---|
| 0:100 | 0% Fly Ash + 100% Sand |
| 20:80 | 20% Fly Ash + 80% Sand |
| 40:60 | 40% Fly Ash + 60% Sand |
| 60:40 | 60% Fly Ash + 40% Sand |
| 80:20 | 80% Fly Ash + 20% Sand |
| 100:0 | 100% Fly Ash+ 0% Sand |

### TESTING PROGRAMME

Since fly ash generate in huge quantity from thermal power plants. mainly work has been done on fly ash not on Sand so in the project we want to investigate that what is the effect of engineering property on mixing of fly ash and Sand in different proportions and how Sand can be safely used with fly ash in geotechnical applications and other civil engineering projects. So following testing is done on fly ash and Sand and its mixtures in different proportions.

- Grain size analysis
- Specific gravity
- Standard protector test
- Permeability test
- Direct shear test
- California Bearing Ratio test

## RESULT AND DISCUSSION

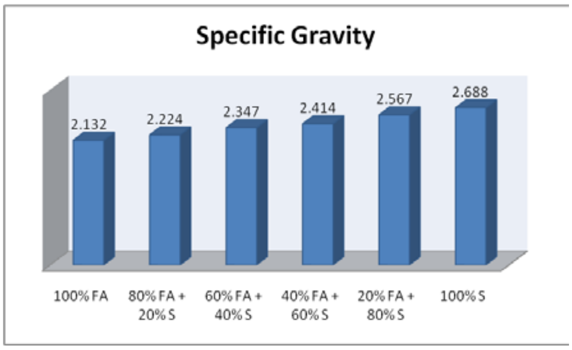
This investigation has been carried out to find the effect of fly ash and Sand mixture on optimum moisture content, maximum dry density, permeability, shear strength, particle size analysis and CBR values. In the present investigation fly ash and Sand has been taken from NTPC Dadri (U.P.) The results of these investigations have been presented in the form of tables and graphs in this chapter. Brief discussions on the laboratory test results are given below.

### Specific Gravity

Specific gravity is a significant property being associated to its density and viscosity. It is one of the aspects to conclude density of mixture. If the specific gravity of mixture is more than 3.19 then it has more moisture content, which will affect the mix and bonding. The specific gravity was found out for fly ash, Sand, and fly ash and Sand mixtures in different proportions and it is presented in Table. The specific gravity of fly ash is 2.132 and for Sand it is 2.688.

**Table: Specific Gravity for mixtures of Fly Ash and Sand**

| Mix designation | Specific Gravity |
|---|---|
| 100% FLY ASH | 2.132 |
| 80% FLY ASH + 20% Sand | 2.224 |
| 60% FLY ASH + 40% Sand | 2.347 |
| 40% FLY ASH + 60% Sand | 2.414 |
| 20% FLY ASH + 80% Sand | 2.567 |
| 100% Sand | 2.688 |

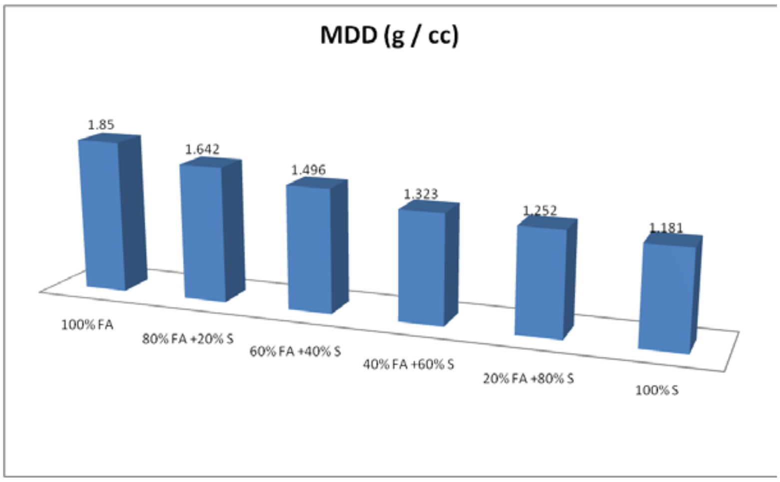


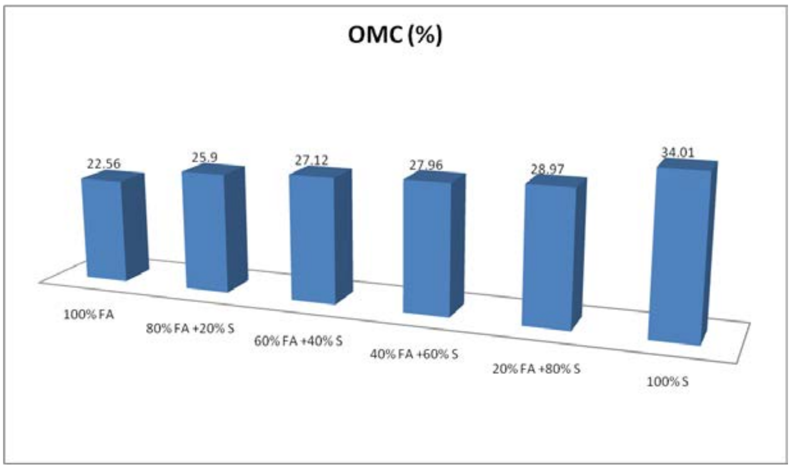

**Optimum moisture content and Maximum dry density**

When placing mixture of fly ash and soil as fill materials, it is important to achieve suitable compaction, primarily in order to reduce the susceptibility of a mixture to settlement. The ability to attain acceptable levels of compaction is reliant on the moisture content of the mixture of fly ash and soil being placed along with the compactive effort. In order to monitor compaction of soils placed on site, in-situ density testing is frequently undertaken. In the experiment with increasing the amount of sand in the sand and fly ash mixture the MDD decreases. The maximum MDD were for 80% FLY ASH +20% Sand mixture which were 1.252 (g / cc) while the minimum MDD were for 20% FLY ASH +80% Sand mixture which were 1.642 (g / cc). While increasing the amount of sand in the sand and fly ash mixture the OMC increases. The maximum OMC were for 20% FLY ASH +80% Sand mixture which were 28.97 (g / cc) while the minimum OMC were for 80% FLY ASH +20% Sand mixture which were 25.9 (g / cc).

**Table: Optimum moisture content and Maximum dry density for mixtures of Fly Ash and Sand**

| Mix designation | MDD (g / cc) | OMC (%) |
|---|---|---|
| 100% FLY ASH | 1.85 | 22.56 |
| 80% FLY ASH +20% Sand | 1.642 | 25.9 |
| 60% FLY ASH +40% Sand | 1.496 | 27.12 |
| 40% FLY ASH +60% Sand | 1.323 | 27.96 |
| 20% FLY ASH +80% Sand | 1.252 | 28.97 |
| 100% Sand | 1.181 | 34.01 |



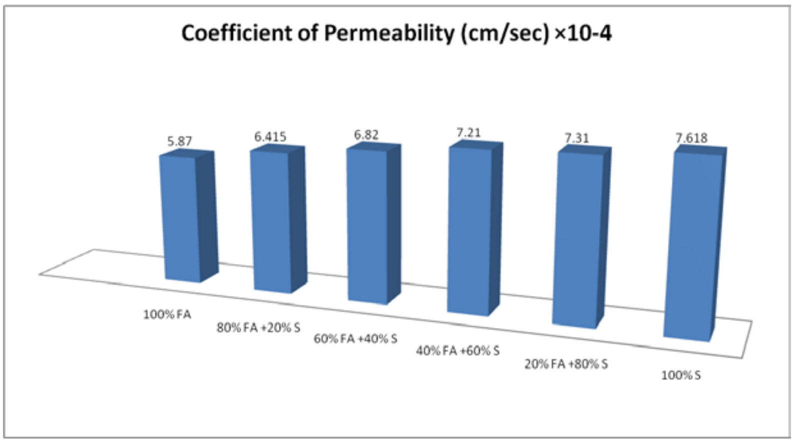



**Coefficient of Permeability:**

Permeability and porosity as an essential Factors in the Long term Durability of mixture. Permeability of concrete generally refers to the rate at which water or other aggressive substance (sulphates, chlorides ions, etc.). It plays an important role in the long- term durability of concrete material. In the experiment with increasing the amount of sand in the sand and fly ash mixture the coefficient of permeability increases. The maximum coefficient of permeability were for 20% FLY ASH +80% Sand mixture which were $7.310\times10^{-4}$ (cm/sec) while the minimum coefficient of permeability were for 80% FLY ASH +20% Sand mixture which were $6.415\times10^{-4}$ (cm/sec).

**Table: Specific Gravity for mixtures of Fly Ash and Sand**

| **Mix designation** | **Coefficient of Permeability (cm/sec)** |
|---|---|
| 100% FLY ASH | $5.870\times10^{-4}$ |
| 80% FLY ASH +20% Sand | $6.415\times10^{-4}$ |
| 60% FLY ASH +40% Sand | $6.80\times10^{-4}$ |
| 40% FLY ASH +60% Sand | $7.20\times10^{-4}$ |
| 20% FLY ASH +80% Sand | $7.310\times10^{-4}$ |
| 100% Sand | $7.618\times10^{-4}$ |

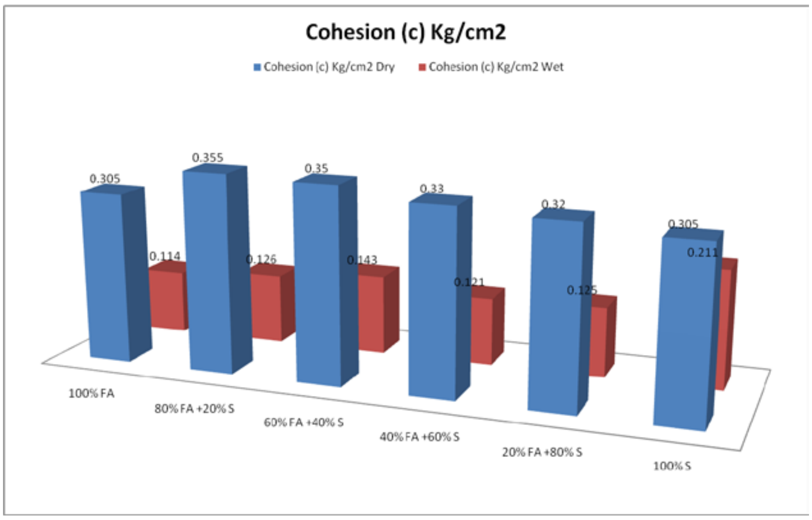


**Cohesion:**

The role of the cohesion (yield strength) of the grout mixture as the deter- mining factor in the depth of penetration of grout into cracks is emphasized. A simple laboratory or field procedure for determining the cohesion is given. In the experiment with increasing the amount of sand in the sand and fly ash mixture the cohesion decreases in dry state while increase in wet state. The maximum cohesion were maximum for 80% FLY ASH +20% Sand mixture which were 0.36 Kg/cm$^2$ while the minimum cohesion were for 20% FLY ASH +80% Sand mixture which were 0.32 Kg/cm$^2$ in dry state while in wet state the trends were a increases maximum cohesion were maximum for 20% FLY ASH +80% Sand mixture which were 0.125 Kg/cm$^2$ while the minimum cohesion were for 80% FLY ASH +20% Sand mixture which were 0.121 Kg/cm$^2$

**Table: Cohesion for mixtures of Fly Ash and Sand**

| Mix designation | Cohesion (c) Kg/cm$^2$ | |
|---|---|---|
| | **Dry** | **Wet** |
| 100% FLY ASH | 0.305 | 0.114 |
| 80% FLY ASH +20% Sand | 0.36 | 0.121 |
| 60% FLY ASH +40% Sand | 0.35 | 0.123 |
| 40% FLY ASH +60% Sand | 0.33 | 0.122 |
| 20% FLY ASH +80% Sand | 0.32 | 0.125 |
| 100% Sand | 0.305 | 0.211 |

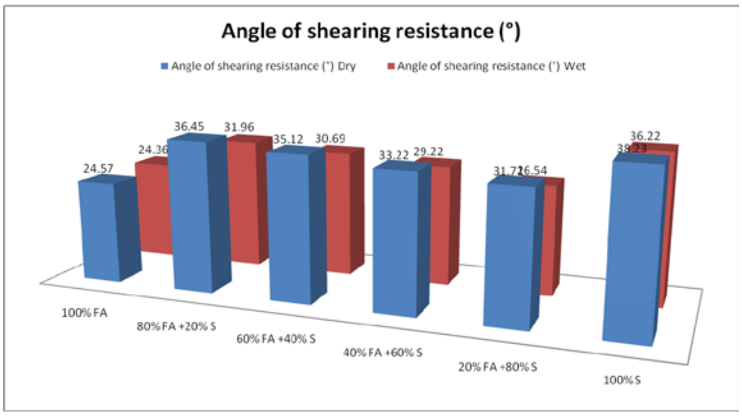



**Angle of shearing resistance:**

A strength prerequisite is a fundamental hypothesis in engineering purposes of geotechnical materials; accordingly, assessment of the strength characteristics of geotechnical materials is particularly significant and imperative. Direct shear properties is mainly use in appraisal level design or a screening level evaluation of an existing structure. In the experiment with increasing the amount of sand in the sand and fly ash mixture the Angle of shearing resistance decreases in dry state as well as in wet state. The maximum cohesion were maximum for 80% FLY ASH +20% Sand mixture which were 36.45° while the minimum cohesion were for 20% FLY ASH +80% Sand mixture which were 31.71° in dry state while in wet state the trends were also decreases maximum cohesion were maximum for 80% FLY ASH +20% Sand mixture which were 24.36° while the minimum cohesion were for 20% FLY ASH +80% Sand mixture which were 26.54°.

**Table: Angle of shearing resistance for mixtures of Fly Ash and Sand**

| Mix designation | Angle of shearing resistance (°) | |
|---|---|---|
| | Dry | Wet |
| 100% FLY ASH | 24.57 | 24.36 |
| 80% FLY ASH +20% Sand | 36.45 | 31.96 |
| 60% FLY ASH +40% Sand | 35.12 | 30.69 |
| 40% FLY ASH +60% Sand | 33.22 | 29.22 |
| 20% FLY ASH +80% Sand | 31.71 | 26.54 |
| 100% Sand | 38.23 | 36.22 |



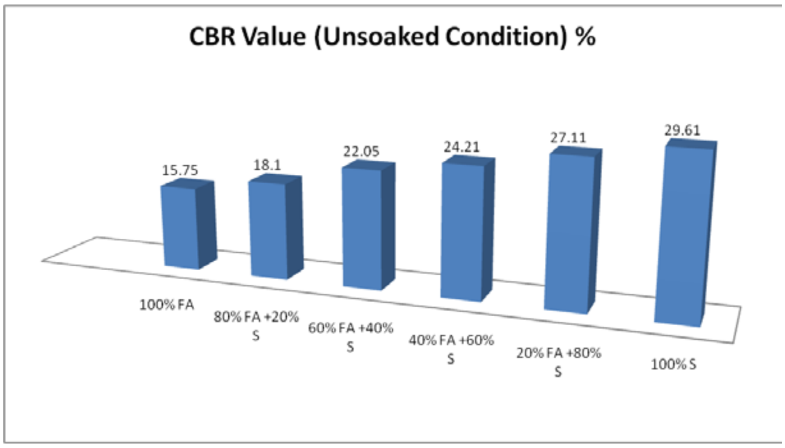

**CBR Value :**

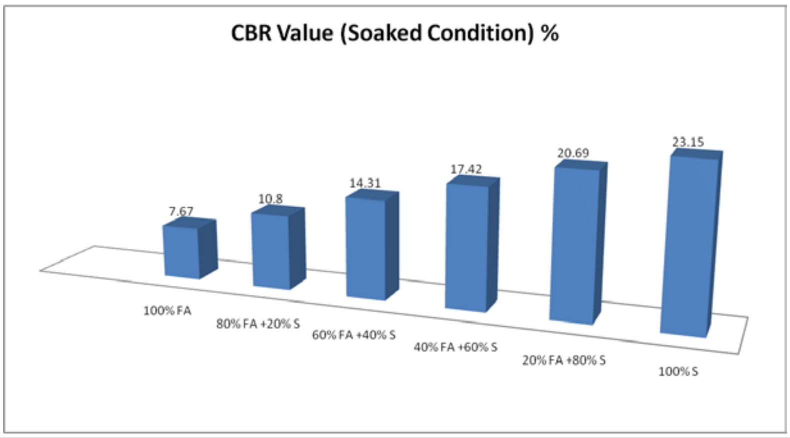
The California Bearing Ratio (CBR) is a measure of the strength of the subgrade of a road or other paved area, and of the materials used in its construction. In the experiment with increasing the amount of sand in the sand and fly ash mixture the CBR Value increases in Unsoaked Condition as well as in soaked Condition. The maximum cohesion were maximum for 20% FLY ASH +80% Sand mixture which were 27.11 % while the minimum cohesion were for 80% FLY ASH +20% Sand mixture which were 18.1% in unsoakesd state while in soaked atate the trends were also increases maximum cohesion were maximum for 20% FLY ASH +80% Sand mixture which were 20.69% while the minimum cohesion were for 80% FLY ASH +20% Sand mixture which were 10.8%.

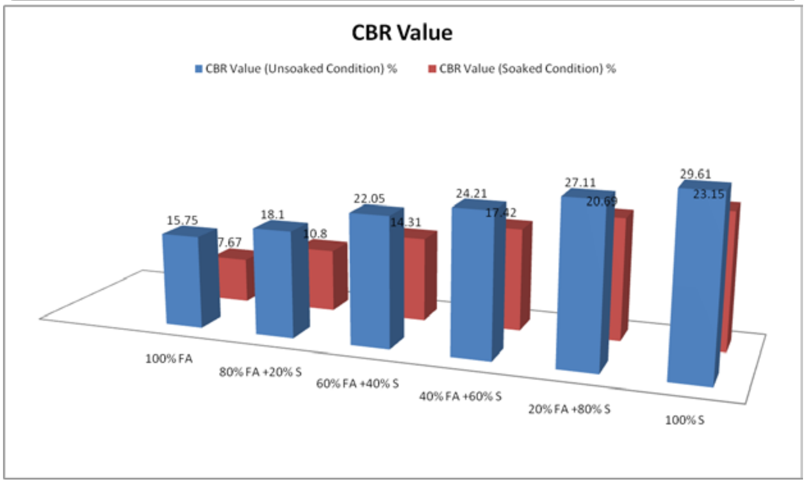
**Table: CBR Value for mixtures of Fly Ash and Sand**

| Mix designation | CBR Value (Unsoaked Condition) % | CBR Value (Soaked Condition) % |
|---|---|---|
| 100% FLY ASH | 15.75 | 7.67 |
| 80% FLY ASH +20% Sand | 18.1 | 10.8 |
| 60% FLY ASH +40% Sand | 22.05 | 14.31 |
| 40% FLY ASH +60% Sand | 24.21 | 17.42 |

| | | |
|---|---|---|
| 20% FLY ASH +80% Sand | 27.11 | 20.69 |
| 100% Sand | 29.61 | 23.15 |




**CONCLUSION**

fly ash is a by product from the coal based thermal power plant but after long research it has been used as a good construction material for roads and embankments. The benefits obtained by using fly ashes on the place of soil in embankment fill material are distinguished. The replacements of topsoil by the fly ashes were also environmentally effective and also low cost. With leading requirement of urbanization needs more and more road establishment foe proper transportation which leads many problems for road construction industry, but enough consideration should be paid to description and classification of fly ash and quality management at the time of road construction for enhanced. From the above experiment of using fly ash a mixture of fly ash and soil in different proportion will lead to different output.

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