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Study of Durability Properties of Alccofine based Concrete

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***Abstract—This Study is carried out to find t*he influence of Alccofine and brass coated micro steel fiber on the behaviour of concrete by evaluating strength and durability properties. The alccofine was added in proportion of 5%, 10% and 15% of total weight of concrete and addition of brass coated fiber of 1%, 1.5% and 2% by weight of cement. Compressive strength test, acid attack test, sulphate attack test and sorptivity tests were performed on different mixesw. The test results revealed that concrete mixtures with a substitution rate of 15% alccofine and 2% brass coated steel fiber, there is enhancement in mechanical and durability propertied of made concrete.**

Keywords— Alccofine powder, Steel fiber, Durability, Acid attack, Sorptivity

1. INTRODUCTION

Concrete comes second in terms of usage after water. Now a day's advancement has been noted in terms of concrete technology, which leads to alteration in properties of concrete in order to have longer life span. A stronger structure needs high quality ingredients in order to perform well in different categories for certain levels.

Mechanical and durability properties are a major concern for concrete structures for their service life, especially when they are exposed to an aggressive environment. Concrete is a porous material that has vulnerability to corrosion, which can penetrate through interconnected macro and micro cracks. Fibre Reinforced concrete has emerged as a new technique in recent years which can be used for various purposes, amongst which remediation of cracks in concrete is the primary one [2]. Alteration in concrete has bought many changes due to usage of chemical and mineral admixtures which has significantly solved many problems. Materials like Alccofine 1203 and Brass Coated Steel Fibres will help to alter concrete in terms of mechanical and durability properties [3, 4]. As an example structures are facing various problems regarding acid rain and sulphur content in the air which leads acid attack and sulphur attack, furthermore it leads damage in molecular bonding of concrete, which will be assisted.

2. MATERIALS

2.1 Ordinary Portland Cement (53 Grade)

Cement used in this study is Coromandel king of 53 grade of ordinary Portland cement. Specific gravity of ordinary Portland cement is 3.15 and standard consistency is 28 %. Properties of cement are tested by references of IS 12269-1987 is shown in Table 1.

Table 1- Properties of Ordinary Portland Cement

Properties	Value	Codal Specification IS (8112-1989)
Specific Gravity	3.15	3.10 to 3.15
Consistency	28%	30% to 35%
Initial Setting Time	35-minutes	30-minutes
Final Setting Time	178 minutes	600 minutes

2.2 Fine Aggregate

Sand passed through 4.75mm sieve (IS) is used and it is locally available, having specific gravity of 2.1 and 3.04 are used as fine aggregates. Bulk density is 1094 kg/m^3 for loose and 1162 kg/m^3 for compacted with water absorption rate of 1.583%.

2.3 Coarse Aggregate

The coarse aggregates with the sizes of 20mm aggregates are used. Specific gravity of 20mm coarse aggregates is 2.6 and fineness modulus is 7.18.

2.3 Water

Water used in mixing was free from all injurious amounts of acids, organic and inorganic impurities, and it is used for proper curing of concrete.

2.4 Alccofine 1203

Alccofine 1203 powder shown in Fig.1 was obtained from ambuja cement Ltd, Ahemdabad, Gujarat. Alccofine is additional cementitious material which is used in substitute of silicafumes for usage in high performance concrete. Powder sample is grounded to fine particles which range more than 12000 microns. Table 1 and Table 2 shows physical and chemical characteritics of Alccofine 1203.

Fig 1. Alccofine 1203

Table 1- Physical Properties of Alccofine 1203

Fineness (cm^2/gm)	>12000
Specific Gravity	2.8 ± 0.2
Bulk Density (kg/m^3)	690
Particle Size Distribution D10	1.5 Micron
Particle Size Distribution D50	4.3 Micron
Particle Size Distribution D90	8.9 Micron

Table 2- Chemical Properties of Alccofine 1203

Constituent	**Ratio**
SiO_2	35.1 %
Al_2O_3	21.9 %
Fe_2O_3	0.8 %
CaO	33.8 %
SO_3	0.08 %
MgO	6.6 %

2.5 Brass Coated Micro Steel Fibres

Brass coated micro steel fibres used in this study are of 13mm, they are also available in 6mm length. Brass coated micro steel fibres were obtained from G.I.D.C. Ahmedabad. Table 3 and Table 4 shows physical and chemical properties of brass coated micro steel fibres.

Table 3- Physical Properties of Brass Coated Micro Steel Fibre

Items	Technical Data
Diameter	0.2mm
Ultimate Tensile Strength	2800 N/mm^2
Length	13 mm (± 10%)
Surface Finish	Brass Coated

Table 4- Chemical Properties of Brass Coated Micro Steel Fibres

Constituent	Standard Value	Test Results
%C	0.72 - 0.80	0.76
% Mn	0.50 – 0.80	0.65
% Si	0.10 – 0.30	0.19
% S (Max)	0.035	0.015
% P (Max)	0.035	0.030
% Ni (Max)	0.20	0.12
% Cr (Max)	0.15	0.11
% Mo (Max)	0.05	0.01
% Cu (Max)	0.25	0.19
Al	0.01	-

3. METHODOLOGY

3.1 Mix Design and Mix Proportion

Selection of different ingredient and their proportions forms concrete mix with constituents of cement, water, sand and aggregates. Mix design is made according to IS codal provisions (IS 10262-2009) as shown in Table 5[1]. The changes are made and capacities of constituent materials used to cast Alccofine 1203 & Brass Coated Micro Steel Fibre to make hybrid concrete.

Table 5- Mix Design

Material	Weight (kg/m^3)
Cement	450
Water	186
Fine Aggregate	461.95
Coarse Aggregate	1081.97
w/c ratio	0.40

Table 6- Mixes

Mix Proportion*	Usage of Alccofine 1203 (%)	Usage of Brass Coated Micro Steel Fibre (%)
(Control)	0	0
AL5F1	5	1
AL5F1.5		1.5
AL5F2		2
AL10F1	10	1
AL10F1.5		1.5
AL10F2		2
AL15F1	15	1
AL15F1.5		1.5
AL15F2		2

*Control- Control Mix

*AL5F1- 5% of Alccofine 1203 & 1% of Brass Coated Micro Steel Fibres based concrete

*AL5F1.5- 5% of Alccofine 1203 & 1.5% of Brass Coated Micro Steel Fibres based concrete

*AL5F2- 5% of Alccofine 1203 & 2% of Brass Coated Micro Steel Fibres based concrete

*AL10F1- 10% of Alccofine 1203 & 1% of Brass Coated Micro Steel Fibres based concrete

*AL10F1.5- 10% of Alccofine 1203 & 1.5% of Brass Coated Micro Steel Fibres based concrete

*AL10F2- 10% of Alccofine 1203 & 2% of Brass Coated Micro Steel Fibres based concrete

*AL15F1- 15% of Alccofine 1203 & 1% of Brass Coated Micro Steel Fibres based concrete

*AL15F1.5- 15% of Alccofine 1203 & 1.5% of Brass Coated Micro Steel Fibres based concrete

*AL15F2- 15% of Alccofine 1203 & 2% of Brass Coated Micro Steel Fibres based concrete

Alccofine 1203 was added in proportion of 5%, 10% and 15% of total weight of concrete. For the case of Brass Coated Micro Steel fibre, it will be added by total Cement weight which will be 1%, 1.5 % and 2%, respectively. Different mixes were prepared as shown in Table 6.

3.2 Compression Strength Test

Compression test was carried out on cube as well as on cylinders. For cube test specimens, cubes of (150mm × 150mm × 150mm) are used. Filling concrete into moulds require tamping from tamping rod (25 times in three divided layers) and mould should be vibrated properly in order to avoid pores and air voids into concrete. Specimens are tested on compression testing machine after 7 or 28 or 56 days of curing decided curing age. Load was given gradually at the rate of 5.2 kN per second till the Specimens gets failure.

3.3 Acid Attack

This test is to study the outcome of sulphuric acid on Alccofine 1203 and brass coated micro steel fibre reinforced concrete. The test specimen needed for compressive strength and change in mass are 150mm × 150mm × 150mm. The specimen cubes are immersed in the solution after curing for a specific interval of time. In this test, the solution is made of Sulphuric acid having a slandered concentration of 5%. To prepare a solution of 5% concentration, it is needed to have 50 grams of Sulphuric acid and 950 grams of water for every 1 litre of solution. After preparing the solution, the pH of the solution should be measured with the digital pH meter. This initial pH should be maintained till the end, if the pH rises then add water to the solution.

3.4 Sulfate Attack

This test is to study the outcome of sodium sulfate on Alccofine 1203 and brass coated micro steel fibre reinforced concrete.

The test specimen needed for compressive strength and change in mass are 150mm × 150mm × 150mm. The specimen cubes are immersed in the solution after curing for a specific interval of time.

In this test, the solution is made of sodium sulfate powder having a slandered concentration of 5%. To prepare a solution of 5% concentration, it is needed to have 50 grams of sodium sulfate powder and 950 grams of water for every 1 litre of solution. After preparing the solution, the pH of the solution should be measured with the digital pH meter. This initial pH should be maintained till the end, if the pH rises then add water to the solution.

3.5 Sorptivity Test

Determining permeability is one of the important parameter which calculates the flow of water under pressure in a saturated porous medium while, Sorptivity is measurement for finding ability of material to absorb or transmit water through capillary suction. Absorbing water by unsaturated, hardened concrete is termed as sorptivity. This is a simple parameter which determines concrete's resistance towards aggressive environments. Sorptivity, or capillary suction, makes liquid travel through porous mediums because of surface tension in capillaries and due to viscosity, density and surface tension of liquid. It is measured as the rate of uptake of water.

4. RESULTS

Compression Test Results

Compression test was carried out on cubes which were made of different mixes by subjecting axial compression loadings. 10% of Alccofine 1203 is the optimum replacement in this study due to its high particle density which gives more strength and more durability due to presence of Brass Coated Micro Steel Fibres. Due to usage of both materials the transformation of macro crack to micro crack stops and helps in avoiding cracks which can further helps in avoiding corrosions.

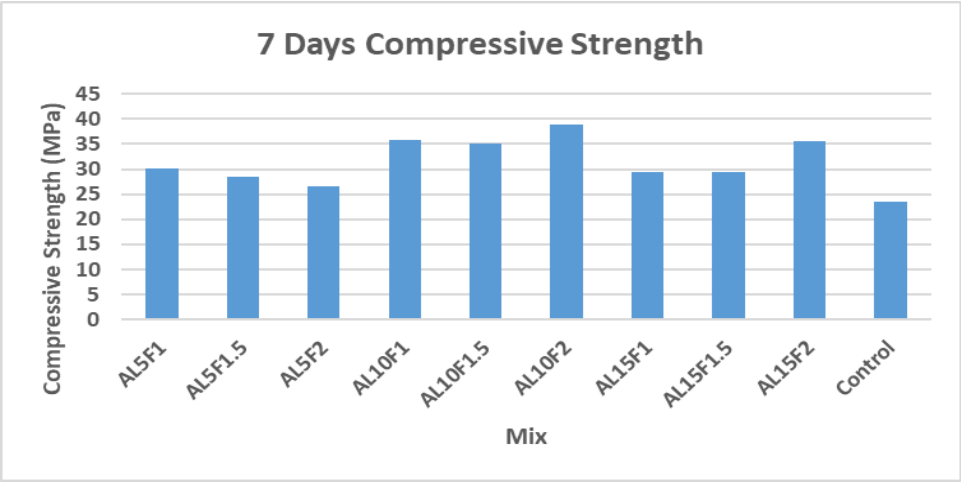

Fig 2. Compressive Test at 7 days

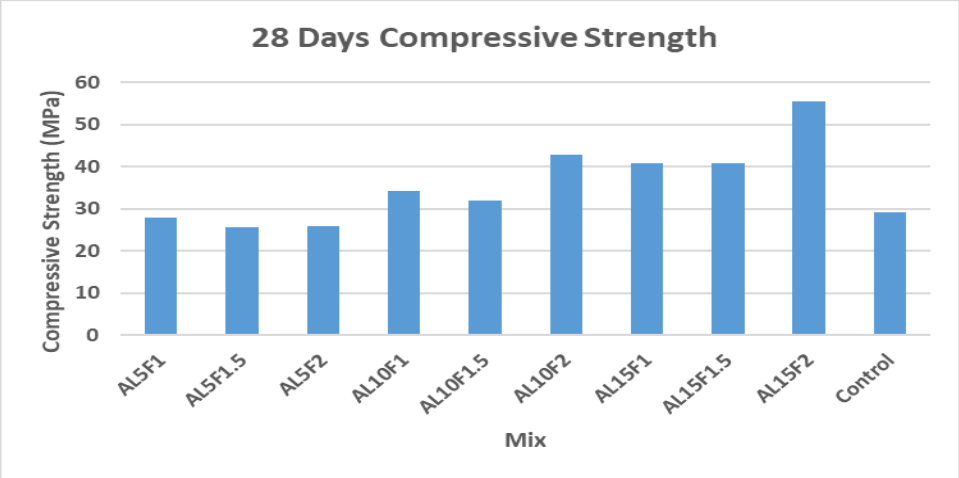

Fig 3. Compressive Test at 28 days

Fig. 2 and Fig.33 shows compressive strength for mix of AL10F2 and AL15F2 which gives 38.97MPa and 55.6MPa with compare to control concrete respectively which is 23.80MPa and 28.75MPa for 7 and 28 days.

Acid Attack

After 28-days of immersing in acid solution (H_2SO_4), the specimens were taken out and were washed in running water and kept in atmosphere for 2-day for constant weight. Specimens are weighed and tested for compressive strength and the percentage loss of weight and percentage loss in compressive strength was calculated as shown in.

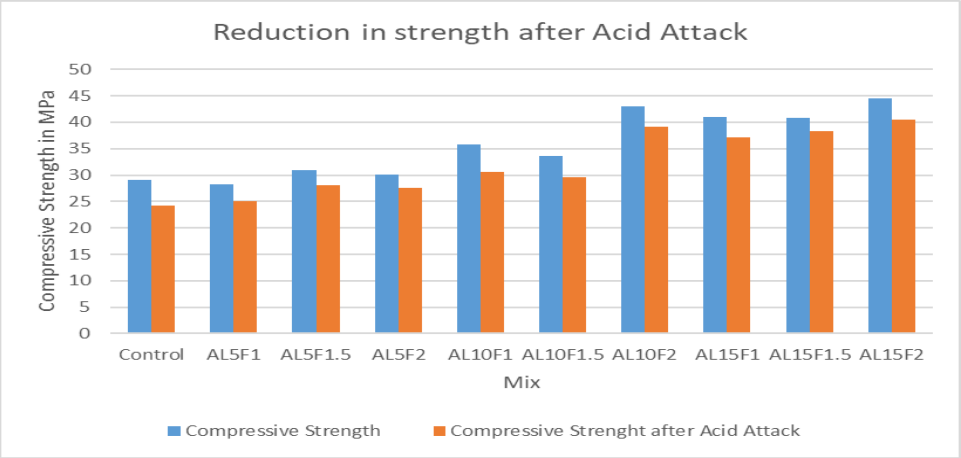

Fig 4. Reduction in Strength after Acid attack

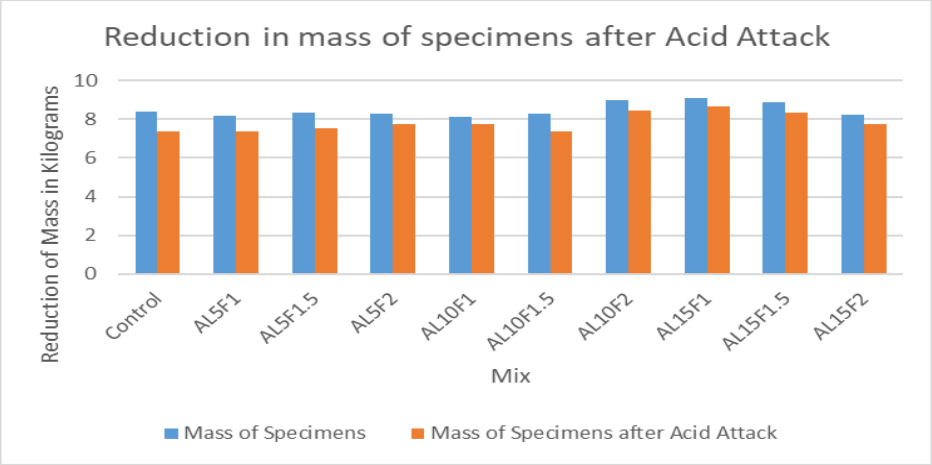

Fig 5. Reduction in Mass of Specimens after Acid Attack

Fig. 4 and Fig.5 shows Reduction in strength and mass for different mixes, where mix AL15F2 in acid attack gets less reduction of mass and strength with compare to control and other mix.

Sulphate Attack

In Sulphate attack, 5% Na_2SO_4 is added in water of appropriate volume, which is in powder form and gets mixed properly into water. As powder gets mixed into curing water, cube specimens are cured for 28 days. After the curing duration gets over weight of cube is noted and the compressive strength is calculated.

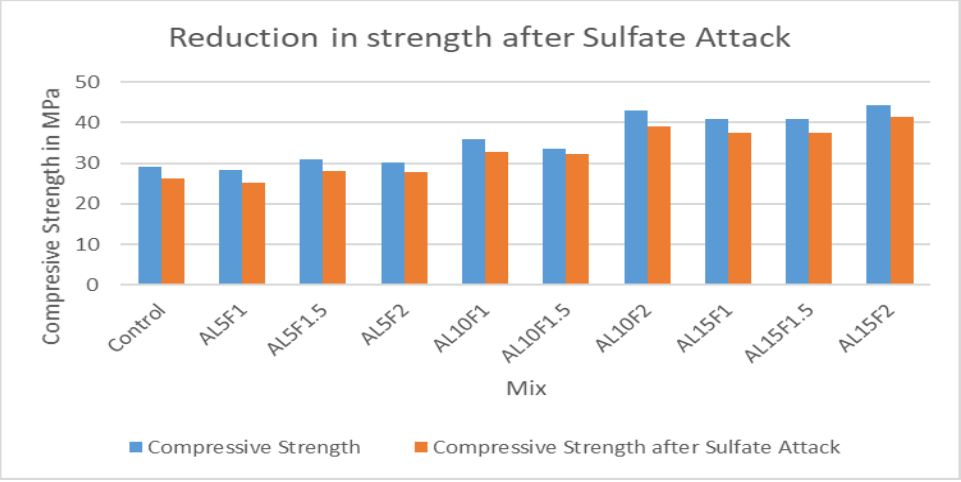

Fig 6. Reduction in Strength after Sulphate Attack

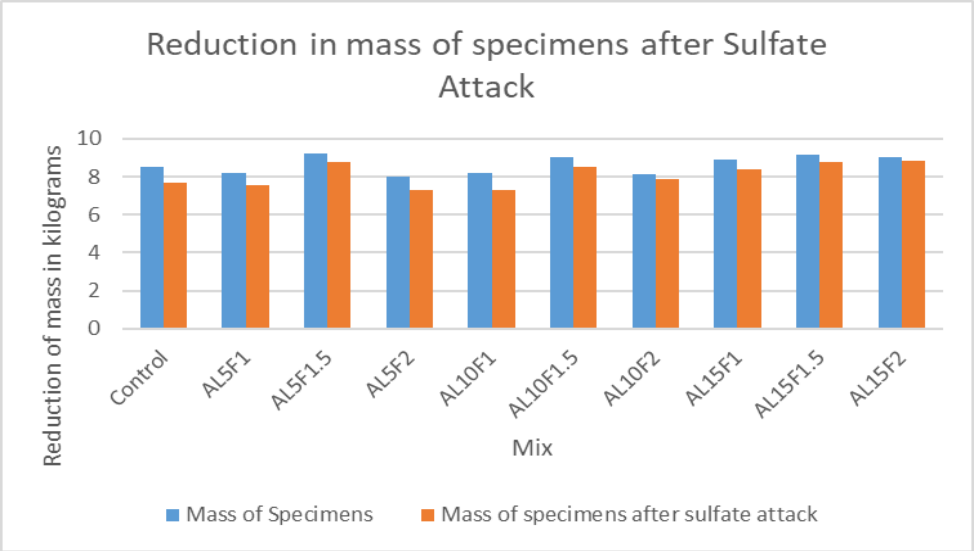

Fig 7. Reduction in Mass of Specimens after Sulphate Attack

Fig. 6 and Fig.7 shows Reduction in strength and mass for different mixes, where mix 15A2FC in sulphate attack gets less reduction of mass and strength with compare to control and other mix.

Sorptivity Test

For sorptivity test, concrete cylinder of size 100mm diameter x 50mm thickness are prepared for various percentages of Alccofine 1203 of 5%, 10% and 15% and added brass coated micro steel fiber from 1% to 2%. Table 3.11 shows the Initial of dry weight of specimen after 30 min, final wet weight was noted to check out the total percentage of sorprivity is reduced at 28 days.

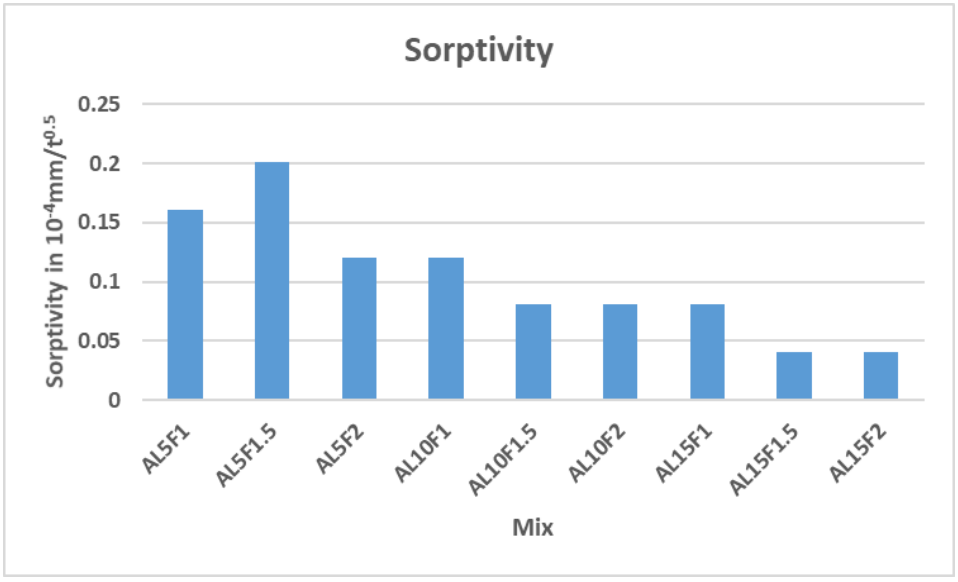

Fig 8. Sorptivity Test

Fig.8 shows least sorptivity earned by mix AL15F2 with compare to control and other mix.

5. CONCLUSIONS

The following conclusions were derived from the above research work.

1. The optimum mix obtained from the study is AL15F2.
2. At 7 and 28 days, there is an increase in compressive strength by 60.55% and 52.35% in 10A2FC and 15A2FC mix, respectively as compared to control concrete mixture for M40 grade of concrete which is 23.80MPa and 28.75MPa
3. The reduction in strength and mass was observed in concrete due to acid attack. At 15% Alccofine 1203 and 2% brass coated micro steel fibre the strength was reduced 8.88% for 28 days compared to result achieved with normal compressive strength. At optimum value the mass was reduced at 6.11% for 28 days compared to result achieved.
4. The reduction in strength and mass was observed in concrete due to sulfate attack. At 15% Alccofine 1203 and 2% brass coated micro steel fibre the strength was reduced 6.88% for 28 days compared to result achieved with normal compressive strength. At optimum value, the mass was reduced at 2.21% for 28 days compared to result achieved.
5. At optimum replacement level of Alccofine 1203 and brass coated micro steel fibers the sorptivity value decreased because of particle packing effect and reduced permeability.
6. Alccofine 1203 and brass coated micro steel fibre can be utilized as a mineral admixture in concrete due to economical and environmental benefits, without any compromise with its performance. Alccofine 1203 can be used as one of the alternative material for the cement.

6. REFERENCES

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