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SELF-COMPACTING CONCRETE IN PRECAST ELEMENTS INDUSTRY

BY

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In this paper the authors present informations about the Self-Compacting Concrete and experimental results regarding the use of them into precast elemet industry.

This type of concrete 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 experimental programme has take into account two prestressed beams which were prefabricated and tested on a special stands. The beams of Self-Compacting Concrete with the length of 24 m were prepared at "Beton-Star" KfT, Kecskenét, Hungary, and used at the CASCO, Satu-Mare.

1. Introduction

One of the most outstanding advances in concrete technology during the last decade is represented by Self-Compacting Concrete (SCC). This type of concrete 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 engineering properties and durability as traditional vibrated concrete.

Due to its specific properties, SCC may contribute to a significant improvement of the quality of concrete structures and open up new fields for the application of concrete.

The SCC concept was introduced into scientific world in Japan in 1986 by Professor Hajime O k a m u r a from Tokyo University [1]. The first prototype was developed in 1988 by K. O z a w a from Tokyo University [2] as a response to the growing problems associated with concrete durability and the high demand for skilled workers.

In Europe it was first used in civil works in Sweden in the middle 1990's.

Like another new materials SCC have some limitations: the higher material costs (not only for the admixture itself, but for the increased quality-control testing needed for concrete and aggregates).

In future, in the same time with technologies development, this type of concrete will have a large utilization in concrete industry.

2. Mix Composition and Properties of Concrete

For SCC the basic components for the mix composition are the same as used in conventional concrete.

To obtain the requested properties of fresh concrete, in SCC a higher proportion of ultra-fine materials and the chemical admixtures (an superplasticizer and viscosity-modifying agent) are necessary to be introduced.

Ordinary filler materials which can be utilized are: limestone powder, quartzite powder and recycling industrial waste (like fly ash, limestone powder, blast furnace slag and silica fume).

A typical mix design of SCC in comparison with conventional concrete is shown in Fig. 1.

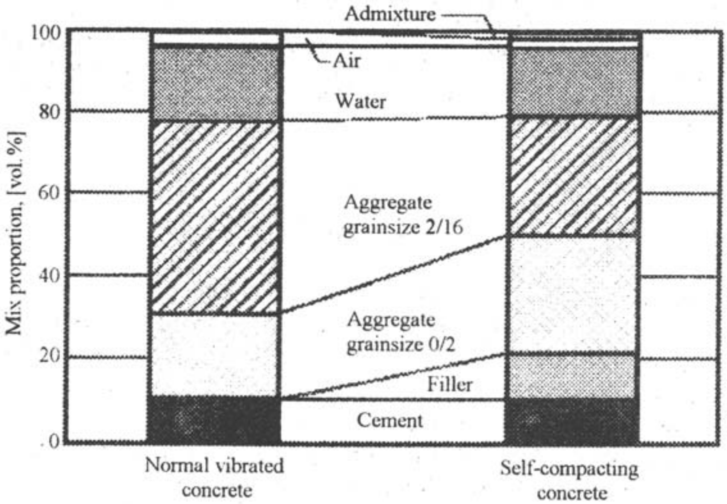

Fig. 1.– Mix composition of SCC in comparison with normal vibrated concrete

SCC should flow easily and completely fill spaces between congestion reinforcement and forms by virtue of its own weight.

Based on the original conception of Okamura and Ozawa, at this moment, three types of SCC can be distinguished:

a) Powder Type – increase of the flour grain content.

b) Viscosity-Agent Type – use of viscosity-modifying admixture.

c) Combination Type – combination of both before presented types.

In comparison with vibrated concrete all concepts work with an increased amount of superplasticizer. The chosen one of these three conceptions is made in function of economical and technical criterions.

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 flowability);

b) *V*-funnel test (for viscosity);

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

d) segregation resistance test.

Conformity criteria for the properties of SCC are presented in Table 1.

Table 1

Property	Criteria
Slump-flow class SF1	$\geq$ 520 mm, $\leq$ 700 mm
Slump-flow class SF2	$\geq$ 640 mm, $\leq$ 800 mm
Slump-flow class SF3	$\geq$ 740 mm, $\leq$ 900 mm
Slump-flow class specified as a target value	$\pm$ 80 mm of target value
V-funnel class VF1	$\leq$10 s
V-funnel class VF2	$\geq$ 7 s, $\leq$ 27 s
V-funnel specified as a target value	$\pm$ 3s
L-box class PA1	$\geq$ 0.75
L-box class PA2	$\geq$ 0.75
L-box specified as a target value	Not more than 0.05 below the target value
Sieve segregation resistance class SR1	$\leq$ 23
Sieve segregation resistance class SR2	$\leq$ 18

The uses of SCC can induce the next benefits for concrete producers:

a) a reduction of noise during casting from vibrators;

b) speed of placement, resulting in increased production efficiency;

c) homogeneity of the concrete production;

d) improved surface quality (without blowholes or other surface defects);

e) reduced energy consumption from vibration equipment;

f) excellent pump ability;

g) a shortening of the construction time (an improved productivity);

h) waste recovery (friendly environment);

i) reduced wear and tear on forms from vibration;

j) reduced wear on mixers due to reduced shearing action;

k) reduced permeability.

When SCC is utilized, the reduction of costs caused by better productivity, shorter construction time and improved working conditions will compensate the higher material costs and, in many cases, may result in more favourable prices of the final product.

3. Experimental Programme

The experimental programme have take into account two prestressed beams which were prefabricated and tested on a special stands. The beams of SCC with the length of 24 m were prepared at "Beton-Star" KfT, Kecskenét, Hungary and used at the CASCO, Satu-Mare (Fig. 2).

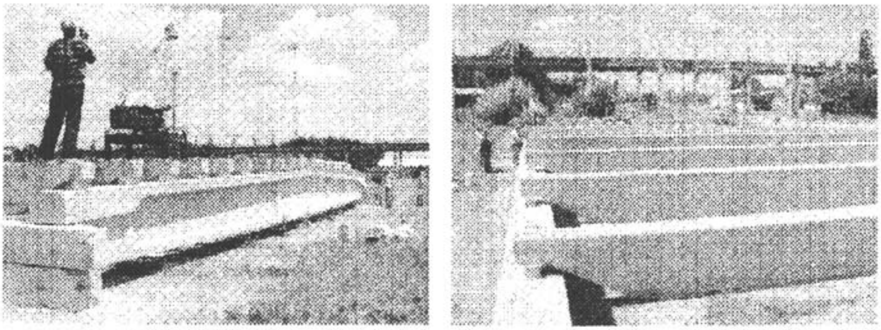

Fig. 2.– The pairs of beams charging.

The pair of beams with the span of 24 m have been supported on two bearing and was loaded with twenty secondary beams in four steps:

Step 1 – with eight secondary beams which represent a load of $8P/2 = 8 \times \times 35.5/2 = 142$ kN.

Step 2 – consist of five secondary beams which means $5P/2 = 88.75$ kN on each main beam. The sum of two steps is $13P/2 = 230.75$ kN.

Step 3 – was represented by other three secondary beams and the total load on each main girder is $16P/2 = 284$ kN.

Step 4 – was characterized by the last four secondary beams and the total load was $20P/2 = 355$ kN on each main beam. The total load is obtained by adding at 355 kN of self weight of each main beam, which is of 139.2 kN (5.8 kN/m), so the total load become 494.2 kN and it touch 24.71 kN/m.

The load were applied in two cycles of charging–descharging during a two days.

The design loads used for a roof are:

a) the weight of the component layers of the roof:	5.4 kN/m;
b) self weight of the beam:	5.8 kN/m;
c) variable weight (including snow):	5.4 kN/m.
Total load	16.6 kN/m

The ratio between the design and experimental loads is

$$\frac{P_{\text{exp.}}}{P_{\text{calc.}}} = \frac{24.71}{16.6} = 1.49.$$

The theoretical deflection, f_{ld}, at final stage, is

$$f_{ld} = \frac{5}{384} \cdot \frac{ql^4}{E_b^{ld} I} = 13.26\,\text{cm},$$

where

$$E_b^{ld} = \frac{0.8E_b}{1 + 0.5v\overline{\rho}} = 14,190\,\text{N/mm}^2.$$

The theoretical short term deflection is

$$f_{sd} = \frac{5}{384} \cdot \frac{ql^4}{E_b^{sd} I} = 2.38\,\text{cm},$$

where

$$E_b^{sd} = 0.8E_b = 27,600\,\text{N/mm}^2.$$

The theoretical final deflection is

$$\Delta f = f_{ld} - f_{sd} = 13.96 - 2.38 = 10.88\,\text{cm},$$

and

$$\Delta f_u = 10.88 - 3.5 = 7.38\,\text{cm} < f_a = \frac{1}{250} = 9.6\,\text{cm},$$

where 3.5 cm is the negative deflection due to prestressing effect.

The experimental deflection measured during tests is

$$f_{\text{expl.}} = 8.2\,\text{cm} < f_a = \frac{1}{250} = 9.6\,\text{cm}.$$

4. Conclusions

1. The using of Self-Compacting Concrete in precast prestressed elements is a possible solution.

2. The tests on a pair of beams of 24 m span, at static loads, seem a well behaviour at serviceability's limit stages.

3. Regarding construction practice and performance, combined with the health and safety benefits, make Self-Compacting Concrete a very attractive solution for both precast concrete and civil engineering construction. Based on these facts it can be concluded that Self-Compacting Concrete will have a bright future.

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BETONUL AUTOCOMPACTANT ÎN INDUSTRIA ELEMENTELOR PREFABRICATE

(Rezumat)

Betonul autocompactant este una din cele mai importante inovaţii din industria betonului din ultima perioadă. Are proprietăţi speciale find utilizat la construcţii importante şi este prietenos cu mediul (prin eliminarea zgomotului produs de echipamentele utilizate la vibrare şi prin utilizarea unor deşeuri industriale).

Programul experimental a avut in vedere testarea unei perechi de grinzi prefabricate din beton precomprimat. Grinzile de acest tip, avand lungimea de 24 m (Fig. 2), au fost realizate din beton autocompactant la firma "Beton-Star" KFT, Kecskemét, Ungaria, şi sunt utilizate la executarea investiţiei CASCO, Satu-Mare.

Încercarea la încărcări statice a arătat o comportare satisfăcătoare la stările limită ale exploatării normale asemănătoare betonului obişnuit vibrat. Rezultatele obţinute prin determinările efectuate atestă posibilitatea folosirii betonului autocompactant la elemente prefabricate.