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THE FUTURE CONCRETE: SELF-COMPACTING CONCRETE

BY

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Abstract. The paper presents the characteristics of the self-compacting concretes, their advantages and disadvantages when they are used in buildings. Due to its properties and composition, the self-compacting concrete is described here as being one of the future friendly enviromental material for buildings. Tests concerning to obtaining a self-compacting concrete, together with the specific fresh concrete properties tests, are described.

Key words: self-compacting concretes; enviromental friendly materials; fly ash; durability; sustenability.

1. General Considerations about Self-Compacting Concretes

1.1. Introduction

The concrete is the man-made material which has the vastest utilization worldwide. This fact leads to important problems regarding its design and preparation to finally obtain an economic cost of the product on short and long time periods. The material has to be also "friendly with the environment" during its fabrication process and also its aesthetical appearance when it is used in the structures. Its success is due to: a) its raw materials that have a large spreading into the world; b) the prices of raw materials that are low; c) the properties and the performances of the concrete that confers it a large scale of application.

Concrete's performances have continuously rise in order to accomplish the society needs. Many studies have been made concerning the use of additives

and super–plasticizers in the concrete for passing the frontier of minimum water content for a good workability of a concrete. As a result of this, high performance concretes developed having a superior durability.

Self-compacting concrete (SCC) is an innovative concrete that does not requires vibration for placing and compaction. It is able to flow under its own weight, completely filling formwork and achieving full compaction, even in the presence of congested reinforcement. The hardened concrete is dense, homogeneous and has the same mechanical properties and durability as traditional vibrated concrete.

SCC has many advantages such as the followings:

a) from the contractors point of view costly labor operations are avoided improving the efficiency of the building site;

b) the concrete workers avoid poker vibration which is a huge benefit for their working environment;

c) when vibration is omitted from casting operations the workers experience a less strenuous work with significantly less noise and vibration exposure;

d) SCC is believed to increase the durability relatively to vibrated concrete (this is due to the lack of damage to the internal structure, which is normally associated with vibration) [1].

1.2. Development of Self Compacting Concrete

The SCC concept was introduced into scientific world in Japan in 1986 by Professor Hajime Okamura from Tokyo University. The first prototype was developed in 1988 by K. Ozawa from Tokyo University as a response to the growing problems associated with concrete durability and the high demand for skilled workers.

In Europe it was probably first used in civil works for transportation networks in Sweden, in the middle of 1990's. The EC funded a multi-national, industry lead project SCC 1997-2000 and since then SCC has found increasing use in all European countries.

SCC was first developed so that durability of concrete structures can be improved. Since then, various investigations have been carried out and the concrete has been used in practical structures in Japan and Europe, mainly by large construction companies. Investigations for establishing a rational mix-design method and self-compact ability testing methods have been carried out from the viewpoint of making it a standard concrete. Recommendations and manuals for self-compacting concrete were also written [1].

To make durable concrete structures, sufficient compaction by skilled workers is required. However, the gradual reduction in the number of skilled workers in construction industry has led to a similar reduction in the quality of construction work. One solution for the achievement of durable concrete structures, independent of the quality of construction work, is the use of the

SCC, which can be compacted into every corner of a formwork, purely by means of its own weight and without the need of vibrating compaction (Fig. 1) [1].

In Japan, in the year 1988, SCC emerged on the scene and it has been the subject of numerous investigations in order to adapt it to modern concrete production. At the same time the producers of additives have developed more and more sophisticated plasticizers and stabilizers tailor-made for the precast and the ready-mix industry.

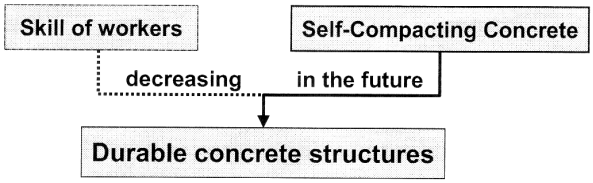

Fig. 1 – Necessity of Self-Compacting Concrete[1].

For last 20 years, the problem of the durability of concrete structures was a major topic of interest. SCC is a concrete which flows to a virtually uniform level under the influence of gravity without segregation, during which it de-aerates and completely fills the formwork and the spaces between the reinforcement [2]. It is a high-performance concrete with the special property of the fresh concrete of "self-compacting". As with other high-performance concretes (*e.g.* high-strength concrete, acid-resistant concrete) the special properties of these concretes, which differ from normal concretes, are achieved only by systematic optimization both of the individual constituents and of the composition. The flow ability and mix stability of the SCC are determined primarily by the interactions between the powder (cement and additions with a particle diameter < 0.125 mm), water and plasticizer. The gradation of the individual size groups in the overall grading curve also affects the property of the concrete in the sense of not being blocked by the reinforcement.

It has been found that, in contrast with vibrated concrete, the workability properties required for self compaction cannot be maintained relatively easily over a fairly long period. Fluctuations in the workability of vibrated concrete can be largely offset by the intensity of vibration applied during placement, but this is not possible with SCC. The effects of production and transport on the workability properties of SCC must therefore be taken into account in the initial testing [2].

2. Self - Compacting Concrete Composition

The basic components for the mix composition of SCC are the same as used in conventional concrete.In order to obtain the requested properties of fresh concrete for SCC a higher proportion of ultra fine materials and chemical

admixtures (in particularly an effective superplasticizer and viscosity-modifying agent) are necessary to be introduced.

Ordinary and approved filler materials are: limestone powder, quartzite powder and recycling industrial waste like fly ash, blast furnace slag and silica fume.

A typical mix design of SCC in comparison with conventional concrete is shown in Fig. 2.

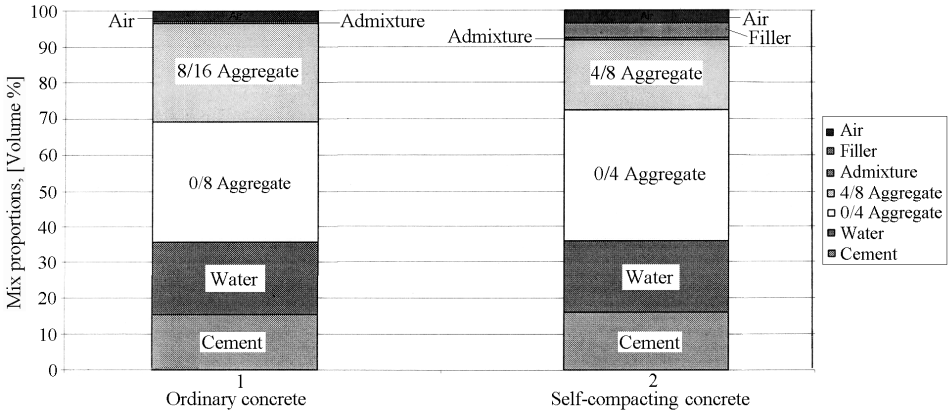

Fig. 2 – Mix composition of SCC in comparison with normal vibrated concrete.

"The European Guidelines for Self Compacting Concrete", elaborated in May 2004, define SCC and many of the technical terms used to describe its properties and use. They also provide information on standards related to testing and to associated constituent materials used in the production of SCC.

The requirements from *"The European Guidelines for Self Compacting Concrete"* for fresh self-compacting concrete shall be measured by means of the following tests (for characteristic):

a) slump-flow and T_{500} test (for flow ability) (Fig. 3);

Fig. 3 – Slump-flow test.

b) *V*-funnel test (for viscosity) (Fig. 4);

Fig. 4 – *V*-funnel test.

c) *L*-box test for (passing ability) (Fig. 5);

Fig. 5 – *L*-box test.

d) segregation resistance test.

2.1. Experimental Research Concerning the Obtaining a Self -Compacting Concrete

The composition of the SCC established by the authors of this paper was done during a research program over two years in a CEEX – research-development project titled: "*Innovative Solution of Optimization of the Self-Compacting Concrete's Microstructure for Performant Realization of Precast Concrete Elements*" [3]. Experimental tests followed the purpose of obtaining some recepies for SCC that can be succesfully used in precast elements and structures. The parameters taken into account mainly refers to the concretes

composition. Table 1 presents the final composition that was established for a competitive self-compacting concrete.

Table 1

Composition		Self-Compacting Concrete
Cement CEM I 42,5 R, [kg/m^3]		477.2
Silica fume, [kg/m^3]		53.5
Fly ash, [kg/m^3]		53.5
Fine aggregate, [kg/m^3]	0/4 mm river	987.3
Coarse aggregate, [kg/m^3]	4/8 mm crushed	526.5
Superplastifiant, [kg/m^3]	GLENIUM ACE 30	7.2 (1.5% from cement)
Water, [kg/m^3]		198.8
W/C		0.416
Total, [kg]		2,304

Fresh concrete characteristics are presented in Table 2.

Table 2

Characteristic			Self -compacting concrete
Volumetric mass, [kg/m^3]			2,304
Workability	Limits		
	Slump, [mm]	600…800	680
	L-box, h_1/h_2	0.8...1	8.3/9 = 0.92
	V-funnel, [sec.]	6…12	12

The samples were striked after 48 h and kept in water for 7 days. Then, until test have been done, the samples were placed on a grill over a water tank. The obtained hardened concrete properties (Table 3) for self-compacting concrete prove that it can be reffered to, as SCC in the concrete resistance class C50/60.

Table 3

Characteristic	Self -Compacting Concrete
Volumic mass, [kg/m^3]	2,305 2,317/2,311
Compression strength on cubes, [N/mm^2]	63.11 64.89/64.00
Compression strength on prisms, [N/mm^2]	52.0
Bending tensile strength, [N/mm^2]	8.3
Modulus of elasticity, [kN/mm^2]	47.5

The obtained results are in accordance with similar tests presented in literature.

The elasticity modulus have high values for the studied case, proving that self compacting concretes are not very deformable ones, so that they can be applied for precast structures with large spans.

4. Conclusions

1. Fly ash can replace a significant part of the necessary filler when used into a self compacting concrete composition.

2. The elimination of vibrating equipment improves the environment protection near construction and precast sites where concrete is being placed, reducing the exposure of workers to noise and vibration.

3. SCC is favourably suitable especially in highly reinforced concrete members like bridge decks or abutments, tunnel linings or tubing segments, where it is difficult to vibrate the concrete, or even for normal engineering structures.

4. The improved construction practice and performance, combined with the health and safety benefits, make SCC a very attractive solution for both precast concrete and civil engineering construction. Based on these facts it can be concluded that SCC will have a bright future.

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BETONUL VIITORULUI: BETONUL AUTOCOMPACTANT

(Rezumat)

Se prezintă caracteristicile betoanelor autocompactante, avantajele şi dezavantajele acestora când sunt utilizate în structuri de beton. Datorită proprietăţiilor şi

compoziției sale, betonul autocompactant este prezentat ca fiind unul dintre materialele viitorului „prietenoase cu mediul înconjurător”. Sunt descrise testele experimentale efectuate pentru obținerea unei compoziții de beton autocompactant