THE FUTURE CONCRETE: SELF COMPACTING CONCRETE

Sajad Hussain¹, Vikash Kumar Karn², Imtiyaz Farooq Rather³

¹,²,³Department of Civil Engineering,
IIMT College of Engineering, Greater Noida U.P. (India)

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 environmental materials for buildings. Tests concerning the obtaining of self-compacting concrete, together with the specific fresh concrete properties, are described.

Keywords: -Durability; environmental-friendly materials; flyash; Self-compacting concretes; sustainability

1. GENERAL CONSIDERATION ABOUT SELF-COMPACTING CONCRETE

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 over short and long time periods. The material hastobealso “friendly with the environment” during its fabrication process and also its aesthetic 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 performance of the concrete that confer it a large scale of application.

Concrete’s performances have continuously risen in order to accomplish the society needs. Many studies have been made concerning the use of addition. And super-plasticizers in the concrete for passing the frontier of minimum water content for 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 require 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 following:

a) From the contractor's 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 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.

e) Faster construction.

f) Reduction in site manpower.

g) Easier placing.

h) Uniform and complete consolidation.

i) Better surface finishing.

j) Improved durability.

k) Increased bond strength.

l) Greater freedom in design.

m) Reduced noise levels, due to absence of vibrations, and

n) Safe working environment.

1.2 Development of Self Compacting Concrete

The SCC concept was introduced into the 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 forestablishing a rational mix-design 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.

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 the formwork purely by means of its own weight and without the need of vibrating compaction (Fig. 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 to modern concrete production. At the same time, the producers of additives have developed and more sophisticated plasticizers and stabilizer tailors made for the precast and the ready-mix industry.

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 flowability and mix stability of the SCC are determined primarily by the interactions between the powder (cement and additions with 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 fair 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.

II. 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 ultrafine materials and chemical admixtures (in particular, an effective super plasticizer and viscosity-modifying agent) are necessary to be introduced. Ordinary and approved
Filler materials are: limestone powder, quartzite powder and recycling industrial waste like flyash, blastfurnaceslag 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 concretes shall be measured by means of the following tests (for characteristic):

a) Slump-flow and 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

III. EXPERIMENTAL RESEARCH CONCERNING THE OBTAINING A SELF- COMPACTING CONCRETE

The composition of the SCC established by the author of this paper was done during research program over two years in CEEX – research development project titled: “Innovative Solution of Optimization of the Self-Compacting Concrete’s Microstructure for Performant Realization of Precast Concrete Elements”. Experimental tests followed the purpose of obtaining some recipes for SCC that can be successfully used in precast elements and structures. The parameter taken into account mainly refers to the concrete composition. Table 1 presents the final composition that was established for a competitive self-compacting concrete.

<table>
<thead>
<tr>
<th>Composition</th>
<th>Self-Compacting Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cement CEM I 42.5P [kg/m³]</td>
<td>477.2</td>
</tr>
<tr>
<td>Silica fume [kg/m³]</td>
<td>53.5</td>
</tr>
<tr>
<td>Fly ash [kg/m³]</td>
<td>53.5</td>
</tr>
<tr>
<td>Fine aggregate [kg/m³]</td>
<td>987.3</td>
</tr>
<tr>
<td>Coarse aggregate [kg/m³]</td>
<td>526.5</td>
</tr>
<tr>
<td>Superplastifiant, [kg/m³]</td>
<td>GLENIUM 7.2</td>
</tr>
<tr>
<td>Water [kg/m³]</td>
<td>198.8</td>
</tr>
<tr>
<td>W/C</td>
<td>0.416</td>
</tr>
<tr>
<td>Total, [kg]</td>
<td>2,304</td>
</tr>
</tbody>
</table>

Fresh concrete characteristics are presented in Table 2.
Table 2

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Self-Compacting Concrete</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volumetric mass, [kg/m³]</td>
<td>2.304</td>
</tr>
<tr>
<td>Limits</td>
<td></td>
</tr>
<tr>
<td>Slump, [mm]</td>
<td>600...800</td>
</tr>
<tr>
<td>L-box, h₁/h₂</td>
<td>0.8...1</td>
</tr>
<tr>
<td>V-Tunnel, [sec.]</td>
<td>6...12</td>
</tr>
</tbody>
</table>

The samples were struck after 48 h and kept in water for 7 days. Then, until tests 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 proved that it can be used to replace SCC in the concrete structure, for example C50/60.

Table 3

<table>
<thead>
<tr>
<th>Characteristic</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Volumemass, [kg/m³]</td>
<td>2.305</td>
</tr>
<tr>
<td>Compression strength on cubes, [N/mm²]</td>
<td>63.11</td>
</tr>
<tr>
<td>Compression strength on prisms, [N/mm²]</td>
<td>52.0</td>
</tr>
<tr>
<td>Bending tensile strength, [N/mm²]</td>
<td>8.3</td>
</tr>
<tr>
<td>Modulus of elasticity, [KN/mm²]</td>
<td>47.5</td>
</tr>
</tbody>
</table>

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

IV. CONCLUSIONS

1. Flyash can replace a significant part of the necessary filler when used into self-compacting concrete composition.
2. The elimination of vibrating equipment improves the environment for construction near construction and precast sites where concrete is being placed, reducing the exposure of worker to noise and vibration.
3. SCC is favorably suitable especially in high reinforced concrete members like bridge deck slabs, tunnels, railway 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.
5. SCC could be developed without using VMA as was done in the study.
6. Labour cost can be minimized.
7. Overall strength of RCC structures is increased.
8. Workability parameters for initial mix design of SCC which need to be assessed can be summarized as filling ability, passing ability and segregation resistance.
9. It is evident that the properties of SCC in hardened state are similar to those of conventional concrete.
10. Different studies show that high strengths and adequate durability can be obtained using SCC.
Better internal frost resistance was exhibited by SCC as compared to normal concrete.

11. Permeation properties like water sorptivity and oxygen permeability was lower for SCC. Also, SCC had higher resistance against chloride penetration, frost freeze thaw and scaling, due to the increased dispersion of cement and filler, and a denser ITZ compared to conventional concrete.

REFERENCES


5. ** Innovative Solutions for Optimization of Microstructure Composition of Self-Compacting Concrete for Performant Realization of Precast Concrete Elements. CNCSIS/MEC, Contract no 96/2006, partnership with ICECON Bucharest, “Politehnica” Univ. of Timişoara, Techn. Univ. of Construction Bucharest, Univ. of Cluj-Napoca.


