A Research Article on "Alccofine Concrete"

K Ashwini, P Srinivasa Rao

Abstract: *After water the most widely used substance on Earth is concrete. Manufacturing of cement for concrete consumes vast quantities of energy and releases CO2 in the process, which can be conserved by using supplementary cementitious materials. These materials enable to use hundreds of millions of tons of byproduct materials thereby reducing waste disposal problem and replacing part of cement without deduction of equivalent engineering properties in binary blended or even ternary blended concrete. India is growing at an unprecedented pace and roads, bridges, dams, skyscrapers etc. are the need of an hour of the city. The Skyline is changing and with it demand for a sustainable, durable, eco-friendly and high performance concrete is increasing, to address this challenge a new generation micro fine pozzolanic material Alccofine can be used in concrete which opened the path for innovative research in the field of civil engineering. In this paper review on effect of recently developed Alccofine for sustainable development of concrete industry is studied.*

Keywords: *alccofine, cement, concrete, high performance concrete*

I. INTRODUCTION

Infrastructure development is a key driver for increasing Indian economy. Due to increase in urbanization rapid growth in different sectors of infrastructure industry is increasing with the increase in involvement of foreign investments in this field. In India construction is the second largest activity with contribute to economy after agriculture therefore it is crucial that infrastructure development should occurs in eco-friendly and sustainable manner. High-performance concrete is being paid more and more attention. Sustainable and Environmental friendly high performance concrete is a demand in our new generation. However, the most important ingredient used in the production of concrete is cement which is one of the primary producers of CO2 and contributes to greenhouse gas. Climate change and global warming are current and major concerns for humanity. Due to scarcity of natural resources or growing concern over greenhouse gases or both, time will come when production of cement will have to be curtailed or cannot be increased to have the ecological balance. Therefore it is essential to find solutions for sustainable production of eco-friendly concrete. To meet the above requirements Supplementary cementing materials are often used to enhance concrete properties through pozzolanic and hydraulic activity or both and make concrete mixtures more economical. Supplementary cementitious materials(SCMs) like GGBS, Metakaolin, Fly ashes and Silica fume etc. are the byproducts of industrial processes by using these materials waste disposal problem is solved.

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To meet the requirement Alccofine a new generation generation supplementary cementitious material becoming popular and opened the path for innovative research in the field of civil engineering.

In this paper a review on use of Alccofine as supplementary cementing materials to enhance strength and durability properties of concrete is studied.

II. SIGNIFICANCE OF STUDY

Alccofine is a recently developed material and being a micro fine mineral additive can be use to improve the performance parameters of concrete in wet and hardened stage. But very few researches have been done using alccofine. Therefore this study is carried out to know the behaviour of different parameters of concrete using alccofine as an additive.

III. ALCCOFINE

Alccofine 1203 is ultrafine slag or ultrafine GGBS (UFGGBS) micro fine pozzolanic material having particle size less that 10µm with low calcium silicate and having fineness 12000 cm2/gm and high glass content. It has a bulk density of 600 to 700 Kg/m3. Particle size distribution of Alccofine/Ultrafine GGBS is shown in fig.1 [20].

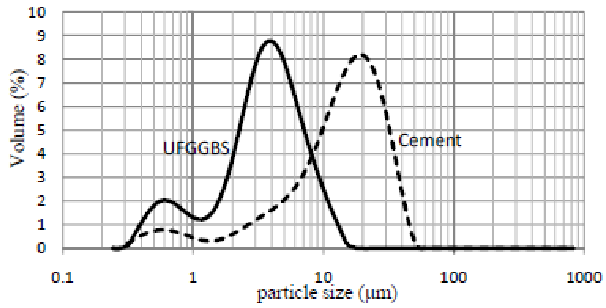

Fig. 1: Particle size distributioncurve of Alccofine (UFGGBS) and cement

IV. LITERATURE REVIEWED

The fundamental properties of concrete like characteristic strength, modulus of rupture, resist to chemical attack, flowability etc. which influence the structural performance of concrete using alccofine is reviewed.

A. Fresh properties of concrete incorporating Alccofine

Mohan et al. [17] studied fresh properties of self compacting concrete using alccofine and silica fume and found spread of 670–720 mm for all the blends and workability of concrete using silica fume reduced but that of concrete with alccofine was better due to its pore filling property.

Parveen et al. [20] prepared concrete sample using low calcium class F fly ash(350,375 &400kg/m3) alccofine10% particles, sodium hydroxide and sodium silicate and conducted slump cone test to find workability and concluded that the slump values increased by 15% as the fly ash content changes from 350 to 400 kg/m3.

Luo Ting et al. [24] conducted experiments using alccofine varying from 10 to 50% by mass and found that as the dosage increases the concrete sets earlier and fluidity reduced. Shear stress increased with increase in percentage of alccofine.

Ahmad et al. [16] concluded that with the increase of percentage replacement of cement with ultrafine slag, use of superplasicizer admixture dosage gets reduced as shown in fig.no.2.

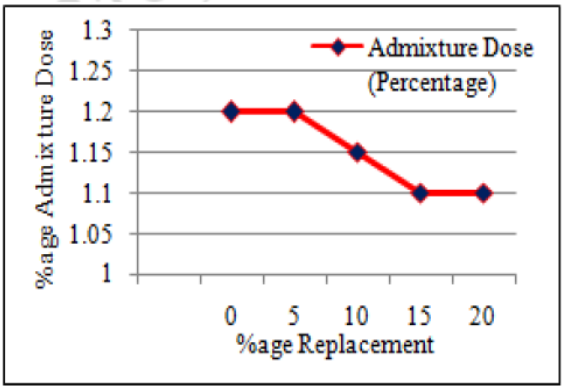

Fig. 2: Percentage reduction in admixture dosage

B. Strength properties of concrete incorporating Alccofine

Performance of concrete is evaluated from mechanical properties which include Compressive strength, Split tensile strength, flexural strength, and modulus of elasticity etc. Influence of these properties on concrete using Alccofine is reviewed below.

Reddy et al. [2] conducted experiments using fl ash 25%, Alccofine 10% and colloidal nano silica(0.5 to 3%) in M30 concrete and found that concrete using 1% colloidal nano silica showed better strength properties due to its increased hydration process.

Upadhyay et al. [3] found that concrete using Alccofine 10% and Fly Ash 30% for M60 concrete had maximum compressive strength and as the w/c ratio chances from 0.45 to 0.5 minor differences was seen compressive strength.

Balamuralikrishnan et al. [4] reported that Alccofine 10% and GGBS 30% showed 28.76% higher compressive strength than the control mix.

Gayathri et al. [5] concluded that for M20 concrete using Alccofine upto 15% gave higher compressive strength than all other mixes further increase in dosage decrease the strength gradually because it act as a filler material as shown in Table no.1[5].

Table no.1: Compressive Strength of M20 concrete at 28days

Sr. No.	Alccofine %	Comp. Strength N/mm2
1	0	31.24
2	5	33.27
3	10	37.63
4	15	42.16
5	20	41.49

Avuthu Narender Reddy et al. [6] conducted experiments using fl ash, Alccofine and GGBS found that 25% fly ash and 10% Alccofine showed maximum compressive strength than that of mix with GGBS and alccofine and conventional mix.

Chakravarthy et al. [7] found that for M25 concrete maximum compressive strength was observed at 16% alccofine for both 7 and 28 days.

Magdum et al. [8] conducted compressive strength and flexural test using alccofine percentage 5, 7.5, 10, steel fiber and polypropylene and found that compressive and flexural strength maximum 7.5 % alccofine and 80% steel fiber and 20% polypropylene fiber by weight of cement.

Sumathi et al. [9] concluded that M60 concrete with Alccofine 10% and micro steel fiber the compressive and flexural strength of concrete increases with the inclusion of micro steel fiber in concrete as shown in fig no.3 &4[9].

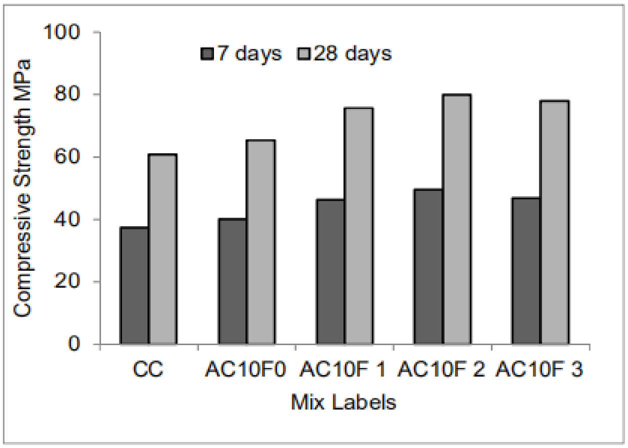

Fig. 3: Compressive strength for 10% Alccofine and Micro steel fiber (%).

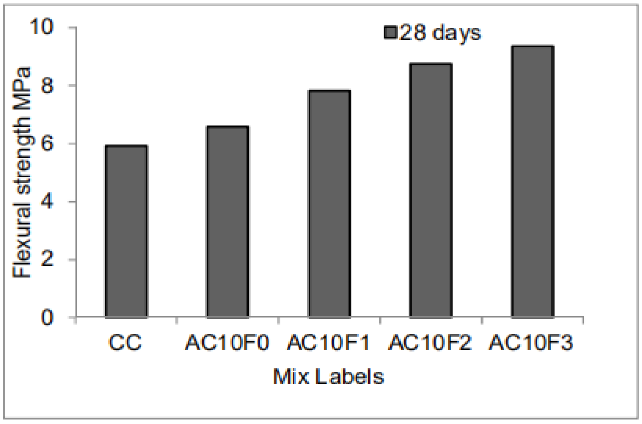

Fig. 4: Flexural strength for 10% Alccofine and Micro steel fiber (%).

Sinha et al. [10] observed that M60 steel fibre reinforced concrete with Fly ash 10% and Alccofine 9.75% gave higher compressive and tensile strength of about 10.10 % and 12.8% and 21.93% and 20.09% respectively thereafter they showed a decreasing trend for 7 and 28 days as compared to control mix a shown in table no.2[10].

Table no.2: Compressive Strength of M60 concrete at 28days

Sr. No.	Fly+Alccofine+steel fibres(%)	Comp. Strength N/mm2
1.	0	68.3
2.	0+0+1	73.04
3.	10+0+1	68.59
4.	20+0+1	66.96
5.	10+6.5+1	71.11
6.	10+9.75+1	77.04
7.	10+13+1	73.33
8.	10+16.25+1	72.89

Patel et al. [11] reported that compressive, spilt tensile and tensile strength was highest for 6% Alccofine and 10% pond ash.

Saurav et al. [12] compared M50 concrete cylindrical and cubical strength by varying the percentage of Alccofine in cement and observed that cylindrical and cubical strength increases with increase in Alccofine and optimum percentage was 13% but the cylindrical strength was less than cubical strength of concrete.

Shaheen et al. [13] carried out research on the concrete with w/c ratio 0.45 and cement partially replaced by metakaolin and alccofine, observed that compressive strength and flexural strength of the concrete with optimum of 10% of Alccofine increased with increase in replacement levels of metakaolin as shown in fig no. 5[13].

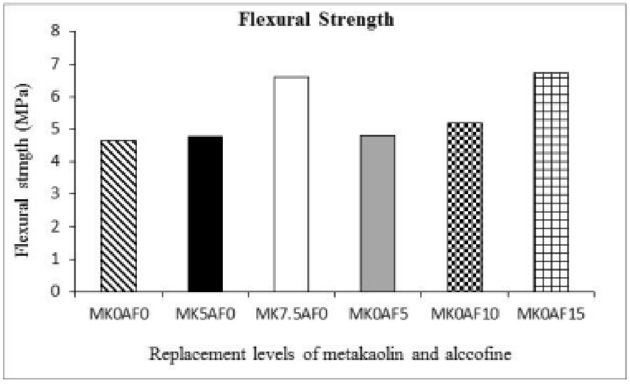

Fig. 5: Flexural strength of concrete

Sharma et al. [15] casted **c**oncrete samples of M100 grade using Alccofine 15% and portland pozzolana cement with the percentage of foundary sand varying from 10 to 50% found that foundary sand of 45% had higher compressive strength, split tensile strength and flexural strength at the age of 7, 14, 28, 56 and 90 days

Ahmad et al. [16] studied the high strength concrete using Ultrafine Slag as a replacement of fly ash based Portland Pozzolana Cement with 5%, 10%, 15% and 20% to make concrete more environmental friendly and found that 20 % replacement achieved higher strength as compared to other replacement as shown in figure no. 6[16].

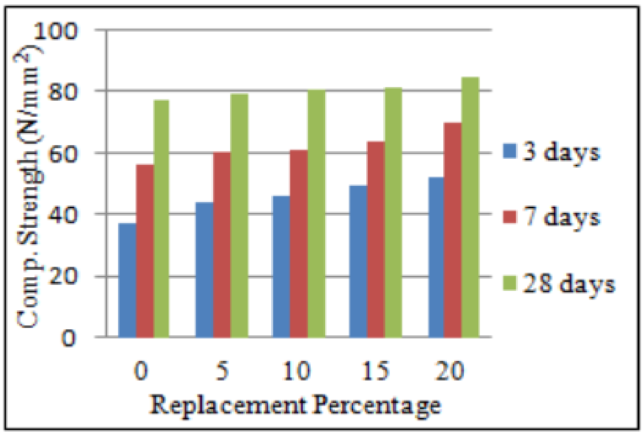

Fig. 6: compressive strength at 3,7 &28 days

Mohan et al. [17] obtained maximum compressive strength and flexural strength for Alccofine and silica fumes incorporated self compacting concrete with 10% alccofine as replacement of cement.

Reddy et al. [18] conducted experiments for M30 concrete using GGBS (10,20,30&40) and alccofine (8, 10, 12, & 14) observed that the optimum percentage of GGBS was 10% and which was then used with different percentage of alccofine and found that increase in percentage of Alccofine decreased compression strength at different ages compared to control concrete and GGBS concrete.

Lim et al. [19] studied the effect of Alccofine on concrete by performing Compressive strength, flexural strength, and modulus of elasticity tests with (w/c) ratio 0.35 & 0.28 and Alccofine 30%. and found that average increase in compressive strength was 23% for 3, 7, 28, 56 & 90 days. The flexural strength was maximum as compared to the conventional concrete which varied from 5% to 23% for the w/c 0.35 and between 40% to as much as 60% for w/c 0.28.

Parveen et al. [20] concluded that concrete using fly ash 400 kg/m3 and alccofine showed greater compressive, split tensile and flexural strength of values 41MPa, 3.75Mpa and 4.23Mpa respectively than conventional concrete. SEM images showed that concrete using alccofine have denser matrix and fewer microcracks or pores. Fig.8 [21].

Reddy et al. [21] investigated the influence alccofine 25% with different water to binder ratios 0.38, 0.4 and 0.45 reported that compressive strength and split tensile strength of concrete with alccofine improved by 5.26%and 1.92% for W/c .38. From XRD analysis as shown in Fig.7[21] found that Calcium silicate hydrate (CSH) more in Alccofine concrete enhance strength of the concrete. From thermogravimetric analysis alccofine concrete was found to have more bound water and less calcium hydroxide (due to pozzolanic action) with respect to normal concrete at different water to binder ratios.

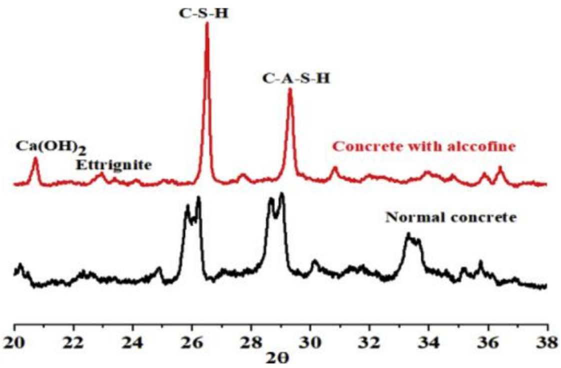

Fig. 7: XRD analysis of the normal concrete and alccofine concrete

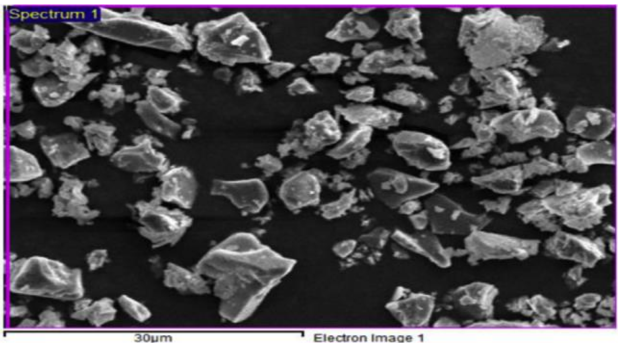

Fig. 8: SEM image of Alccofine

C. Durability properties of concrete incorporating Alccofine

The durability of concrete is very important as it defines the longevity of the material against various environmental condition. Influence of these properties on concrete using Alccofine is reviewed below.

Reddy et al. [2] concluded that concrete using fl ash 25%, Alccofine 10% and colloidal nano silica 1% in concrete showed decrease in water absorption percentage of 2.84%, with respect to the conventional concrete mix for 28days.

Balamuralikrishnan et al. [4] conducted acid, sulphate attack and chloride attack test and found that minimum losses of weight and loss of compressive strength is achieved by using Alccofine 10% and GGBS 30% and RCPT test results revealed that total charge passed in coulombs is very lower than all other mixes.

K. Gayathri et al. [5] reported that for M20 concrete using Alccofine 15% against Acid attack, Sulphate Attack, Chloride Attack and Rapid chloride permeability than the control concrete mix.

Sumathi et al. [9] found that after acid, sodium sulphate and magnesium sulphate curing strength was reduced to a maximum of 2 MPa, 1.6MPa and 1.2 MPa for Alccofine 10% and sorpitivity coefficient was least.

Patel et al. [14] studied durability properties of concrete using fly ash 20% and alcoofine 8% found that due to addition of Alccofine strength of concrete was minimum against chloride resistance and sea water test due to its pore filling and pore refining ability. Rapid chloride permeability test value was less and weight loss of the steel using Alccofine in accelerated electrolytic corrosion test was found less, therefore using Alccofine normal cover is sufficient to prevent steel from corrosion.

Sharma et al. [15] studied Carbonation of M100 grade concrete using Alccofine 15% and portland pozzolana cement with the percentage of foundary sand varying from 10 to 50% found the alkalinity and permeability of concrete improved with increase in foundary sand.

Mohan et al. [17] concluded that self compacting concrete using silica fume reduced the water permeability, unrestrained shrinkage, resistance to chloride penetration and Water sorptity better than alccofine as shown in figure9&10[17] . Concrete using alccofine showed better resistance to acidic environment than silica fume due to excess release of hydrated calcium silicate in transition zone

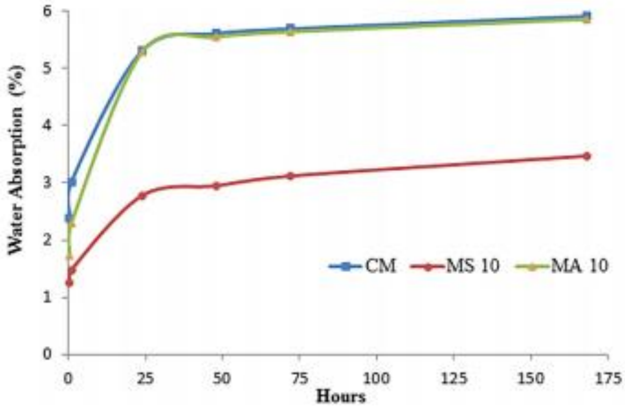

Fig. 9: Water absorption

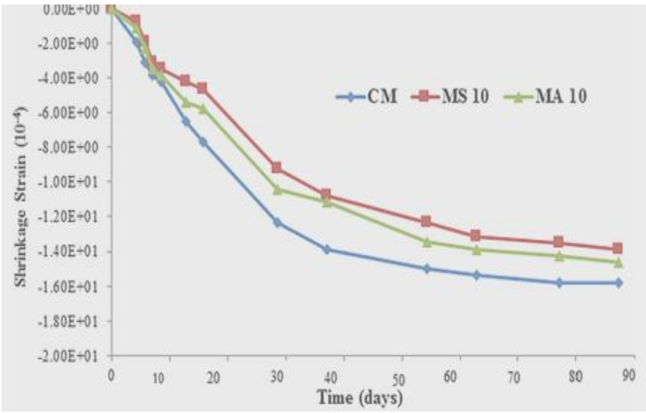

Fig. 10: Unrestrained shrinkage

Lim et al. [19] studied the durability aspect of the concrete using RCMT to obtain the chloride migration coefficient and found that for 30% replacement of alccofine chloride migration coefficient becomes smaller as the concrete curing age increases from 3 to 90days, due to increase in hydration and permeability of the concrete also decreases.

V. CONCLUSION

The present paper summarizes the utilization of Alccofine for the development of sustainable concrete. By using Alccofine we can reduce the construction industry's contributions towards global warming and at the same time, utilize accumulated amount of industrial by-product in the correct mechanism and the concrete industry can overcome these deficits and achieve concrete that is stronger and lasts longer. On the basis of literature reviewed following are the conclusions can be drawn for the use of alccofine in concrete:

- Alccofine as has high surface area therefore consistent mix is possible

- It reduces the permeability of concrete is significantly.
- It increases rate of hydration and pozzolanic reaction compared to the conventional GGBS.
- It is able to refine and fill the pore in transition zone of concrete.
- It improves properties of fly ash based Geopolymer concrete.
- It improves the strength and durability properties of concrete.
- It lowers water demand and admixture dosage.
- It improves package density of paste.
- Alccofine without superplasticizer affects the fluidity of concrete.
- It results in fast setting of concrete
- It leads to the formation of calcium silicate hydrate thereby enhancing strength of the concrete.
- It shows more bound water and less calcium hydroxide (due to pozzolanic action) with respect to normal concrete
- Combination of GGBS and Alccofine reduces strength properties of concrete as compared to conventional mix.

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