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# Enhancement of Strength Characteristics of Poorly Graded Soil by Flyash and Cement

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## ABSTRACT
Fly Ash is the waste material, which is obtained after burning coal in Thermal Power Plants. It can be used as a stabilizer for soil due to its pozzolanic effect or an inherent self-hardening property under favourable conditions of moisture and compaction. This project aims at increasing the strength of poorly graded soils by using Fly Ash and cement as admixtures. Some percentage of Fly Ash without any additives was utilized so as to reduce the cost of construction and this is a good method for disposal of it. Fly Ash was added in various percentages like 10, 20, 30 and 40 percentages (% by volume). Initially all basic Geotechnical properties of the soil such as liquid limit, plastic limit, shrinkage limit, Grain Size Analysis, Specific Gravity, Free Swell Index, Unconfined Compressive Strength, OMC and MDD were determined. Later on the stabilized mixes were tested for CBR (California Bearing Ratio) which is an indirect measurement of strength. After the detailed experimental investigation it is observed that 30% addition of Fly Ash has shown maximum strengths, so that to obtain much more strengths cement was added in 2, 5, 8 and 10 percentages to this optimum mix of Fly Ash with soil. After that the soil mixes were tested for CBR (California Bearing Ratio) to check it's feasibility in Flexible Pavement constructions. The strengths were checked in both Unsoaked and soaked conditions and at various curing periods like 7 and 28 Days. Among all proportions 30% Fly Ash+8 % of the cement has shown maximum strengths, so that it was decided as optimum mix. 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 project work facilitates an economical, strong and durable construction material for Flexible Pavements.

***Keyword:*** *Soil, Flyash, Cement (OPC 43 grade), CBR and UCS*

## I. INTRODUCTION
Soil is the cheapest available material utilized for various construction-related purposes. In this connection, utilization of by-products like Fly Ash as suitable ingredients for geotechnical construction is necessary. Soil improvement is necessary for local soils in many places. Soils with low bearing capacities underlying heavy structures are always problematic from the geotechnical engineering point of view. It is essential to overcome this problem by strengthening the soil. Precautions can be taken by modifying the local soils, which can be achieved either by mechanical or chemical stabilization.

There are many methods available for soil stabilization. For chemical stabilization of soils, there are many additives available such as lime, cement, gypsum and Fly Ash. Among all of them, Fly Ash is the cheapest one. Soil stabilization by means of Fly Ash has environmental benefits in preventing pollution of water and air that can result from its mere disposal near thermal power plants. Most of the sub grade soils can be stabilized by means of admixtures. Many research results have indicated that Fly Ash is an effective material and also has the potential application to stabilize soft sub-grade soils. The effect of Fly Ash is prominent essentially through the reactivity, and the California bearing ratio (CBR) of soil-Fly Ash mixes soil increases due to the pozzolanic reaction. Unconfined compressive strength (UCS) increases with curing periods for soil-Fly Ash mixtures, and this is primarily due to the pozzolanic reaction. The increase in percentage content of Fly Ash in Fly Ash-soil mixtures leads to decrease in dry unit weight, which is attributed to the low specific gravity of Fly Ash. The addition of a small percentage of cement to soil-Fly Ash mixture increases the unconfined compressive strength value. The influence of cement on the behaviour of sandy soil has been studied and it has been reported that the addition of cement increases the stiffness as well as peak strength. Brittle behaviour is more marked in soil-Fly Ash-cement mixes than in soil-fly-ash-fibre mixes with concurrent increase in UCS value. Fly Ash has low dry unit weight and exerts less lateral earth pressure. The use of class F Fly Ash amended soils as highway base materials has been investigated. Some researchers have suggested that the performance analysis of Fly Ash should be based upon laboratory tests such as index properties, compaction, unconfined compressive strength and CBR tests of a specific soil. The strength approach can be applied to estimate the optimum mixture design. The literature review has indicated that the strength gain due to stabilization depends upon several factors: Fly Ash content mounding water content, compaction delay and curing period.

The use of Fly Ash in geotechnical engineering applications such as construction of highway embankments, different layers of road pavement etc. is increasing. In view of the above, the objective of this study was to investigate the strength properties of soil-Fly Ash and soil-Fly Ash-cement mixtures.

## II. MAJOR FORMAT GUIDELINES

**METHODOLOGY:**

**Materials Used:**

**Fly Ash:** For the present study Fly Ash was collected from the National Thermal Power Corporation (NTPC), which is located at paravada in Visakhapatnam.

**Cement:** The cement used in this project work is OPC43 grade (Nagarjuna cement) which is collected from the local construction site.

**LABORATORY TESTING:**

The following tests were conducted on poorly graded sand. The index and engineering properties of poorly graded sand were determined.

1. Grain Size Analysis
2. Atterberg Limits
3. Specific Gravity
4. Unconfined Compressive Strength Test
5. California Bearing Ratio Test
6. Free Swell Index
7. Mini compaction.

**CEMENT TEST**

1. Specific Gravity of Cement
2. Initial and Final setting Time Test on Cement
3. Standard Consistency Test

## III. RESULTS & DISCUSSIONS

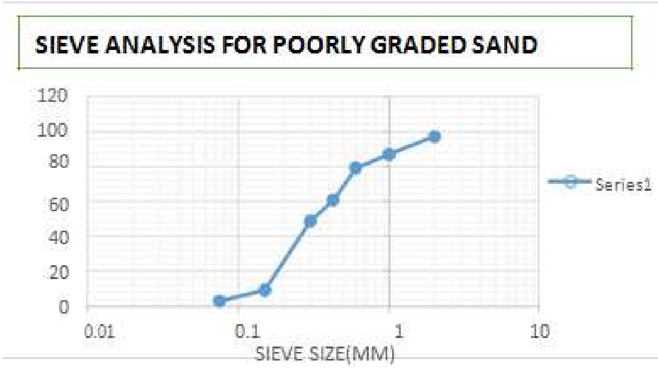
**PHYSICAL PROPERTIES:** the basic geotechnical parameters were determined for soil fly ash and cement

| Property of the soil | Value |
|---|---|
| Colour | Brown |
| Specific Gravity | 2.68 |
| Unconfined Compressive Strength (UCS) kg/cm2 | 0.3 |
| Liquid limit (%) | 26.50 |
| Plastic limit (%) | 22.60 |
| Shrinkage limit | 13.4 |
| Plasticity index | 3.90 |
| California Bearing Ratio(CBR) | 2.6 |
| Grain Size Distribution | |
| a) Coarse sand (%) | 3.06 |
| b) Medium sand (%) | 36.36 |
| c) Fine Sand (%) | 57.60 |
| d) Silt& clays (%) | 2.90 |
| Free swell index | 4.20% |

| Property of the Fly Ash | Value |
|---|---|
| Appearance | Powder form |
| Colour | Grey |
| Specific Gravity | 2.3 |
| Liquid limit (%) | 26 |
| Plastic limit (%) | Non plastic |
| Wet sieve analysis | |
| a) % of passing through 75 micron | 65 |
| b) Retained (%) | 35 |
| Free swell index (%) | 9 |

| S. NO | PROPERTY OF THE CEMENT | VALUE |
|---|---|---|
| 1 | SPECIFIC GRAVITY | 3.1 |
| 2 | NORMAL CONSISTENCY | 31% |
| 3 | INTIAL SETTING TIME | 40MIN |
| 4 | FINAL SETTING TIME | 160MIN |

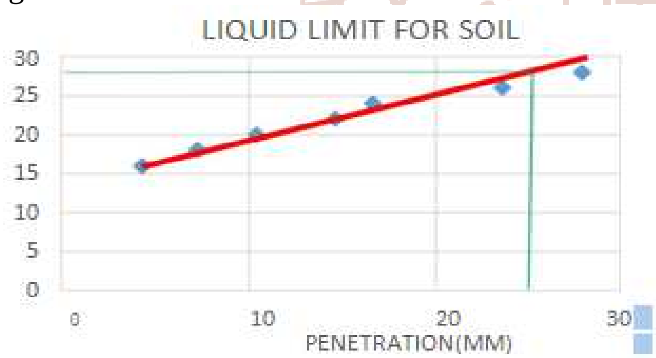
The Particle size Distribution of the soil sample is as shown below in the Figure




**C**o efficient of uniformity Cu = 1.375
Co efficient of Curvature Cc = 0.752
Soil Designation" **Poorly Graded Sand (SP)** "

The Index Properties of the Soil sample were tested and the results are as shown below

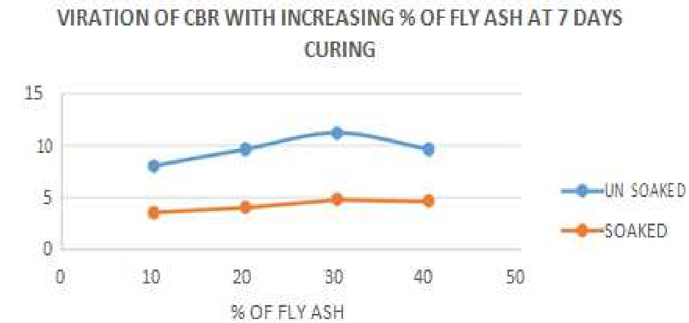
The liquid Limit of the sample was determined using Digital cone penetrometer apparatus
i.e Uppal's Method the curve is as shown in the Figure




**COMPACTION CHARACTERISTICS:**
**Optimum Moisture Content & Maximum Dry Density**
The parameters like OMC (Optimum Moisture Content) and MDD (maximum Dry Density) were determined for the soil sample. The parameters were found by using MINI COMPACTION apparatus which is suggested by Professor A. Sridharan and Professor P.V.Sivapullaiah of IISC Bangalore.

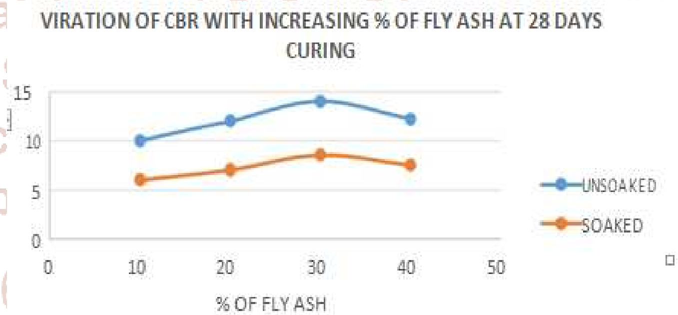
**VARIATION OF CBR WITH CHANGE IN % OF FLY ASH AT 7 DAYS CURING IN BOTH SOAKED AND UN SOAKED CONDITIONS:**

| S. NO | % OF FLY ASH | % OF CBR AT 2.5 MM | % OF CBR AT 2.5 MM (SOAKED) |
|---|---|---|---|
| 1 | 10 | 8 | 3.5 |
| 2 | 20 | 9.6 | 4 |
| 3 | 30 | 11.2 | 4.8 |
| 4 | 40 | 9.6 | 4.6 |




VARIATION OF CBR WITH CHANGE IN % OF CEMENT AT 28 DAYS CURING IN BOTH SOAKED AND UN SOAKED CONDITIONS:

| S. NO | % OF CEMENT+30 %FA | % OF CBR AT 2.5 MM (US) | % OF CBR AT 2.5 MM (S) |
|---|---|---|---|
| 1 | 2 | 16 | 9 |
| 2 | 5 | 24 | 15 |
| 3 | 8 | 38 | 23 |
| 4 | 10 | 40 | 25 |




## IV. CONCLUSIONS

- It is observed from all experimental results that the certain proportions of Fly Ash added to the soil improved the CBR values.
- The optimum content of the Fly Ash was **30%** for the soil at both Un soaked & soaked conditions.
- The optimum content of the cement was decided as **8%** for optimum mix of Fly Ash-soil at both un soaked & soaked conditions.
- 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 percentage increase in Fly Ash increases the maximum dry density and decreases the optimum moisture content.
- The percentage increases in cement and optimum percentage of Fly Ash (30%) combination leads to the increase in maximum dry density and decreases the moisture content.

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