Experimental Investigations on Effect of Alccofines and Microsilica on Durability Properties of High Performance Concrete-A Comparative Study

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Abstract

Large scale production of cement is affecting environment due to enormous emission of CO_2 This has led to use industrial by-products as supplementary cementitous materials in making concrete. The main parameters in this research investigation is comparison of addition of micro silica and alccofine in production of High Performance Concrete by keeping maximum cement content 450kg, water bonder ratio of 0.32 , slump of fresh concrete 100 ± 10mm as constant for all mixes used, Both microsilica as well as Alccofine were added separately to concrete mix as a partial replacement to cement by 5% ,10% and 15% respectively for comparative study in production of high performance concrete. The present experimental investigation includes detailed comparative studies using microsilica and alccofine on hardened properties of High Performance concrete like: compressive strength, water permeability, rapid chloride penetration test and modulus of elasticity. From experimental result it is seen that addition of microsilica perform better than alccofine in concrete mix

Keywords: **Supplementary cementitious material, Microsilica, Alccofine, High performance concret , Strength and durability test.**

1. Introduction

The Concrete is an artificial conglomerate stone made essentially of Portland cement, water, and aggregates. Production of one ton of cement requires about 2 ton of raw materials and it will release 0.95tonne (≈ 1 ton) of CO_2. The global release of CO_2 from all sources is estimated at 23 billion ton in one year and the Portland cement production accounts for about 7% of total CO_2 emissions. In its most basic form, concrete is a mixture of Portland cement, sand, coarse aggregate and water. The principal cementitious material in concrete is Portland cement. Today, most concrete mixtures contain supplementary cementitious materials that make up a portion of the cementitious component in concrete. These materials are generally by products from other processes or natural materials. They may or may not be further processed for use in concrete. Some of these materials are called pozzolans, which by themselves do not have any cementitious properties, but when used with Portland cement, react to form cementitious compounds.

Supplementary cementitious materials can be used for improved performance of concrete both in its fresh and hardened state. They are basically used for improved work-ability, durability and strength. These materials allow the concrete producer to design and modify the concrete mixture based on the desired application. Concrete mixtures with high Portland cement contents are susceptible to cracking and increased heat generation. These effects can be controlled to a certain degree by using supplementary cementitious materials. Supplementary cementitious materials such as slag and silica fume enable the concrete industry to use hundreds of millions of tons of by product materials that would otherwise be landfilled as waste.

2. Material used

2.1 Ordinary Portland Cement

The Ordinary Portland Cement (OPC) is available in different grades, the most common in India are grade-53 and Grade 43. The grade cement used is ACC 53Grade, OPC.

2.2 Fine aggregates

The sand used for this study was manufactured sand. The sand passing through 4.75 mm sieve was used. The sand conforms to grading Zone II as per IS: 383-1970. The properties of sand such as fineness modulus and specific gravity were determined as per IS: 2386-1963**.**

2.3 Coarse aggregates

In the present study aggregate passing through 20mm and retained on 12.5mm is used **2.4 Micro silica**

Micro silica also called as silica fume, is another material that is used as an artificial pozzolanic admixture. It is a product resulting from reduction of high purity quartz with coal in an electric arc furnace in the manufacture of silicon or ferrosilicon alloy. **2.5 Alccofine**

Alccofine is obtained by quenching molten iron slag (a by-product of iron and steel-making) from a blast furnace in water or steam, to produce a glassy, granular product that is then dried and ground into a fine powder.

2.6 Chemical Admixture

.GLENIUM B233 (also called Master Glenium SKY 8233) is an admixture of a new generation based on modified polycarboxylic ether. The product has been primarily developed for applications in high performance concrete where the highest durability and performance is required. GLENIUM B233 is free of chloride & low alkali. It is compatible with all types of cements.

Typical Properties:

Aspect: Colourless to pale yellow free flowing liquid

Relative Density: 1.09 ± 0.01 at 25°C

pH: > 6

Chloride ion content: < 0.2%.

2.7 Water

The water used in the mix design was potable water from the water supply network system and is free from suspended solids and organic materials, which might have affected the properties of the fresh and hardened concrete. The water used for both mixing and curing of Concrete should be free from impurities, injurious amounts of acids, alkalis, oils, salts, organic matter or other substances that may be deleterious to concrete or steel. The water should be colourless and odourless. The presence of chlorides and sulphates are injurious to reinforcing bars as they may be corroded.

3. Experimental work

The aim of the experimental programme is to compare the properties of concrete made with microsilica and alccofine, used as supplementary cementing materials.

Concrete mix design is done according to (IS:10262-2009)

Concrete Mix design is done for all the variations like

1A. 5% addition of ALCCOFINES

1B. 5% addition of MICROSILICA

2A. 10% addition of ALCCOFINES
2B. 10% addition of MICROSILICA
3A. 15% addition of ALCCOFINES
3B. 15% addition of MICROSILICA
Details of mix proportion is given in the table 1

Table 1: Details of mix proportions

Mix designation	Cement	Fine aggregate	Coarse aggregate	Mineral admixture	Water	Chemical admixture
1A	1	1.55	2.416	0.05	0.32	$4*10^{-6}$
1B	1	1.53	2.39	0.05	0.32	$4*10^{-6}$
2A	1	1.53	2.385	0.10	0.32	$4.22*10^{-6}$
2B	1	1.52	2.372	0.10	0.32	$4.22*10^{-6}$
3A	1	1.51	2.358	0.15	0.32	$2.2*10^{-6}$
3B	1	1.50	2.342	0.15	0.32	$2.2*10^{-6}$

3.1. Hardened concrete property

3.1.1 Compression test: Specimen of size 150mmX150mmX150mm is caste and kept for curing. In the case of cubes, the specimen shall be placed in the machine in such a manner that the load shall be applied to opposite sides of the cubes as cast, that is, not to the top and bottom. The load shall be applied without shock and increased continuously at a rate of approximately 140 kg/sq. cm/min until the resistance of the specimen to the increasing load breaks down and no greater load can be sustained. The maximum load applied to the specimen shall then be recorded

The measured compressive strength of the specimen shall be calculated by dividing the maximum load applied to the specimen during the test by the cross-sectional area, calculated from the mean dimensions of the section and shall be expressed to the nearest kg per sq. cm.

3.1.2 Determination of the Modulus of Elasticity by Means of an Extensometer

The test specimens shall consist of concrete cylinders 150 mm in diameter and 300 mm long. Normally test shall be made at the age of 28 days of curing. An extensometer is required having a gauge length of not less than 10.2 cm and not more than half the length of the specimen. They shall be capable of measuring strains to an accuracy of 2×10^{-6}. Mirror extensometers of the roller or rocker type are suitable. The test procedure is as follows

1.The three test specimens are to be prepared for a particular mix and needs to be cured at 27^0 C for 28 days. The specimen is to be wetted 2 hours before the conduction of the test.

2. Capping needs to be done prior the testing with a thin layer of plaster of Paris on the flat ends to facilitate uniform loading. 2 metallic buttons need to be attached to the specimen exactly mid-way of the length of specimen such that they are 100mm apart.

3. Fix the dial gauge firmly on to the specimen by means of stretchable steel wires. Check for firmness of the dial gauge.

4. place the set up in the compression testing machine and set the dial gauge to zero just when the load is applied now apply the load in a uniform rate of 2.3k N/s such that there is recordable readings on the dial gauge.

5. Note down the dial gauge reading for every increment of 10 kN on the loading scale till the stress reaches one third of the maximum cube compressive stress of the same mix.

3.2 Durability Properties

3.2.1 Water Permeability Test: This test is conducted to determine the impermeably of concrete to water, i.e., is to determine whether the concrete is impermeable at a certain water pressure. This test is done in accordance with DIN 1048- 1991 Part -5. This test is on Permeability - Flow under pressure differential (water permeability test).

The slabs shall be built into the testing equipment so that the water pressure operates on the test surface of diameter d, in such a manner that the water can enter only at the testing surface and leave at the observation surface.

At first, a pressure of 5 kg/cm^2 operates for 3 days. After the test, the depth of penetration and the distribution of water in the cross-section of the cube shall be determined by splitting the specimen

3.2.2 Rapid Chloride Penetration Test (RCPT): This test is done in accordance with ASTM C 1202-97. Chlorides from external sources must penetrate through the concrete cover down to the embedded steel in order to initiate corrosion. Chloride transport in concrete occurs by one of two mechanisms: convection or diffusion. Convection occurs when dry concrete is exposed to chloride-contaminated water; in such cases the water and chlorides dissolved in the water are sucked into the concrete by capillary forces. Diffusion is the process wherein ions in solution move from locations with a high concentration to locations with a low concentration. There are many tests for measuring the resistance of concrete to penetration by water, water vapor or chloride ions, but the most commonly used test currently is standard test method for electrical indication of concrete ability to resist chloride penetration. This test is commonly referred to as the Rapid Chloride Permeability Test or the RCPT

The test specimen is a 95-mm diameter disc that is 50mm thick. The disc is sealed between two compartments, one of which is filled with a solution of NaCL and other with a solution of NaOH. The compartments also contain electrodes. A constant 60-volt direct current is passed between the two electrodes for 6 hours period for every 30 minutes record the total charge, measured in coulombs, that passes through the specimen during this period is a measure of the chloride ion penetrability

4. Results and Discussions

The results of various tests on durability and strength properties of concrete performed are as follows

4.1. Compressive strength

Table 2. Average Compressive strength for various concrete mix

SL.No	Variations	Average Compressive strength (N/ mm^2)
1	1A	72.60
2	1B	75.73
3	2A	75.73
4	2B	81.36
5	3A	79.87
6	3B	89.75

The below figure 1(a, b & c) shows the variation of compressive strength by addition of 5,10,15% alccofine and microsilica respectively

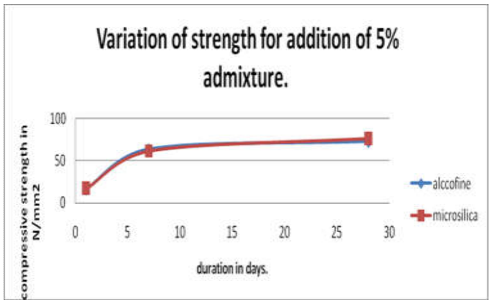

Fig 1(a)

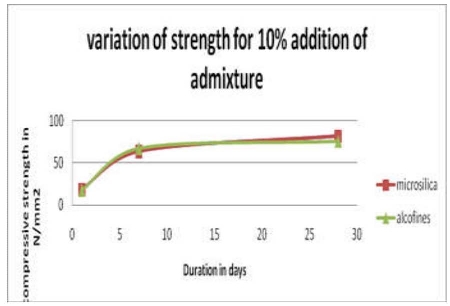

Fig 1(b)

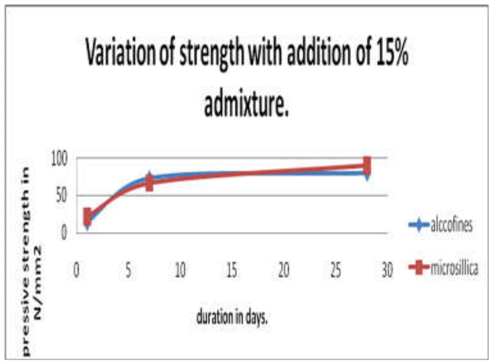

Fig 1(c)

Figure 1. variation of compressive strength by addition of 5,10,15% alccofine and microsilica Figure Label

4.2. Permeability Test

Table 3 : Permeability test results

Trail no.	% Increase of Micro Silica/ Alccofine	Depth of penetration of water(mm)[DIN-1048]	
		alccofines	Microsilica
1	5	9.83	7.48
2		9.72	7.96
3		9.92	8.20
1	10	9.48	6.84
2		9.20	7.25
3		9.89	6.52
1	15	8.75	6.20
2		9.20	6.90
3		8.63	6.45

Permeability test results for various mix design are shown in figure 2

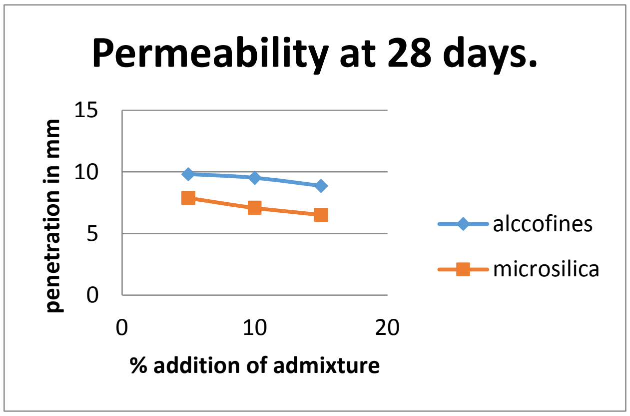

Fig 2: Variation of permeability of concrete at 28 days by addition of 5%,10%,15% of Alccofine and microsilica

4.3 Rapid chloride penetration test

Table 4: RCPT variation for different Percentage of micro silica and Alccofine.

RCPT variation for different percentage	Alccofines	Micro Silica
5	776	829
10	703	400
15	285	113

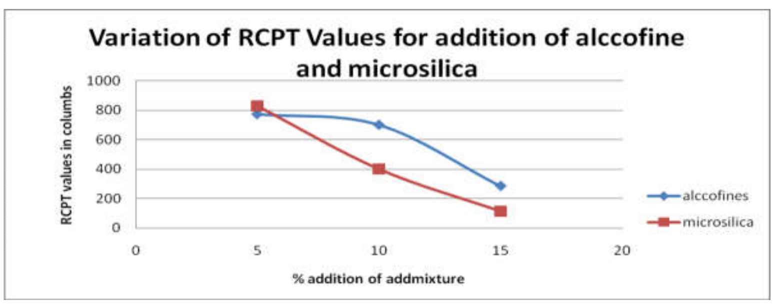

Figure 3: Variation of RCPT values for addition of Alccofine and microsilica

4.4 Modulus of elasticity

Table 6: Modulus of elasticity value in k N/mm^2

Mix details	Modulus of elasticity value in k N/mm^2	
	Theoretical value	Experimental value
5% alccofines	43.52	44.00
5% microsilica	43.65	42.60
10% alccofines	43.51	47.15
10% microsilica	45.09	49.50
15% alccofines	44.68	44.68
15% microsilica	47.37	50.90

The modulus of elasticity for various meixes are shown in figure 4

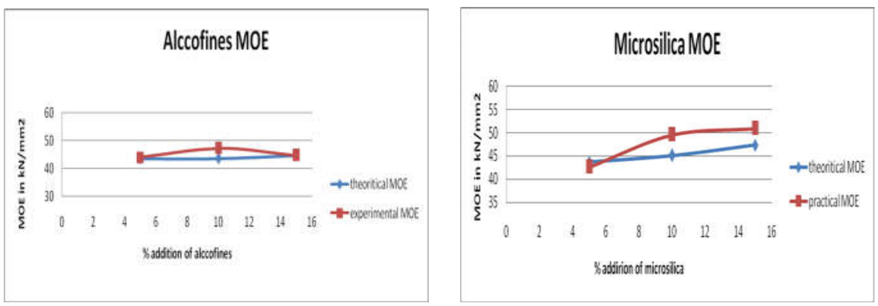

Fig 4: Variation of MOE values for addition of Alccofine and microsilica

5. Conclusions

The main parameters investigated in this study is addition of micro silica and alccofine, by keeping maximum cement content 450kg and water cement ratio of 0.32 as constant for all mixes. The slump of fresh concrete was practically kept around 100 ± 10mm for all the concrete mixes considered in this study. Both Micro Silica as well as Alccofine were added separately to concrete mixes as a partial replacement to cement by 5% ,10% and 15% respectively for comparative study in production of high performance concrete.

In the present experimental investigation, a detailed comparative study using micro silica and alccofine, on hardened properties like compressive strength, and durability properties like water permeability, rapid chloride penetration test and modulus of elasticity were carried. It was found that the strength and durability properties of concrete increased substantially with the addition of mineral admixtures.

The following observations were made from the experimental work conducted with the use of microsilica and alccofine in concrete.

- Early age compressive strength of concrete was found to be 22% of the 28-day strength for 5% alccofine addition and 22.06% for that of 5%microsilica addition.
- The 7-day compressive strength of concrete was found to be 87.27% of 28-day strength for 5% alccofine addition and 80.61 % for that of 5% microsilica addition.
- Early age compressive strength of concrete was found to be 23.13% of the 28-day strength for 10% alccofine addition and 22.64% for that of 10%microsilica addition.

- The 7-day compressive strength of concrete was found to be 88.73% of 28-day strength for 10% alccofine addition and 77.63 % for that of 10% microsilica addition
- Early age compressive strength of concrete was found to be 16.78% of the 28-day strength for 15% alccofine addition and 20.8% for that of 15%microsilica addition.
- The 7-day compressive strength of concrete was found to be 91.15% of 28-day strength for 15% alccofine addition and 73.42 % for that of 15% microsilica addition.
- Water Permeability results for addition of 5%, 10% and 15% alccofine and microsilica show an increased resistance to penetration of water. The performance of microsilica is better than alccofine for water permeability.
- Chloride ion penetration is more in concrete with alccofine than that with microsilica, hence performance of microsilica is better for resisting chloride ion penetration than alccofine.
- For higher % addition of admixture, the modulus of elasticity of concrete with microsilica was found to be higher than that of concrete with alccofine.
- For higher % addition of admixture the modulus of elasticity value is greater in concrete with microsilica when compared with that of concrete with alccofines.

  Hence, we can conclude that performance of concrete with 5%, 10% and 15% microsilica is better than performance of concrete with 5 % ,10%and 15% alccofin.

6. References

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