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CONSTRUCŢII. ARHITECTURĂ

EFFECT OF DIFFERENT TYPES OF SUPERPLASTICIZERS ON THE PROPERTIES OF HIGH STRENGTH CONCRETE INCORPORATING LARGE AMOUNTS OF SILICA FUME

BY

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High strength concretes incorporating large amounts of silica fume (SF) are analysed for different types of admixtures. Properties of fresh and hardened concrete were analysed for dosages of SF between 30% and 50% and were compared with a witness concrete with 10% SF. Influence of admixtures in the case of large amounts of SF is significant only in the case of fresh concrete. In the case of hardened concrete, for admixture type superplasticizer containing calcium sulfonat can be obtained the best results.

1. Introduction

The use of high strength concrete has developed in the construction field, especially where durability depends on compressive strength, that commonly is 70 MPa or higher. It is well established that inclusion of silica fume (SF) represents one method for producing high-strength concrete. Also, the concrete with SF will have a reduced permeability, thus improving concrete durability. As in the case of other mineral admixtures that are used in high strength concrete in significant amounts, SF can replace cement in different dosages [1].

Near addition of supplementary cementing materials, high strength concrete requires also: high-quality aggregates, low-heat cement and chemical additives. These requirements were established for concretes that are presented with use of SF, high quality aggregates and different types of additives.

In the present study five commercial superplasticizer have been used: type *1*-hyperplasticizer – is a solution based on sulfonate polymers; type *2*-superplasticizer containing calcium sulfonate; type *3*-superplasticizer and water reduction containing a solution of napthalene–sulfonate polymer; type *4*-plasticizer, water reduction and air-entraining containing lignosulfonate and type *5*-plasticizer containing lignosulfonate. They were used at the dose level as recommended by the manufactures.

The aggregates were: sand 0...3 mm and dolomite crushed stone, the sorts being 3...8 mm and 8...16 mm.

The cement was of type CEM I-42.5 R (SREN 197-1) with compressive strength at 28 days of 42.5 N/mm^2. The cement dosage was 550 kg/m^3.

SF is a by-product of the ferro-silicon manufacturing process. It contains 92...98% silicon dioxide; it has spherical particles of 0.1...0.2 μm sizes.

2. Experimental Program

In the experimental program, concrete mixtures with large amounts of SF for high strength concrete were studied. For each mixture, the properties of fresh and hardened concrete were evaluated.

In the first phase of research program, using the data given in [2], the concrete composition was determined for a grade Bc 70/80, with SF as addition in a dosage of 10% from cement weight [3]. Then the cement was replaced in the following dosages: 30%, 40% and 50% from cement weight.

In Table 1 the mix of concrete for grade 70/80 is presented.

Table 1

Sample	Cement dosage kg/m^3	Aggregate mm			Water l/m^3	w/c w/c+SUF	Additive l/m^3	SF addition kg/m^3
		0...3	3...8	8...16				
*B*I Additive type *1*	550	457	359	815	153.3	0.30 0.264	11	55
*B*II Additive type *2*	550	457	359	815	153.3	0.30 0.264	11	55
*B*III Additive type *3*	550	457	359	815	159.5	0.295 0.264	6.6	55
*B*IV Additive type *4*	550	457	359	815	162.4	0.295 0.264	3.08	55
*B*V Additive type *5*	550	457	359	815	162.4	0.295 0.273	3.3	55

For determining the compressive strength were realized cubes of 141 mm size; for determining split tensile strength and tensile strength by bending were realized prisms of 100×100×550 mm size, according to romanian standard. The samples were kept at a constant temperature of $20° \pm 2°C$ and demoulded after 24 h; then were cured for 7 days under water and stored at a temperature of $20° \pm 2°C$.

The following properties of fresh concrete were analysed: densities, workability, consistency, compaction degree; for hardened concrete were determined the tensile strength by bending, split tensile strength and compressive strength.

3. Test Results

3.1. Fresh Concrete

On fresh concrete there were determined the consistency, compaction degree, workability; the obtained results are given in Table 2. For all mixes the slump was zero and the workability was reduced.

Table 2

Sample	Density kg/m^3	Time VE-BE s	Consistency	R_c N/mm^2	R_{ti} N/mm^2	R_{td} N/mm^2
*B*I	2,568	5.4	low plastic	85.5	5.35	5.79
*B*II	2,568	12.4	viscous	87.5	5.6	5.57
*B*III	2,542	8.7	low plastic	90.3	5.53	4.01
*B*IV	2,569	16.8	viscous	75.8	5.35	5.45
*B*V	2,506	12.2	viscous	72.1	5.15	6.88
*B*I 30%SF	2,512	8.2	low plastic	67.2	4.1	3.2
*B*I 40%SF	2,478	4	plastic	60.2	4.46	2.99
*B*I 50%SF	2,515	4.7	plastic	57.6	4.13	1.98
*B*II 30%SF	2,597	5	plastic	71.9	5.08	2.5
*B*II 40%SF	2,505	5.2	low plastic	65.5	4.39	2.25
*B*II 50%SF	2,542	4.7	plastic	59.2	4.42	3.12
*B*III 30%SF	2,496	10.8	viscous	70.8	4.65	3.43
*B*III 40%SF	2,478	5.7	low plastic	64.3	4.46	4.29
*B*III 50%SF	2,533	5.2	low plastic	69.1	4.13	3.5
*B*IV 30%SF	2,533	5.1	low plastic	59.9	4.26	2.3
*B*IV 40%SF	2,469	4.3	plastic	59.1	4.03	2.32
*B*IV 50%SF	2,524	6.4	low plastic	63.0	3.71	1.91
*B*V 30%SF	2,551	4.8	plastic	67.8	3.77	2.16
*B*V 40%SF	2,542	4.7	plastic	69.1	4.06	3.2
*B*V 50%SF	2,533	4.5	plastic	62.5	4.0	3.18

From Table 2 it results that reduced values of densities were obtained for concrete with additive type *4* and 40% SF, and the biggest density for additive type *2* with 30%SF.

In Table 2 are presented the data for concrete consistency determined by VE-BE method. It results that the concrete are low-plastic or plastic and the basic concretes that were viscous with high dosage of SF they became plastic or low-plastic.

3.2. Hardened Concrete

The mechanical properties were determined at 28 days: compressive strength (R_c), tensile strength by bending (R_{ti}) and split tensile strength (R_{td}), that are given in Table 2. In Figs. 1,...,3 are presented the strengths of concrete function of the admixture type.

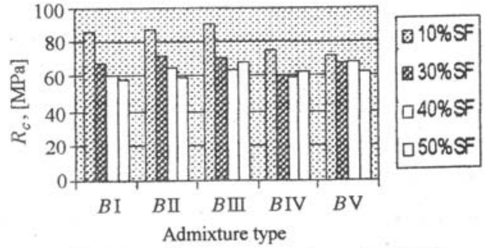

Fig. 1.– Compressive strength,[MPa].

From Fig. 1 it results that for concretes with large amount of SF the *compressive strengths* are smaller than in the case of basic mixture with 10% SF for all types of admixtures. All the mixtures have compressive strength smaller than that required for grade 70/80, so they are of inferior grade. The results are close only for admixture type *5*. For all other types of admixtures the strength differences are important: for the basic mixture the strengths are superior to that for concretes with large content of SF. For *admixture type 1 and 2* it appears that with the increasing of SF, the compressive strength decreases. For *admixture type 3 and 4* it results that with the increasing of SF dosage, the compressive strengths are near the same, with a slow increasing for a content of 50% SF. In the case of *admixture type 5* the compressive strengths are also close, but with a reduction for a content of 50% SF.

In the case of a dosage of 10% SF, the best results are obtained for admixture type *3* and for an increased dosage of SF the maximum value of compressive strength is for *admixture type 2*.

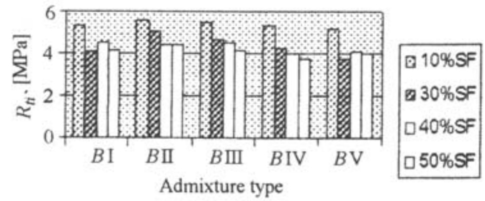

Fig. 2.– Tensile strength by bending.

In Fig. 2 the graph shows the influence of admixture type on the *tensile strength by bending*: for a large content of SF the strength values are much smaller than that for the basic composition for all types of superplasticizer (the increasing of SF dosage will result in reduction of tensile strength by bending). The maximum value was obtained for *admixture type 2*.

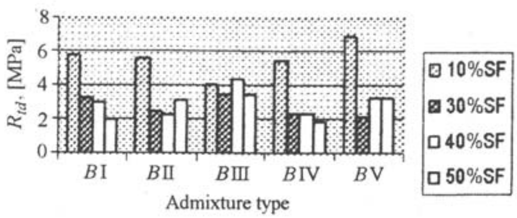

Fig. 3.– Split strength.

From Fig. 3 it can be observed that for all types of admixture the *split strength* is much smaller than the strength of basic concrete. Only in the case of *admixture type 3*, for a content of 40% SF, the split strength is bigger than in the case of basic concrete (in the case of this test many errors can occur). From test results it may be observe that the increasing of dosage can increase the split strength, for *admixture type 2, 3 and 5.*

4. Conclusions

The type of superplasticizer influences the properties of high strength concrete with large amounts of SF in the following ways:

a) *Fresh concrete:* for *admixture type 5* (plasticizer type lignosulfonate), all fresh mixtures were plastic. For *admixture type 3*, the fresh mixtures were viscous-low plastic. For all type of admixtures the fresh concrete have a better workability in the case of high dosage of SF.

b) *Compressive strength:* is smaller for all type of admixture compared with basic concrete. For large amounts of SF the best result is obtained for *admixture type 2* (superplasticizer containing calcium sulfonate), but for the smaller dosage (30%). The *admixture type 5* doesn't give high strengths, but it maintains the strength at high dosage of SF.

c) *Tensile strength by bending:* is smaller for all type of admixture and with increasing of SF dosage it decreases. The best results were obtained for *admixture type 2* (superplasticizer containing calcium sulfonate).

d) *Split tensile strength:* is much smaller for all admixtures than in the case of basic concrete; only in the case of *admixture type 3* (superplasticizer and water reduction containing a solution of napthalene – sulfonate polymer) the strength is close to that for basic concrete.

In conclusion, the admixtures do not influence in the case of concrete with large amount of SF the properties of hardened concrete, but they can influence the properties of fresh concrete.

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EFECTUL DIFERITELOR TIPURI DE SUPERPLASTIFIANŢI ASUPRA PROPRIETĂŢILOR BETOANELOR DE ÎNALTĂ REZISTENŢĂ CU CONŢINUT RIDICAT DE SILICE ULTRAFINĂ

(Rezumat)

Se analizează betonul de înaltă rezistenţă cu un conţinut ridicat de silice ultrafină (SF) funcţie de mai multe tipuri de aditivi. Au fost studiate proprietăţile betonului proaspăt şi întărit pentru

dozaje de SF cuprinse între 30% şi 50% şi comparate cu cele ale unui beton martor cu 10% SF. Influenţa aditivilor în cazul dozajelor ridicate de SF este semnificativă doar pentru betonul proaspăt. În cazul betonului întărit, pentru aditivii de tipul superplastifiant cu conţinut de sulfonat de calciu se obţin cele mai mari valori ale rezistenţelor.