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# Study on Strength Properties of Concrete by Replacement of Cement with Fly Ash and Sand with Stone Dust

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## Abstract:

Performance Concrete (HPC) is currently widely employed in the building sector all over the world. For a sturdy and long-lasting structure, high-performance concrete appears to be a preferable option. To manufacture these particularly designed concrete that must meet a mixture of performance requirements, normal and special materials must meet a combination of performance requirements. In this project, strength properties such as compressive strength, split tensile strength, and flexural strength of M40 grade HPC mixes were investigated using different replacement levels such as 25 percent, 30 percent, 35 percent, and 50 percent cement by fly ash, and 60 percent, 65 percent, 70 percent, 75 percent, and 100 percent stone dust with sand using a water-binder ratio of 0.35. For greater workability in high-performance concrete, a superplasticizer (BASF) is utilised. The normal HPC mix, grade M40 concrete is designed according to IS: 10262-1982 IS: 456-200. Compressive strength, split-tensile strength, and flexural strength were investigated mechanically.The findings illustrate the strength characteristics of stone dust as well as the features of fly ash-based concrete mixtures. Based on the findings, the decision was made to replace 100% stone dust and 25% fly ash with 1.2 percent super plasticizer, which has superior properties. This report contains the details of the investigations as well as the findings.

*Keywords* **—High Performance Concrete, Fly Ash, M-Sand, Compressive Strength, Split Tensile, Flexural Strength, super plasticizer**

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## I. INTRODUCTION

High performance concrete (HPC) is a type of concrete that meets certain performance and uniformity requirements that can't always be met by using regular ingredients and traditional mixing, inserting, and natural action techniques. Chemical and mineral admixtures, in addition to the same materials that are generally used in standard concrete, are frequently required to produce high-performance concrete. Several studies have recently been conducted to improve the qualities of concrete in terms of strength, durability, and performance as a structural material. There are a variety of materials in the unit, including ash, chamber dross, stone filth, and silicon oxide fume, among others. One of these unique concretes is made from newly emerging stone soil combined with cutting-edge construction materials to produce high-strength, high-performance concrete for particular constructions. The interest in ash and stone dust began in pollution control management in numerous countries.This implies that the trade had to avoid releasing emotional ash into the air. To find a solution to the current problem, research was started, and after some examination, it was discovered that ash and stone dirt may be used as a very useful element in concrete. Improved stone dirt and ash are now being used on a daily basis in India.

In this study, a shot is being created within the laboratory to grasp the behaviour of fly ash gravelly sand mixtures to utilize fly ash within the pavement construction. The strength, lightweight and changed compaction, cosmic background radiation tests were conducted on the fly ash gravelly sand mixtures. The gravelly sand collected from the outer bypass space was employed in the study. The fly ash employed in the study was collected from the Vijayawada Thermal station (VTPS), Vijayawada in AP state. The fly ash proportions adopted within the study area unit 1/3, 5%, 10%, 15%, two hundredth and twenty fifth by dry weight of soil. Researchers have disbursed studies towards utilization of fly ash for varied engineering applications since 3 decades. a number of the studies conferred within the type of articles in conferences, journals, and within the type of reports within the recent past area unit reviewed recognize|to grasp} and know the extent of analysis work disbursed regarding utilization of fly ash and is conferred in Chapter a pair of.

## II. FLY ASH IN PORTLAND CEMENT CONCRETE

Fly ash are often employed in Portland cement concrete to boost the performance of the concrete. Portland cement is factory-made with quicklime (CaO), a number of that is free during a free state throughout association. the maximum amount as twenty pounds of free lime is free throughout association of a hundred pounds of cement. This liberated lime forms the mandatory ingredient for reaction with fly ash silicates to make sturdy and sturdy cementing compounds, therefore improves several of the properties of the concrete. a number of the ensuing advantages are: (i). higher final strength, (ii). enlarged sturdiness, (iii). improved workability, (iv). reduced harm, (v). enlarged resistance to salt attack, (vi). enlarged resistance to alkali-silica reactivity and (vii). reduced shrinkage.

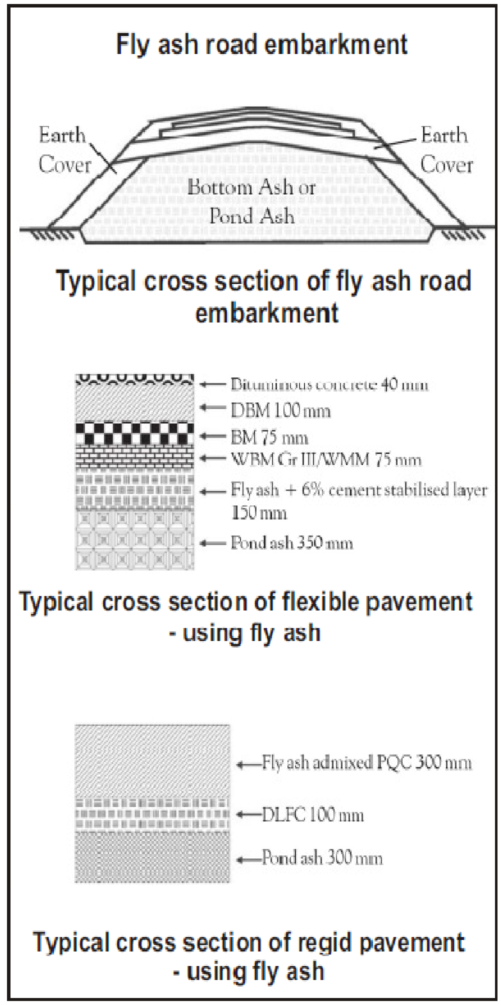


Fig. 1 Use of Fly ash in road hill (Parisara ENVIS newssheet, 2007

Fly ash utilization, particularly in concrete, has important advantages including: (i) increasing the lifetime of concrete roads and structures by rising concrete sturdiness, (ii) internet reduction in energy use and greenhouse emission and different adverse air emissions once fly ash is employed to switch or displace factory-made cement, (iii) reduction in quantity of coal combustion product that has to be disposed in landfills, and (iv) conservation of different natural resources and materials. Typically, fifteen to thirty per cent of the Portland cement is replaced with fly ash.

From the higher than advantages of mistreatment of fly ash, it's additional giving scope to use fly ash in pavement construction. additional to grasp the parameters to be targeted within the study, towards utilization of fly ash, a short literature of recent past has been reviewed and conferred below.

## III. REVIEW OF LITERATURE

Depending on the soil type, a range of compaction instrumentation is frequently used to increase the relative compaction of fly ash soil mixtures. Fly ash is a good stabiliser for granular and fine-grained materials because of its self-cementing characteristics. Fly ash has a low cementation price on its own, but in the presence of water, it combines with chemicals to generate cementation compounds, which contributes to the development of soil strength and sponginess. It has a long history as an engineering material and has been successfully used in geotechnical applications. Fly ash is made up of hollow spheres of element, metal, and iron oxides, as well as unoxidized carbon.

Nicholson received a number of patents (1977, 1982) for a series of studies on cement oven mud (CKD) and fly ash mixes for the manufacture of moulding materials using various aggregates. By weight of the mixture, CKD was depleted to Sixteen Personality Factor Questionnaire, producing a robust material by reacting with water at close temperatures.

Khoury and rain tree (2002) reportable on the impact of wet-dry cycles on resilient modulus (Mr), modulus of elasticity (E), and unconfined compressive strength (UCS) for sophistication C fly ash-stabilized ten soft limestones combination. Mr enlarged fifty fifth for specimens cured for 3 days and so subjected to thirty wet-dry cycles. many cured specimens exhibited a rise in Mr for up to twelve cycles, at which period Mr began to decrease. The authors additionally discovered that E and UCS values enlarged because the range of wet-dry cycles enlarged.

From the same literature review, it's perceive that the heap of labor is being disbursed relevant to stabilization of pavements particularly on clayey subgrade soil mistreatment varied admixtures equivalent to fly ash, stone dust, coarse furnace dross, lime, cement oven mud and cement. There are unit few studies reportable on utilization of fly ash in pavement construction in conjunction with the gravelly sand. during this study, a study has been planned to grasp the behavior of fly ash + gravelly sand mixtures to be used in pavement construction. The fly ash proportions by the dry weight of soil adopted within the study area unit 1/3, 5%, 10%, 15%, two hundredth and twenty fifth has been reportable.

## IV. MATERIALS EMPLOYED IN THE STUDY

### *A. Soil*

The gravelly sand employed in the current study was collected from the outer bypass space AP state, India. The soil could be a greyish to brown colored gravelly sand and has no cohesion. The soil collected was unbroken in controlled conditions within the laboratory and was used for checking as per the Indian customary specifications given within the various test codes. For this soil, the fundamental tests were conducted within the laboratory for its characterization. As per the fundamental properties of soils area unit involved, it indicates that the soil is greyish to brown in color and has soil proportions of gravel, sand and tiny fine fraction. within the soil the kids slit and clay is around seven-membered, sand is seventieth and gravel is around twenty third is gift.

TABLE I
BASIC GEOTECHNICAL PROPERTIES OF GRAVELLY SAND EMPLOYED IN THE STUDY

| **Property** | **Value** |
|---|---|
| Specific gravity | 2.68 |
| **Direct Shear Results (at OMC):** | |
| Cohesion, c (kPa) in Light Compaction | 0 |
| Cohesion, c (kPa) in Modified Compaction | 0 |
| Angle of Internal Friction, ϕ (deg) in Light Compaction | 39.5 |
| Angle of Internal Friction, ϕ (deg) in Modified Compaction | 45 |
| Optimum Moisture Content, OMC (%)in Light Compaction | 8.0 |
| Optimum Moisture Content, OMC (%)in Modified Compaction | 7.5 |
| Maximum Dry Density, MDD (kN/m$^3$) in Light Compaction | 19.95 |
| Maximum Dry Density, MDD (kN/m$^3$) in Modified Compaction | 20.90 |

  

| California Bearing Ratio Values, CBR (%) (at OMC): | |
|---|---|
| Unsoaked CBR (%) in Light Compaction | 62 |
| Soaked CBR (%) in Light Compaction | 46 |
| Unsoaked CBR (%) in Modified Compaction | 85 |
| Soaked CBR (%) in Modified Compaction | 85 |
| **Grain Size Distribution:** | |
| % Gravel | 21.3 |
| % Coarse Sand | 14.6 |
| % Medium Sand | 38.3 |
| % Fine Sand | 18 |
| % Silt & Clay | 7.8 |
| Effective Diameter, $D_{10}$ (mm) | 0.16 |
| Coefficient of Uniformity, $c_u$ | 12.5 |
| Coefficient of Curvature, $c_c$ | 1.75 |
| Soil Classification | SW |

### *B. Fly Ash*

TABLE III
PHYSICAL PROPERTIES OF FLY ASH EMPLOYED IN THE STUDY

| Property | Value |
|---|---|
| Specific gravity | 1.97 |
| **Direct Shear Results:** | |
| Cohesion, c (kPa) in Light Compaction | 13 |
| Cohesion, c (kPa) in Modified Compaction | 10 |
| Angle of internal friction, ϕ (deg) in Light | 29 |
| Angle of Internal Friction, ϕ (deg) in Modified | 31.5 |
| **Compaction Characteristics:** | |
| Optimum Moisture Content, OMC (%) in Light | 19.5 |
| Optimum Moisture Content, OMC (%) in Modified | 18 |
| Maximum Dry Density, MDD ($kN/m^3$) in Light | 12.65 |
| Maximum Dry Density, MDD ($kN/m^3$) in Modified | 13.85 |
| **California Bearing Ratio Values, CBR (%):** | |
| Unsoaked CBR (%) in Light Compaction | 27 |
| Unsoaked CBR (%) in Modified Compaction | 34 |
| Soaked CBR (%) in Light Compaction | 9 |
| Soaked CBR (%) in Modified Compaction | 16 |
| **Grain Size Distribution:** | |
| % Gravel | 0 |
| % Coarse Sand | 0 |
| % Medium Sand | 0 |
| % Fine Sand | 97.5 |
| % Silt & Clay | 2.5 |
| Effective Diameter, $D_{10}$ (mm) | 0.085 |
| Coefficeint of Uniformity, $c_u$ | 2.2 |
| Coefficient of Curvature, $c_c$ | 1.2 |

### *C. Tests Conducted*

TABLE IIIII
CHEMICAL PROPERTIES OF FLY ASH EMPLOYED IN THE STUDY

| Content of the Component | **Value** |
|---|---|
| % $SiO_2$ | 60.5 |
| % $Al_2O_3$ | 30.8 |
| % $Fe_2O_3$ | 3.6 |
| % CaO | 1.4 |
| % MgO | 0.91 |
| % $SO_3$ | 0.14 |
| % $K_2O+Na_2O$ | 1.1 |
| Loss of ignition (LOI) | 0.8 |
| Specific surface area, $m^2/kg$ | 338 |
| Lime reactivity, $N/mm^2$ | 6.2 |

1) *Grain Size Distribution*
2) *Relative Density Check*
3) *Changed Compaction test*
4) *Cosmic Background Radiation*
5) *Direct Shear Check*

## V. RESULTS AND DISCUSSIONS

### *A. Compaction Characteristics*

The compaction results of fly ash gravelly sand mixtures for lightweight compaction and changed compaction area unit conferred in Figs. presents the compaction curves for gravelly sand tested for lightweight compaction and changed compaction. From this figure, it are often seen that because the compactive effort will increase the water content is reducing and therefore the most dry density is increasing. because of the rise in compactive effort the utmost dry density is enlarged from nineteen.95 $kN/m^3$ to twenty.9 $kN/m^3$ equally the optimum wet content is small from eight to seven.5%. Fig 3 presents the compaction curves for the ash tested at lightweight compaction and changed compaction. From this figure, it are often seen that because the compaction effort will increase the MDD of ash is increasing and therefore the OMC of ash is decreasing.

  

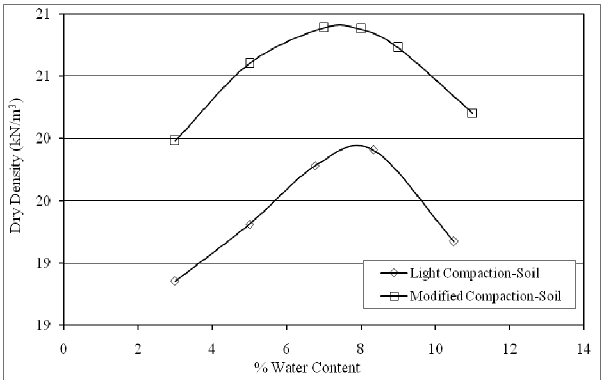


Fig. 2 Compaction curves for gravelly sand subjected to lightweight and changed compaction

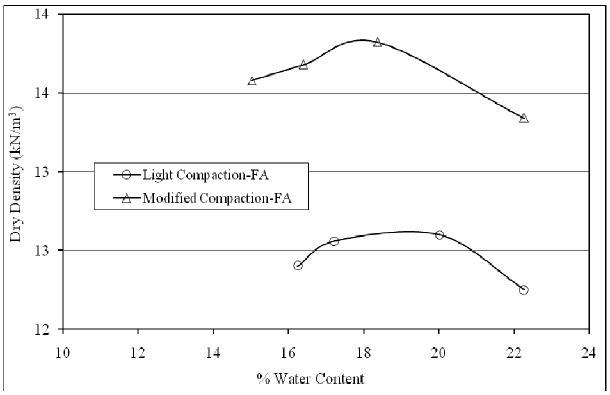


Fig. 3 Compaction curves for fly ash subjected to lightweight and changed compaction

### *B. Compression test*

After 7 days, 14 days and 28 days of curing, three 150mm cubes of a concrete mixture were tested using the compression machine. These cubes were loaded on their sides during compression testing such that the load was exerted perpendicularly to the direction of casting. The average value of the three cubes was taken as the compressive strength.

TABLE IVV
COMPRESSIVE STRENGTH(N/MM2) - FLY ASH

| S.No | Specimen | 7 Days | 14 Days | 28 Days |
|---|---|---|---|---|
| 1 | C | 46.76 | 64.66 | 71.48 |
| 2 | C1-25% | 38.45 | 50.59 | 58.80 |
| 3 | C2-30% | 35.54 | 50.32 | 56.0 |
| 4 | C3-35% | 34.79 | 47.44 | 54.71 |
| 5 | C4-40% | 31.2 | 43.2 | 48.00 |

TABLE V
COMPRESSIVE STRENGTH(N/MM2) – STONE DUST

| Sno | Specimen | 7 Days | 14 Days | 28 Days |
|---|---|---|---|---|
| 1 | C | 46.46 | 64.46 | 71.38 |
| 2 | S1-60% | 35.68 | 49.01 | 54.76 |
| 3 | S2-65% | 35.32 | 49.63 | 55.38 |
| 4 | S3-70% | 35.89 | 49.87 | 55.68 |
| 5 | S4-75% | 40.37 | 55.82 | 61.28 |
| 6 | S5-100% | 44.0 | 60.99 | 67.72 |

### *C. Split Tensile test*

The test was carried out by placing the cylindrical specimen horizontally between the loading surfaces of a compression testing machine and load is applied until the initial crack of the specimen occurs, along the diameter.

TABLE VI
SPLIT TENSILE STRENGTH(N/MM2) – FLY ASH

| S.No | Specimen | 7 Days | 14 Days | 28 Days |
|---|---|---|---|---|
| 1 | C | 2.92 | 4.0 | 4.8 |
| 2 | C1-25% | 2.92 | 4.0 | 4.8 |
| 3 | C2-30% | 2.86 | 3.83 | 4.4 |
| 4 | C3-35% | 2.77 | 3.62 | 4.0 |
| 5 | C4-40% | 2.64 | 3.54 | 4.1 |

TABLE VII
SPLIT TENSILE STRENGTH(N/MM2) – STONE DUST

| S.No | Specimen | 7 Days | 14 Days | 28 Days |
|---|---|---|---|---|
| 1 | C | 2.9 | 4.0 | 4.8 |
| 2 | S1-60% | 2.67 | 3.52 | 3.93 |
| 3 | S2-65% | 2.58 | 3.63 | 3.96 |
| 4 | S3-70% | 2.67 | 3.39 | 3.86 |
| 5 | S4-75% | 2.82 | 3.83 | 4.34 |
| 6 | S5-100% | 3.30 | 4.35 | 4.83 |

### *D. Workability*

TABLE VIII
WORKABILITY

| Workability | Fly Ash | | Stone Dust | |
|---|---|---|---|---|
| S.No | Specimen | Slump(mm) | Specimen | Slump(mm) |
| 1 | C | 30 | C | 30 |
| 2 | C1-25% | 50 | S1-60% | 45 |
| 3 | C2-30% | 51 | S2-65% | 43 |
| 4 | C3-35% | 53 | S3-70% | 40 |
| 5 | C4-40% | 55 | S4-75% | 37 |
| 6 | --- | ---- | S5-100% | 35 |

TABLE IX
FINAL MIX – 1:0.35:2.43:0.78 WITH 25% FLY ASH &100% STONE DUST

| Compressive Strength ($N/mm^2$) | Split Tensile Strength ($N/mm^2$) | FlexuralStrength ($N/mm^2$ | Workability (mm) |
|---|---|---|---|
| 61.4 | 4.65 | 5.6 | 50 |

## VI. CONCLUSIONS

From the higher than attention-grabbing points detected within the compaction, strength and cosmic background radiation results, it's perceive that up to regarding ten of fly ash addition to gravelly sand, the properties of gravelly sand don't seem to be dynamic drastically and therefore the mixture is showing encouraging results towards utilization of fly ash in conjunction with gravelly sand for low volume and high volume pavement construction. The penetration response is rigid {in case just in case} of changed compaction as compared to lightweight compaction and additionally the response is rigid in case of unsoaked condition as compared thereto of soaked condition. Hence, up to ten of fly ash are often used in conjunction with gravelly sand in pavement construction while not compromising the strength and stability aspects area unit involved.

## VII. FUTURE SCOPE OF THE STUDY

From the results conferred within the gift study, it are often perceive that regarding ten of fly ash are often used for the pavement construction in conjunction with the gravelly sand while not compromising the cosmic background radiation and Strength values. Even at twenty fifth addition of fly ash to the gravelly sand, it's discovered that the cosmic background radiation price is over two hundredth. Hence, for specific cosmic background radiation values of two hundredth and simply higher than, it is often susceptible that even twenty fifth of fly ash are often used for the building.

A detailed study is often extended on fly ash gravelly sand mixtures towards utilization of fly ash within the low volume and high volume roads. The behavior of mixture underneath drain conditions is often studied. The behaviour of mixture underneath repetitive loading conditions are often disbursed. Model pavement studies are often conducted to check the steadiness aspects of fly ash gravelly sand mixtures towards building.

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