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PROPERTIES OF SELF-COMPACTING CONCRETE WITH DIFFERENT TYPES OF ADDITIVES

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***Abstract**. Self–compacting concrete is one of "the most revolutionar developement" in concrete research; this concrete is able to flow and to fill the most restacted places of the form work without vibration. There are several methods for testing it's properties in the fresh state: the most frequently used are slum–flow test, L–box and V–funnel.*
This work presents properties of self–compacting concrete, mixed with different types additives: fly ash, silica fume, hydraulic lime and a mixture of fly ash and hydraulic lime.

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

1. INTRODUCTION

The developement of Self-Compacting Concrete (SCC) has recently been one of the most important developements 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 constructores 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 designs 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 optimised grading envelope. Another method is to evaluate and optimise 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

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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 caracteristics and and properties of mixtures with different additions: fly ash, silica fume, hydraulic lime and a mixture of fly ash and hydraulic lime.

2. TEST METODS

Basic requirements for self-compacting concrete are those in the fresh state: flowability, viscosity (measure of the speed of flow), passing ability (flow without blocking) and segregation resistance. A concrete mix can only be classified as SCC if the requirements for all characteristics are fullfilled. Each of them can be addressed by one or more test methods. The most repeated are:

Slump flow and T_{500} time is a test to asses the flowability and the flow rate of SCC in the absence of obstructions. It is based on the slump test described in EN 1235-2. The result is an indication of the filling ability of SCC, and the T_{500} time is a measure of the speed of flow and hence the viscosity. The fresh concrete is poured into a cone. When the cone is upwards the time from commencing upward movement the cone to when the concrete has flowed to a diameter of 500 mm is measured; this is the T_{500} time. The largest diameter of the slow spread of the concrete and the diameter of the spread at right angles to it are then measured and the mean is the slump-flow, Figure 1 [8].

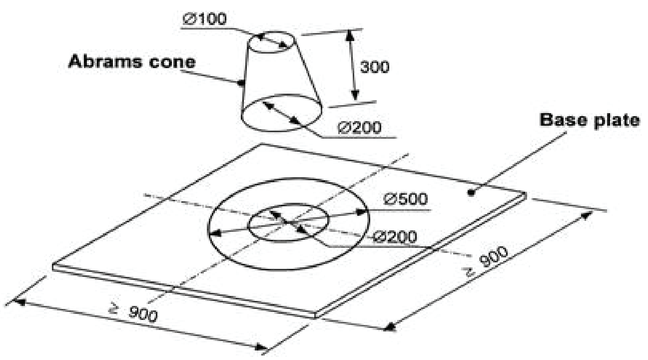

Fig. 1. Apparatus for The Slump-flow test

Slump- flow classes are shown in the table 1:

Table 1. Slam–flow classes

Class	Slump-flow in mm
SF1	550 to 650
SF2	660 to 750
SF3	760 to 850

L-box test is used to assess the passing ability of SCC to flow through tight openings including spaces between reinforcing bars and other obstructions without segregation or blocking. L-box has arrangement and the dimensions as shown in Figure 2.

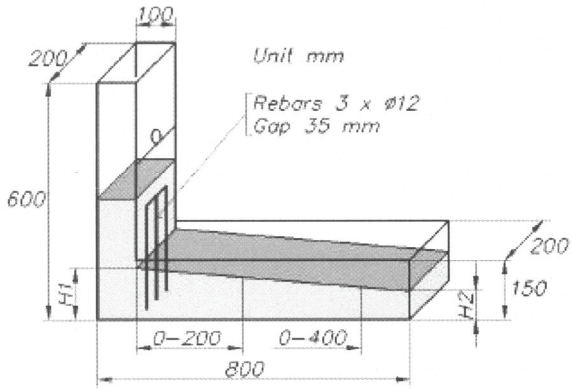

Fig. 2. L-box

Test procedure is to support the L-box on a level horizontal base and close the gate between the vertical and horizontal sections. Pour the concrete from the container into the filling hopper of the box and allow to stand for (60±10) s. When movement has ceased, measure the vertical distance, at the end of the horizontal section of the L-box, between the top of the concrete and the top of the horizontal section of the box at three positopns equally spaced across the with of the box. By difference with the height of the horizontal section of the box, these three measurements are used to calculate the mean depth of concrete as H2 mm. The same procedure is used to calculate the depth of concrete immediately behind the gate as H1 mm. The passing ability is calculated from the following equation: PA=H2/H1 [8]. Passing ability classes are given in the Table 2:

Table 2. PA classes [1]

Class	Passing ability
PA1	>0.80 with 2 rebars
PA2	>0.80 with 3 rebars

The V-funnel test is used to assess the viscosity and filling ability of SCC. Procedure is to clean the funnel and bottom gate, then dampen all the inside surface including the gate. Close the gate and pour the sample of concrete into the funnel, without any agitation or rodding, then strike off the top with the straight edge so that the concrete is with the top of the funnel. Place the container under the funnel in order to retain the concrete to be passed. After a delay of (10±2)s from filling the funnel, open the gate and measure the time t_v, to 0.1 s, from opening the gate to when is possible to se vertically through funnel into the container below for the first time. t_v is the V-funnel flow time. V-funnel is shown in Figure 3 [8].

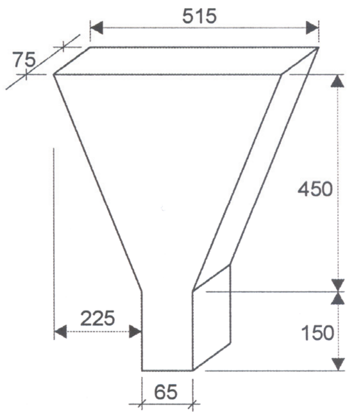

Fig. 3 V-funnel

Viskosity classes are shown in table 3:

Table 3 Viskosity classes [1]

Class	T_{500},s	V-funnel time in s
VS1/VF1	<2	<8
VS2/VF2	>2	9 to 25

3. EXPERIMENTAL RESULTS

Table 4 Mixture proportions [6]

	NC	SCCFA	SCCSF	SCCHL	SCCFAHL
Cement (kg/m^3)	410	390	384	384	384
Fly ash(kg/m^3)	xx	58	xx	xx	38
Silica fume(kg/m^3)	xx	xx	38	xx	xx
Hydraulic lime(kg/m^3)	xx	xx	xx	77	38
Sand 0.15-0.6 (kg/m^3)	360	437	418	418	418
Sand 0.3-2.4 (kg/m^3)	360	437	418	418	418
Aggregate 6-15mm (kg/m^3)	1127	881	863	891	891
Water/cement (kg/kg)	0.40	0.40	0.55	0.48	0.48
Superplasticer Viscocrete 3000 (%)	1.50	2.5	2.4	2.4	2.4
Water/powder materials (kg/kg)	0.40	0.35	0.36	0.33	0.33

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 ash and hydraulic lime. Each mixture has a cement aggregates mass proporcional equal to 1:4.5.

Table 5. Test results

		NC	SCCFA	SCCSF	SCCHL	SCCFAHL
Slump	mm	35	-	-	-	-
Slump flow	sec	-	4'81"	1'34"	2'53"	3'29"
	mm	-	650	680	675	650
L-box	T_{40} sec	-	5'46"	3'93"	2'81"	4'00"
	H2/H1	-	0.86	0.60	0.86	0.50
V-funnel	sec	-	10'00'	13'00"	12'29"	15'00"
Compessive strength at 28 days	Mpa	40	25.5	29.0	26.0	34.4

4. CONCLUSIONS

Due to test results, the addition of fly ash to the mixture containing hydraulic lime is quite beneficial, bringing a supstantial improvement of the behaviour of SCCFAHL concrete. 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 behaviour 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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SVOJSTVA SAMOUGRAĐUJUĆEG BETONA SA RAZLIČITIM DODACIMA

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Samougrađujući beton je jedno od "najrevolucionarnijih otkrića" u razvoju tehnologije betona; ovaj beton može da teče i da ispuni i teško dostupne oplate bez vibriranja. Postoji više metoda za ispitivanje njegovih svojstava u svežem stanju: najšeće koriććene su slum–flow test, L–box and V–funnel.

U ovom radu su pokazana svojstva samougrađujućeg betona sa različitim dodacima: letećim pepelom, silikatnom prašinom, krečnim brašnom i mešavinom letećeg pepela i krečnjačkog brašna.