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Correlation of Material and Mechanical Properties of the Cement Paste with Fly Ash, depending on the Water Content

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Abstract. In a commonly used Portland cement CEM II is possible according to ČSN EN 197-1 to replace the clinkers from 20 to 35% by weight of cement with another. This compensation is usually slag, but it is currently expensive and especially scarce material. Therefore, the effort to implement this compensation and other material, for example fly ash. This paper deals with the properties of cement paste with different proportion of fly ash in the mixture. Specifically, the experimental analysis of mechanical and material properties depending on the water content in the mixture hardened, he would replace 40 respectively 50% by weight of cement by fly ash.

Introduction

Fly ash can be used in different sectors, but by far the most applying this material in the construction industry [1]. Fly ash are produced annually with regard to the method of energy production in the Czech Republic above average amount compared to Europe and the world. This is one of the main reasons why this material in the Czech Republic more attention. Another is currently insufficient amount of slag in Europe, which is widely used in composite cements. Here we see the main use of large quantities of fly ash. Standard ČSN EN 197-1 defines the composition of mixed cement and clinker can be replaced from 20 to 35% by weight of cement another component [2]. Basic standards for fly ash is standard ČSN 72 2071. This standard addresses both the coal and combustion processes, which arise from different fly ashes, as well as control and the methods of testing their properties for various construction purposes [3]. Our main concern is the behavior of the resulting material. This paper deals with the properties of cement paste with 40 and 50% replacement of cement with fly ash and the influence of water content in the mixture on the resulting material properties and their dependence. As shown in the detailed analysis of the 50-year-old concrete from Orlík dam, where it was used to reduce the heat of hydration 30% replacement of cement with fly ash, can have such material excellent properties [4].

Material and specimens

For the purpose of the experiment was necessary to produce high-quality mixture of water, cement and fly ash. Cement used was Portland cement CEM I 42,5 R from the locality Radotín. Fly ash was chosen from locations Melnik type of fly ash into concrete according to

EN 450 [1]. They were made three types of mixtures where the refund was 0, 40 and 50% by weight of cement with fly ash (a designation mixture - CFA 1000; CFA 6040 and CFA 5050). Water ratio has always been 0.4 to the total binder. For the purpose of the experiment was made several sets of beams with dimensions 20x20x100 mm and 40x40x160 mm. Before the specimens tested were stored in a water bath, one group of samples of one month and the second 14 months.

Volume density

Volume density listed in Tab. 1 was evaluated on specimens with dimensions of 40x40x80. For drying, the four sides painted with epoxide to define the flow of moisture. Both processes, saturation (at 20°C) and drying (105°C), were conducted for a period of time before a steady weight. The results show that the total loss is about 20% and the more fly ash mixture contains, the greater the losses. However, when the body temperature loaded from 150-600°C which was held for 24 hours and then there was a spontaneously cooling to 20°C can be observed an interesting trend and that there is almost no loss of density in mixtures with 50% replacement of cement with fly ash compared to "pure cement" [5].

Tab. 1: The average values of volume density for each mixture and their decrease due to drying

Mixture	Ø ρ_{sat}	Ø ρ_{dry}	Decrease
	[kg/m^3]	[kg/m^3]	[%]
CFA 1000 1m	1996,333	1616,951	17,9
CFA 6040 1m	1814,867	1416,040	21,2
CFA 5050 1m	1812,567	1430,977	22,1
CFA 1000 14m	2011,820	1651,535	19,0
CFA 6040 14m	1824,075	1437,126	22,0
CFA 5050 14m	1779,493	1386,952	21,1

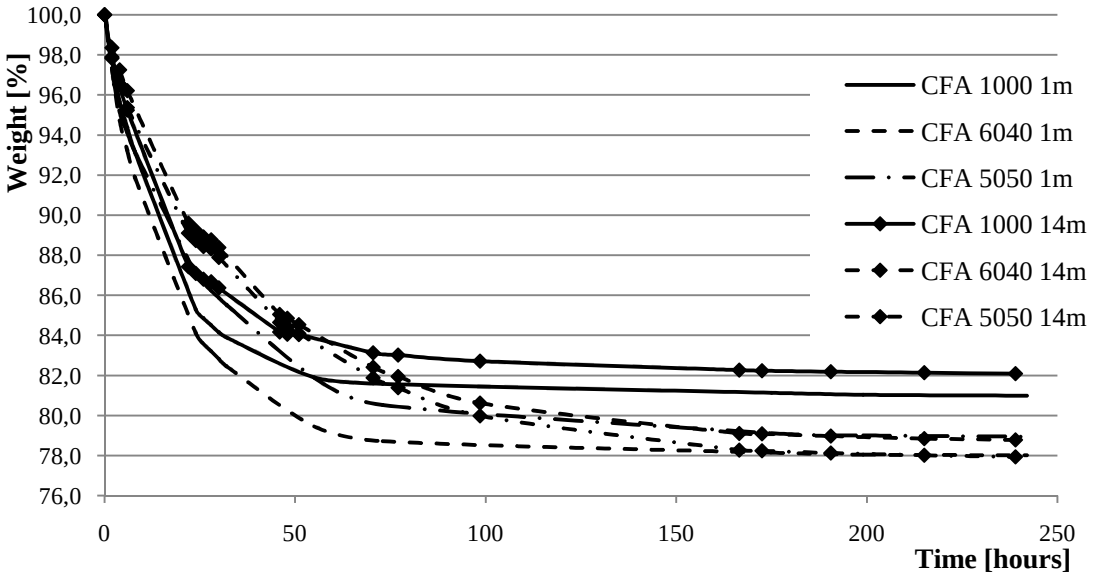

Fig. 1: Percentage change in weight of specimens of cement paste with different proportion of fly ash in time due to drying

On Fig. 1 is shown diagrammatically decline in the average percentage weight during drying. The process took about 10 days, when the weight has stabilized. Can be observed that during the first approximately 48 hours, occurring in all mixtures to rapid weight loss (15 to 20%). Then the process was slow progression.

Compressive strength

The results of all measurements were statistically evaluated. Average values of the compressive strength with a standard deviation of less than 5%, are shown in Fig. 2, which shows the value of the cement paste without fly ash and 50% substitution at 1 and 3 months. From the results it is evident that the resulting values are higher for the dried specimens and the value at time significantly increased.

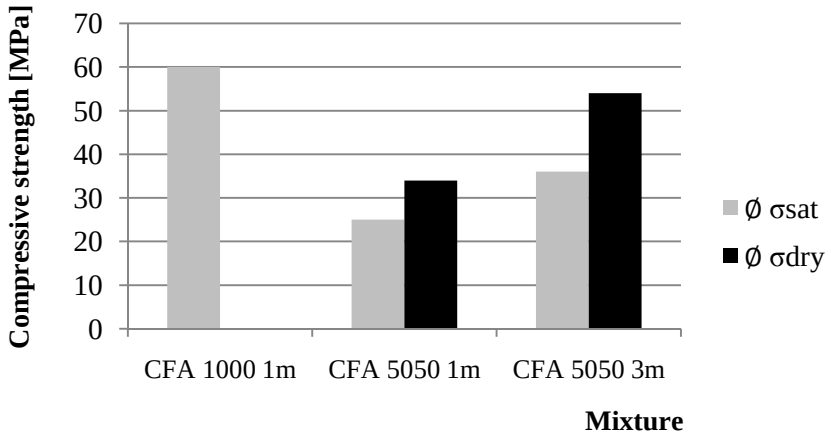

Fig. 2: The average values of compressive strength for each mixture and time

Static modulus of elasticity

The average values of the static elastic modulus are shown in Fig. 3. Compared to the compressive strength can be observed the opposite trend. Higher values were saturated samples. The increase in the values of static modulus of elasticity over time is also significant in this group of specimens. The dried specimens, the increase is minimal.

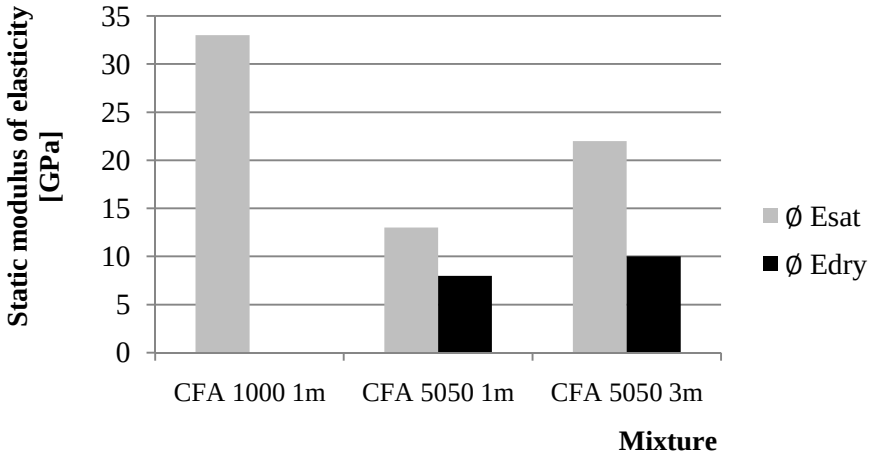

Fig. 3: The average values of static modulus of elasticity for each mixture and time

Summary

Experiment dealt material and mechanical properties of the cement paste and cement paste with 40 and 50% replacement of cement by fly ash. Water ratio had a value of 0.4 for all mixtures, specifically the effect of water content on the measured properties. Results of measurements and calculations were statistically analyzed and compared with each other. For the experiment shows, that the direct relationship between the compressive strength and density of dried and saturated specimens. The same goes for static modulus of elasticity. Weight of test specimens during drying was measured until a steady state. The largest reduction in all mixtures occurred during the first 48 hours drying. Difference at the end of the test between specimens, which was one month old and 14 months old, was from each mixture 2% maximum. It can therefore be stated here that the content of fly ash in the mixture does not play too big a role.

The further work is given in detail as problem areas. Specifically, the variability of fly ash, delay the beginning of solidification a slow increase in initial strength or carbonation [6]. The result should be setting limits for individual properties. Another big problem is the absorbability of fly ash in powder form, which in the literature is addressed too. We would like to dedicate but also the positive effects of fly ash when added to a mixture of them and define criteria for various purposes use in construction. Here's environmental and economic influence, reducing the heat of hydration and improving porosity. The long-term goal should be greater use of fly ash with the help of experiments supported simulations.

Acknowledgement

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