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Properties of cement Paste with Addition of Fly Ash from the Perspective of Creep

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Abstract: Waste materials are usable in the building material for the production of building components and elements. Between the usable waste materials may be counted as fly ash, which is predetermined by their properties for construction use. The article presents an overview of the behavior of one of the materials - cement paste with addition of fly ash in creep. Creep from the perspective of an important long-term durability of building materials. Data from the measurements have been treated to remove the influence of shrinkage and has been worked upon with only basic creep. This paper presents the influence of water saturation on the size of the material creep. The article includes a comparison of experimentally obtained data with the model for the creep of concrete creep B3.

Keywords: Fly Ash, Cement Paste, Creep, Shrinkage.

1. Introduction

The power plants produce annually 8 million tons of fly ash in the Czech Republic. Fly ash is generated as the secondary product by burning brown coal in the lignite power plants. The generated quantity of the fly ash is between 10 % and 30 % of the original volume of burned coal. Grain size fly ash from power plants is between 1 and 1000 microns [1]. Density of ash from power plants is between 750 and 950 kg/m^3. From the perspective of chemistry, the fly ash is inert material; the main component is SiO_2 and $Al2O_3$ and CaO and SO_4. The fly ash is a suitable building material for their inert behavior.

Conventional fly-ash contains up to 80 % glass phase, as the main component. Sulfur content (expressed as SO_3) usually does not exceed 1 %. In the high-temperature combustion of coal is not necessary to add ground limestone into burnt mixture. The resulting ash typically does not contain calcium compounds such as $CaSO_4$, and also higher amount of sulfur in the form of SO_3. The combination of cement paste and fly-ash from power plants creates an interesting productivity, which has its advantages, but also its weaknesses. Among the positive properties can be conceived: a higher resistance to aggressive environments, lower density and improved workability.

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Among the negatives can to include decreased compressive strength and the potential increased content of heavy metals that are contained in the ash. The strength of concrete [2], [3] is also possible improve in case of using of the fly ash by their activating in concrete. Fly ash is contained in many types of cement as an additive. Activation of fly ash can be started, appropriately CaO content in cement, which are often very complicated.

In several previous works have been defining the characteristics of cement paste mixed with ash from power plants [4]. Tensile bending strength of cement paste with addition of fly ash reaches higher values than the pure cement paste. Modulus of elasticity of the final mixed material is lower [5]. Fracture energy [9] of cement paste with fly ash also decreases, but this decrease is not so significant [6]. Very good values of tensile strength in bending were achieved when the weight ratio of cements and fly ash was 1:1.

2. Cement paste and preparation

The experiments were realized by the cement paste with addition of the fly ash. The components of cement paste were: Portland cement CEM I 42.5 R, fly ash and water [10]. From components were prepared the cylindrical specimens into the plastic moulds. Water / cement ratio of the prepared cement paste was 0.4. In the cement paste was used 40 % water of the weight of solid components. The specimens were taking out from moulds one day after production. After that the specimens were placed into the water basin.

The specimens were cut shorted on the length 70 mm. A diameter of prepared cylinders was 10 mm. For the experiments were prepared six specimens. First two specimens were determined for a measurement of creep in drying condition. Other two specimens were used for a measurement of shrinkage. The last two specimens were used for a measurement of creep in water saturated condition.

The specimens were placed in water basin for five month.

3. Data from measurement

The age of the tested specimens was 150 days. The measurement of creep was realized in the lever mechanisms. The total number of specimens was six of which two specimens were tested on shrinkage, only. The other two specimens were tested in water saturated condition and the last two specimens in water dried condition. Applied load on specimen achieved size 697N. This force was unchangeable during

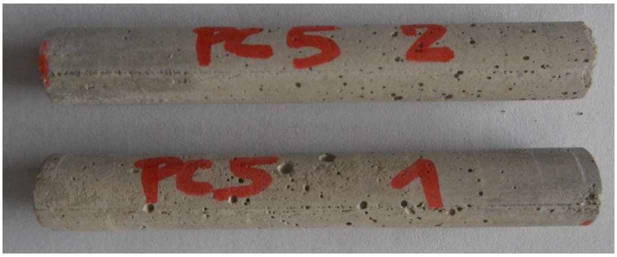

Fig. 1. Specimens for creep tests.

process of measurement. All specimens were covered in the foil due to guarantee condition of the humidity. The specimens were loaded by a plumbs after their placing in the lever mechanisms. For example see Figure 2, where loading is show in increasing curve of the creep at deformation 68μm.

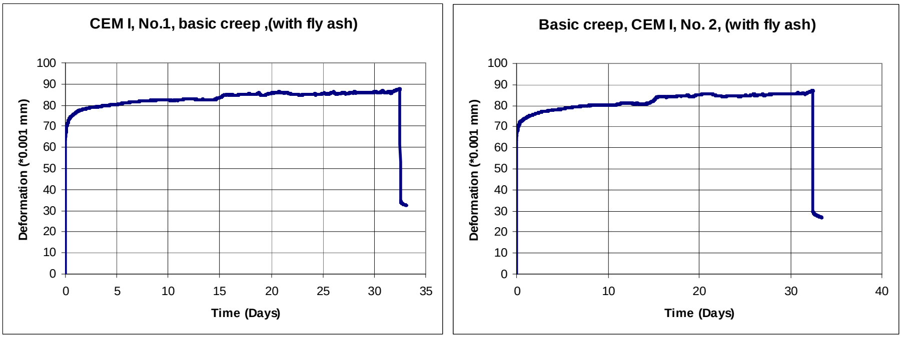

Fig. 2. Basic creep of specimens No. 1 and No. 2 in dry condition.

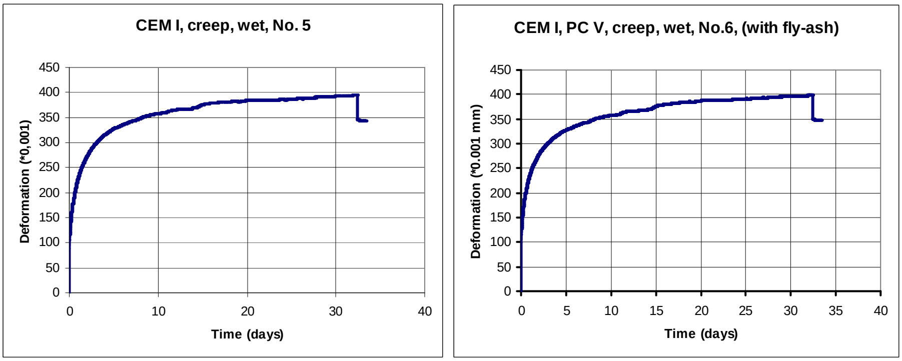

Fig. 3. The creep of specimens No. 5 and No. 6 in dry condition.

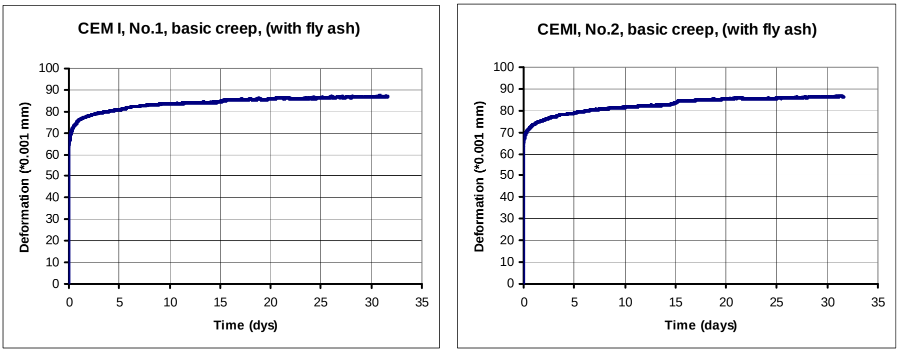

Fig. 4. Basic creep of specimens No. 1 and No. 2 in dry condition. Basic creep is calculated with shrinkage of the specimen No.4.

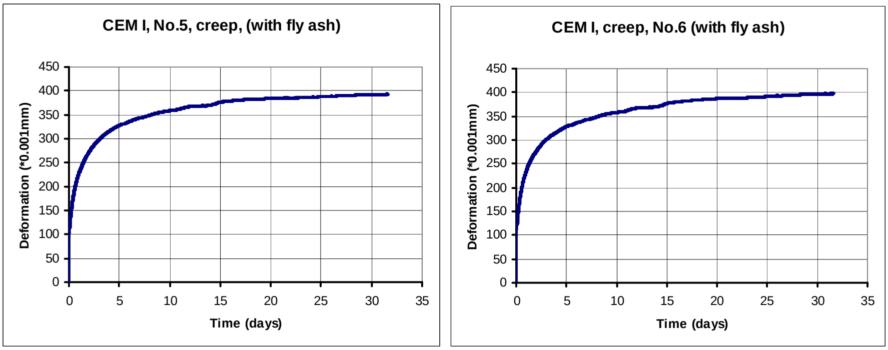

Fig. 5. The creep of specimens No. 5 and No. 6 in dry condition. Basic creep is calculated with shrinkage of the specimen No.4.

Figures 2 a 3 display results calculated with shrinkage of the specimen No.3. Next a figures 4 and 5 display results calculated with shrinkage of the specimens No.4. Between the graphs are some little differences caused by the differences between the curves of shrinkage specimens. Length of testing was 32 days. In the figures 2 and 3 is possible see unloading after finishing of test.

4. Results

At figures 6 – 9 are displayed results of comparison between curves of creep and simulation of creep. The curves of basic creep are displayed in the figures 6 and 7. The curves of creep of specimens saturated of water are displayed in the figure 8 and 9.

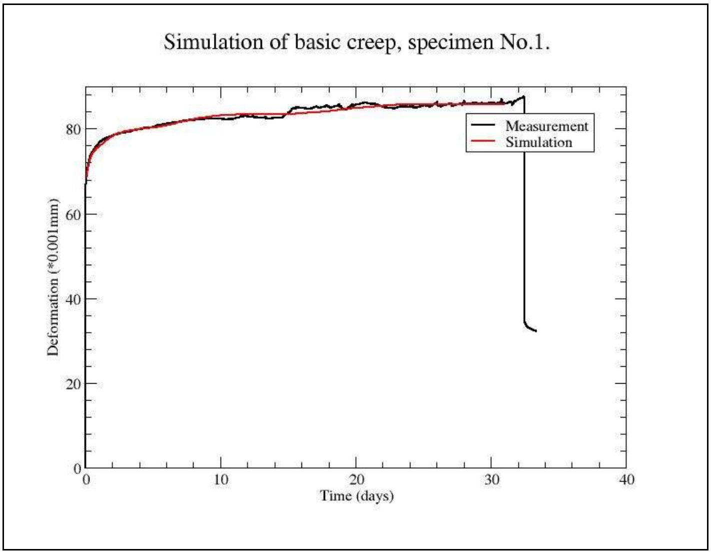

Fig. 6. Comparison between the measurement and simulation of basic creep for specimen No.1.

The simulations of creep were solved in OOFEM program [7]. It is the programming environments with built/in model B3 for creep [8].

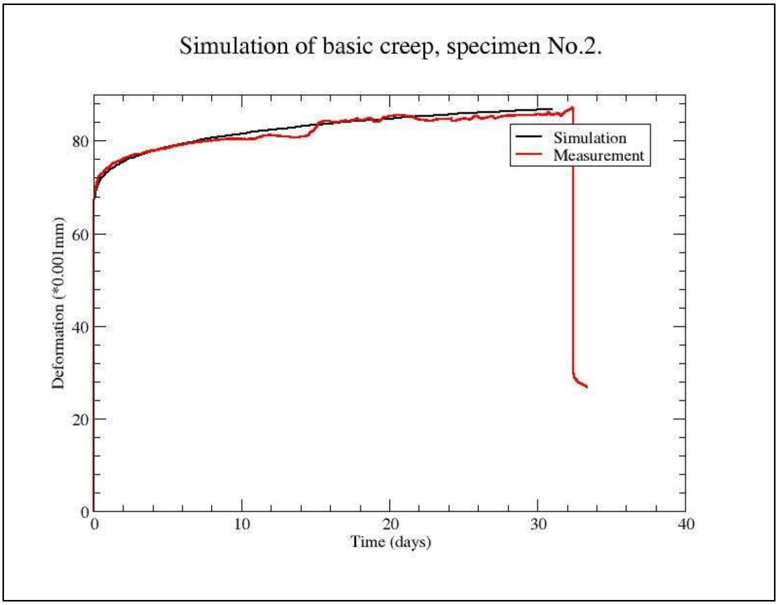

Fig. 7. Comparison between the measurement and simulation of basic creep for specimen No.2.

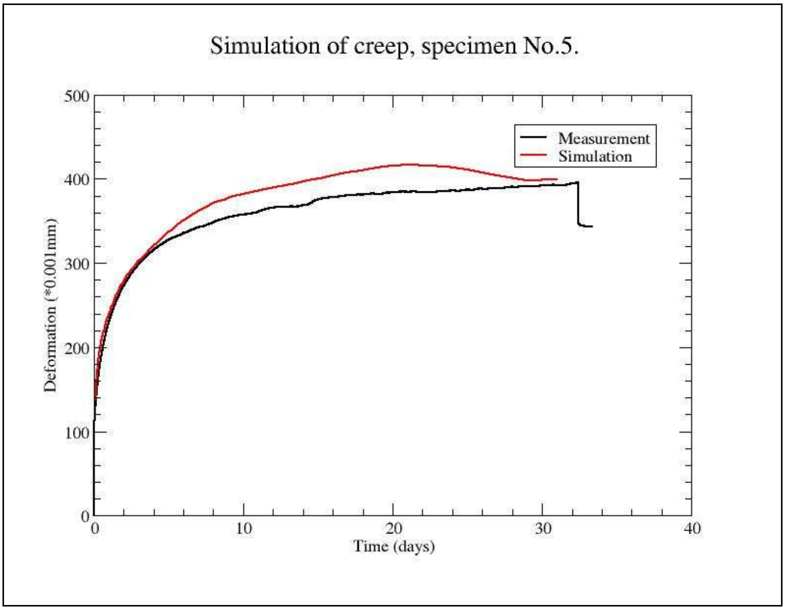

Fig. 8. Comparison between the measurement and simulation of creep for specimen No.5.

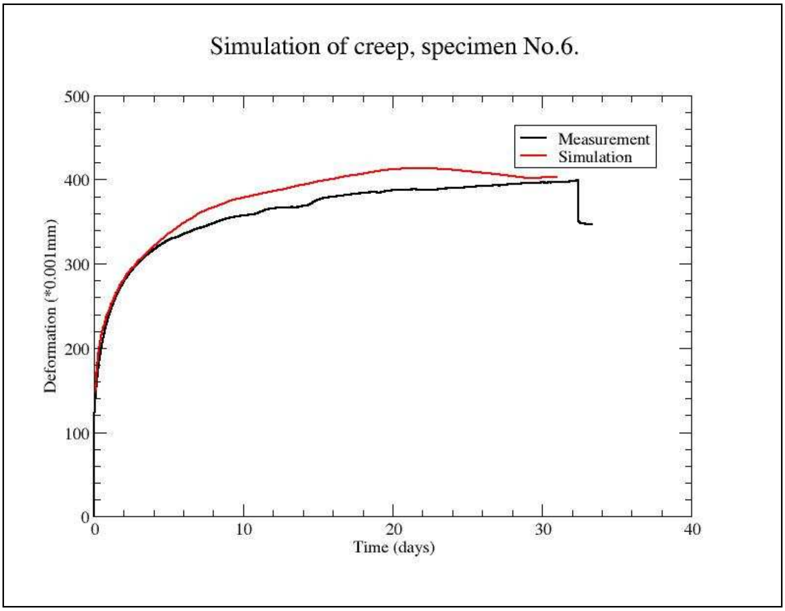

Fig. 9. Comparison between the measurement and simulation of creep for specimen No.6.

5. Summary

The presented graphs show, the basic creep reach in value over 32 days to 16 microns. Nearly identical results are obtained using the curves of shrinkage of specimen No. 3 and No.4.

The water-saturated specimens [8] reaches very high values creeping. Creep without the influence of shrinkage after 32 days reached values near to 220 microns. All specimens were tested in the age five months. The age of the production has a significant influence on the size of creeping at the initial stage of measurement. In all cases, measurements of deformation solids, the increase was steepest during the first 5 days.

In the past, compliance tests were conducted simulations of creep of pure cement paste model B3 [9]. Even if the simulation creeping of cement paste mixed with fly ash is possible to achieve good agreement between the model and real measurements. Table 1 contains the overview of selected factors creeping q.

Table 1. Coefficients q for simulation.

Specimens	q_1	q_2	q_3	q_4
No.1	0.052144	27.53022	-2.14529	0.088075
No.2	0.076967	-68.15178	5.62104	-0.192593
No.5	-0.02951	-1981	162.62	-6.8547
No.6	-0.02951	-2318	190.15	-8.0907

Acknowledgements

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