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UTJECAJ LETEĆEG PEPELA NA SVOJSTVA MEHANIČKO AKTIVIRANIH CEMENTNIH SMJESA

FLY ASH AND ITS INFLUENCE ON THE PROPERTIES OF MECHANO-ACTIVATED CEMENT COMPOSITIONS

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Stručni članak

Sažetak: *Ovaj članak bavi se utjecajem letećeg pepela na cementne komponente, tj. na efektivnu viskoznost, kinetičku promjenu egzotermnog zagrijavanja i na njegovo vrijeme stvrdnjavanja. Utvrđen je pozitivni efekt mehaničke aktivacije na kompresijsku snagu cementnog morta sa pepelom kao veznim aditivom.*

Ključne riječi: *kompresijska snaga, efektivna viskoznost, leteći pepeo, mehanička aktivacija, portland cement*

Professional paper

Abstract: *This article deals with influence of fly ash on components of cement, that is, the effective viscosity, kinetics changes of exothermic warm-up and it's setting periods. The positive effect of mechanical activation on the compressive strength of mortar cement with ash as a binding agent has been established.*

Keywords: *compression strength, effective viscosity, flyash, mechanical activation, Portland cement*

1. INTRODUCTION

Despite the fact that the use of fly ash in Portland cement has long been known [1,2,3,4], this issue remains relevant considering the need to obtain high-quality building materials and also by saving resource for bind materials.

The fine particles of ash that are located in the space between the grains of cement, are performing the role of a lubricant, enhacing the rheological properties of the composition. Ash also has a sealing effect on the structure of cement stone. At the same time, due to low activity of ash during the hydration of portland cement [5,6,7] there is need for increased of binder flow to provide the required strength properties of the solution.

Known methods of increasing the chemical activity of fly ash increases it's dispersion by mechanical activation [8,9]. In the process of mechanical activation spherical particles of ash are destroyed, which significantly reduces its plasticizing effect [10].

2. EXPERIMENTAL INVESTIGATION

In OGASA (Odessa's academy of civil engineering and architecture) speed thermomixer was designed and developed with fundamentally new design for the mechanical activation of mineral binders and it's additives.

Activation of disperse systems is realized through the collision of particles without destroying them in the active zone of mixer. The collision of the dispersed phase in the turbulent flow leads to a modification of the particle surface without substantially increasing the specific surface, which causes a change in the physical and mechanical processes and effects at the phase boundary [11,12].

Interest is to determine the influence of mechanical activation in proposed speed mixer on the properties of cement-ash compositions (the effective viscosity, exothermic heating, setting time) and the strength of the thereof mortar. In the experiment, Portland cement PC I-500 from Kamenec-Podoski cement factory is used as a binder. As an additive, Ladizhinskoi TES fly ash was used. Ash consumption ranged from 0 to 80% weight of binder. For plastification of ash-cement suspensions superplasticizer C-3 was used, concentration of which was varied in the range from 0 to 1% weight of the binder.

Activation time of ash-cement suspension in a high-speed mixer (n = 2800 spin/min) was 150 seconds. Effective viscosity measurements was carried out every 30 seconds.

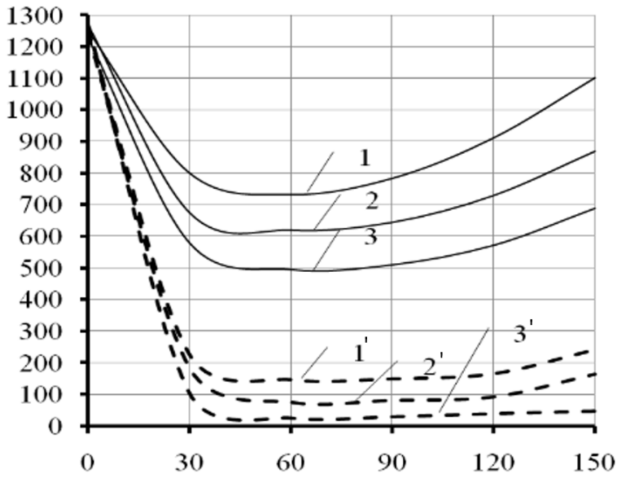

Figure. 1. Effect of the activation time on the effective viscosity change of the ash-cement suspensions

X axis represents the time of activation, while y axis represents the effective viscosity.

1,2,3 - the effective viscosity of a suspensions with fly ash content of 0, 40 and 80%. C-3 = 0%

1',2',3' - the effective viscosity of a suspensions with fly ash content of 0, 40 and 80%. C-3 = 1%

3. EXPERIMENTAL RESULTS

Experimental results of effective viscosity of ash-cement suspension depending on the activation time of ash quantities in portland cement are shown on Fig 1. It has been established that speed mixing reduces the effective viscosity of the suspension.

The minimum value of the effective viscosity is achieved after 60-90 second activation of suspension in mixer. Further activation of suspension leads to increase of effective viscosity, apparently due to increase of internal friction between the dispersed particles of the binder. The analysis of the experimental data (Fig. 1. curves 1, 2, 3) indicates that fly ash has a plasticizing effect on cement-containing suspension.

Thus, replacement of 80% Portland cement with ash reduces the effective viscosity of the suspension after 60 seconds activation with 720 to 500 cps; i.e. almost 30%. Plasticizing effect significantly increases from the combined influence of superplasticizer C-3 and ash on the suspension speed mixing.

Activation of ash-cement suspension (fly ash = 80%) in the presence of superplasticizer-3 leads to a decrease in effective viscosity of the suspension from 1250 cps (inactivated suspension; content of fly ash - 0%, the concentration of C-3 = 0%) to 26 cps, i.e. almost 50 times.

Process of hydration of portland cement is accompanied with increasing of temperature [13]. The character of the curves of the isothermal warming of suspensions gives an indication about the impact on the hydration process of cement mechanical activation as well as the content of fly ash and the concentration of superplasticizer C-3 in the binder.

Determination of exothermic heating solidifying suspension was carried out in a thermos-type calorimeter with temperature fixation after each hour of solidification. The volume of solidifying suspension was 500 ml.

Curves of the exothermic heating shown on Fig 2 indicate that activation of the binder leads to a drastic acceleration of hydration. This is typical for all analyzed concentrations of fly ash in Portland cement.

At the same time it should be noted that increasing the fly ash content in the binder leads to slow heat dissipation, as well as reducing its maximum temperature of isothermal heating.

Thus, if heating of suspension on pure cement clinker reaches its maximum through 6 hour period and then when replacing the 80% of Portland cement with ash, maximum heating-up is achieved after 9 hours.

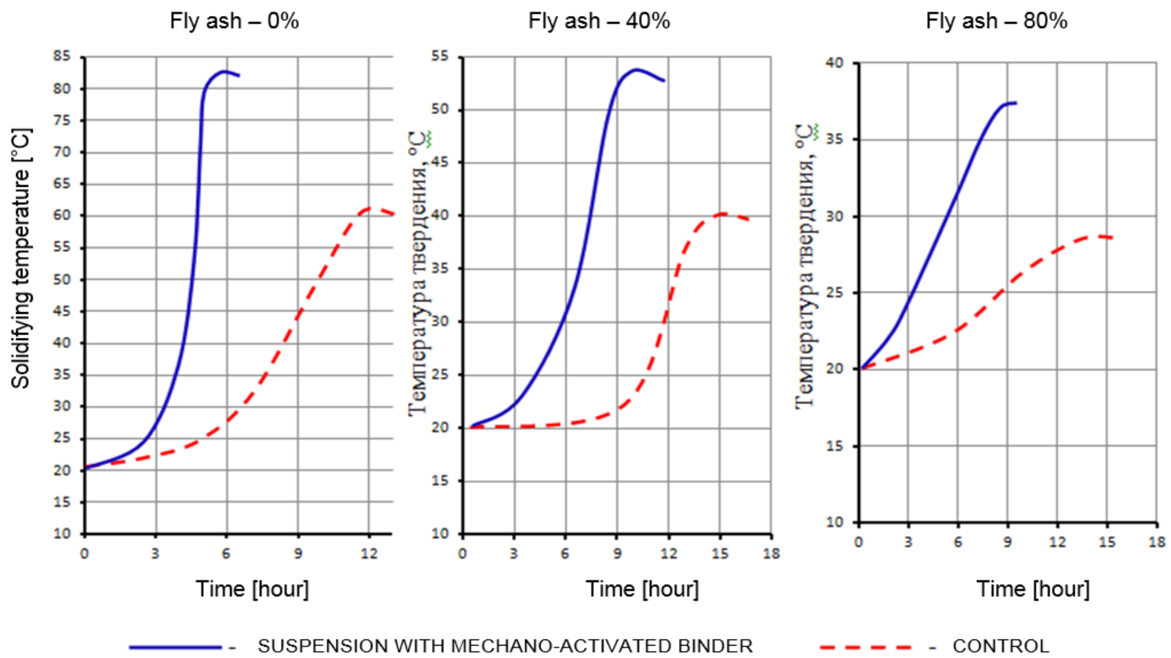

Figure 2 Kinetics of changes in temperature exothermic heating-up of solidifying ash-cement suspensions

Setting time was determined on a test of normal density. The normal density of cement paste (depending on the ash content in the Portland cement and the concentration of C-3) was adjusted by water mixing. The amount of ash in the binder was varied from 0 to 80%. Experimental data on the setting time of cement paste are presented in Table 1.

It has been established for the cement paste in the mechanically activated binder (C-3 = 0%) inserting ash to Portland cement in an amount of 40% delays the setting of the test with from 1 hour 10 min to 1 hour. 40 min. Cement paste with 80% ash in Portland cement starts setting after 2 hours 0 min.

Table 1 Setting time of cement paste

№	Fly ash, %	Cement %	C-3, %	The setting time, hour: min			
				Activated binder		Activation of the binder is absent (control)	
				Start, $\tau_н$	End, $\tau_к$	Start, $\tau_н$	End, $\tau_к$
1	0	100	0	1:10	3:45	2:00	5:15
2	40	60	0	1:40	4:25	2:55	6:10
4	80	20	0	2:00	5:10	3:30	7:20
5	0	100	0,5	1:15	4:45	2:10	6:40
6	40	60	0,5	3:05	8:00	5:30	11:20
8	80	20	0,5	5:50	12:05	10:10	17:00
9	0	100	1	1:40	6:20	3:00	9:00
10	40	60	1	4:05	11:55	8:05	16:55
12	80	20	1	6:30	14:30	11:20	20:25

Setting of cement paste on a non-activated binder starts (with similar content fly ash in Portland cement) occurs in 2 hours 55 minutes and 3 hours and 30 min, accordingly.

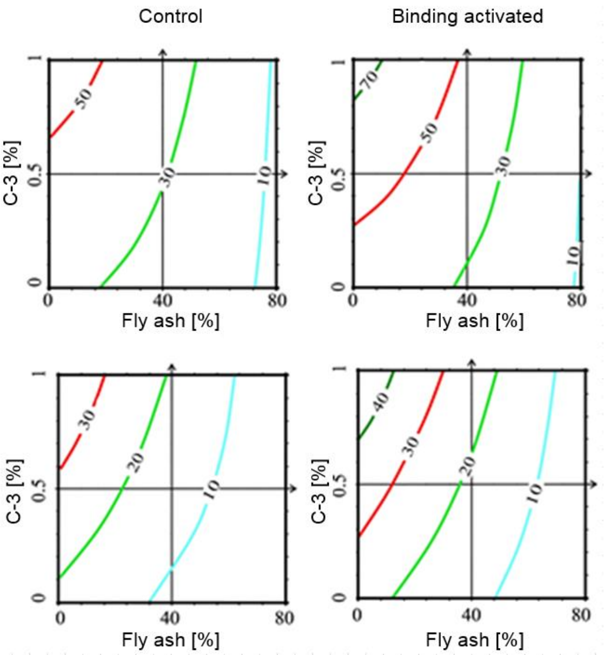

Figure 3 Effect of fly ash and superplasticizer C-3 on the compression strength of the mortar [Mpa]

It should be noted that insertion of additive-3 in cement paste n an amount of 1% even reduces its normal density at 5 ÷ 20% (depending on the content of fly ash in Portland cement) nevertheless slows down the process of structure formation, which effects on slowdown of setting time start. This is typical for both the cement test on a pure Portland cement, as Portland cement with fly ash additive of 40 and 80%. Decelerating influence of fly ash and superplasticizer C-3 also affects the end of the cement paste setting.

Of interest to determine the effect of the ash content and the concentration of C-3 in Portland cement on the compressive strength of mortar mix composition of 1: 2. In the experiment quartz sand was used with Md = 2,7. The experiment was carried out by 2 factorial designs. As independent variables, following factors of variation were adopted: X1- consumption of ash in Portland cement (40 ± 40)%; X2 concentration of C-3 in the binder (0,5 ± 0,5)%.

Two parallel series of experiments were carried out. First - (Control) - by the traditional technology, the second - with mechanical activation. The activated suspension was mixed with quartz sand in the low-speed mixer until it reached homogeneously state.

According to the obtained experimental and statistical models, diagrams have been constructed, showing the influence of varying factors of composition on the compression strength of the mix, Fig. 3. Mechanical activation increases the strength of mix to 20 ... 25%, thus allowing (by obtaining the mixes of equal strength) 15 ... 20% of Portland cement clinker component to be replaced with the fly ash.

4. CONCLUSION

After experimental and statistical models, we can conclude following:

1) Fly ash has a plasticizing effect on cement-composition, which is confirmed by reduction of the effective viscosity.
2) Activation of ash-cement suspension leads to acceleration its exothermic heating according to comparison with control.
3) Mechanical activation increases the strength of mix to 20 ... 25%, thus allowing 15 ... 20% of Portland cement clinker component to be replaced with the fly ash.

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