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CONCRETE WITH SELF COMPACTING PROPERTY IN CONSTRUCTION WORK

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1.Abstract

additions. low w/b ratio and superplasticizer are in common use. as in the case of normal concrete mixture to obtain a compact microstructure of hardened concrete. The current state of information are not sufficient to effectively govern the workability of HPSCC with the addition of calcareous fly ash. Further research is needed. particularly embracing the influence of the physicochemical properties changes of calcareous fl y ash and of the type of cement. It was established. that calcareous fly ash can be used as the partial replacement of cement in concrete. or as cement constituent [1-2]. Totally new issue is also the problem of workability of steel fibre reinforced self-compacting concrete with the addition of calcareous fly ash. Mineral additions is key part in the modern concrete technology and their use allows to modify the properties of the concrete and give the significant economic benefits. as well as is in accordance with the strategy for sustainable development. Mineral additions are selected in regard of the strength and durability requirements of concrete. Their application. however. also significantly influences the rheological properties of the mixture. As the mineral additions siliceous fly ashes. ground granulated blast furnace slag and silica fume are commonly used. The main effects of these mineral additions application are thoroughly presented in numerous papers [3-5]. The good workability of SCC mixture during the whole process of concrete placing is the basic requirement for this concrete designing and producing. The high content of mineral additions is typical for SCC which assures its chosen properties. Previous papers point out the problem of worsened workability of concrete mixture with calcareous fly ash. In connection with the fact. that workability is the key part for the self- compacting concrete production. the goal of the series of tests was to verify the possibility of the HPSCC making with the addition of calcareous fly ash. The results of these studies. embracing the HPSCC. are presented in this paper.

2. Rheological properties of concrete mixtures

From numerous research of the concrete mixture workability it is well known. that under stress this mixture behaves like Bingham body [6]. The stress yield value g and plastic viscosity h are the matter constants characterizing the rheological properties of the mixture. Regarding the workability. the stress yield value is a parameter of basic importance. The plastic viscosity is of lower importance for the concrete mixtures compacted by vibrating. however. in the case of self – compacting concrete mixtures the workability is governed by both: stress yield value and plastic viscosity. The concrete rheology was discussed in detail in the book of Szwabowski [6]. Among others in the papers of Banfill [7] and Gołaszewski [8] it was shown that due to the similar nature of influence of basic constituents on fresh mortars and concrete mixtures rheology. the results for mortars could be applied to predict the changes of rheological properties of concrete mixtures. It applies mainly to influence of additions and admixtures.

3. Methods

The basic problem of self-compacting concrete. including those containing the calcareous fly ash. is its workability. In this paper. the rheological parameters of concrete mixtures were tested with rheometer BT2 and Viskomat XL and approximated with Bingham model. It is assumed that the stress yield value g is correspondent with the maximal flow diameter SF. whereas plastic viscosity h is corresponding the flow time for 500 mm diameter T_{500}. while both of these parameters are measured by slump-flow test according to standard EN 12350-8:2009. In the research the influence of the following factors were taken into account: batch of calcareous fly ash (CFA): A and B (Table 1). fineness of HCFA (Table 2) and content of HCFA replacing cement (10-20-30% of mass). The compositions of tested HPSCC mixtures are presented in Table 3.

Table 1. Chemical composition of HCFA

Constituent. %	SiO_2	Al_2O_3	Fe_2O_3	CaO	MgO	SO_3	Na_2O	K_2O	CaO_w
HCFA batch A	40.17	24.02	5.93	22.37	1.27	3.07	0.15	0.20	1.46*
HCFA batch B	40.88	19.00	4.25	25.97	1.73	3.94	0.13	0.14	1.07

* glycol method

Table 2. Physical properties of HCFA

HCFA		Density. g/cm^3	Residue on sieve 45μm. %	Blaine specific surface. cm^2/g	Bulk density. kg/m^3
			Batch A		
A0	Unground	2.64	55.6	1900	1060
A1	Ground 20 min	2.71	20.0	4060	-
			Batch B		
B0	Unground	2.60	46.3	2370	1030
B1	Ground 15 min	2.67	20.8	3520	-

Table 3. Composition of HPSCC mix

Cement CEM I 42.5R	Sand (0-2mm)	Basalt aggregate (2-8mm)	Silica fume	HCFA	Superplasticizer	Stabilizer	W/C
kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	kg/m^3	-
490	756	944	49	49-98-147	17	1.6	0.42

4. Research results and discussion

The effect of HCFA addition on HPSCC mixture workability

In Fig. 1. the influence of HCFA (batch A) and its fineness on flow diameter SF and flow time T_{500} of HPSCC mixtures is shown. Together with the increase of HCFA content in the mix. a small decrease of flow diameter SF was found. Additional grinding of HCFA did not cause a workability loss of HPSCC mixture. The increase of HCFA content in the mixture had caused the increase of the flow time T_{500} of the SCC mixture. however. only on a small degree. Moreover. the decrease in workability in time has been observed. but on a degree allowing to preserve self-compacting properties of the mixture. Similar effect has been observed in the case of HCFA (batch B) addition to HPSCC mixtures. which are presented in Fig. 2.

a b

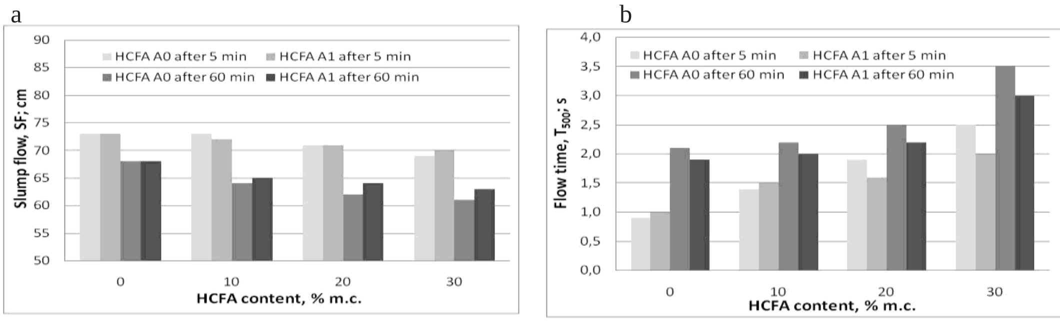

Fig. 1. Influence of HCFA content (batch A) and its degree of grinding on SF and T_{500} of HPSCC mixtures (a). (b).

a b

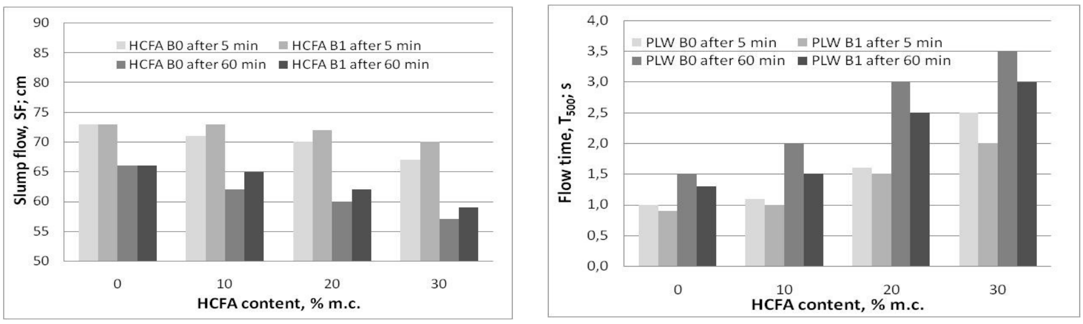

Fig. 2. Influence of HCFA content (batch B) and its degree of grinding on SF and T_{500} of HPSCC mixtures (a). (b).

The effect of HCFA addition on rheological properties of HPSCC mixtures

In Fig. 3. the influence of HCFA content and its fineness on the rheological parameters g and h of the HPSCC mixtures. tested with BT2 rheometer is shown. It was found that the stress yield value g is rising with the increase of HCFA content in A0 and A1 mixtures. In the case of additionally grinding of fly ash. the stress yield value g decreased simultaneously with the increase of calcareous fly ash content. Plastic viscosity h has increased if the addition of fly ash was rising. Similar relationships were found in the study of the influence of the HCFA (batch B) content and its fineness on the stress yield value g and plastic viscosity h of the HPSCC mixtures (Fig. 4).

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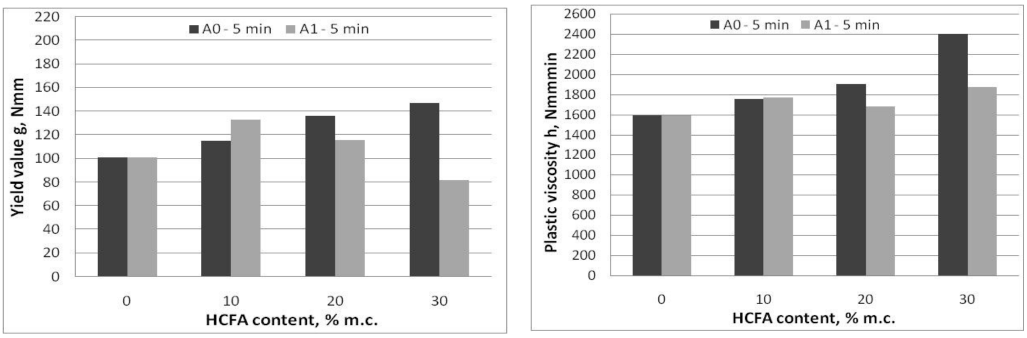

Fig. 3. Influence of HCFA content (batch A0) on the yield value g and plastic viscosity h of HPSCC mixtures (Rheometer BT2) (a). (b)

In Fig. 5 the influence of HCFA content on rheological parameters g and h of HPSCC mixtures. tested with XL rheometer with two repetitions. and approximated with Bingham model is presented. In the case of the mixtures HPSCC (B0) without fly ash the following value was found: g = 223.8 and 225.6 and h = 3.5 and 3.7 (Fig. 11). However. the same mixtures with 10% addition of calcareous fly ash gave the following results: g = 193 and 227.8 and h = 4.9 and 3.6. For the same mixture with the 20% addition of calcareous fl y ash the following results were found: g = 190 and 249.4 and h = 5.4 and 4.4. Finally the same mixture. but with 30% addition of HCFA gave the following results: g = 156.8 and 229.7 and h = 10.7 and 5.6.

In rheological tests with Viskomat XL the rise of yield value g with the increase of HCFA content in HPSCC mixture. was not observed. However. the increase of plastic viscosity h simultaneously with the rise of the HCFA content in HPSCC mixture. was found.

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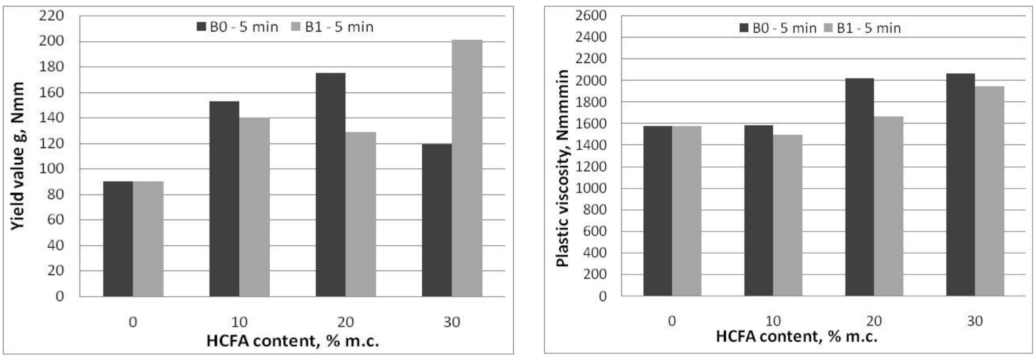

Fig. 4. Influence of HCFA content (batch B0) on the yield value g and plastic viscosity h of HPSCC mixtures (Rheometer BT2)

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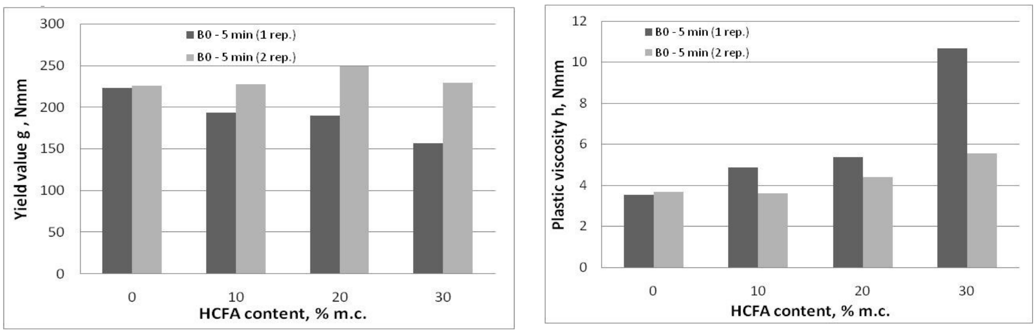

Fig. 5. Influence of HCFA content (batch B) and its degree of grinding on the yield value g and plastic viscosity h of HPSCC mixtures (Viskomat XL) (a). (b)

The effect of variable amount of HCFA additive on mechanic parameters of HPSCC was show in Fig. 6. The addition of HCFA reduces the compressive and flexural strength of concrete. especially if more ash was introduced. The higher the amount of ash in self-compacting concrete is. the lower concrete strength is. Such effect is not observed in concrete compacted in a traditional way. It is most likely the effect of lower mixtures self-compacting (increasing the amount of the air in mixture) with higher addition of ash. which results in higher porosity and strength of hardened concrete. Compressive strength ($f_{cm.28d}$) obtained in tests on concrete is in the range of 60-85 MPa and fulfills the strength requirements for high performance concrete. Concrete strength with content of grind HCFA does not much differ from 100% CEM I of concrete strength. and 30% of grind HCFA concrete strength is about 10% smaller.

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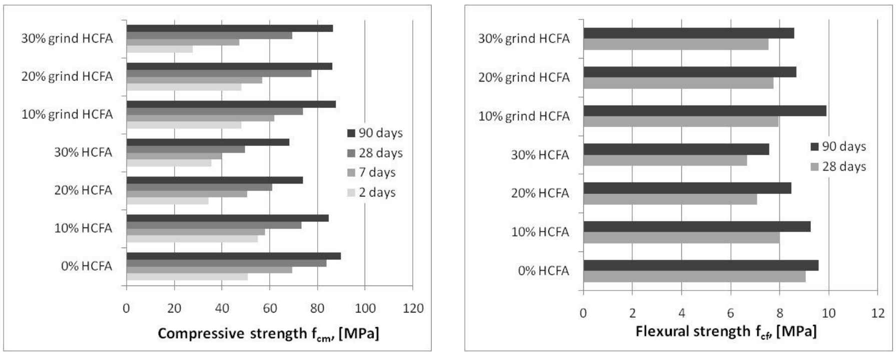

Fig. 6. Influence of HCFA content (batch A0) on compressive and flexural strength of HPSCC concrete.

5. Summary

The presented research confirmed the possibility of HCFA application in high-performance self –compacting concrete. The possibility of preserving the assumed rheological parameters in tested concrete mixtures was proved. The loss of workability with the increase of the calcareous fly ash content in HPSCC was observed. but to the degree allowing to preserve the self – compacting properties of the mixtures.

In the research no significant influence of fly ash grinding on the workability of HPSCC mixtures improvement was found. The additional grinding of fly ashes certainly has the advantageous influence on their properties. however. there is no effect of this change of fly ash fineness on properties of HPSCC mixtures. The compressive and flexural strength of concrete with addition of high-calcium fly ash type II. does not differ significantly from strength of analogous concrete from cement CEM I. if the class of cements is similar. In the initial stage of aging. the presence of high-calcium fly ash shows the development of compressive strength. The self – compacting properties of concrete mixtures with the calcareous fly ash were satisfactory and fulfilled the standard requirements.