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Strength and Durability study on Concrete with Alccofine as Cement Replacement

Swar Shah*[1], Alka Tomar[2]

*[1]Civil Engineering Department-M.Tech Student, Parul University/Parul Institute of Engineering and Technology/ Vadodara, Gujarat, India

[2]Civil Engineering Department-Asst. Professor, Parul University/ Parul Institute of Engineering and Technology / Vadodara, Gujarat , India

ABSTRACT

Concrete is third most widely used material in world and cement is major ingredient of it.One ton cement production cause emission of one ton of CO_2 gas which is harmful to environment. ALCCOFINE is a new generation supplementary cementitious material (SCM) with a built-in high tech content which can be used as cement replacement. Alccofine is approved by Green Building Certification Agency-LEED

Keywords : Cement Replacement, Alccofine, Environment impact of Cement Production

I. INTRODUCTION

Portland Cement is currently the most widely used material in the construction industry .It is a fine powder produced by heating materials in a kiln .It mainly consists of silicates and aluminates in its chemical composition. This cement when mixed with water, sand and aggregates produces Portland Cement Concrete. This Concrete is used nowadays in the construction industry with the fact that it is even cheaper than water. For manufacturing of 1 ton of Cement approximately 1 Ton of CO2 is released as per the environmental reports which is not good from environmental point of view.Several studies have been done to reduce the usage of Portland Cement and find its alternatives.The studies suggested the usage of Fly-Ash , Slag, Rice Husk and Metakaolin as Pozzolanic Materials to partially replace the cement.

Alccofine1203 is a specially processed product based on slag of high glass contentwith high reactivity obtained through the process of controlled granulation. The raw materials are composed primarily of low calciumsilicates. The processing with other select ingredients results in controlled Particle Size Distribution (PSD). The computed blaine value based on PSD is around 12000 cm2/gm and is truly ultra fine

ALCCOFINE is a specially processed product based on 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 selected ingredients results in controlled particle size distribution (PSD). The computed blain value based on PSD is around 12000cm2/gm and is truly ultra fine. Due to its unique chemistry and ultra fine particle size, ALCCOFINE provides reduced water demand for a given workability, even up to 70% replacement level as per requirement of concrete performance. ALCCOFINE can also be used as a high range water reducer to improve compressive strength or as a super workability aid to improve flow

ALCCOFINE 1203 is a new generation Supplementary Cementations Material (SCM) with a built-in high tech content. In spite of its high finenessit does not increase water demand at the dosage range of 5 to 15 percentof normal OPC in general. In fact concrete slump is seen to be improved,due to the dense packing of cementitious material, producing low void content. The use of ALCCOFINE 1203 results in hydrated cement matrix to comprise of very small pores.

Strength development increases drastically at early ages and the later onstrengths are higher compared to traditional supplementary cementitiousmaterial due to its unique PSD.Concretes of over 100 MPa are possible to be made using ALCCOFINE1203. Judicious use of ALCCOFINE 1203 can produce concrete of superior properties and performance in every way.

The product is processed from Granulated Blast Furnace Slag conforming to IS 12089-1987. This will also be covered under clause no 5.2.2 IS 456-2000 (GGBFS may be used as part replacement of Ordinary Portland Cements)

II. METHODS AND MATERIAL

With 20% cement replacement by Alccofine1203 Concrete of M30 Grade is prepared and compressive strength and flexural strength is measured.In addition to that High Strength Concrete M60,M70,M80 is prepared with 5% cement replacement by Alccofine1203 and compressive ,flexural ,split tensile strength is measured.

Concrete Mix Design is done as per IS 10262:2009

Table 1

Compressive Strength(N/mm²)	Nos of Day	Flexural Strength
23.4	3	3.5MPa
29.8	7	5.6MPa
31.44	28	6.8MPa

M30 Grade Concrete with 20%Cement replacement

Table 2

Grade of Concrete	Avg.Compressive Strength(N/mm²)	Avg. Split Tensile Strength (N/mm²)	Avg. Flexural Strength (N/mm²)
M60	42.5	3.9	5.6
M70	45.6	4.32	5.9
M80	60.3	4.5	6.3

7days Test Result of High Strength Concrete with 5%Cement Replacement

Mix Design

M-30 CONCRETE MIX DESIGN

As per IS 10262-2009 & MORT&H

A-1 Stipulations for Proportioning

1 Grade Designation M30

2 Type of Cement OPC 53 grade confirming to IS-12269-1987

3 Maximum Nominal Aggregate Size 20 mm

4 Minimum Cement Content (MORT&H 1700-3 A) 310 kg/m3

5 Maximum Water Cement Ratio (MORT&H 1700-3 A) 0.45

6 Workability (MORT&H 1700-4) 50-75 mm (Slump)

7 Exposure Condition Normal

8 Degree of Supervision Good

9 Type of Aggregate Crushed Angular Aggregate

10 Maximum Cement Content (MORT&H Cl. 1703.2) 540 kg/m3

11 Chemical Admixture Type Superplasticiser Confirming to IS-9103

A-2 Test Data for Materials

1 Cement Used Coromandal King OPC 53 grade

2 Sp. Gravity of Cement 3.15

3 Sp. Gravity of Water 1.00

4 Chemical Admixture BASF Chemicals Company

5 Sp. Gravity of 20 mm Aggregate 2.884

6 Sp. Gravity of 10 mm Aggregate 2.878

7 Sp. Gravity of Sand 2.605
8 Water Absorption of 20 mm Aggregate 0.97%
9 Water Absorption of 10 mm Aggregate 0.83%
10 Water Absorption of Sand 1.23%
11 Free (Surface) Moisture of 20 mm Aggregate nil
12 Free (Surface) Moisture of 10 mm Aggregate nil
13 Free (Surface) Moisture of Sand nil
14 Sieve Analysis of Individual Coarse Aggregates Separate Analysis Done
15 Sieve Analysis of Combined Coarse Aggregates Separate Analysis Done
15 Sp. Gravity of Combined Coarse Aggregates 2.882
16 Sieve Analysis of Fine Aggregates Separate Analysis Done

A-3 Target Strength for Mix Proportioning
1 Target Mean Strength (MORT&H 1700-5) 42N/mm2
2 Characteristic Strength @ 28 days 30N/mm2

A-4 Selection of Water Cement Ratio
1 Maximum Water Cement Ratio (MORT&H 1700-3 A) 0.45
2 Adopted Water Cement Ratio 0.42

A-5 Selection of Water Content
1 Maximum Water content (10262-table-2) 186 Lit.
2 Estimated Water content for 50-75 mm Slump 160 Lit.
3 Superplasticiser used 0.5 % by wt. of cement

A-6 Calculation of Cement Content
1 Water Cement Ratio 0.42
2 Cement Content (160/0.42) 380 kg/m3
Which is greater then 310 kg/m3

A-7 Proportion of Volume of Coarse Aggregate & Fine Aggregate Content
1 Vol. of C.A. as per table 3 of IS 10262 62.00%
2 Adopted Vol. of Coarse Aggregate 62.00%
Adopted Vol. of Fine Aggregate (1-0.62) 38.00%

A-8 Mix Calculations
1 Volume of Concrete in m3 1.00
2 Volume of Cement in m3 0.12
(Mass of Cement) / (Sp. Gravity of Cement)x1000
3 Volume of Water in m3 0.160
(Mass of Water) / (Sp. Gravity of Water)x1000
4 Volume of Admixture @ 0.5% in m3 0.00160
(Mass of Admixture)/(Sp. Gravity of Admixture)x1000
5 Volume of All in Aggregate in m3 0.718
Sr. no. 1 – (Sr. no. 2+3+4)
6 Volume of Coarse Aggregate in m3 0.445
Sr. no. 5 x 0.62
7 Volume of Fine Aggregate in m3 0.273
Sr. no. 5 x 0.38

A-9 Mix Proportions for One Cum of Concrete (SSD Condition)
1 Mass of Cement in kg/m3 380
2 Mass of Water in kg/m3 160
3 Mass of Fine Aggregate in kg/m3 711
4 Mass of Coarse Aggregate in kg/m3 1283
Mass of 20 mm in kg/m3 924
Mass of 10 mm in kg/m3 359
5 Mass of Admixture in kg/m3 1.90
6 Water Cement Ratio 0.42

Mix Design of High Strength Concrete

Concrete mix design is a procedure of selecting the suitable ingredients of concrete and their relative proportions with an objective to prepare concrete of certain minimum strength, desired workability and durability as economically (value engineered) as possible.

Designing high strength concrete – HSC (Grades M60 and above) become a challenges in terms of selecting right proportions of conventional concrete ingredients (cement, sand and aggregate) and necessary inclusions of Chemical admixture (one or more) and Mineral admixture (one or more).

High strength concrete(HSC) has been feasible with latest generation High Range water Reducing admixture (HRWRA) and high reactive mineral admixtures like Silica Fumes, Matakaolin etc. High strength concrete becomes high performance concrete with right concrete mix design.

Applications of High Strength concrete are high rise building (typically above 30 story), high strength concrete made such projects feasible due to enhance load carrying capacity, it also allowed for the reduction of column and beam sizes. Lower dead loads result in reducing the loads connected with foundation design. Also, end user if benefitted economically since the amount of rentable floor space, increases as the space occupied by the columns decreases. It is estimated that for a 50-story structure with 1.2m diameter columns using M30 concrete can reduce column diameters by approximately 33% by using M60 concrete.

Production of HSC has to be cautiously monitored at site level to ensure the required end results.

Final Mix Proportion for M60[As per IS10262:2009]

Cement = 400 kg/m3

Fly Ash = 80 kg/m3

Slica fume = 40 kg/m3

HRWRA = 5.2 kg/m3

Water = 161 kg/m3

Fine aggregates = 703 kg/m3

Coarse aggregate = 1094 kg/m3

Water-cementitious ratio = 0.32

Final Mix Proportion for M70[IS10262:2009]

Cement = 475 kg / m³

Water = 166 kg / m³

Fine aggregate = 891 kg (IS 650:1991)

Coarse aggregate = 856 kg

Chemical admixture = 3.8 kg / m³

Water Cement ratio = 0.35

Hence, the proportion is 1 : 1.8 : 1.8

Final Mix Proportion of M80[IS10262:2009]

Cement = 539 kg/m3

Fly ash = 135kg/ m3

Water = 153kg/ m3

Fine aggregate = 662.76 kg/ m3

Coarse aggregate = 964.53 kg/ m3

Chemical admixture = 4.8 kg/ m3

W/C = 0.23

28days test results of 5%cement replacement

Table 3

Grade	Compressive Strength[MPa]	Flexural Strength[MPa]	Split Tensile Strength [MPa]
M60	62.5	6.1	4.1
M70	71.3	6.3	4.9
M80	82.2	6.8	5.1

Durability Test:

5% weight by volume solution of Sodium Hydroxide and Sulphuric Acid has prepared and concrete cubes immersed in it for 28 days and compressive strength has measured

Test results for acid attack:

Table 4

Grade of Concrete	Compressive Stregth[MPa]
M60	52.3
M70	58.6
M80	66.4

Test result for Alkali attack

Grade of Concrete	Compressive Strength[MPa]
M60	57.3
M70	61.3
M80	69.6

III. RESULTS AND DISCUSSION

Experimental Work on M30 Grade and On High Strength Concrete shows that Replacement of Cement by Alccofine is giving acceptable results. Hence Alccofine is proper material which can use as partial replacement of cement.

IV. CONCLUSION

Using Alccofine as cement replacement in three different grade of concrete indicates test results confirming to INDIAN STANDARDS. Hence Alccofine is new generation Supplementary Cementations Material.

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