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Effect of Mineral Admixture (Alccofine-1203) on Durability of Hybrid Fiber Reinforced Concrete

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Abstract

Objective: To estimate effect of mineral admixture (Alccofine-1203) on durability of Hybrid Fiber Reinforced Concrete. **Methods/Analysis:** This paper presents effect of hybrid fibers and alccofine-1203 on estimation of durability of hybrid fiber reinforced concrete with different combinations. The final combination is used as fiber volume fraction - 1.5% (80% steel fibers and 20% polypropylene fibers) by volume of concrete and Alcoffine-1203 with 7.5% by weight of cement. **Findings:** The study presents behavior of hybrid fiber (steel fibers and polypropylene fibers) reinforced concrete including mineral admixture like Alccofine-1203. The hybrid fibers help to reduce the cracks due to shrinkage, creep and early age thermal cracking along with increase in ductility, toughness and fatigue resistance. The mineral admixture (Alccofine-1203) enhances strength of concrete, modulus of elasticity along with workability, durability and reduction in segregation. **Novelty/Improvement:** Addition of Hybrid fibers and mineral admixture (Alccofine-1203) increases the ductility, crack resistance strength and durability of concrete.

Keywords: Alccofine-1203, Durability, Hybrid Fibers, Permeability

1. Introduction

Hybrid fiber-reinforced concrete is a type of fiber-reinforced concrete characterised by its composition. It contains at least two or more types of fibers of different sizes, shapes or origins which improve properties of fresh and hardened concrete[1].

Durability is the ability of concrete to resist weathering action, chemical attack and abrasion while maintaining its required engineering properties. It generally refers to the period or life span of trouble-free performance. Different concretes require different degrees of durability depending on the exposure environment and properties desired[2]. The concrete structures design represents a very complex task which includes analysing many parameters such as ultimate bearing capacity, stability, deflection and rigidity of structure. Also the essential part, which has to be paid attention to, is also fire resistance defined as the ability of building components to perform their intended load-bearing functions under fire exposure[3].

The purpose of this investigation was to estimate the effect of hybrid fibers and alccofine-1203 on durability of concrete. The experimental parameters and their levels were chosen accordingly. It is derived from experimental study that the optimum proportion would be expected from 7.5% Alccofine-1203 and 1.5% hybrid fibers with 80% steel fibres and 20% polypropylene fibres results in optimum compressive and flexural strength.

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2. Materials and Experimental Work

2.1 Constituent Materials

2.1.1 Cement

Ordinary Portland cement (Birla Super Cement) of grade 53 conforming to IS 12269:1987 is used for the experimental study.

2.1.2 Aggregate

River sand having a specific gravity of 2.6 and conforming to zone-I of IS 383-1970 is used in the experimental study as a fine aggregate, while VSI crushed aggregate of specific gravity 2.8 is used as coarse aggregate. To determine the physical properties of fine and coarse aggregate laboratory tests are conducted on FA and CA and the results obtained are in accordance with IS: 383-1970.

2.1.3 Chemical admixture

A super plasticiser is used to obtain the desired workability. Super plasticiser, Trade Name Conplast P211 (Fosroc-Polycarboxylic ether based) is used.

2.1.4 Mineral admixture

Alccofine-1203 (ultrafine low calcium silicate product with high glass content with high reactivity obtained through the process of controlled granulation) is used for the experimentation.

2.1.4 Hybrid fibers

The combination of two or more fibers is called hybrid fibers. The Hybrid fibers used in the study are glued hooked steel fibers (Dramix® steel fibers, Bekaert) and fibrillated mesh polypropylene fibers (Strongcrete, Dolphin floats Pvt. Ltd.).

2.2 Mix Design

Mix design was performed for M60 grade concrete as shown in Table 1 by following ACI method[4]. The objective of the mix design was to achieve the desired properties of concrete by selection of the ideal combination of the ingredients of concrete.

2.2.1 Casting

Cubes of dimension 150 × 150 × 150 mm for water permeability test and acid attack and cubes of dimension 100 × 100 × 100 mm for fire resistance test are casted according to the mix proportion and by using hybrid fibers and alccofine-1203.

2.2.2 Sample Combinations

Durability assessment is carried out on different samples as listed below,

- Plain Concrete (PC)
- Alccofine Concrete (AC) – contains 7.5% Alccofine-1203.
- Hybrid Fiber Concrete (FC) – contains 1.5% fibers which include 80% steel and 20% polypropylene fibers.
- Alccofine Fiber concrete (AF) – contains 7.5% Alccofine-1203 and 1.5% fibers which include 80% steel and 20% polypropylene fibers.

2.3 Tests Carried Out

2.3.1 Water permeability

The test as per BS/EN 12390:2009 consists in subjecting the mortar or concrete specimen of known dimensions, contained in a specially designed cell, to a known hydrostatic pressure from one side, measuring the quantity of water percolating through it during a given interval of time and computing the coefficient of permeability[5]. The test permits measurement of the water entering the specimen as well as that leaving it. Cubes of size 150 × 150 × 150 mm are used.

Table 1. Concrete mix design (ACI method)

Cementitious material (kg/m³)	Alccofine-1203 (kg/m³)	Fine aggregate (kg/m³)	Coarse aggregate (kg/m³)		Water (kg/m³)	Super plasticizer (kg/m³)
			10mm	20mm		
575	43.125 (7.5%)	655	392	588	190	3.45

2.3.2 Acid attack

Acid is a very harmful substance for concrete structures. Resistance against acid is very important for strong and durable structures. In this test we have checked the reaction of acid on concrete cubes. Cubes of size 150 × 150 × 150 mm are used[6]. The acid attack test on concrete cube is conducted by immersing the cubes in the acid water for 56 days. Concentrated Sulphuric Acid, 5% by weight of water is added in curing water in which the concrete cubes are stored.

2.3.3 Fire Resistance

A fire test is a way of finding whether fire products meet bare minimum performance criteria as a set out in a building code or other relevant legislation. Fire test is carried out on a component or material to ensure whether the component can sustain fire effect[7]. For this test cubes of size 100 × 100 × 100 mm are used. Specimens are taken out of curing tank, after 28 days. They are weighed. Then they are kept in muffle furnace at 500°C for the interval of 30 min, 60 min and 90 min.

3. Results and Discussion

Figure 1 shows water permeability on various samples AC, FC, PC and AF. Permeability is found lowest for concrete mix with AC and maximum in case of FC. The alccofine-1203 and hybrid fibers together, the concrete permeability reduces than FC. The alccofine-1203 reduces the permeability of concrete.

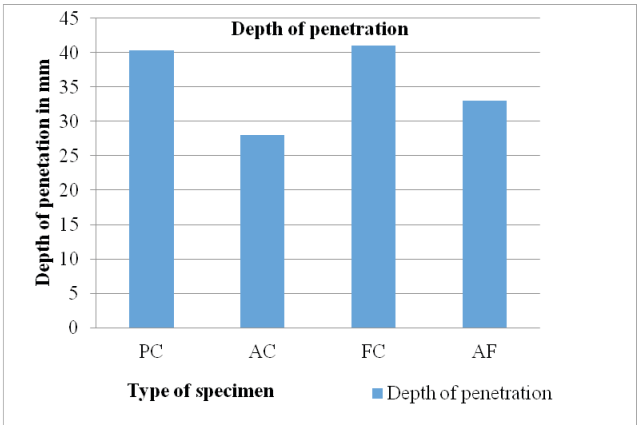

Figure 1. Depth of penetration for various types of specimen.

Figure 2 shows result of acid attack on concrete. By studying the Acid attack test results, compressive strength of specimen having combination of alccofine-1203 and hybrid fibers is maximum (AF).

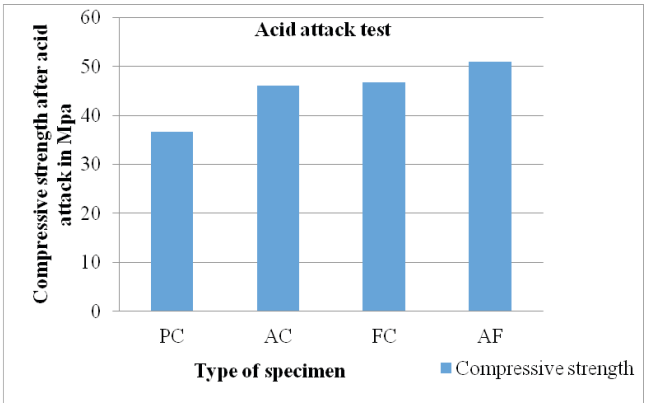

Figure 2. Acid attack test results for various types of specimen.

Figure 3 shows result of variation of fire resistance of concrete. In the fire test; specimens are kept in muffle furnace for 30 min., 60 min. and 90 min. Percentage increase in loss of weight is observed as time increase. While the reduction in compressive strength is noticed as time increases.

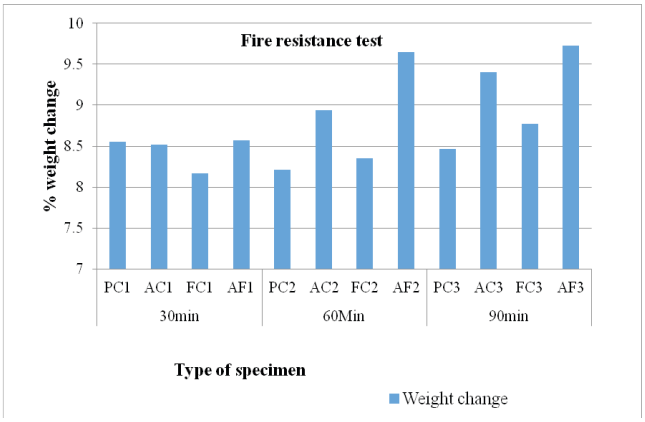

Figure 3. Fire resistance test results for various types of specimen.

4. Conclusions

- HFRC with optimum proportions (AF) satisfies the durability aspects such as resistance to water permeability, water absorption, acid attack and fire resistance.

It is noted that the water penetration is 22% lower than plain concrete.

- The compressive strength of HFRC with optimum proportions (AF) is 39% higher than Plain Concrete (PC) in case of acid water curing for 56 days (acid attack).
- The compressive strength of HFRC with optimum proportions (AF) is 30% higher in case of water absorption and about 15% higher in case of fire resistance than plain concrete.
- It is also recommended that the utilization of mineral admixture as Alccofine-1203 in concrete as cement replacement is possible which helps in reducing the global warming.

5. References

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