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An experimental study on the mechanical properties of alccofine based high grade concrete

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Abstract
This is an experimental research on mechanical properties of alccofine- (Alccofine 1203 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) on high strength concrete of grade M60. Concrete attains high strength at a very early age, due to the presence of alccofine material. The mechanical properties studied here are compressive strength on concrete cubes at 3,7,14 and 28 days of water curing and flexural strength on prisms at 7 and 28 days of water curing. It is observed from the results that the alccofine material increases the strength (both in compression and in flexure) to a large extent at 10% replacement level of cement.

Keywords: Compressive strength, Particle size distribution, Alccofine, high grade concrete.

1. Introduction
Creating quality concrete in the present climate does not depend solely on achieving high strength property. Improving the durability of the concrete to sustain a longer life span and producing a greener concrete are becoming one of the main criteria in obtaining quality concrete. Compressive strength of concrete is important because the main properties of concrete such as elastic modulus, tensile strength are related to this property. Concrete compression strength also plays a vital role on load bearing capacity of structures. Compression test is the most common test conducted on the hardened concrete because it is an easy test to perform and most of the desirable characteristic properties of concrete are qualitatively related to its compressive strength. In this work the replacement of cement by different percentages of ultra-fine slag (Alccofine) has been studied. It has been found that use of alccofine not only improves the compressive strength of concrete but also improves the workability and fluidity of the mix. Alccofine-1203 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 12000cm^2/gm. and is truly ultra-fine. Due to its unique chemistry and ultra-fine particle size, Alccofine-1203 provides reduced water demand for a given workability, even up to 70% replacement level of cement as per requirement of concrete performance.

1.1 Mechanical properties

1.1.1 Compressive Strength Test
The compressive strength is obtained by conducting test on Compression testing machine for different types of concrete mixes. In this study, we have selected different age of concrete Such as 3 Days, 7 Days, 14 Days and 28 Days of water curing. The cube mould of 150mm x 150mm x 150mm size is taken as per IS: 516-1959 specification.

1.1.2 Flexural Strength Test
The flexural strength test on prism was conducted as per the IS: 516-1959 specification by flexural testing machine for all types of concrete mixes. For the present study, the concrete prisms of size 100mm x 100mm x 500mm were prepared. A total 3 Nos. of prisms were cast for each type of concrete mixes. All the prisms were cured for a period of 7 days and 28 days in water. The prisms were placed on the support normal to the casting face and symmetrical two-

point load system, each at one third points was adopted for the flexural tensile strength test. The deflection of the prisms was measured by the dial gauge of LC=0.01mm, which was placed in the middle third portion of the beam.

$$\text{Flexural Strength [Fb]} = {}^{Pl}/_{bd^2}$$

2. Materials and methods

Cement, fine aggregate, coarse aggregate and water are the common ingredients used. In addition alccofine -1203, and superplactisizer (Conplast SP-430) which was used to improve workability.

2.1 Cement

Cement used for casting of all specimens is Ordinary Portland Cement of 43 grade conforming to IS 8112-2013. The sample of cement is shown in Fig. 2.1

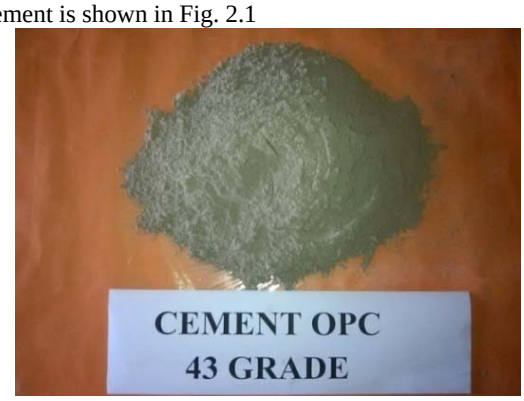


Fig 2.1: OPC-43

2.2 Alccofine-1203

As can be seen from the chemical analysis Table 2.1 'Alccofine-1203' is ultrafine material having unique chemical composition mainly with 30-34% of Cao and 30-36% of SiO2. Table 2.1 shows the chemical ingredients found in alccofine on chemical analysis. The sample of ultrafine material alccofine is shown in Fig. 2.2

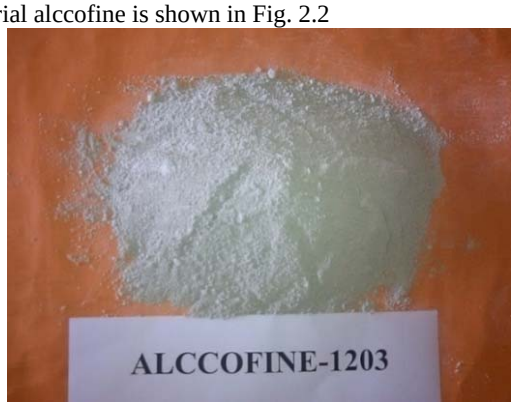


Fig 2.2: Alccofine-1203

Table 2.1: Chemical composition of Alccofine

Chemical Analysis	Mass %
CaO	33
Al_2O_3	22.1
Fe_2O_3	2.1
SO_3	0.3
MgO	7.5
SiO_2	35

2.3 Fine Aggregate

The Fine Aggregate is as per IS 383-1970 Code conforming that is coming under ZONE III.

2.4 Coarse Aggregate

Well graded coarse aggregate conforming to the provision of IS: 383-1970 was used throughout the investigation. Two types of aggregate of maximum nominal sizes, 12mm and 20mm, were blended to a desired proportion and mixed intimately to obtain well graded aggregate.

2.5 Water

Potable water was used for mixing concrete and curing the specimens.

2.6 Superplactisizer (Conplast SP430): Superplactisizer - ConplastSP430 as shown in Fig. 2.3 is used where a high degree of workability and its retention are required as also necessitate in places where delays in transportation or placing are likely or else when high ambient temperatures cause rapid slump loss. It facilitates further in the production of high quality concrete

Fig 2.3: Conplast SP430

Properties:
Specific gravity -1.21
Chloride content -Nil as per IS: 9103-1999 and BS: 5075
Air entrainment - Approx. 1% additional air over control mix

2.7 Concrete

The physical properties and tests of cement are carried out in accordance with procedure laid down in IS: 1489-1991: 'Specification for Portland-pozzolana cement'. The maximum size of aggregate was 20mm and the size of fine aggregate ranges between 150 microns and 4.75mm. After casting, the specimens need to be allowed to cure in standard room temperature for about 28 days so as to help the concrete to stabilize its own properties like compressive strength and flexural strength.

3.0 Preliminary tests on materials

Basic tests like specific gravity and sieve analysis were carried out on the materials. Testing was done and the results were tabulated as given below.

3.1 Specific gravity of materials

The specific gravity of the materials used for making concrete is determined as per IS 2386 – 1963. The values obtained are given in the table 3.1.

Table 3.1 Specific Gravity

Sl. No	Name of the Material	Specific Gravity
1.	OPC Cement	3.15
2.	Alccofine	2.86
3.	Fine Aggregate	2.63
4.	Coarse Aggregate	2.74

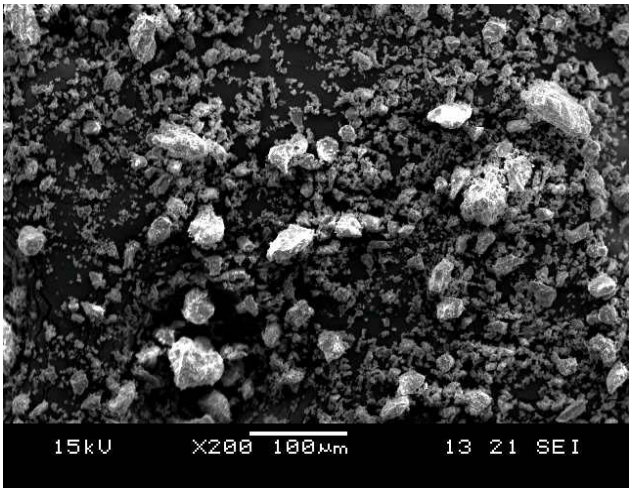
3.2 Sieve Analysis

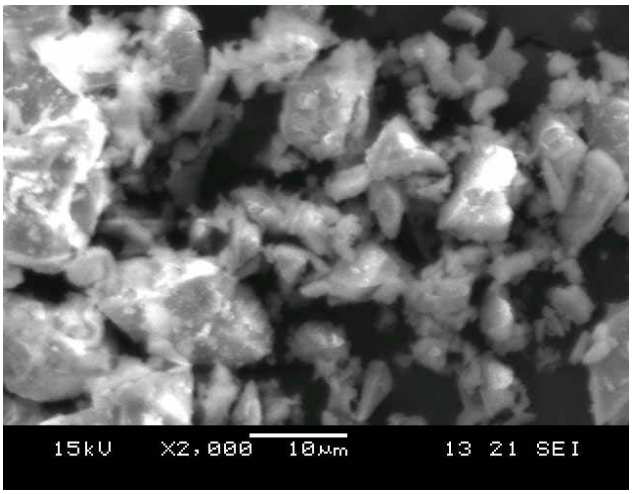
The locally available river sand is used as a fine aggregate (up to 4.75 mm) which was tested for sieve analysis to determine the grading zone as per IS 383 – 1970. It was found that the fine aggregate conformed to grading zone III of IS 383:1970 and its fineness modulus was found to be 2.23.

3.3 Scanning Electron Microscope (SEM) Analysis

The cementitious materials are analysed in SEM analysis to find in the materials shape and size of the samples.

3.4.1 Ordinary Portland Cement-43





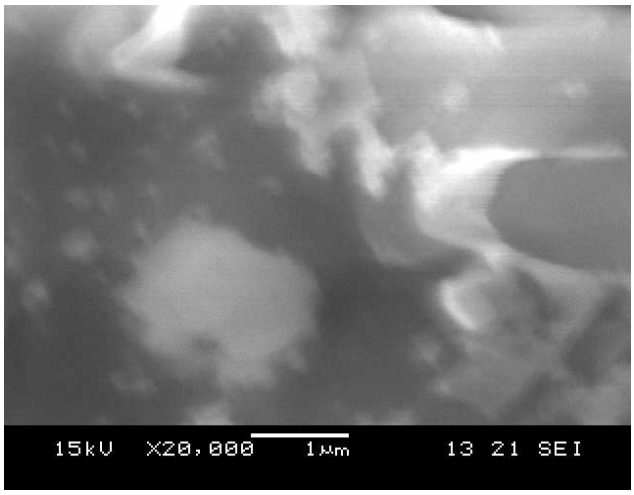
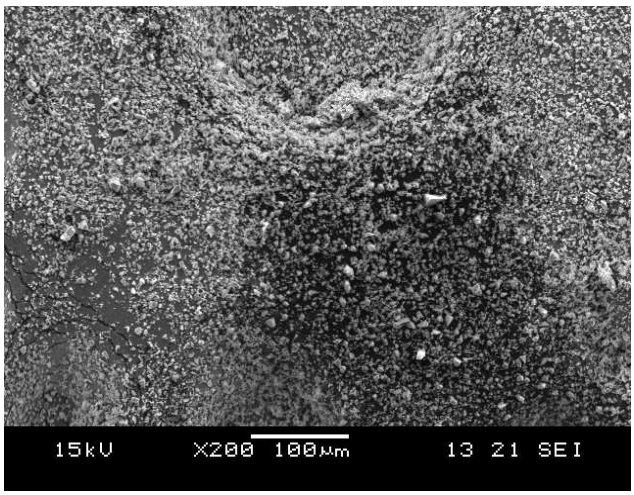
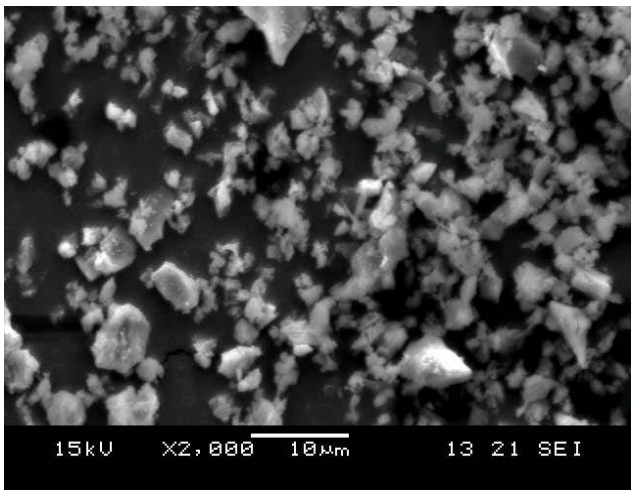


Fig. 3.4 (a): SEM analysis of OPC 100µ, 10µ and 1µ

3.4.2 Alccofine-1203





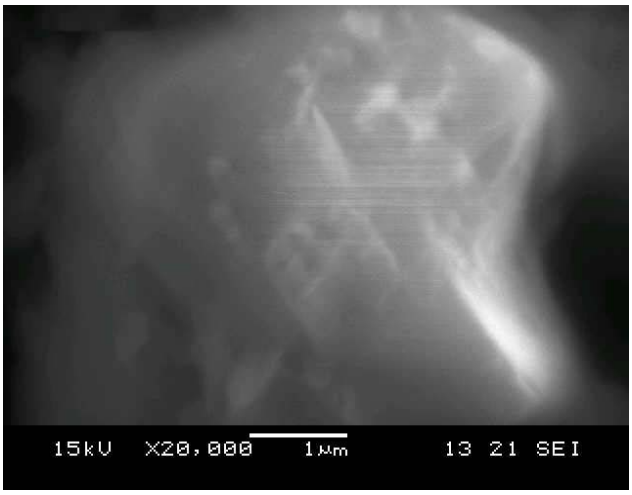


Fig. 3.4 (b): SEM analysis of Alccofine 100µ, 10µ and 1µ

3.4.3 Workability test

The slump test is carried out using the slump cone as per IS 1199-1959. The cone is placed on a hard non-absorbent surface. This cone is filled with fresh concrete in three layers, each layer is tamped using a rod of standard dimensions. At the end of the third stage, concrete is struck off flush to the top of the mould. The mould is carefully lifted vertically upwards, so as not to disturb the concrete, the cone is placed by the side of concrete and the slump value is measured from top as shown in Fig 3.5. The slump value measured was 40 mm.

Fig 3.5: Slump test on concrete

3.5 Mix ratio for M60 grade of concrete

The design mix for M 60 grade of concrete is carried out as per the standards IS 10262 – 2009. The mix proportions for various dosages of alccofine are given in Table 3.2.

Table 3.2: Mix Ratio

Sl. No	CEMENT	F.A	C.A	WB	AF	SP
1.	1	1.20	2.68	0.3	0.00	0.013
2.	1	1.20	2.68	0.3	0.05	0.013
3.	1	1.20	2.68	0.3	0.10	0.013
4.	1	1.20	2.68	0.3	0.15	0.013
5.	1	1.20	2.68	0.3	0.20	0.013

3.6 Mix proportions in Kg/m^3

The quantities of various ingredients in volume for the designed concrete mix per cubic meter of concrete are presented in Table 3.3

Table 3.3: for Mix Proportion

Sl. No	CEMENT Kg/m^3	F.A Kg/m^3	C.A Kg/m^3	WB Lit/m^3	AF Kg/m^3	SP Lit/m^3
1.	483.33	586	1297.39	145	0.00	5.19
2.	458.2	586	1297.39	145	21.73	5.19
3.	434.32	586	1297.39	145	44.05	5.19
4.	410.44	586	1297.39	145	65.78	5.19
5.	386.56	586	1297.39	145	87.51	5.19

4. Results & Discussion

4.1 Compressive Strength

The compressive strength is the capacity of a material or structure to withstand loads. It can be measured by plotting applied force against deformation in a compression testing machine. Some materials fracture at their compressive strength limit; others deform irreversibly, so a given amount of deformation may be considered as the limit for compressive load. Compressive strength is a key value for design of structures. All the test specimens cast for compressive strength were tested using a compression testing machine. The values obtained are shown in Table 4.1

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Table 4.1: Compressive Strength of Cubes

Sl. No	% of Alccofine	3 Days N/mm^2	7 Days N/mm^2	14 Days N/mm^2	28 Days N/mm^2
1.	A0	29.77	48.52	53.20	58.82
2.	A5	42.46	55.16	57.46	59.11
3.	A10	46.71	64.45	67.06	74.48
4.	A15	54.48	58.27	60.15	65.27
5.	A20	56.88	59.76	63.43	69.76

4.2 Flexural Strength

The flexural strength represents the highest stress experienced within the material at its moment of rupture. It is measured in terms of stress. The flexural strength was tested using a two point loading frame. The values obtained are shown in table 4.2.

Table 4.2: Flexural Strength of Prism

Sl. No	% of Alccofine	7 Days N/mm^2	28 Days N/mm^2
1.	A0	6	7.1
2.	A5	4.6	5.8
3.	A10	7.2	9.6
4.	A15	4.4	5.2
5.	A20	5	6.3

5. Analysis

5.1 Analysis of Compressive Strength

The compressive strength results obtained are presented in Table 4.1. The tests were carried out conforming to IS: 516-1959 to obtain compressive strength of concrete at the age of 3,7,14 and 28 days. The compressive strength was found to be 64.45 MPa at 7 days and 74.48 MPa at 28 days for alccofine replacement of 10 % which was the highest. There is a significant improvement in the compressive strength of concrete because of the high pozzolanic nature of alccofine and its void filling ability. The results are plotted in the Fig 5.1(a) and 5.1(b).

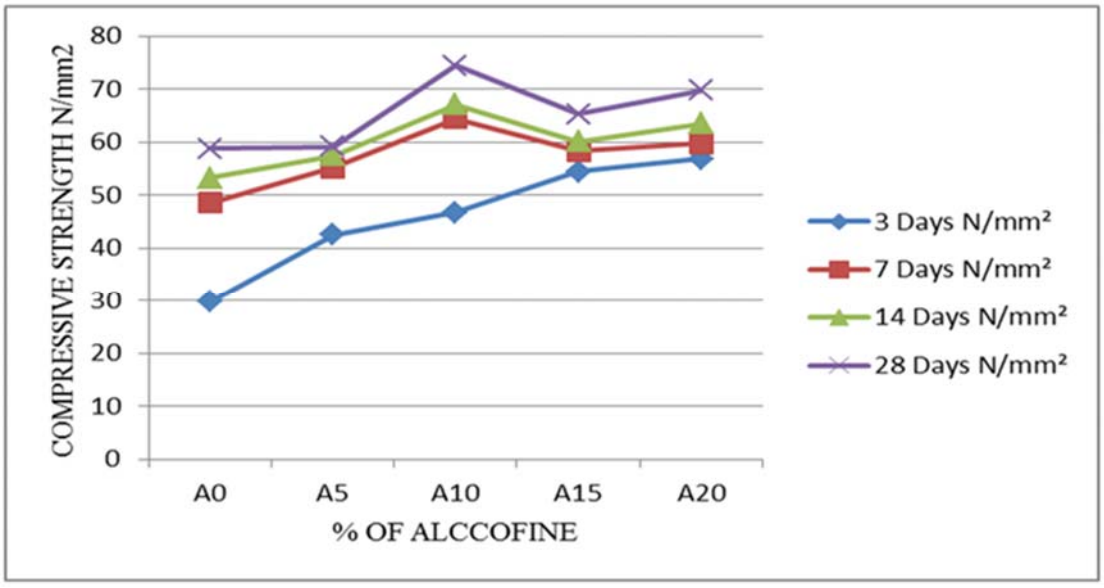

Fig. 5.1 (a): Compressive Strength

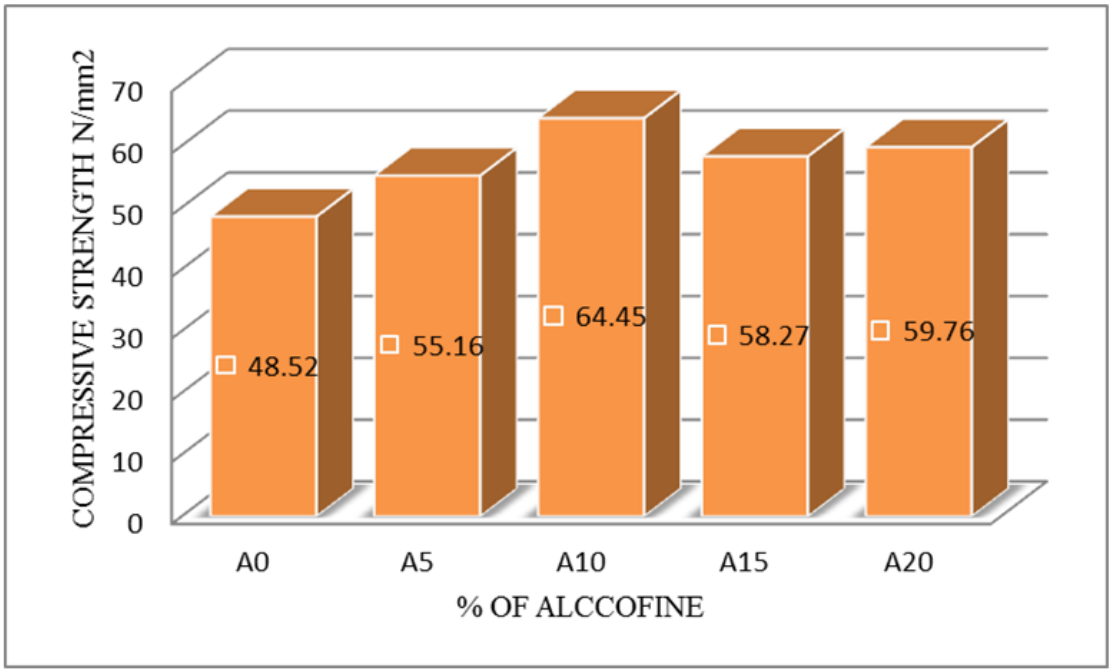

Fig 5.1(b): Compressive Strength at 7 days

The compressive strength results of high strength concrete (HSC) mixes at the ages of 3, 7, 14, 28 days are presented in table 4.1.The development of compressive strength of M60 grade of HSC mixes containing 0, 5, 10, 15 & 20 percent alccofine at the various stages are plotted in the form of graphs are shown in figure 5.1.This result shows that Cement replaced by alccofine at 10% gives the excellent result compared to the controlled mix and other percentage of alccofine mix.

5.2. Analysis of Flexural Strength

The Flexural strength of concrete after14 & 28 days of curing are shown in Fig. 5.3.The result shows that optimum percentage is 10% when cement is replaced by alccofine which gives excellent result compared with controlled mix and with other percentages of alccofine mix.

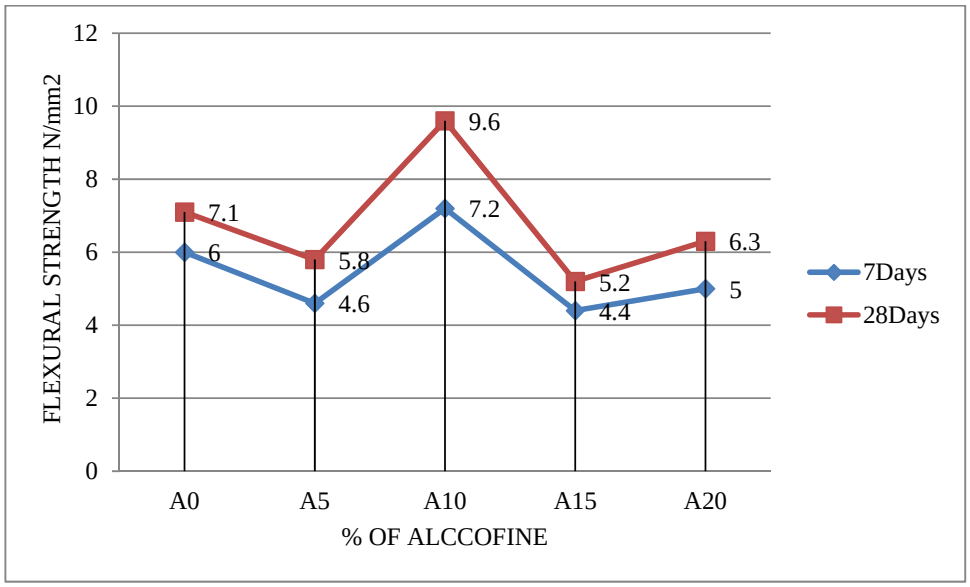

Fig.5.2 Comparison of flexural strength

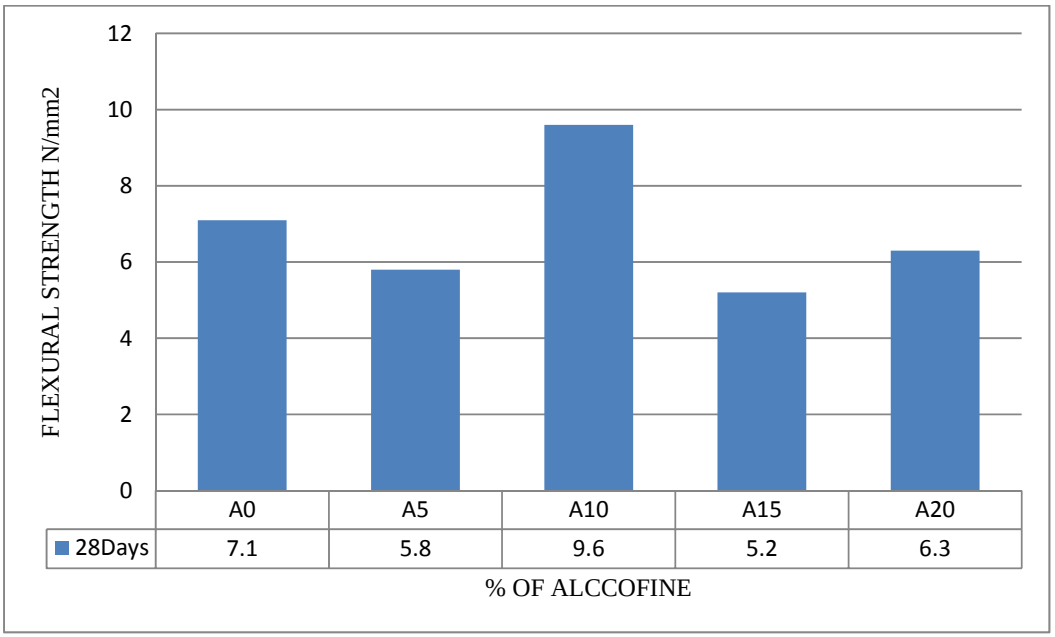

Fig 5.3: Flexural test on Prism

6. Conclusions

The conclusions from the experimental investigations are as follows:

The cementitious materials are analyzed in SEM analysis to find out shape and size of the binding materials, the optimum replacement of cement by the alccofine is 10 % of the volume of the cement. The cement replacement by 10% of alccofine gives higher values of all other mix. Compressive strength mainly depends upon the percentage of alccofine based on this its high pozzolanic nature to form more dense of Calcium silicate hydrate (C S H) gel. The strength development of concrete is carried out at all ages of curing and it is observed that the strength increasing suddenly at the initial stage but after that it is increasing gradually.

From the experimental results, it is seen that the 7 days compressive strength when compared between control mix and cement replaced by 10 % alccofine an increase of 25.5 % is observed.

From the experimental results, when 28 days curing has been done it is found that the flexural strength increased by 27.6% when control mix(0% alccofine) is compared with 10% cement replaced by alccofine . It is clear from the results 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. Since the materials are costlier than the cement, concrete cost will be higher but that can be adjusted during the execution/construction of structures. It is recommended to utilize the alccofine material with cement after checking its durability studies.

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