Journal of Civil Engineering and Environmental Technology
Print ISSN: 2349-8404; Online ISSN: 2349-879X; Volume 1, Number 6; August, 2014 pp. 18-20

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Workability of Self-Compacting Concrete (SCC) Made with FLY-ASH

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Abstract: **Self-compacting concrete (SCC) is an innovative concrete that does not requires any vibration for placing and compaction. The main objective of this study is to investigate the effect on the workability of self compacted concrete, when OPC is partially replaced by 18 % of fly-ash. With different locally available material, experimental tests are performed to check the workability of SCC. Several tests, such as Slump test, T50, V-funnel, J-ring, L-box and orimet test were carried out to determine the properties of fresh concrete. On the basis of experimental results it may also conclude that out of the seven trial mixes under test, three mixes comply with the required criteria for SCC.**

Keywords: **Self-compacting Concrete; Fly Ash; Fresh Properties**

1. INTRODUCTION

Self–compacting concrete (SCC) is as emerging technology to the construction industry, and has been described as the most revolutionary development in concrete construction for several decades. Okamura of the Koche University of Technology (Japan) had first developed SCC in year 1986. Through their definition it can be defined as concrete that is able to flow and consolidate under its own weight, completely fill the formwork even in the presence of dense reinforcement, whilst maintaining homogeneity and without the need for any additional compaction. In order to do this, SCC requires higher paste content and lower coarse aggregate fraction compared to conventional vibrated concrete or non vibrated concrete, and uses superplasticizer. These would ensure high deformability of paste and resistance to segregation. For SCC, it is generally necessary to use superplasticizer in order to obtain high mobility. Adding a large volume of powdered material or viscosity modifying admixture can eliminate segregation. The powdered materials that can be added are fly ash, silica fume, lime stone powder, glass filler and quartzite filler. Natural sand and aggregates (maximum size 12.5 mm) obtained from Gola barrage and OPC 43 grade cement were used in the presented investigation for preparing SCC. For preparing SCC, 18 % OPC was replaced by FA (class F-fly ash). The use of fly ash in concrete is both economical and modifies the properties of concrete in fresh states which improve its workability. In addition, the storage and disposal problem of fly ash, which is an industrial waste or by-product, is also solved by the use of fly ash in concrete; otherwise, fly ash has to be disposed of in landfills at a considerable cost.

2. EXPERIMENTAL INVESTIGATION

2.1 Materials and Concrete Mix Proportions.

2.1.1 Cement

Ordinary Portland cement (Grade 43) was used.

Table 1: Physical characteristics of Portland cement

Type of cement	Fineness m^2/kg (min)	Soundness by	Setting time		Min. Compressive strength (mpa)			
		Le-cchatelier (%) max.	Initial (min)	Final (min)	1 days	3 days	7 days	28 day
43 grade OPC (IS 8112-1989)	225	10	30	600	Ns	23	33	43

Table 2: Chemical Composition of Portland cement

Sr. No	Name of compound	Oxide composition	Abbreviation	Approx. Percentage	Function
1	Tricalcium silicate	$3CaO.SiO_2$	C_3S	45-55	Mainly responsible for early strength (1 to 7 days)
2	Dicalcium silicate	$2CaO.SiO_2$	C_2S	20-30	Mainly responsible for later strength (7 days and beyond)

3	Tricalcium aluminate	$3CaO.Al_2O_3$	C_3A	6-10	C_3A increases rate of hydration of C_3S. C_3A gives flash set in absence of gypsum
4	Tetracalcium aluminoferrite	$4CaO.Al_2O_3.Fe_2O_3$	C_4AF	15-20	It hydrates rapidly but Its contribution to strength is uncertain and generally very low.

Fly ash

Class 'F' Fly ash obtained from ''Lalkuan Pulp and Paper Mill", Lalkuan (Uttrakhand) was used. For preparing SCC, 18 % OPC was replaced by FA (class F-fly ash).

Table 3: Chemical composition of Portland cement and fly-ash

	Portland cement (% by mass)	**Fly-ash (% by mass)**
CaO	64.01	0.37-27.68
SiO_2	20.13	27.88-59.40
Al_2O_3	5.78	5.23-33.99
Fe_2O_3	2.35	1.21-29.63
MgO	1.19	0.42-8.79
SO_3	3.53	0.04-4.71
Na_2O	0.11	0.20-6.90
K_2O	0.77	0.64-6.68
TiO_2	0.37	0.24-1.73
LOi	1.63	0.21-28.37

2.1.3 Aggregate

Natural sand and crushed aggregate from "Gola river" (Haldwani, Uttrakhand) were used. The sand complied with the requirements of BS812. The specific gravity and fineness modulus of fine aggregate was 2.60 and 2.59.

2.1.4 Superplasticizer

Conplast SP430-SRV obtained from Fosroc chemicals (I) ltd. was used in present experimental research. It conforms to Indian standard code, IS: 9103-1999. Conplast SP430-SRV is used where a high degree of workability is required and also as an aid to workability retention where delays in transportation or placing are likely or when high ambient temperatures cause rapid slump loss to facilitate production of high quality concrete of improved durability and water tightness 2 litres of superplasticizer per 100 kg of cementitious material was used as per the manufacture recommendations.

Table 4: physical properties of superplasticizer

Properties	**Conplast SP430**
Composition	Sulphonated naphthalene Formaldehyde condensate
Active solids (% by wt.)	40
Appearance	Brown liquid
Specific gravity	1.20 at 20°c
Air entrainment (%)	< 2
Chloride content (%)	Nil
Ph value	7.0 - 8.0

2.1.5 Mix Design

The weights of various constituent materials per m^3 of concrete are given below:-

Table 5: Mix design for one m^3 concrete of SCC

Mixes design	**Mortar percentage (In %)**	**Aggregate percentage (In %)**	**Mortar**			**Aggregates**	**Water/binder ratio (by volume)**
			Cement (Kg)	**Fly-ash (Kg)**	**Sand (Kg)**	**Coarse aggregates (Kg)**	
SCC 1	40	60	419.119 401.8	70.07 88.2	665.162	905.52	1.30
SCC 2	45	55	437.71 419	73.18 91	699.66	830.06	1.30
SCC 3	50	50	456.299	70.29	724.16	754.61	1.30
SCC 4	55	45	470.79	78.71	753.67	679.14	1.32
SCC 5	40	60	489.225	81.79	783.17	603.68	1.32
SCC 6*	40	60	493.47	82.50	783.17	603.68	1.30
SCC 7	37	63	504.63	84.37	800.87	558.40	1.30
Superplasticizer = 2 litre per 100 Kg of paste							

SCC 6 was used in the present study

3. RESULTS AND DISCUSSION

3.1 Fresh Concrete

Table: Fresh concrete properties of SCC with fly-ash

Mix	Slump test		V-Funnel (sec)	J-Ring Height difference (mm)	L-Box (H_2/H_1) ratio	Orimet (sec)	Result
	Slump Flow (mm)	T_{50} (Sec)					
Limit value	650-800	2 - 5	6 - 12	3 - 10	0.8 – 1	0 - 5	
SCC 1	400	-	-	-	-	-	Failed*
SCC 2	480	-	-	-	-	-	Failed*
SCC 3	520	4.8	6	6	0.98	6	Failed*
SCC 4	600	7	9	10	0.98	5	*passed*
SCC 5	*655*	*6*	*8*	*8.3*	*0.95*	*5*	*passed*
SCC 6	*720*	*5*	*7*	*6.5*	*0.89*	*3*	*passed*
SCC 7	870	4	5	5	0.81	3	Failed#

Failed* = Slump Flow value below the standard limits (concrete does not flow)

Failed# = Slump Flow value beyond the standard limits (segregation occurs, concrete over flows)

4. CONCLUSION

On the bases of the experimental results it is concluded that the mix SCC4, SCC5 and SSC6 have been passed the slump test (slump flow and T_{50}), V- funnel, J- ring, L-box and Orimet test, and results are within the required limits. Out of the three passed mixes i.e. SCC4, SCC5 and SCC6, SCC6 gives comparatively better result for good workability.

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