Study on Alccofine Based High Performance Concrete

G.SRINIVASAN
Associate Professor, Department of Civil and Structural Engineering, Annamalai University, Annamalainagar, TamilNadu state, India-608002, drgs72@gmail.com.

Abstract

In this present scenario of construction practice, new materials are being used as additive to the High Performance Concrete. Alccofine 1203 is one of such additive which proposed to use, in order to increase the compressive strength and durability of concrete. Alccofine 1203 is primarily composed of low calcium silicates which is processed and obtained through controlled particle size distribution (PSD). When compared to cement, the particle size distribution and specific gravity of Alccofine 1203 is higher and lower respectively, thus making more suitable as an additive to cement. In this thesis, it is proposed to study the Alccofine based high performance concrete with various proportions. M50 grade of concrete is planned to study by their mechanical properties such as compressive strength, flexural strength, elastic modulus of concrete and other durability properties. For all the tests, standard experiments are followed to determine the properties as per Indian standards. The results are presented and discussed. It is observed that 10% Alccofine added with the cement is giving increase in strength.

Key Words : Alccofine 1203, Conplast SP430, High performance concrete, Compressive strength, Flexural Strength, E for concrete, Durability properties and Elastic Workability.

1. Introduction

High Performance Concrete (HPC) exceeds the properties and constructability of normal concrete. Normal and special materials are used to make these specially designed concretes that must meet a combination of performance requirements[3]. HPC has been primarily used in tunnels, bridges, and tall buildings for its strength, durability, and high modulus of elasticity. High-performance concretes are made with carefully selected high-quality ingredients and optimized mixture designs; these are batched, mixed, placed, compacted and cured to the highest industry standards. One of such high-quality ingredients is the Alccofine 1203, a fine mineral admixture[5][7].

ALCCOFINE1203 is a specially processed product based on high glass content with high reactivity obtained through the process of controlled granulation. The raw materials are composed primary of low calcium silicates. The processing with other select ingredients results in controlled particle size distribution (PSD). The computed blain value based on PSD is around 12000cm²/gm. and is truly ultra-fine[6] [8]. Due to its unique chemistry and ultrafine particle size, ALCCOFINE 1203 provides reduced water demand for a given workability, even up to 70%
replacement level as per requirement of concrete performance. ALCCOFINE 1203 can also be used as a high range water reducer to improve compressive strength or as a super workability aid to improve flow[9] [10].

Ground granulated blast-furnace slag is a non-metallic product consisting essentially of silicates and aluminates of calcium and other bases. The molten slag is rapidly chilled by quenching in water to form a glassy sand like granulated material. The granulated material when further ground to less than 45 micron will have specific surface of about 400 to 600 m²/kg (Blaine). Alccofine is a well graded particle size smaller than cement and higher than Micro Silica[1] [2]. It is generally considered that fineness of cement and cementitious materials have influence on strength. Use of Alccofine enhances the performance of concrete in terms of durability due to its superior particle size distribution. Alccofine has particle range 0.1 to 17 microns, average particle size is 4 micron. Effectiveness of packing depends upon differences in particle size between cement and additives and extent of hydrated products generated during hydration. The secondary hydrated products formed due to pozzolonic and cementitious hydration reaction fills the pores. This reduces the permeability of hydrated product to great extent, thus enhances durability of concrete. Many deteriorating effects like corrosion, carbonation, sulfate attack etc., may be minimized or stopped[2] [8].

Fig. 1 Alccofine - 1203

ALCCOFINE 1203 is a new generation supplementary cementitious material (SCM) with a built-in high tech content. In spite of its high fineness it does not increase water demand at the dosage range of 5 to 15 percent of normal ordinary Portland cement (OPC) in general. In fact concrete slump is seen to be improved, due to the dense packing of cementations material, producing low void content. The use of AF results in hydrated cement matrix to comprise of very small pores.
Strength development increases drastically at early ages and the later on strengths are higher compared to traditional supplementary cementitious material due to its unique PSD. Concretes of over 100 MPa (HPC / UHPC) are possible to be made using AF. Judicious use of AF can produce concrete of superior properties and performance in every way.

Table 1. Chemical composition and physical composition of Alccofine 1203.

| Chemical Analysis | Mass % | Physical analysis | Range       |
|-------------------|--------|-------------------|-------------|
| CaO               | 30-34  | Bulk Density      | 600-700 kg/m³ |
| Al2O3             | 18-25  | Surface Area      | 12000 cm²/gm |
| Fe2O3             | 0.8-3.0| Particle shape    | Irregular   |
| SO3               | 0.1-0.4| Particle Size,d10 | < 2 μm     |
| MgO               | 6-10   | d50               | < 5μm       |
| SiO2              | 30-36  | d90               | < 9 μm      |

2. Materials and Methods

The experimental investigations are planned to study concrete when added with Cement Replacement Material [CRM] partially. Different mix proportions are designed and standardized. The aim of the study is to determine the compressive strength, flexural strength, Elastic modulus of concrete and durability RCPT test with various mix proportions are casted and cured, made ready for testing. The test specimens are cast and tested and its results are present here. To obtain high performance in concrete, design mix M50 is planned to cast in the form of cubes. Since the aim of the project is to determine the compressive strength of concrete, the properties of different materials to be used are determined by standard laboratory tests. Then the mix proportions are casted and cured, made ready for testing. The cubes are tested to find out the compressive strength of the various design mixes.

The main objective of this work is as follows:

- To design the mix portion for Alccofine 1203 partially replacing the conventional cement in various percentage such as 5%, 10%, 15% and 20%.
- To determine the compressive strength of the partially replacement of Alccofine 1203 in HPC.
To determine the flexural strength of the partially replaced Alccofine 1203 in HPC.

To determine the elastic modulus for the HPC with Alccofine 1203.

To determine the durability of the concrete the partially replaced Alccofine 1203.

To find out the optimum percentage of Alccofine required for early age strength.

The materials like OPC, river sand, 20mm -12.5 mm aggregate are used for making of concrete with desired ratio of water for various mix proportions. The specimens are standard cube (150×150×150), cylinder (150mm diameter and 300mm length), and flexural prism (100×100×500) and prism 100x100x300 for RCPT. After casting the specimens need to be allowed for curing for about 3, 7, 14,28 and 56 days so as to help the concrete to stabilize its own properties like compressive strength, flexural strength, modulus of elasticity and durability RCPT tests.

Conplast SP430 is used where a high degree of workability and its retention are required, where delays in transportation or placing are likely or when high ambient temperatures cause rapid slump loss. It facilitates production of high quality concrete.

2.1. Mix Proportions

The various mix proportions of concrete using cement, AF, SF, are designed the table shown Mix proportions in kg/m³

| Sl.No | Mix Degination | Cement | Alccofine | Fine Aggregate | Coarse Aggregate | Water Binder | Super Plasticizer |
|-------|----------------|--------|-----------|----------------|------------------|--------------|------------------|
| 1     | AO             | 429    | 0         | 638            | 1295             | 150          | 6                |
| 2     | A5             | 407    | 22        | 638            | 1295             | 150          | 6                |
| 3     | A10            | 386    | 43        | 638            | 1295             | 150          | 6                |
| 4     | A15            | 365    | 64        | 638            | 1295             | 150          | 6                |
| 5     | A20            | 343    | 86        | 638            | 1295             | 150          | 6                |

2.2. Casting of Specimens
The various mix proportion of concrete using cement, Alcocine (AF) is identified and the number of specimens has been found, the details of various test specimens are given in the table.

Table 3. The table shows the total number of specimens casted.

| Sl. no | MIX  | CUBE | CYLINDER (150mm) | PRISM |
|-------|------|------|------------------|-------|
|       |      | SPECIMEN |                 |       |
|       |      | 3 days | 7 days | 14 days | 28 days | 56 days | Total |
| 1     | A0   | 3     | 3      | 3       | 3       | 3       | 15    |
| 2     | A5   | 3     | 3      | 3       | 3       | 3       | 15    |
| 3     | A10  | 3     | 3      | 3       | 3       | 3       | 15    |
| 4     | A15  | 3     | 3      | 3       | 3       | 3       | 15    |
| 5     | A20  | 3     | 3      | 3       | 3       | 3       | 15    |
| 6     | A0   | -     | -      | 3       | 3       | 3       | 6     |
| 7     | A5   | -     | -      | 3       | 3       | 3       | 6     |
| 8     | A10  | -     | -      | 3       | 3       | 3       | 6     |
| 9     | A15  | -     | -      | 3       | 3       | 3       | 6     |
| 10    | A20  | -     | -      | 3       | 3       | 3       | 6     |
| 11    | A0   | -     | -      | 3       | 3       | 3       | 6     |
| 12    | A5   | -     | -      | 3       | 3       | 3       | 6     |
| 13    | A10  | -     | -      | 3       | 3       | -       | 6     |
| 14    | A15  | -     | -      | 3       | 3       | -       | 6     |
| 15    | A20  | -     | -      | 3       | 3       | -       | 6     |

2.3 Testing of Specimens

Specimens stored in water shall be tested immediately on removal from the water and while they are still in the wet condition. Surface water and grit shall be wiped off the specimens and any projecting fins removed. Specimens when received dry shall be kept in water for 24 hours before they are taken for testing.
The compressive strength is the capacity of a material or structure to withstand loads tending to reduce size. It can be measured by plotting applied force against deformation in a testing machine.

![Standard Test setup for compressive strength](image)

**Table 4. Compressive Strength (M50).**

| Sl. No | % of Alcocine | Compressive strength in N/mm² |
|--------|---------------|-------------------------------|
|        |               | 3 days | 7 days | 14 days | 28 days | 56 days |
| 1      | A0            | 33.33  | 46.69  | 48.60   | 49.55   | 52.53   |
| 2      | A5            | 41.11  | 43.75  | 49.36   | 51.07   | 52.97   |
| 3      | A10           | 45.55  | 48.35  | 51.33   | 51.79   | 55.31   |
| 4      | A15           | 41.58  | 42.87  | 43.53   | 50.11   | 51.12   |
| 5      | A20           | 40.00  | 40.44  | 40.94   | 45.44   | 48.97   |

The flexural strength represents the highest stress experienced within the material at its moment of rupture.
Table 5. Flexural Strength (M50).

| Sl. No. | Mix Proportion | Flexural Strength at age of 14 days N/mm² | Flexural Strength at age of 28 days N/mm² |
|---------|----------------|------------------------------------------|------------------------------------------|
| 1       | A0             | 7.3                                      | 8.2                                      |
| 2       | A5             | 8.1                                      | 9.9                                      |
| 3       | A10            | 9.1                                      | 10.5                                     |
| 4       | A15            | 8.3                                      | 9.2                                      |
| 5       | A20            | 7.7                                      | 8.2                                      |

The elastic modulus of an object is defined as the slope of its stress–strain curve in the elastic deformation region. A stiffer material will have a higher elastic modulus.
Table 6. Elastic modulus in GPa at the age of 28 days

| Sl No | Mix designation | Elastic Modulus in GPa at the age of 28 days |
|-------|-----------------|-----------------------------------------------|
| 1     | A0              | 35.01                                         |
| 2     | A5              | 25.23                                         |
| 3     | A10             | 40.15                                         |
| 4     | A15             | 27.24                                         |
| 5     | A20             | 20.06                                         |

3. Results and Discussions

The aim of the study is to determine the compressive strength, flexural strength, Elastic modulus of concrete with various mix proportions. The results of test specimens are presented in the form of bar charts and graphs.

The results obtained from the compressive strength of the concrete with various mix proportions are presented in the form of bar charts and graphs as shown in figures.

Table 7. Comparison of various mix of compressive strength

| Sl. No | % of Alccofine | Compressive strength in N/mm² |
|--------|----------------|-------------------------------|
|        |                | 3 days | 7 days | 14 days | 28 days | 56 days |
| 1      | A0             | 33.33  | 46.69  | 48.60   | 49.55   | 52.53   |
| 2      | A5             | 41.11  | 43.75  | 49.36   | 51.07   | 52.97   |
| 3      | A10            | 45.55  | 48.35  | 51.33   | 51.79   | 55.31   |
| 4      | A15            | 41.58  | 42.87  | 43.53   | 50.11   | 51.12   |
| 5      | A20            | 40.00  | 40.44  | 40.94   | 45.44   | 48.97   |
Fig: 5. Comparison of various mix of compressive strength

The results obtained from the flexural strength of the concrete with various mix proportions are presented in the form of bar charts and graphs as shown in figures.

Table. 8. Comparison of various mix flexural strength.

| Sl. No. | Mix Proportion | Flexural Strength at age of 14 days N/mm² | Flexural Strength at age of 28 days N/mm² |
|---------|----------------|------------------------------------------|------------------------------------------|
| 1       | A0             | 7.3                                      | 8.2                                      |
| 2       | A5             | 8.1                                      | 9.9                                      |
| 3       | A10            | 9.1                                      | 10.5                                     |
| 4       | A15            | 8.3                                      | 9.2                                      |
| 5       | A20            | 7.7                                      | 8.2                                      |
The results obtained from the Elastic modulus of the concrete with various mix proportions are presented in the form of bar charts and graphs as shown in figures.

Table 9. Elastic modulus in GPa at the age of 28 days

| Sl No | Mix designation | Elastic Modulus in GPa at the age of 28 days |
|-------|-----------------|--------------------------------------------|
| 1     | A0              | 35.01                                      |
| 2     | A5              | 25.23                                      |
| 3     | A10             | 40.15                                      |
| 4     | A15             | 27.24                                      |
| 5     | A20             | 20.06                                      |
4. Conclusions

The conclusions from the experimental investigations are as follows:

- From the experimental results, the optimum replacement of cement by the Alccofine is 10% of the volume of the cement.

- The strength development of Alccofine based concrete is greater than all other concrete at all age of curing.

- From the experimental results, when compressive strength compare to control mix, the \text{A}_{10} mix is improved by 6.5%.

- From the experimental results, when flexural strength compare to control mix, the \text{A}_{10} mix is 22% improved.

- It is clearly known that the Alccofine material increases the strength only at the addition of 10% replacement of cement.

- If the percentage level of Alccofine is increased beyond that level it acts as a filler material and yields good workability to the concrete.
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