47

ISSN 0352 – 6852
eISSN 2334 – 9573
DOI: 10.14415/konferencijaGFS2014

ЗБОРНИК РАДОВА ГРАЂЕВИНСКОГ ФАКУЛТЕТА

МЕЂУНАРОДНЕ КОНФЕРЕНЦИЈЕ САВРЕМЕНА ДОСТИГНУЋА У ГРАЂЕВИНАРСТВУ

JOURNAL OF FACULTY OF CIVIL ENGINEERING

INTERNATIONAL CONFERENCE CONTEMPORARY ACHIEVEMENTS IN CIVIL ENGINEERING

Е. III

СУБОТИЦА
2014

ADDITIONAL RULES FOR SELF – COMPACTING CONCRETE (EN 206 – 9:2010)

Iva Despotović[1]
Zoran Grdić[2]

UDK: 666.972.5
DOI: 10.14415/konferencijaGFS2014.068

Summary: *Developed in 1988. in Japan, because of his extraordinary perfomances, Self – Compacting Concrete became very popular during 90 – s, especially in Europe, where pushed out vibrated concrete. It has a different technology and properties in fresh state and different testing metods, so Europian standard EN 206 – 1:2000 could not apply on Self – Compacting Concrete literally. CEN approved an addict EN 206 – 9:2010 with extra conditionals only for this kind of concrete. Those changes and finally assimilated rules for Self Compacting Concrete are explained in this work.*

Keywords: *Self compacting concrete; testing concrete, EN 206 – 1:2000, EN 206 - 9:2010, EN 12350*

1. INTRODUCTION

Definition of Self – Compacting Concrete is: concrete that is able to flow and compact under its own weight, fill the formwork with its reinforcement, ducts, boxouts etc., whilst maintaining homogeneity. 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. Although SCC can have even better properties in hardened state than vibrated concrete, the differency in technology is exactly in the fresh state. The main four characteristics which concrete must have to become self- compacting are: **flowability** - the ease of flow of fresh SCC when unconfined by formwork and/or reinforcement, **viscosity** - the resistance to flow of fresh SCC once flow has started, **passing ability** - the ability of fresh SCC to flow through tight openings such as spaces between steel reinforcing bars without segregation or blocking, **segregation resistance** - the ability of fresh SCC to remain homogeneous in composition while in its fresh state [1].
Testing and proofing of these properties is a novelty than vibrated concrete testing. It took about 20 years of intensive investigations for recomendations to become the official Europian Standard. Because of it's extraordinary properties SCC spread away from Japan onto the whole world. A lot of different investigation resulted with about 15

[1] Iva Despotović, MScCe, Belgrade University College of Applied Studies in Civil Engineering and Geodesy, Hajduk Stankova 2, Belgrade, Serbia, tel: ++381 64 1918539, e – mail: ivickad@gmail.com
[2] Zoran Grdić, Ph.D, Faculty of Civil Engineering and Architecture, Nis

methods of testing [2] with the test interpretation which could vary from country to country. Whole teams were formed in Europe whose work was united in the form of recomendations first, and the part of EN much later.
European Standard EN 206-1:2000 specifies requirements for: the constituent materials of SCC, the properties of fresh and hardened SCC and their verification, the limitations for SCC composition, the specification of SCC, the factory production control procedure, the conformity criteria [3].
The testing of SCC in the fresh state became a part of EN 12350, which defines the testing methods (fresh concrete) in these chapters [4]:
EN 12350-8, *Testing fresh concrete - Part 8: Self-compacting concrete – Slump-flow test*
EN 12350-9, *Testing fresh concrete - Part 9: Self-compacting concrete – V-funnel test*
EN 12350-10, *Testing fresh concrete - Part 10: Self-compacting concrete – L box test*
EN 12350-11, *Testing fresh concrete - Part 11: Self-compacting concrete – Sieve segregation test*
EN 12350-12, *Testing fresh concrete - Part 12: Self-compacting concrete – J-ring test*

The final criteria for SCC evaluation is assimilated in 2010. in Europian standard EN206-9:2010 Concrete - Part 9: Additional Rules for Self-compacting Concrete (SCC). This European Standard was approved by CEN (EUROPEAN COMMITTEE FOR STANDARDIZATION/ COMITÉ EUROPÉEN DE NORMALISATION) on 27 February 2010. CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland,Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.
Testing methods and result interpretation according to Europian Standards EN12350 and EN 206-9:2010 are shown in this paper.

2. TESTING SCC IN THE FRESH STATE ACCORDING TO EN 206 – 9:2010

Where the flowability of self-compacting concrete is to be determined, it shall be measured as a slump-flow test in accordance with EN 12350-8 [4].
Where the viscosity of self-compacting concrete is to be determined, it shall be measured either by means of: *t*500 test conforming to EN 12350-8
V-funnel test conforming to EN 12350-9.
Where the passing ability of self-compacting concrete is to be determined, it shall be measured either by means of : L-box test conforming to EN 12350-10
J-ring test conforming to EN 12350-12.
Where the resistance to segregation of self-compacting concrete is to be determined, it shall be measured by means of : Sieve segregation resistance test conforming to EN 12350-11.

It should be noticed that the flowability, viscosity, passing ability and resistance to segregation may also be determined by alternative test methods valid in the place of use if there is an established relationship with EN 206-1:2000.

3. SLUMP-FLOW TEST AND $_T$500 TEST CONFORMING TO EN 12350-8

This test needs mould in the shape of a truncated cone with the internal dimensions 200 mm diameter at the base, 100 mm diameter at the top and a height of 300 mm, conforming to EN 12350-2 (Fig.1). About 6 litre of concrete is needed to perform the test, sampled normally.
The base plate and inside of slump cone are moistened, the cone is filled and raised vertically, so the concrete can flow out freely. Simultaneously, the stopwatch is strated and the time taken for the concrete to reach the 500mm spread circle is recorded. This is the T50 time. **Viscosity classes – *t*500 (s)** [5]: VS1 < 2,0   VS2 ≥ 2,0
The average of the two measured diameters in two perpendicular directions is the slumpflow in mm.
Slump-flow classes [5]: SF1 550 to 650 mm; SF2 660 to 750 mm; SF3 760 to 850 mm

Figure 1: Slump – flow test

4. V FUNNEL TEST

The test was developed in Japan (Ozawa) . The equipment consists of a V-shaped funnel, shown in Fig.2. An alternative type of V-funnel, the O funnel, with a circular section is also used in Japan. The described V-funnel test is used to determine the filling ability (flowability) of the concrete with a maximum aggregate size of 20mm. The funnel is filled with about 12 litre of concrete and the time taken for it to flow through the apparatus measured.
After this the funnel can be refilled concrete and left for 5 minutes to settle. If the concrete shows segregation then the flow time will increase significantly.
V-funnel flow time (s) [5]: VF1: < 9,0   VF2 9,0 to 25,0

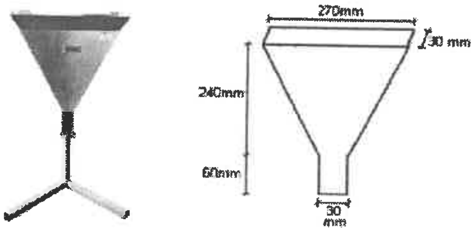

Figure2: V-funnel

5. L BOX TEST

This test, based on a Japanese design for underwater concrete, has been described by Petersson.The apparatus consists of a rectangular-section box in the shape of an 'L', with a vertical and horizontal section, separated by a moveable gate, in front of which vertical lengths of reinforcement bar are fitted (Fig.3). The vertical section is filled with concrete, then the gate lifted to let the concrete flow into the horizontal section. When the flow has stopped, the height of the concrete at the end of the horizontal section is expressed as a proportion of that remaining in the vertical section. This is an indication passing ability, or the degree to which the passage of concrete through the bars is restricted.

Figure 3: L-box test

The horizontal section of the box can be marked at 200mm and 400mm from the gate and the times taken to reach these points measured. These are known as the T20 and T40 times and are an indication for the filling ability.
L-box ratio [5]: PL1 $\geq 0{,}80$ with 2 rebars PL2 $\geq 0{,}80$ with 3 rebars

6. SIEVE SEGREGATION TEST

This is very simple test. About 5kg of concrete is poured onto the sieve (d=5mm). After 2 minutes the passed quantity is measured. The result is ratio between passed and poured concrete (Fig.4).

Segregated portion (%) [5]: SR1 ≤ 20; SR2 ≤ 15

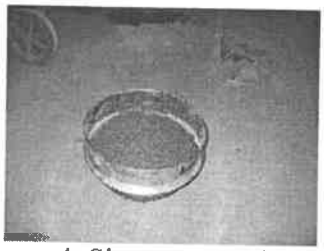

Figure 4: Sieve segregation test

7. J RING TEST

The principle of the J Ring test may be Japanese, but no references are known. The J Ring test itself has been developed at the University of Paisley. The test is used to determine the passing ability of the concrete. The equipment consists of a rectangular section (30mm x 25mm) open steel ring, drilled vertically with holes to accept threaded sections of reinforcement bar. These sections of bar can be of different diameters and spaced at different intervals: in accordance with normal reinforcement considerations, 3x the maximum aggregate size might be appropriate. The diameter of the ring of vertical bars is 300mm, and the height 100 mm. The J Ring is used with the slump flow cone. The Self – Compacting Concrete should pass through the bars without stucking and segregation (Fig.5). The average of the difference in height at four locations (in mm) of the concrete just inside the bars and that just outside the bars is the measure of the test.
J-ring step (mm) [5]: PJ1 ≤ 10 with 12 rebars; PJ2 ≤ 10 with 16 rebars

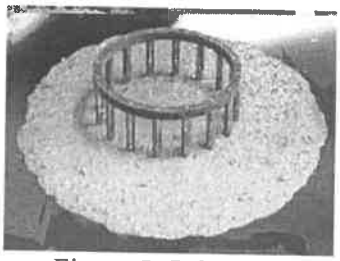

Figure 5: J ring test

8. CONCLUSION

After 25 years from the inception and after a huge number of different investigations, the testing procedure for Self - Compacting Concrete is finally defined in Europian Standards: EN 206-1:2000 (materials, composition, properties), EN 12350 (testing methods) and EN 206-9:2010 (result interpretation). In Serbia, the latest version of EN 12350 (2009) is assimilated in 2010 (vibrated concrete – 7 chapters) and in 2012 (Self – Compacting Concrete – 5 chapters), and EN 206-9:2010 is not assimilated yet.

REFERENCES

[1] EFNARC, ERMCO, EFCA, bibm: The Europian Guidelines for Self – Compacting Concrete, Specification, Production and Use, 2005, p.68
[2] EFNARC: Specification and Guidelines for Self – Compacting Concrete, 2002, p.32
[3] Europian Standard EN 206 – 1:2000 (serbian translation)
[4] Europian Standard EN 12350
[5] Europian Standard EN 206-9:2010

ДОДАТНА ПРАВИЛА ЗА САМОУГРАЂУЈУЋИ БЕТОН: EN 206-9:2010

Резиме: *Настао 1988. у Јапану, а захваљујући својим изузетним особинама, самоуграђујући бетон је постао врло популаран 90 - тих година, посебно у Европи, где је потиснуо вибрирани бетон. Одликује се другачијом технологијом и особинама у свежем стању и има различите методе испитивања, тако да европска норма EN 206 – 1:2000 није могла у потпуности да се примени на овај бетон. CEN је одобрио додатак EN 206 – 9:2010 са прописима само за ову врсту бетона. Те промене и финално прихваћена правила испитивања самоуграђујућег бетона су објашњена у овом раду.*

Кључне речи: *Самоуграђујући бетон, испитивање бетона, EN 206 – 1:2000, EN 206 -9:2010, EN 12350*