Study on New Supplementary Cementitious Material in Construction of Green Building

Pooja S. Naringrekar[1] Dr. Sumedh Y. Mhaske[2]
[1,2]Department of Civil and Environmental Engineering
[1,2]V.J.T.I. (University of Mumbai)

Abstract— The construction of green building requires new material which is sustainable and economical. The material technology in concrete during the construction of green building has undergone tremendous change. The concrete when present in fresh state needs high degree of cohesiveness, high workability, pumpability, slump retention. The design and execution of construction projects has focused on how sustainable practices which can reverse the impacts of global warming. Hence the demand of ecofriendly and sustainable material has increased. In this study cement is partially replaced by ALCCOFINE 1203 and Silica Fumes for M80 grade of concrete. The comparative studies has been done with the help of live project (Nathani heights) in Mumbai. Some tests and cost analysis on live project has been done to prove that ALCCOFINE 1203 is eco-friendly, sustainable and economical.

Key words: ALCCOFINE 1203, Green building, Silica Fumes, sustainable, economical, M80 grade

I. INTRODUCTION

Environmentally "green building" or sustainable building construction has experienced significant growth during the past 10 years. The public is becoming more aware of the benefits of green construction. In the "green building" word green refers to a method of design and construction that minimizes burdens on our natural resources and the environment. There is no such single definition of green building. Green building is "The careful design, construction, operation, and reuse or removal of the built environment in an environmentally, energy-efficient and sustainable manner; may be used interchangeably with high performance building, green construction, whole building design, sustainable building, and sustainable design. Green building concept has following attributes:

- Eco-friendly structure and environment
- utilize minimum natural resources and preserving them for future generations
- conservation of energy by means of smart devices
- use recyclable materials
- sustainability i.e. having internal means of generating resources as far as possible.
- User friendly environment, work practice and discipline.

Introduction and use of new green material has become important for construction of sustainable and economical building. It can minimize the consumption of material, greenhouse gas emissions and maximize their reuse. It will help u to maintain and protect the natural environment inside the building as well as outside the building. A Green building may cost more up front, but saves through lower operating costs over the life of the building. Even with the tight budget, many green building measures can be incorporated with minimal or zero increased up-front costs and they can yield enormous savings. There are benefits of construction of green buildings i.e. lower running costs, lower maintenance costs, increased productivity, adaptability.

Concrete is most widely used manufactured substance on earth owing to its remarkable versatility as a building material, which has drawback to create harmful effect on environment slowly. Using green material in concrete to replace the ordinary Portland cement and natural aggregates can eliminate the drawback.

Hence study on new ecofriendly green material is important when we are using high performance concrete in construction of green building. Objective of this paper is given as follow:

- To identify new material in construction of green building and its sustainability.
- To minimize the consumption of water, materials, natural energy during the construction of building while use of new material.
- To identify whether new technique is economical or not.

II. ALCCOFINE 1203

ALCCOFINE 1203 is a specially processed product based on slag of high glass content with high reactivity obtained through the process of controlled granulation. The raw materials are composed primary of low calcium silicates. The processing with other select ingredients results in controlled particle size distribution (PSD). The computed blain value based on PSD is around 12000 cm2/gm and is truly ultra fine. Due to its unique chemistry and ultra fine particle size, ALCCOFINE 1203 can also be used as a high range water reducer to improve compressive strength or as a super workability aid to improve flow.

This cementitious particles are much finer than normal cement grains and coarser than associated product like silica fume. The presence of ultrafine, cementitious and pozzolanic materials particles and creates a 'wall effect' in the transition zone between the paste and the aggregate. The weaker interface zone is strengthened owing to the superior bond developed between these two phases. It also refines the concrete microstructure and enhances the degree of impermeability, thus normally improve the strength and durability characteristics of concrete. ALCCOFINE 1203 performs in superior manner than all other mineral admixtures used in concrete within India. Due to its inbuilt CaO content, ALCCOFINE 1203 triggers two way reactions during hydration.

- Primary reaction of cement hydration
- Pozzolanic reaction

III. ECOFRIENDLY MATERIAL

Alccofine1203 could be an especially prepared product support scoria of additional glass content with more reactivity acquire through the method of restricted required degree of fines. Owing to its unique chemistry and ultra fine particle

sizeAlccofine 1203 is proprietary low calcium silicate based mineral additive. Controlled granulation process results in unique particle size distribution. Its latent hydraulic property and pozzolanic reactivity results in enhanced hydration process. Addition of Alccofine 1203 improves the packing density of paste component. This results in lowering water demand, admixture dosage and hence improving strength and durability parameters of concrete at all ages. The chemical composition as given as follow.

Following are the properties of ALCCOFINE 1203 and comparison between it, silica fumes and OPC

Chemical Analysis	Mass % Alccofine	Mass % Silica Fumes	Mass % OPC
CaO (Calcium Oxide)	31.97	89.5	67.8
Al2O3 (Aluminum Oxide)	1.28	1.9	2.8
Fe2O3 (Iron Oxide)	1.4	0.7	4.5
SO3(Sulfur Trioxide)	0.16	0.56	2.8
MgO (Magnesiam Oxide)	9.88	0.78	6
SiO2(Silicon dioxide)	31.34	94.6	23.6

Table 1: Comparison of Chemical Properties

Physical analysis	Range Alccofine	Range Silica Fumes
Bulk Density	600-700kg/m3	480–720 kg/m3
Surface Area	12000 cm2/gm	13,000–30,000 m2 /kg
Particle shape	Irregular	Irregular
Particle Size, d (10)	< 2 µ	< 1 µ
d (50)	< 5 µ	< 5 µ
d (90)	< 9 µ	< 9 µ

Table 2: Physical Properties

IV. FIELD AND LABORATORY TESTS

In this study field test and laboratory tests has been done to prove that, ALCCOFINE 1203 which is used during the mixing of M80 grade concrete is ecofriendly, sustainable and economical. Following are the different materials used in making of M80 grade concrete

1) OPC (Ordinary Portland cement) : Ordinary Portland cement Zuari-53 grade conforming to IS: 12269-1987 [6] with specific gravity 3.15.
2) Aggregates and M sand : A crushed granite rock with a maximum size of 10mm with specific gravity of 2.74 was used as a coarse aggregate. Manufacturing sand from River in with specific gravity of 2.60 was used as fine aggregate conforming to zone- II of IS 383-1970 [7].
3) Water : potable water is used for mixing and curing of concrete cubes.
4) Flyash : Flyash is obtained from Thermal power station which is collected near Vasai, Mumbai, India., with specific gravity 2.2.
5) ALCCOFINE 1203 :Alccofine is a specially processed product based on slag of high glass content with high reactivity obtained through the process of controlled granulation.
6) Silica Fumes: very fine non – crystalline silica product in electric arc furnaces as a by – product of production of elemental silicon or alloys containing silicon. It is a usually a grey coloured powder, somewhat similar to Portland cement or some fly ashes. Silica fumes is a byproduct of producing silicon metal or ferrosilicon alloys in smelters using electricarc furnaces.
7) Admixture : Ceraplast is a high performance, low dosage superplasticizer based on Melamine Formoldehyde Sulphorate (MFS). Highly recommended for increased early strength of concrete, which is a must for precast and prestressed concrete industries. Ceraplast disperses cement particles more rapidly in the concrete mix.

V. PACKING DENSITY

In above tables there are two types of sample i.e. sample 1 and sample 2. Sample 1 contains two design mixes of silica fumes and Alccofine 1203 which has opc, Manufacturing sand, water, fly ash, admixture 1 and admixture 2 with aggregate of 20mm. Sample 2 contains two design mixes of silica fumes and Alccofine 1203 which has opc, Manufacturing sand, water, fly ash , admixture 1 and admixture 2 with aggregate of 10mm. there is only difference in content aggregates. So results found after the compressive test has been performed on both samples. There is no much difference between the result i.e. compressive strengths. Hence it is said that Alccofine 1203 can replaced aggregate of 20mm with the aggregate of 10mm. Its because of Alccofine , in this experiment aggregate 20mm can replace by aggregate 10mm to form better packing density of concrete.

MATERIAL	DESIGN MIX (SILICA FUMES) KG/m^3	DESIGN MIX (ALCCOFINE 1203) KG/m^3
Ordinary Portland Cement	460	460
M Sand	790	790
Aggregate 20mm	840	840
Water	160	160
Silica fumes	0	0
ALCCOFINE 1203	0	0
Fly Ash	180	180
Admixture 1	0.1%	0.1%
Admixture 2	0.5%	0.5%
Compressive Strength		
7 days	71.51	72.31
28 days	69.84	83.90
90 days	72.51	81.93

Table 3: M80 Design Mix With 20 Mm Aggregate And Result.

MATERIAL	DESIGN MIX (SILICA FUMES) KG/m^3	DESIGN MIX (ALCCOFINE 1203) KG/m^3
Ordinary Portland Cement	460	460
M Sand	790	790
Aggregate 10mm	840	840
Water	160	160
Silica fumes	60	0
ALCCOFINE 1203	0	60
Fly Ash	180	180
Admixture 1	0.1%	0.1%
Admixture 2	0.5%	0.5%
Compressive Strength		
7 days	71.51	72.31
28 days	69.84	80.4
90 days	72.51	81.93

Table 4: M80 Design Mix With 10 Mm Aggregate And Result.

So, following are the design mix of M80 grade (one cubic meter) for Silica Fumes and Alccofine 1203 respectively use for different tests. In the present work, a proportion for standard concrete mix design of M40 was carried out according to IS:10262-2009 [8] recommendations

MATERIAL	DESIGN MIX (SILICA FUMES) KG/m3	DESIGN MIX (ALCCOFINE 1203) KG/m3
OPC	460	460
M Sand	790	790
Aggregate 10mm	840	840
Water	160	160
Silica fumes	60	0
Alccofine 1203	0	60
Fly Ash	180	180
Admixture	0.1%	0.1%

Table 5: Design Mix Of M80

VI. Compressive Strength

Concrete is designed for M80 following table shows constituting of each material. After mix design concrete cement is tested for setting time and concrete is tested for workability. Specimen size of concrete sample for compressive strength test was taken as (150.0 mm X 150.0 mm X150.0 mm) to make better control. After 24 hrs of casting the cubes were demoulded and kept in normal tap water for curing. Following are the results of this test.

Compressive strength		
7 days	71.51	72.31
28 days	69.84	83.9
90 days	72.51	81.93

Table 6:

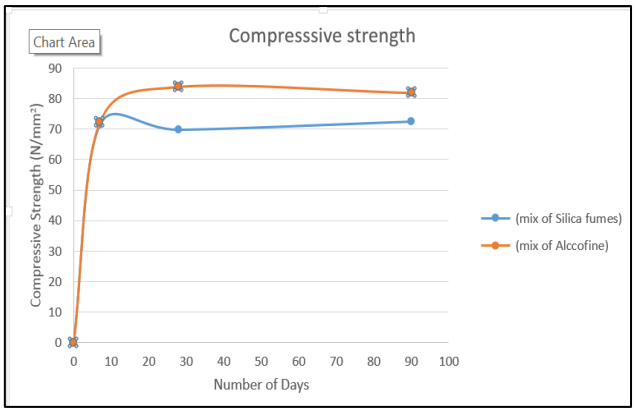

Fig. 1: Graph I

VII. Flow Table Test

The flow test is used for high workability concrete (with a slump of more that 175 mm). The 700 mm square flow table is hinged to a rigid base, proved with a stop that allows the far end to be raised by 40 mm. A cone, similar to that used for slump testing but truncated, is filled with concrete in two layers. Each layer is tamped 10 times with a special wooden bar and the concrete of the upper layer finished off level with the top of the cone. Any excess is cleaned off the outside of the cone. The cone is then raised allowing the concrete to flow out and spread out a little on the flow table. The table top is then raised until it meets the stop and allowed to drop freely 15 times. This causes the concrete to spread further, in a roughly circular shape. The flow diameter is the average of the maximum diameter of the pool of concrete and the diameter at right angles. M80 grade of concrete is tested and following are the results test. Following is the process of flow table test which has been done for this paper.

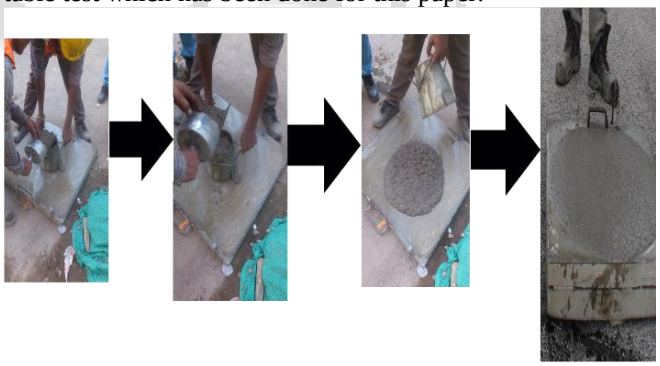

Fig. 2: Flow table test

As a result, flow for M80 grade concrete which is made using silica fumes is 600mm and flow for M80 grade concrete which is made using ALCCOFINE 1203 is 700mm which we get after the flow table test.

VIII. Assessment of Water Demand

The quality feature feature of ALCCOFINE 1203 is the optimized particle size distribution and unique chemical composition, which reduces the water demand to achieve a specific slump value. In this methodology, the binder content and admixture content were kept constant and the outcome on water requirement and compressive strength were measured. Following are the mix design used for concrete and the average compressive strength of samples for 7 days , 28 days and 90 days.

Fig. 3: Casting Of M80 Cubes With Different Water Content

Concrete with ALCCOFINE 1203	Grade	Water quantity (kg)	Cast date	Compressive strength			
				Test date	7 Days	Test date	28 Days
SAMPLE 1	M80	160	08.06.16	15.06.16	72.31	04.06.16	83.9
SAMPLE 2	M80	155	08.06.16	15.06.16	74.89	04.06.16	83.8
SAMPLE 3	M80	150	08.06.16	15.06.16	76.40	04.06.16	83.9
SAMPLE 4	M80	145	08.06.16	15.06.16	78.9	04.06.16	83.9
SAMPLE 5	M80	140	08.06.16	15.06.16	80.2	04.06.16	84.3

Table 7: Test with Different Water Contents.

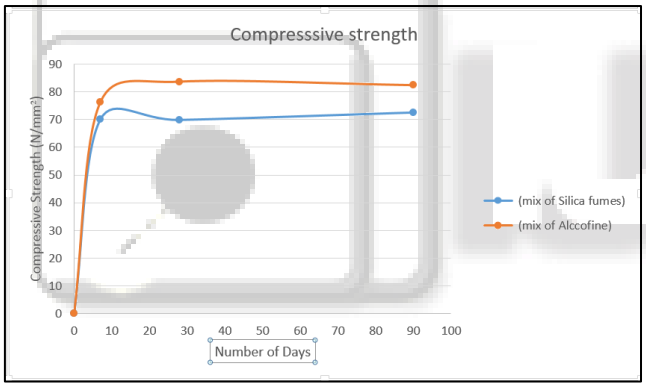

Fig. 4: Graph 2:

IX. WATER PERMEABILITY TEST

The test used to measure the impermeability of concrete was DIN 1048 (German satandard). According to this test the cubes were initially water-cured for 28 days, and then exposed to water pressure of 5 bars for 72 hours after which the cube was divided and the depth of water penetration measured. Penetration of less than 25 mm is generally considered to be impermeable concrete. The proposed water permeability test system and the draft standard highlights the importance of concrete durability research. The test system enables the values of water permeability of a concrete structure as the durability performance indicator to be assessed at the early stage. Its use on the standard 150 mm concrete test cube for the determination of water permeability prior to the standard test for compressive strength will provide useful information on concrete durability. The depth of penetration for silica fumes is 20mm and for ALCCOFINE 1203 is 12mm.

X. COST ANALYSIS

The cost comparison has been done based on market rate availble Table 5 shows the cost comparison for 1cubuc meter of Concrete with ALCCOFINE 1203 and silica fumes. Fig. illustarate that the High performance concrete with ALCCOFINE 1203is more economical as compare to silica fumes Concrete.

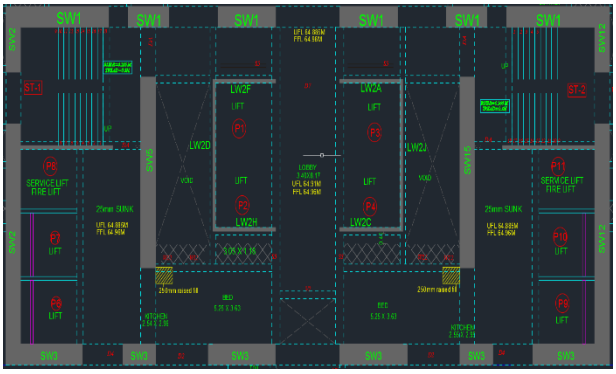

Fig. 3: AutoCAD drawing of core wall (10th floor)

MATERIAL	DESIGN MIX (Silica fumes) KG/m³	DESIGN MIX (ALCCOFINE 1203) KG/m³	DESIGN MIX (OPC) KG/m	Rate/kg Rs.	TOTAL COST For per cum Rs.		
					Silica fumes	Alccofine 1203	Opc
OPC	460	460	560	8	3680	3680	4480
M Sand	790	790	790	0.6	474	474	474
Aggregate	840	840	840	0.5	420	420	420
Water	160	160	160	-	-	-	-
Silica fumes	60	0	0	40	2400	0	0
Alccofine	0	60	0	22	0	1320	0
Fly Ash	180	180	360	1.87	336.6	336.6	336.6
Admixture 1	0.46	0.46	1.5	140	64.4	64.4	64.4
Admixture 2	2.3	2.3	4.6	160	368	368	368
	TOTAL COST				7743	6663	6143

Table 8: Cost Analysis Between ALCCOFINE 1203 And Silica Fumes for 1 Cum.

MATERIAL	DESIGN MIX (Silica fumes) KG/m³	DESIGN MIX (ALCCOFINE 1203) KG/m³	Required quantity (transit truck) 5 m³ M80		Rate/kg Rs.	TOTAL COST Rs.	
			Silica fumes	Alccofine 1203		Silica fumes	Alccofine 1203
OPC	460	460	2300	2300	8	18400	18400
M Sand	790	790	3950	3950	0.6	2370	2370
Aggregate	840	840	4200	4200	0.5	2100	2100
Water	160	160	800	800	-	-	-
Silica fumes	60	0	300	0	40	12000	-
Alccofine1203	0	60	0	300	22	-	6600
Fly Ash	180	180	900	900	1.87	1683	1683
Admixture 1	0.46	0.46	2.3	2.3	140	322	322
Admixture 2	2.3	2.3	11.5	11.5	160	1840	1840
TOTAL COST						38715	33315
NET SAVING			= 35715-33315			**5400**	

Table 9: Cost Analysis Between ALCCOFINE 1203 And Silica Fumes For 5 Cum.

Above is the cost analysis of live project high rise building i.e. nathani heights, Mumbai central. They are using both cementatious material i.e. Silica fumes and

ALCCOFINE 1203 as supplementary cemntatious material for construction. So from above analysis, the net saving they can done of Rs. 5400 for per transit truck if they use Alccofine 1203 as their supplementary cemntatious material. This can help them to reduce the actual project cost, for e.g. the construction of core wall of that high rise building requires approximately 214 m^3 concrete of M80 grade if they are filling floor to floor height. One transit mixer can carry 5 m^3 of concrete at a time. So they required 43 transit trucks to fulfill that requirement. According to above cost analysis, they can save Rs. 5400 per transit truck. So now they can save Rs. 232200 for total 43 transit trucks of M80 grade.

XI. Conclusion

1) ALCCOFINE 1203 has less content of calcium oxide and silicon dioxide compare to silica fumes. Hence ALCCOFINE 1203 is ecofriendly material used in concrete preparation.
2) The Indian construction industry has a realistical approach to use new types of materials for better performance. This cementitious product is proven performance improver that can be used in concrete to have get benefits.
3) The maximum compressive strength of M80 grade concrete for seven days curing period is 72.31 MPa by partial replacement of cement by 15% ALCCOFINE and fine fly ash.
4) 4The maximum compressive strength of M80 grade concrete for 28 days curing period is 83.9 MPa by partial replacement of cement by 15% ALCCOFINE and fine fly ash.
5) High density of the mix was achieved and subsequently higher packing value.
6) The maximum compressive strength of concrete is achieved by using ALCCOFINE 15%.
7) In all mix proportions strength gain up to 3 days is good. Between 3 to 7 days the strength gain is excellent. Between 7 to 28 days strength gain comparatively slow, between 28 to 90 days strength gain is completely slow.
8) Its is proved that concrete of M80 grade will be more workable when we use ALCCOFINE 1203 in preparation of M80 grade of concrete.
9) ALCCOFINE 1203 is more economical cementitious material than silica fumes hence its is also known as green building material.
10) As per cost analysis, its is proved that ALCCOFINE 1203 is cheaper than cement so for better strength and durability of concrete it should be promoted in Indian construction industry.

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