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Comparative Study of Different Type of Self Compacting Concrete

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Abstract:
Concrete is a vital ingredient in infrastructure development with its versatile and extensive applications. The Indian construction industry today is consuming about400 million tons of concrete every year and is expected to reach a billion tons in less than a decade. It is the most widely used construction material because of its mould ability into any required structural form and shape due to its fluid behavior at early ages. However, there is limit to the fluid behavior of normal fresh concrete. Thorough compaction, using vibration, is normally essential for achieving workability, the required strength and durability of concrete. Inadequate compaction of concrete results in large number of voids, affecting performance and long term durability of structures. Self-compacting concrete (SCC) provides a solution to these problems. As the name signifies, it is able to compact itself without any additional vibration or compactive effort. However, wide spread applications of SCC have been restricted due to lack of standard mix design procedure and testing methods. It impertinent to mention that only features of SCC have been included in Indian Standard Code for the present. Slump flow test, L-box test, V-funnel test, are recommended by EFNARC (European Federation for Specialist Construction Chemicals and Concrete system) for determining properties of SCC in fresh state. This paper highlights the use of European standards by various researchers for testing Self compacting concrete in Indian conditions. The paper presents the experimental investigation of Self Compacting Concrete using Fly ash silica fume and Hydraulic lime as mineral admixtures and testing rheological properties as per European Standards

Keywords: *Self compacting concrete, slum flow test,V–funnel fly ash, hydraulic lime.*

Introduction

The development of Self-Compacting Concrete (SCC) has recently been one of the most important developments in the building industry. The purpose of this concrete concept is to decrease the risk due to the human factor, to enable the economic efficiency, more freedom to designers and constructors and more human work. It is a kind of concrete that can flow through and fill gaps of reinforcement and corners of moulds without any need for vibrations and compacting during the pouring process. Because of that, SCC must have sufficient paste volume and proper paste reology. Paste volumes are usually higher than for conventionally placed concrete and typically consist of high powder contents and water-powder ratios.

There is no standard method for SCC mix design and many academic institutions, admixture, ready-mixed, precast and contracting companies have developed their own mixed proportioning methods. Mix design often use volume as a key parameter because of the importance of the need to over fill the voids between the aggregate particles. Some methods try to fit available constituents to an optimized grading envelope. Another method is to evaluate and optimize the flow and stability of first the paste and then the mortar fractions before the coarse aggregate is added and whole SCC mix tested. In any case, the constituent materials are the same as those used in traditional vibrated concrete.

Received February 20, 2008Z. GRDIĆ, I. DESPOTOVIĆ, G. TOPLIČIĆ ĆURČI174 Conforming to EN 206-1: cement, additions (mineral filler, pigments, fly ash, silica fume, ground granulated blast furnace slag, hydraulic lime), aggregate (limited to 20mm),admixture (VMA-viscosity modifying admixture, HRWRA- high range water reducing admixture) and water. This paper analyses characteristics and properties of mixtureswith different additions: fly ash, silica fume, hydraulic lime and a mixture of fly ash and hydraulic lime.

Materials Used

Cement

Ordinary Portland cement (Grade 43) was used. Its physical properties are as given in Table 1.

Fly Ash

Class F Fly ash obtained from "Panipat Thermal Power Station, Haryana, India. The physical and chemical properties of fly ash are given in the Table 2 and Table 3, respectively.

Physical property	**Results obtained**	**IS: 8112-1989 specifications**
Fineness (retained on 90-µm sieve)	8.0	10mm
Normal Consistency	28%	-
Vicat initial setting time (minutes)	75	30 min^{m}
Vicat final setting time (minutes)	215	600 max^{m}
Compressive strength 3-days (MPa)	23	22.0 min^{m}
Compressive strength 7-days (MPa)	36	33.0 min^{m}
Compressive strength 28days(MPa)	45	43.0 min^{m}
Specific gravity		3.15

Table 1: Physical properties of cement

Sr. No.	***Physical Properties***	***Test Results***
1.	Colour	Grey (Blackish)
2.	Specific Gravity	2.13
3.	Lime Reactivity -average compressive strength after 28 days of mixture 'A'	4.90 MPa

Table2: Physical properties of Fly Ash

Sr. No.	Constituents	Percent by Weight
1.	Loss on ignition	4.17
2.	Silica (SiO_2)	58.55
3.	Iron Oxide (Fe_2O_3)	3.44
4.	Alumina (Al_2O_3)	28.20
5.	Calcium Oxide (CaO)	2.23
6.	Magnesium Oxide (MgO)	0.32
7.	Total Sulphur (SO_3)	0.07
8.	Insoluble residue	-
9.	Alkalies a) Sodium Oxide (Na_2O) b) Potassium Oxide (K_2O)	0.58 1.26

Table 3: Chemical properties of Fly Ash

Admixtures

Polycarboxylic ether based super plasticizer complying with ASTM C-494 type F, was used.

Aggregates

Locally available natural sand with 4.75 mm maximum size was used as fine aggregate, having specific gravity, fineness modulus and unit weight as given in Table 4 and crushed stone with 16mm maximum size having specific gravity, fineness modulus and unit weight as given in Table 4 was used as coarse aggregate. Both fine aggregate and coarse aggregate conformed to Indian Standard Specifications IS: 383-1970Table 4 gives the physical properties of the coarse and fine aggregates.

Physical tests	Coarse aggregate	Fine aggregate
Specific gravity	2.67	2.66
Fineness modulus	6.86	2.32
Bulk density (kg/m^3)	1540	1780

Table4: Physical properties of coarse and fine aggregates

Test Methods

Self- Compacting Concrete is characterized by filling ability, passing ability and resistance to segregation. Many different methods have been developed to characterize the properties of SCC. No method has been found until date, which characterizes all the relevant workability aspects, and hence, each mix has been tested by more than one test method for the different workability parameters. Table 5 gives the recommended values for different tests given by different researchers for mix to be characterized as SCC mix.

Sr. No.	Property	Range
1.	Slump Flow Diameter	500-700 mm
2.	T_{50cm}	2-5 sec
3.	V-funnel	6-15 sec
4.	L-Box H2/H1	≥ 0.8

Table 5: Recommended limits for different properties

The slump flow test is used to assess the horizontal free flow of SCC in the absence of obstructions. On lifting the slump cone, filled with concrete, the concrete flows. The average diameter of the concrete circle is a measure for the filling ability of the concrete. The time T_{50cm} is a secondary indication of flow measures the time taken in seconds from the instant the cone is lifted to the instant when horizontal flow reaches diameter of 500mm. It is based on the slump test described in EN 1235-2. The flow ability of the fresh concrete can be tested with the V-funnel test, whereby the flow time is measured, figure 2.The funnel is filled with about 12 liters of concrete and the time taken for it to flow through the apparatus is measured. Further, T_{5min} is also measured with V-funnel, which indicates the tendency for segregation, wherein the funnel can be refilled with concrete and left for 5 minutes to settle. If the concrete shows segregation, the flow time will increase significantly. According to Khayat and Manai, a funnel test flow time less than 6s is recommended for a concrete to qualify for an SCC .

The passing ability is determined using the L- box test. The vertical section of the L-Box is filled with concrete, and then the gate lifted to let the concrete flow into the horizontal section. The height of the concrete at the end of the horizontal section is expressed as a proportion of that remaining in the vertical section (H2/H1). This is an indication of passing ability. The specified requisite is the ratio between the heights of the concrete at each end or blocking ratio to be ≥ 0.8

Experimental Results

	NC	SCCFA	SCCSF	SCCHF	SCCFAHL
Cement(kg/m^3)	410	385	380	380	380
Fly ash(kg/m^3)	x	63	x	X	40
Silica fume(kg/m^3)	x	x	40	X	x
Hydraulic lime(kg/m^3)	x	x	x	80	40
Sand 0.15-0.6(kg/m^3)	380	447	430	430	430
Sand 0.3-2.4(kg/m^3)	380	447	430	430	430
Aggregate6-15mm(kg/m^3)	1100	870	853	890	890
Water/cement(kg/kg)	0.40	0.40	0.55	0.48	0.48
Super plasticizer(%)	1.5	2.5	2.40	2.40	2.4
Water/powder(kg/kg)	0.40	0.37	0.38	0.34	0.34

Table 4: Mixture proportions [6]

Abbreviations were used in accordance with the addition material: NC for normal concrete, SCCFA for self-compacting concrete with fly ash, SCCSF for SCC with silica fume, SCCHL for SCC with hydraulic lime, SCCFAHL for SCC with a mixture of fly as hand hydraulic lime. Each mixture has a cement aggregates mass proportional equal to 1:4.5.Properties of Self-Compacting Concrete with Different Types of Additives 177

Self-Compacting Concrete With Different Types Of Additives

		NC	SCCFA	SCCSF	SCCHL	SCCFAHL
slump	Mm	35	-	-	-	-
Slump flow	Sec Mm	-	4'80" 650	1'40" 680	2'53" 675	3'29" 650
L-box	T40 sec H2/H1	-	5'48" 0.80	3'95" 0.62	2'81" 0.86	4'00" 0.50
V-funnel compressive strength at 28 days	Sec Mpa	40.0	11'00" 24.90	12'00 29.0	12'29" 26.10	13'00" 34.60

Table 5: Test results

Conclusions

Due to test results, the addition of fly ash to the mixture containing hydraulic lime is quite beneficial, bringing a substantial improvement of the behavior of SCCFAHLconcrete. Also, this mixture has smaller filling capacity and fluidity than other mxtures.The silica fume, a more expensive additive, imparts in the SCC a similar behavior to the one of normal concrete compacted by vibrations. It is caused by an incompatibility between silica fume and superplasticisier requiring an increase of water/cement ratio for the same concrete workability.

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