# BEHAVIOUR OF HIGH PERFORMANCE CONCRETE IN HIGHWAY PAVEMENT USING ALCCOFINE AND FLY ASH

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## ABSTRACT

*Concrete is an important structural material in the construction industry. In the present scenario, concrete is regarded as one of the best construction material. This investigation deals the mechanical and rheological properties of high performance concrete with the replacement of cement with industrial by-products like Alccofine and Fly ash. The study is carried out to check the behavior of HPC using Fly ash and Alccofine for road applications. As Alccofine and Fly ash show cementing properties, they can be easily used for producing high performance concrete. The main aim of the study is to design M60 grade HPC according to ACI method and determine mechanical properties. Concrete is produced by blending fixed proportion of flyash and different proportions of Alccofine at water-cement ratio of 0.25. Superplasticizer (3% of cement) is added to increase the flow and to reduce water demand. The mechanical properties like compressive strength, in-split tensile strength and flexural strength are determined at age of 28 days. Alccofine and Flyash increase the rheological property due to their smaller particle sizes. The addition of Alccofine and Flyash is helpful in gaining strength properties and made the concrete environmental friendly without much effect on the cost.*

***Keywords- High Performance Concrete (HPC), cement, fly ash, alccofine, superplasticizer***

## I. INTRODUCTION

Concrete has merits as material for construction as compare to other construction materials. It is one of the most easily available materials and it shows better resistance to water as compare to wood and steel. Therefore, concrete has become reliable material. On other hand, the fresh concrete can be moulded to any shape and structure using frameworks. India's road network is one of the largest networks in the world. Cement concrete roads should be preferred over bitumen roads because of better performance and service life. The use of new technology in HPC not only decreases harmful effects on the environment but also enhance the properties of concrete using SCMs.

## II. EXPERIMENTAL PROGRAM

### 2.1 Materials Used

#### 2.1.1 Cement

There are three grade (33,43,53) of cement available generally in market. Ordinary Portland Cement grade 43 of JK Lakshmi brand is used in HPC conforming to IS:8112-1987. The physical and chemical properties of cement are listed in the Table 2.1 and 2.2.

| S.No. | Properties | Values |
|---|---|---|
| 1 | Sp. Gravity | 3.15 |
| 2 | Consistency | 31% |
| 3 | Initial setting time | 75min |
| 4 | Final setting time | 165min |
| 5 | Compressive strength(MPa) at 3 days | 26.3 |
| | Compressive strength(MPa) at 7 days | 34.9 |

**Table 2.1: Physical Properties of OPC43 Grade Cement**

| S.No | Chemical Properties | Values(%) |
|---|---|---|
| 1 | SiO2 | 23 |
| 2 | Al2O3 | 4.2 |
| 3 | MgO | .20 |
| 4 | Fe2O3 | 1.2 |
| 5 | CaO | 63 |

**Table 2.2: Chemical Properties of Cement**

### 2.1.2 FLY ASH

Fly Ash is the industrial by-product produced by electrostatic process from flue gases of power station furnaces fired with coal. According to ASTM C 618-99, FA is classified into 2 classes i.e. Class F and Class C. The characteristic of Fly ash showing pozzolanic property similar to cement has motivated the use of Fly Ash as partial replacement of cement in concrete. The specific gravity of locally available flyash used in this study is 2.24.

### 2.1.3 ALCCOFINE

Alccofine is new generation product with ultrafine size having less calcium silicate content, easily available in India. It has characteristics to improve the performance of concrete in both fresh and hardened phases. Alccofine shows better properties than other admixtures used in India. Alccofine forms C-S-H gel by consuming $Ca(OH_2)$ which results in denser structure and gain strength. The specific gravity of Alccofine is 2.86 and is used to increase workability. Various properties of Alccofine is presented as per manufacturer data in Table 3.3.

| Chemical Analysis | Mass% | Physical Analysis | Values |
|---|---|---|---|
| CaO | 32-34 | Bulk density | 600-700kg/m$^3$ |
| $Al_2O_3$ | 18-20 | Particle shape | 12000cm$^2$/gm |
| $Fe_2O_3$ | 1.8-2 | Particle shape | Irregular |
| $SO_3$ | .3-.7 | Particle size, D10 | <2 µ |
| MgO | 8-10 | D50 | <5 µ |
| $SiO_3$ | 33-35 | D90 | <9 µ |

Table 2.3: Physical and Chemical Properties of Alccofine

### 2.1.4 AGGREGATE

Concrete consists of aggregates mixed with cement paste produced from hydration of cement. Some admixtures are used to enhance the concrete properties e.g. workability, to retard setting time, to achieve greater compressive strength, and to resist from unwanted materials. Two types of aggregate used in concrete are coarse aggregate and fine aggregate.

#### 2.1.4.1 FINE AGGREGATE

Material passing through an IS sieve 4.75mm is called as fine aggregate. The locally available materials confirming to Zone-II grade IS 383-1970 is used as fine aggregate. Tests of materials have been according to IS Codes and the results are as discussed in Table 2.4.

#### 2.1.4.2 COARSE AGGREGATE

Materials retained on IS sieve 4.75mm is called as coarse aggregate. To produce high strength concrete, it is very important to select proper material. This is investigated from previous research that the use of small coarse aggregate leads to the increase of concrete strength in comparison to the larger aggregate as smaller aggregate is stronger than the larger ones. So, locally available aggregates of maximum 10mm size are used. Testing of materials is done according to IS Codes procedures and the results are shown in the Table 2.5.

| Physical properties | Values |
|---|---|
| Fineness modulus | 3.076 |
| Grade zone | II |
| Specific Gravity | 2.646 |

Table 2.4 Physical Properties of Fine Aggregate

| Physical properties | Values |
|---|---|
| Fineness modulus | 5.96 |
| Specific Gravity | 2.69 |
| Water absorption (%) | 0.905 |
| Crushing value (%) | 19.1 |
| Impact value (%) | 12.02 |
| Los Angeles abrasion value (%) | 21.58 |

Table 2.5 Physical Properties of Coarse Aggregate(10mm)

### 2.1.5 SUPERPLASTICIZER

Non-toxic conplast- SP430 PQC, a concrete superplasticizer based on Sulphonated Naphthalene Polymer is used as a water-reducing admixture and to improve the workability of admixed concrete as shown in Figure 3.4. Conplast SP430A1 (QCDA-579) has been specially formulated to give high water reductions up to 25% without loss of workability or to produce high quality concrete of reduced permeability. Specific gravity of superplasticizer is 1.23 as reported by manufacturer.

### 2.1.6 WATER

Water is an important ingredient in preparation of concrete. Potable water free from deleterious materials, odorless, normal appearance oils, salts with normal temperature is used mixing and curing in this experiment.

### 2.2 Mix Proportion

After the testing properties of materials to be used in experiment for HPC, mix design of M60 grade concrete for highway pavement as per ACI211.4r-08 is done. The water/binder ratio for the mix used is taken 0.25. The final amount of materials (kg/m$^3$) taken after several controlled mixed trials in the concrete and results of these samples are given in following Table. The slump value of this control mix is found to be 32 mm.

| Materials | Quantity(Kg/m$^3$) |
|---|---|
| Cement | 668 |
| Fly ash | 135 |
| Coarse aggregate | 1044 |
| Fine aggregate | 585 |
| Water-binder ratio | 0.25 |

Table3.6: Mix Proportion

### 2.3 Preparation of Samples and Curing

When proportioning of mix is done, the aggregate and cement is mixed with the help of rotating drum type mixture. The mixer machine is rotated for about 1-2 min after adding water and superplasticizer for proper mixing. The moulds are properly cleaned and greased with the help oil just to keep concrete from sticking with moulds. The testing samples are casted in the standard mould of size 15cm ×15cm × 15cm for compressive strength and 15cm diameter and 30cm height of cylindrical mould for split tensile strength and 10cm x 10cm × 50cm beam for flexural strength. The concrete is placed into the moulds in layers and compacted with the help of plate vibrator (Figure 3.9) till surface is leveled. The test samples are placed free from vibration stored at 27°C temperature for 24 hours from the time of addition of water. The samples are demoulded after 24 hours and placed for curing in water tank for 28 days.

### 2.4 Testing Method

Mechanical properties of HPC i.e. compressive, flexural and splitting tensile strength are calculated at 28 days after curing according to IS codes shown in Table 3. 15 cubes, 15 beams and 15 cylinders are prepared for this experiment. Average of 3 samples is taken for individual test results.

## III. RESULTS AND DISCUSSIONS

Tests are carried to evaluate the strength properties i.e. compressive, tensile, and flexural strength for highway pavement using alccofine and flyash. Compressive testing machine is used for testing compressive and split tensile strength whereas flexural testing machine is used to check flexural strength. The samples are designated as MFA1, MFA2, MFA3, MFA4, MFA5 at different proportions of alccofine (3%,6%,9%,12%,15%). Surface of samples is cleaned and adjusted in machine properly so that values don't change. It is observed that optimum value of alccofine is found to be 12 percent. The strength increases from 3% to 12% and then decreases. The

results obtained in testing for compressive, split tensile, flexural strength in given table 3.1 and graphs are also plotted as shown in figures 3.1,3.2,3.3.

| Designation | Cement | Flyash | Alccofine | F.A | C.A (10mm) | Water | Superplasticizer | $F_{ck}$ | $f_{ct}$ | $f_b$ |
|---|---|---|---|---|---|---|---|---|---|---|
| MFA1 | 648 | 135 | 20 | 585 | 1040 | 201 | 24.09 | 59.89 | 3.94 | 2.25 |
| MFA2 | 628 | 135 | 40 | 585 | 1040 | 201 | 24.09 | 64.81 | 4.11 | 6.12 |
| MFA3 | 608 | 135 | 60 | 585 | 1040 | 201 | 24.09 | 65.44 | 4.66 | 6.40 |
| MFA4 | 588 | 135 | 80 | 585 | 1040 | 201 | 24.09 | 66.53 | 5.55 | 7.35 |
| MFA5 | 568 | 135 | 100 | 585 | 1040 | 201 | 24.09 | 65.01 | 5.19 | 6.25 |

*$F_{ck}$= compressive strength (MPa), $F_{ct}$= split tensile strength (MPa), $F_b$= flexural strength (MPa)

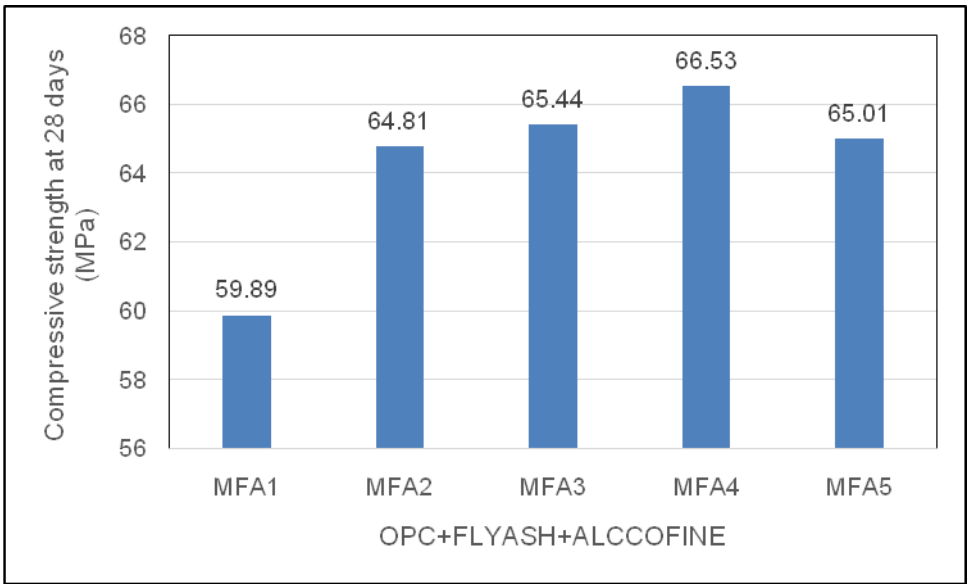


**Fig.3.1: Compressive strength results HPC blending with Flyash and Alccofine**

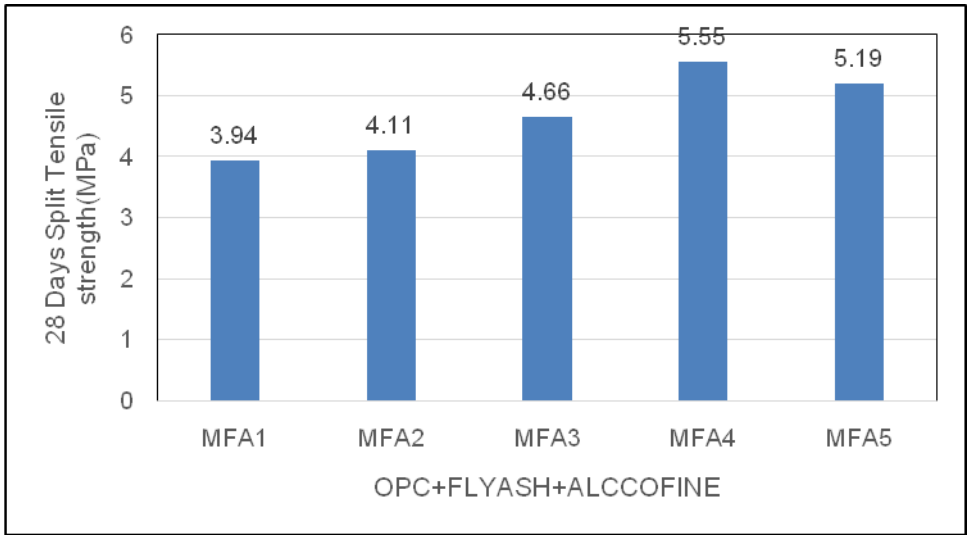

**Fig.3.2: Split tensile strength results HPC blending with Flyash and Alccofine**

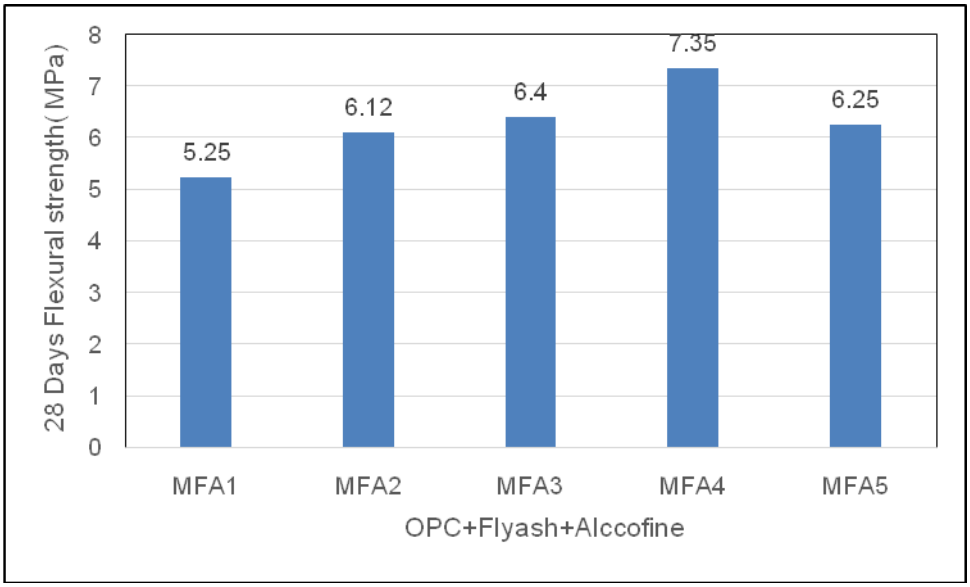


**Fig.3.3: Flexural strength results HPC blending with Flyash and Alccofine**

## VI. CONCLUSIONS

Laboratory tests are performed covering the mechanical and rheological aspects of high performance concrete. The major experimental conclusions are as follows;

1. High performance concrete is modified by blending with Fly Ash and Alccofine as SCMs. These adjustments reduce the $CO_2$ emission and make concrete eco-friendly.
2. From compressive strength of various mix proportions by considering all available SCMs, it is found that mix incorporating fly ash and Alccofine has given good results.
3. The minimum and maximum compressive strength attained at 28 days of curing were found to be 59.89 $N/mm^2$ and 66.53 $N/mm^2$ respectively.
4. The compressive strength of concrete is increased with increase in Alccofine content up to 12%. It is therefore concluded that there is possibility of production of concrete having compressive strength more than 60 MPa from mix incorporating Alccofine and flyash as SCM at 0.25w/c ratio based on investigation.
5. There is considerable improvement in flexural behaviour of concrete mix having flyash and Alccofine. The maximum flexural strength obtained is 7.35 MPa.
6. The minimum and maximum split tensile strength attained at 28 days of curing is found to be 3.94 $N/mm^2$ and 5.55 $N/mm^2$ respectively. High strength achieved through the use of SCMs decreases the maintenance cost of structure.
7. When using a super plasticizing admixture with HPC made with aggregates, adding of admixture in final stage of mixing consistently improves the properties of fresh and hardened concrete compared with the traditional practice of adding the admixture to the mixing water.

8. The cube compressive strength studies indicate that the optimum percentage of Alccofine is about 12%. The density of HPC increases as Alccofine content increases.

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