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USE OF ALCCOFINE IN SFRC AND STUDY ITS TORSIONAL BEHAVIOR

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ABSTRACT

In this experimental work is mainly focus on the study of behavior of PCC using mineral admixture Alccofine as replacement to cement and fiber for reinforcing.

Alccofine are replace and steel fiber were added up to 5% by weight of cement for producing concrete. Alccofine has very high pozzolanic reactivity. It reduces drying shrinkage and resist the shrinkage cracking width. It also help to increase the compressive strength and durability of concrete.

ALCCOFINE1203 performs in good manner than all the mineral admixtures used in concrete in India. Due to its less CaO content, ALCCOFINE1203 triggers two way reactions during hydration.

- Primary reaction of cement hydration.
- Pozzolanic reaction: ALCCOFINE also consumes by product calcium hydroxide from the hydration of cement to form additional C-S-H gel, similar to pozzolanic.

Alccofine is very reactive, while it is used in concrete because of its fine particles, large surface area and high SiO₂ content. It is used as admixture in the concrete mix and it has useful effect on the properties on the resulting material.

This review paper discusses the effects of alccofine on the concrete properties. Characterization of alccofine as well as its physical and chemical properties will also be reviewed in this paper.

Keywords: Alccofine, SFRC, Crimped fibre, Torsion effect

I. INTRODUCTION

Concrete is a proportionate mixture of cement, aggregate, sand and measure quantity of water. Plain concrete is poor in tensile strength, limited ductility and little resistance to cracking. Internal micro cracks are inherently present in the concrete and less tensile strength is due to the propagation of such micro cracks, eventually leading to brittle fracture of the concrete. In plain concrete, structural cracks develop before loading, particularly due to drying shrinkage or other causes of volume change. The width of these initial cracks exceeds a few microns, but their other two dimensions may be of higher magnitude.

When loaded, the micro cracks propagate and open up and outstanding to the effect of stress concentration, additional cracks form in places of minor defects. The structural cracks proceed slowly or by little jumps because they are lagging by various obstacles, changes of direction in by passing the more resistant grains in mix. The development of such

micro cracks is the main cause of inelastic deformations in concrete.

It has been recognized that the addition of small, closely spaced and uniformly dispersed fibers to concrete would act as bridge arrester and would substantially improve its static and dynamic properties. This type of concrete is known as Fiber Reinforced Concrete. Hence Fiber Reinforced Concrete can be defined as a composite material consisting of mixtures of cement, mortar or concrete and discontinuous, discrete, uniformly dispersed suitable fibers.

Necessity

1. To get high early strength of concrete, for example opening the pavement at 3-days.
2. To build high-rise buildings by reduction in column sizes and increasing available space.
3. To build the superstructures of long-span bridges and to enhance the durability of bridge decks.

4. To satisfy the specific needs of special applications such as durability, modulus of elasticity, and flexural strength. Some of these applications include dams, grandstand roofs, marine foundations, parking garages, and heavy duty industrial floors.

Objectives

The objective of this study is to investigate the behavior of fresh Concrete composite with various aspect ratios of fibers and to investigate the following properties:

1. To study the strength properties of concrete with various aspect ratio such as compressive strength, and torsional strength.
2. To investigate the properties of fresh concrete such as Workability, segregation, bleeding.
3. To compare the properties of concrete with for different % of alccofine and steel fiber.

Applications

In the construction of:

1. Buildings
2. Roads
3. Bridges
4. Prefabricated structures
5. Shear walls
6. Off shore constructions

II. Selection of ingredients and mix design

General

The main ingredients of Alccofine Concrete are as follows:-

1. Cement.
2. Fine aggregates.
3. Course aggregate.
4. Water.
5. Alccofine
6. Crimped steel fiber

Material properties

Cement:

Among the chemical content of cement, the most important ones are C_3A , C_3S , C_2S & C_4AF . The C_3A portion of cement hydrates rapidly, thereby reducing the workability of fresh concrete. It also adsorbs the chemical admixtures quickly which leads to reduction in availability of those admixtures for slower setting components of cement viz., C_2S and C_3S . This further affects the workability of fresh concrete and also its rate of reduction of workability. Regarding particle size distribution, it may be noted

that fine particles hydrate faster than coarse particles and hence contribute more to early strength concrete; however, at the same time, the faster the rate of hydration may lead to quicker loss of workability due to rapid and large release of heat of hydration.

Fine Aggregate:

River sand is used as a fine aggregate. The sand particles should also packing to give minimum void ratio, as the test result show that higher void content leads to requirement of more mixing water

Coarse Aggregate:

The properties such as moisture content, water absorption, etc., would help in adjusting the quantity of mixing water for the concrete mix. The strength properties of CA such as aggregate abrasion value, aggregate impact value, compressive strength, aggregate crushing value (10% fine value) etc.

Water:

From concrete mix design consideration, it is important to have the compatibility between given cement and chemical and mineral admixtures along with the water used for mixing. It is generally stated in the concrete codes and also in the literature that the water.

Alccofine

Alccofine 1203 compared with:

- IS 12089:1987 – Specification for control granulated slag for the manufacture of Portland slag cement.
- IS 456:2000 (Clause no.5.2.2) – Plain and reinforce cement concrete code of practice.
- ASTM C 989 99 – Standard specification for ground granulated blast furnace slag for use in concrete and mortar.

Alccofine 1203 is a specially processed product based on slag of high glass content with high reactivity obtained through the process of under controlled granulation. The raw materials are composed primary of low C_aO . The processing with other select ingredients results in controlled particle size distribution. The computed blain value based on particle size distribution is around $12000\text{cm}^2/\text{gm}$ and is truly ultrafine. Due to its unique chemistry and ultra-fine particle size, Alccofine-1203 provides reduction in 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 requirement reducer to

improve compressive strength or as a super workability aid to improve flow.

Packing Effect of Alccofine:

Effectiveness of packing depends upon difference in particle size between cement and admixture and extent of hydrated product generated during hydration .The secondary hydrated product formed due to pozzolanic and cementitious hydration reaction fills the pores. This reduces the permeability of hydrated product to a great extent. ‘Packing effect’ retards ingress of aggressive agents in concrete even by diffusion and thus enhances durability of concrete. Many deteriorating effects like corrosion, carbonation, sulphate attack etc. may be reduce or stopped.

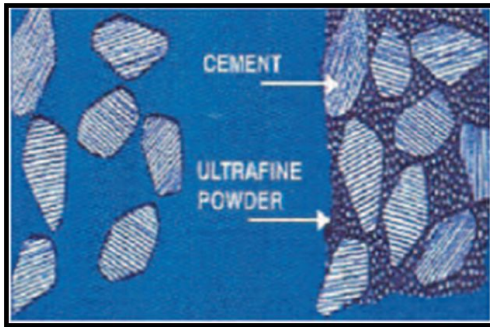


Fig 1. Packing Effect of Alccofine

Optimize particles size distribution

Use of Alccofine improve the performance of concrete in terms of durability due to its ultrafine particle size distribution. Alccofine is well graded particle size less than cement and greater than Micro Silica. It is generally considered that strength is directly proportional to strength gain of concrete. Besides fineness, the particle size distribution shape, surface nature, chemical composition etc. play significant role in strength and performance. Alccofine has particle range 0.1 to 17 microns, average particle size is 4 microns.

Table 1. Characteristics and Properties

Chemical Analysis	Mass %
CaO	32-34
Al ₂ O ₃	18-20
Fe ₂ O ₃	1.8-2
SO ₃	0.3-0.7
MgO	8-10
SiO ₂	33-35

Table 1. Characteristics and Properties

Physical analysis	Range
Bulk Density	600-700 kg/m ³

Surface Area	12000 cm ² /gm
Particle shape	Irregular
Particle Size	-
d10	< 2 μ

Effects of alccofine on concrete

i. Improved durability

Alccofine results in to having a dense pore structure which avoid the chloride and sulphate ions ingress. It also makes concrete more alkaline which provide cover to the reinforced steel in concrete and provides the durable structure.

ii. Improved strength gain

Alccofine results in to formation of dense pore structure and inbuilt CaO provides increased secondary hydrated product because of which increase strength gain at early as well as later ages is observed.

iii. Improved workability and cohesiveness

Alccofine have better particle size distribution compared to other Supporting Cementitious Materials which provide dense mixture pore structure resulting in to reduced water content and good workability.

iv. Better retention of workability

Alccofine has ultrafine smooth sub rounded particles shape and dispersing effective property. This took in better workability, segregation resistance and workability retention properties in fresh concrete.

v. Reduced segregation

Alccofine increases the religious studies of concrete by virtue of filling voids of cement particles by property distributed particles whereby it reduces the bleed water and resulting in to consistent concrete with reduced segregation.

vi. Lowers the heat of hydration

Alccofine has lime content about 34% which provides more substantial of secondary hydrated product. This result in lengthy chemical reaction and responsible for, reduced heat liberated by the hydration process.

vii. Improved flow ability

Alccofine has better packing effect which results in to improve rheology resulting in to improved flow ability

Steel fibre

Crimped type steel fibers is high tensile steel cold drawn wire with crimped types, glued in bundles & specially engineered for use in concrete. Fibers are

made available from Kasturi Composite Pvt. Ltd.; Amravati (Maharashtra).

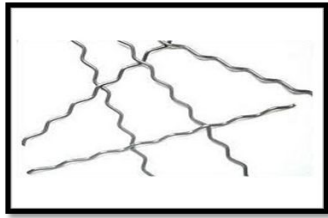


Fig 2. Crimped types steel fiber

Crimped type steel fibers conforming to ASTM A 820 type-I are used for experimental work. CR 50/30 is high tensile steel cold driven wire with crimped types, bonded in bundles & specially engineered for use in concrete. Fibers are made available from Kasturi Composite Pvt. Ltd.; Amravati (Maharashtra) in the literature is given in Table

Table 2. Properties of fiber

Sr. No	Properties	Values
1	Diameter	0.6 mm
2	Length of fiber	30 mm
3	Appearance	Bright in clean wire
4	Average aspect ratio	50
5	Deformation	Continuous deformed circular segment
6	Tensile strength	1025 Mpa
7	Modulus of Elasticity	200 GPa
8	Specific Gravity	7.5

Concrete mix selection:

Mix design is process that consists of two interrelated steps:

1. Selection of suitable ingredients (cement, aggregate, water & admixture) of concrete.
2. Determining their relative quantities to produce, as economically as possible, concrete of appropriate workability, strength & durability.

Factors governing concrete mix selection

1. Strength
2. Durability
3. Water cement ratio
4. Economy
5. Workability
6. Maximum size of aggregate

7. Grading & type of aggregate
8. Air voids & compaction

Factor affecting workability

- a) Water content of mix
- b) Influence of aggregate
- c) Time & temperature
- d) Characteristics of cement
- e) Admixtures

Concrete mix design;

(As per IS 10262-2009)

Data for test;

- a) Grade of Concrete - M25
Characteristic Strength (F_{ck}) - 25 Mpa
Standard Deviation - 4 N/mm²
- b) (Table No – 1, P.No – 2, IS 10262-2009)
- c) Type of cement: OPC 53 Grade
Aggregate Type - Crushed of 20 mm size
Specific Gravity -
 - a) Cement – 3.15 (standard value)
 - b) Fine Aggregate - 2.62 (from test result)
 - c) Coarse aggregate – 2.67 (from test result)

Summary;

Table 3. For 1 m³ volume of concrete

Alccofine (%)	W/C ratio	Cement	alccofine	CA	FA
0	0.4	372	00	1213	731
1	0.4	368.02	3.72	1213	731
2	0.4	364.56	7.44	1213	731
3	0.4	360.84	11.16	1213	731
4	0.4	357.12	14.83	1213	731
5	0.4	353.4	18.60	1213	731

III. Experimental Program

Investigation of concrete Properties:

Comparative study of effect of Alccofine on steel fiber reinforced concrete is done as far as following stated tests are concerned.

1. Compressive strength test.
2. Shear and torsion test

Test setup:

1) Testing of cube specimens for compressive strength:

For the compression test, the cubes are placed in machine in such a manner that the load is applied on the Forces perpendicular to the direction of cast. In compression testing machine, the top surface of machine is fixed and load is applied on the bottom surface of specimen. The rate of loading is gradual and failure (crushing) load is noted. Also the failure pattern is observed precisely.

Shear and torsion

The experimental investigation consisted of casting and testing 12 steel fiber reinforced concrete beams under combined effect Shear and Torsional loading, out of 12, 2beams are without fiber and remaining 10 are with fiber.

The size of each beam is 100 mm X 100 mm X 1000 mm. The variables include the over reinforced state of the cross section and volume fraction of the fiber. The volume fraction of the Fiber and Alccofine content is 0 % to 5 % weight of cement in the interval of 1 %.

The proportioning of concrete is maintained constant throughout the investigation. A concrete mix targeting a compressive strength of 25 MPa is used. Figure shows the cross sectional details of the beam loading arrangement. An effective cover of 15 mm is provided for the transverse reinforcement.

The cured beams are white washed a day before testing to facilitate the crack identification. One end of the beam is supported on rollers, while the other end is supported on rigid support. This type of test setup facilitates free rotation of roller end and provides stability to the test specimen during testing. Specially made twist arms or twist angles are placed at both supports of the beam having an arm length 0.66 m.

Load on twist arm is applied through a Hydraulic jack and the loading is monitored through a proving ring attached to the jack. Absolute care has taken, such that, the plane of loading and twisting arm are perpendicular to the longitudinal axis of the beam. This avoids any possibility of bending of the beam instead of twisting and as a result the beam between the two support is subjected to pure torsion. The complete test setup is schematically presented in photo shows the actual test set up. Load is applied at an eccentricity of 0.66 m from the centre of beam. For every applied load, the corresponding dial gauge reading are noted. Which were placed at L/3 distance from both ends and considering avg. two readings.



Fig 3. Shear and torsion test setup

IV. RESULT & DISCUSSION

Table 4. compressive strength at 28 days

Discussion:

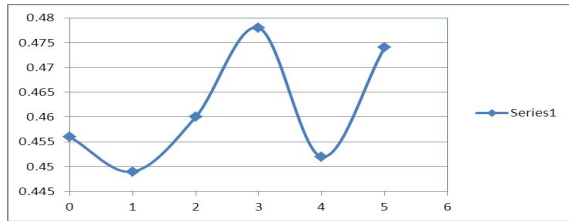
The max compressive strength is 28.21Mpa at 28days, it is obtained at 3% of alccofine content

Alcco fine (%)	Fiber (%)	Load (KN)	C/S AREA (mm ²)	Comp. Strength (N/mm ²)	Av comp Strength (N/mm ²)
0	0	547	22500	24.31	24.15
		538		23.91	
		545		24.22	
1	1	578	22500	25.69	25.67
		594		26.4	
		561		24.93	
2	2	603	22500	26.8	26.46
		595		26.44	
		588		26.13	
3	3	648	22500	28.8	28.21
		625		27.78	
		631		28.04	
4	4	585	22500	26	25.86
		611		27.15	
		550		24.44	
5	5	569	22500	25.29	24.77
		545		24.22	
		558		24.8	

Table 5. Shear and torsion test on beam at 28 days

Alcco fine (%)	Steel fiber (%)	Shear force (KN)	Avg. shear force (KN)	Torsional moment (KN.m)	Avg. torsional moment (KN.m)
0	0	0.453	0.456	10.00	9.584
		0.46		9.168	
1	1	0.445	0.449	15.003	13.336
		0.453		11.669	
2	2	0.46	0.46	15.003	17.503
		0.46		20.004	
3	3	0.475	0.478	14.169	15.836

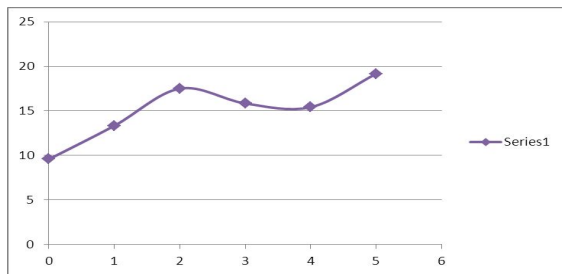
		0.482		17.503	
4	4	0.445	0.452	15.836	15.419
		0.46		15.003	
5	5	0.46	0.474	20.837	19.170
		0.489		17.503	



graph 1. Alccofine(%)Vs shear force

Discussion:

The maximum shear force is 0.478 KN. It is obtained at 3% alccofine content in beam.



graph 2. Alccofine (%)Vs torsional moment

Discussion:

The maximum torsional moment is 19.170 KN.m. It is obtained at 5% alccofine content in beam.

V. CONCLUSION

The compressive strength rapidly increases with the increase of alccofine content. There is increase in the strength rapidly upto 20% of alccofine after that there is reduction in the strength we get maximum compressive strength 16.81% more than normal concrete at 28-days for 3% dose of alccofine.

The properties like shear, torsion and bending is also improve due to addition of fibers in concrete. This is obvious because the addition of fibers resists the development of internal micro crack in the concrete, which are responsible for the failure of the structure.

The shear force is 4.82% more than normal concrete for 3% alccofine and fiber content.

The torsional moment is exactly twice than normal concrete for a 5% of alccofine and steel fiber content.

Scope for Future Work:

The present work has good scope for future research.

Some of the research areas are as follows:

1. Behavior under creep and shrinkage.
2. Behavior of mechanical and physical properties of SFRC at low temperatures.
3. Study the coating for steel fiber to modify bond with the matrix and to provide corrosion protection.
4. Same parameter with recycle aggregate.
5. Fracture analysis.
6. Stress transfer mechanism.

Study of impact resistant, abrasion resistant and permeability of SFRC and resistant to chemical attack

VI. ACKNOWLEDGEMENTS

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