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Study of Effect of Alccofine on Strength Characteristics of Concrete

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Abstract: ***Supplementary Cementitious Materials are becoming the need of any large scale or sustainable building projects, hence leading to a rise in popularity of such additives. Alccofine is a new generation micro fine concrete material for high Strength Concrete which is important in respect of workability as well as strength. Basically, the strength achievement of structure is the main desire which is fulfilled by addition or partial replacement of Alccofine. The aim of this study is to evaluate the performance of concrete by partial replacement of cement with Alccofine. Pozzolanic material like Alccofine can be used for producing highly strength and good quality concrete. In this study cement will be partially replaced by Alccofine for M20 and M40 grade of concrete. Replacements are to be done at 2.5%, 5% and 7.5% of the weight of cement in concrete. Tests will be carried out for 3 days, 7 days and 28 days.***

Keywords: Alccofine, Compressive strength, Split-tensile strength, Workability, SCM (supplementary cementitious material).

I. INTRODUCTION

Cement concrete is probably the most extensively used construction material in the world. However, the plain cement concrete suffers from numerous drawbacks such as, less compression strength, low tensile strength, brittleness, unstable cracking, etc. Therefore to improve the overall performance of concrete various SCM's like fly ash, GGBS, silica fumes, etc. are introduced in the concrete so as to meet the required expectations. Alccofine is one such new-generation SCM which helps in developing a high performance concrete.

It is the product prepared in accordance with IS 12089-1987, Specification for granulated slag for the manufacture of Portland slag cement. Alccofine is a specially processed product based on slag of high glass content (taken from iron factories) with high reactivity obtained through the process of controlled granulation. Alccofine 1203 and Alccofine 1101 are two types with low calcium silicate and high calcium silicate respectively. Alccofine 1203 is the product majorly used in the construction work, which we also use in our experiment.

Fig. 1- Alccofine

Table 1- Physical Properties of Alccofine 1203

Specific gravity	Bulk Density	Surface area	Particle Shape
2.9	600-700 kg/m^3	12000 cm^2/gm	Irregular

Table 2- Chemical Properties of Alccofine 1203

CaO	Al2O3	SIO2	MgO	Fe2O3	Glass content
31-33 %	23-25 %	33-35 %	5-10 %	0.8-3 %	>90 %

A. Field Applications

1) Bridges.
2) Roads and air ports.
3) High rise buildings.
4) High performance concrete with extremely low water to binder ratio.
5) Post tension / pre-stressed concrete slab.

B. Advantages

1) *Strength:* Alccofine 1203 results in formation of dense pore structure and inbuilt CaO helps in proper hydration, due to which improved strength gain at early as well as later stages observed.
2) *Workability and Cohesiveness:* Alccofine 1203 has a better particle size distribution compared to other Supplementary Cementitious Materials which provides dense matrix pore structure resulting in to reduced water content and batter workability.
3) *Lower the Heat of Hydration:* Alccofine 1203 has high lime content, because of which the chemical reaction is prolonged and heat liberated is reduced.
4) *Flow Ability:* Alccofine 1203 is ultrafine and provides dense packing which also results in better flowing and setting of concrete.

II. AIM AND OBJECTIVES

To study the effect of replacement of cement, with Alccofine at proportions of 2.5%, 5% and 7.5% on the strength characteristics of the concrete. Objectives-

A. To determine the effect of Alccofine on compressive and split tensile strength of concrete.
B. To check the effect of Alccofine on the workability and water-cement ratio of the concrete mix.
C. To determine the optimum percentage of Alccofine replacement.

III. EXPERIMENTAL WORK

A. Materials

1) *Alccofine:* Alccofine 1203 is a specially processed product based on slag of high glass content with high reactivity obtained through the process of controlled granulation. Alccofine plays important role in concrete to reducing the water demand as well as it increases compressive strength and workability of OPC concrete. It also fills pores remain between cement particles.
2) *Cement:* Ordinary Portland cement (OPC), grade 43 is used for the project and testing. Specific Gravity of Cement- 3.15.
3) *Fine Aggregate:* Crushed sand (Vertical Shaft Impact) is used as per the IS: 383-1987 is used for testing. Properties determined in the test are-
a) Specific Gravity- 2.72
b) Zone of grading- I
4) *Coarse Aggregate:* Coarse aggregate conforming to IS: 383-1970 is used. Nominal aggregate size is 20 mm. Specific Gravity determined- 2.68.

B. Concrete Mix Design

1) *M20*

Cement – 394 kg/m3
Water – 197 kg/m3
Fine aggregate – 737.664 kg/m3
Coarse aggregate – 1091.224 kg/m3
W/C ratio – 0.50

- Replacement with Alccofine-

2.5% Alccofine- 9.5 kg/m3
5% Alccofine- 19.7 kg/m3
7.5% Alccofine- 29.55 kg/m3

2) M40

Cement – 370 kg/m3
Water – 148 kg/m3
Fine aggregate – 759 kg/m3
Coarse aggregate – 1220 kg/m3
Chemical admixture- 7 kg
W/C ratio – 0.40

- Replacement with Alccofine-

2.5% Alccofine- 9.25 kg/m3
5% Alccofine- 18.5 kg/m3
7.5% Alccofine- 27.75 kg/m3

C. Casting of Specimen

1) *Mixing:* For mixing of the materials, both mechanical and manual method is implemented accordingly. In manual method of mixing, all the quantities are calculated and material is weighted on that behalf. In a big pan, first of all, the materials are mixed in a dry condition. Then the water is added three times by taking two intervals and the concrete is mixed thoroughly. In case of mechanical mixer, the dry mixing is carried out for about 1 minute. Then about 70 % of water is added and mixing is done. Remaining water is added accordingly. The entire mixing should be completed within 3-4 minutes.
2) *Filling the Moulds:* Filling of the moulds should be started as soon as the mixing is completed. The internal surface of the moulds should be oiled adequately before filling. Proper tamping is carried out with the help of tamping rod while filling the moulds with concrete.
3) *Compaction:* The compaction of cube was performed by means of table vibrator. Table vibrator is a mechanical device to generate vibrations. After the proper mixing of concrete, it was filled in moulds. The moulds filled with concrete are kept for vibration for 30-40 seconds.
4) *Curing:* De-moulding of the concrete cubes is done after 18-24 hours. The specimen is then kept for curing immersed completely in water. Curing of concrete is defined as providing adequate moisture, temperature, and time to allow the concrete to achieve the desired properties for its intended use.

D. Testing

The testing was carried on compression strength testing machine (CTM).

Fig.2- CTM

1) *Compressive Strength:* The compressive strength is the capacity of a material or structure to withstand loads. Some materials fracture at their compressive strength limit, others deform irreversibly. The compressive strength of all mixes was measured with cube specimen of size 150mm(length) x 150mm(width) x 150mm(depth).The specimens were tested after curing for 3 days, 7 days and 28 days fully immersed in water tank as per IS 516:1959 for method of tests for strength of concrete.

Compressive strength = P/A (Unit = N/mm2 or MPa)
Where,
P = Load, A = Area of Specimen

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2) *Split-tensile Strength:* The tensile strength of concrete is one of the basic and important properties. Split tensile strength test on concrete cylinder is a method to determine the tensile strength of concrete. The concrete is very weak in tension due to its brittle nature and is not expected to resist the direct tension. The split tensile strength of all mixes was measured with cylinder specimen of size 300mm(length) x 150mm(diameter).

As per IS 5816:1999 for method of test splitting tensile strength of concrete. Splitting Tensile Strength = $2P/\pi ld$ (Unit = N/mm2 or MPa)

Where, P = Load, l = Length of Specimen, d = Diameter of specimen.

IV. RESULTS

A. *Compression Strength Test*

M20

Content	3 day	7 day	28 day
0 %	13.72	16.60	23.10
2.5 %	14.40	18.23	24.72
5 %	19.27	22.62	31
7.5 %	19.44	22.68	30.87

Above results convey that, as there is an increase in percentage of alccofine replacement, the strength also increases to certain extent. However, not much difference is seen in the results of 5% and 7.5% replacing content. Early strength gain properties of alccofine concrete are much impressive. About 7 % to 34 % increase in the strength of concrete.

M40

Content	3 day	7 day	28 day
0 %	20.82	30.2	41.13
2.5 %	21.45	33	42.2
5 %	23.11	35.7	44.3
7.5 %	23.41	37	45.2

The 3 day strength does not show much variation or growth in strength, but at 7 days and 28 days, there is a significant increase in strength of alccofine concrete ranging from 2.6% to 10%.

B. *Split Tensile Strength Test*

M20

Content	7 day	28 day
0 %	1.84	2.32
2.5 %	1.93	2.45
5 %	2.24	2.87
7.5 %	2.37	3.04

There is an increase of about 6 % to 30 % in the 28 days split tensile strength concrete. There is a significant rise in strength at 28 days as compared to 7 days.

M40

Content	7 day	28 day
0 %	2.97	3.38
2.5 %	3.05	3.50
5 %	3.70	4.10
7.5 %	3.87	4.23

There is an increase of about 4 % to 25 % in the 28 days split tensile strength concrete. Not much higher variation in the values of 5 % and 7.5 %.

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C. Workability

Slump cone test is performed to determine the workability of concrete. The concrete slump test ensures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which the concrete flows. It can also be used as an indicator of an improperly mixed batch. The test is popular due the simplicity of apparatus used and simple procedure.

Concrete	Slump value (mm)
0%	75
2.5%	75
5%	85
7.5%	100

Fig.3- Slump Cone Test

V. COST ANALYSIS

The study of cost effectiveness based on the outcomes from this project (for $1m^3$ of concrete) -

Material	Rate	Conventional concrete (M20)		M20 Alccofine concrete (5%)	
		Qty.	Price (Rs.)	Qty.	Price (Rs.)
Cement	6/kg	394 kg.	2364	374.3 kg.	2246
Coarse aggregate	780/m3	0.40 m3	312	0.40 m3	312
Crushed sand	1250/m3	0.28 m3	350	0.28 m3	350
Alccofine	20/kg	--	00	19.7 kg.	394
	Total (Rs/m3)	3026		3302	
	28 day Compr. Strength.	23.10 N/mm2		31 N/mm2	

The study of effect of application of alccofine on the cost of concrete can be basically understood by above analysis. There is about 9% of increase in overall cost for application of alccofine in 1 m^3 of M20 grade concrete. But also, it results in about 34% increase in the compressive strength as compared to the conventional concrete.

VI. CONCLUSIONS

A. Through the analysis of the results obtained in this study, the optimum dosage of alccofine replacement is decided as 5%, by considering the strength, economy, and other properties of fresh as well as hardened concrete.

B. The 5% replacement with alccofine, gives more than 30% increase in the 28 day compressive strength of M20 grade concrete, and about 10% increase in M40 grade concrete.

C. For the Split tensile test, the same replacement shows an increase of about 24% in case of M20 concrete and about 21% in case of M40 grade concrete.

D. As the dosage of alccofine is increased, workability of concrete also increases; hence the w/c ratio can be reduced to a small extent, however, after a certain limit higher replacements do not lead in higher strength.

E. Other development seen in the alccofine is the early strength gain which gives the minimum desired strength at 7 days, which may further lead to early completion of projects on field.

F. The alccofine concrete gives a formation of dense and smooth surface finished concrete with no cracking or honeycombing in the concrete.

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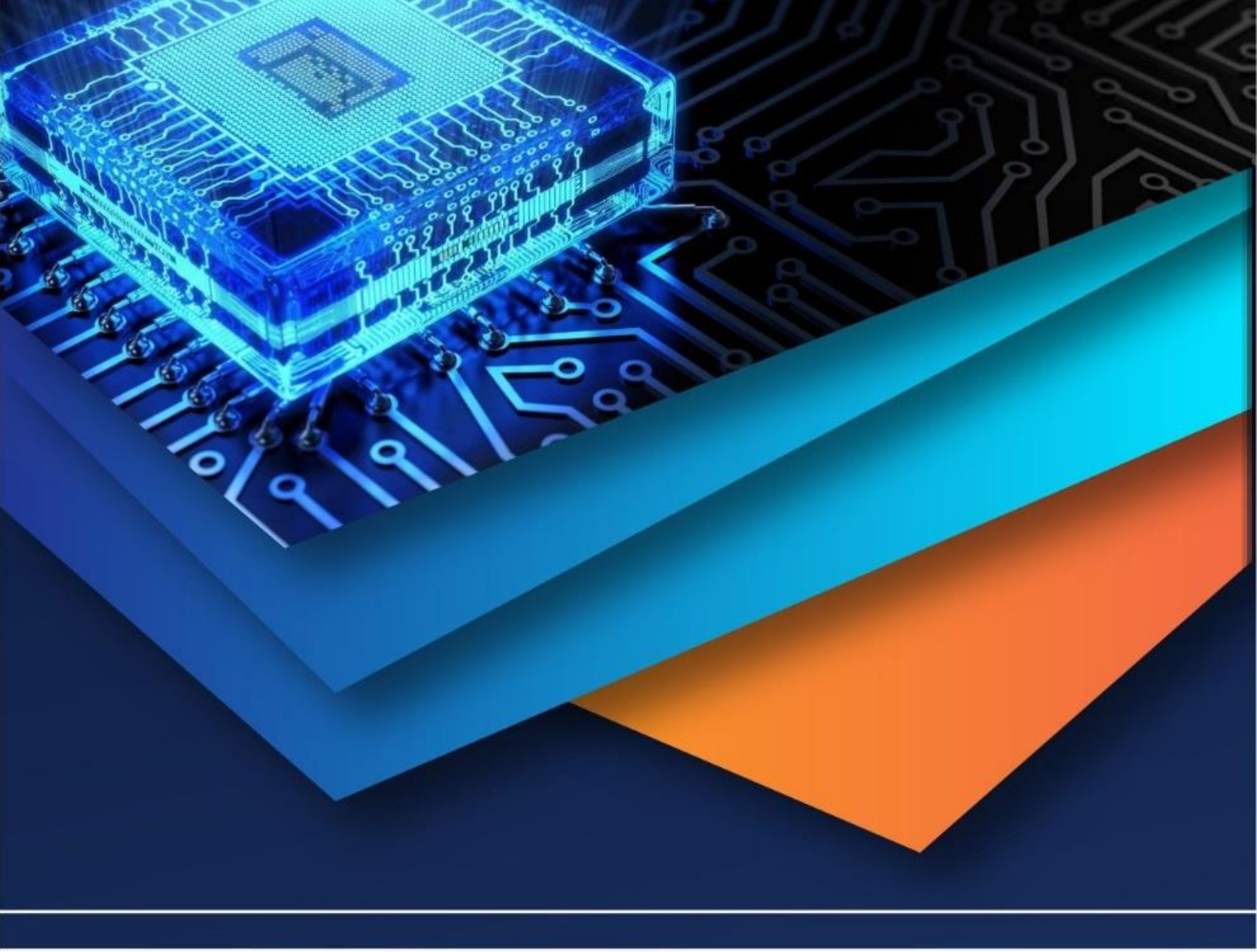

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