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HIGH TEMPERATURE AND ITS INFLUENCE ON THE CREEP OF CEMENT PASTE FROM CEM II

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Abstract: *Material properties provide the basic inputs for mathematic modeling of material. Creep of cement paste is possible to be assigned to the basic properties. In the paper, there are presented results of experimental testing of creep of cement paste. Cement pastes were prepared from Portland cement CEM II. Selected w/c ratios 0.3; 0.4 and 0.5 were used for preparation. Tested specimens were heated by temperature of 300 °C before start of testing. The shape of specimens was a cylinder with diameter 10 mm and length 70 mm, and specimens were tested in special lever mechanism designed for creep test of small-grained materials. The results of testing are divided into the creep of specimens and shrinkage of specimens. In the first chapter, there is described the preparation of specimens. The second one includes the results of material tests, i.e., compression strength and modulus of elasticity. Results of creep tests, especially graphs from creep tests are described in the next chapter, and finally, results are summarized. In the results of creep tests, there are presented graphs of water dried and saturated specimens and results are discussed.*

Keywords: ***Cement paste, creep, shrinkage, compression strength, computational model.***

1. Introduction

The creep is considered to be among primary properties of concrete. Size of creep is very important for design concrete structures. Concrete is a composite material (Neville, 1997) which consists of ingredients: cement, water, aggregates, additives and special admixtures. However, the basic part of concrete is mixture (Rixom, Mailvaganam, 1999) of cement and water (De Larrard, 1999). The mixture of cement and water is named cement paste. The properties of cement paste are basic properties for knowledge about performance of concrete.

Cement paste usually achieves the high values of strength (Takada, 1999). If area of loading is large, then applying high load is necessary for achieving correct level of loading. It is reason for reduction of specimen's loading area. The same type of specimens is used for the creep and compression tests. Cylindrical specimens are made into the plastic moulds. Lengths of made out specimens are between 90 and 100 mm. Sufficient length of specimens is 70 mm for testing the cement paste creep. Small kind of gauges is necessary to use for measurement of deformation. Optoelectronic probes are a suitable alternative to the LVDT gauges. By the optoelectronic probe, it is possible to achieve good results of measuring the creep. Their sensitivity is at 0.2 μmm.

Specimen length 100 mm is reduced to 70 mm, length which is suitable for creep tests. Diameter of all specimens in the moulds is 10 mm. Area of specimen for application of load is 78 mm^2. Specimens were prepared for this set of tests from Portland cement CEM II 32.5R, it is cement with addition of slag and a little bit of fly ash, calcium sulfate and calcite. Properties of cement characterize a lower heat of hydration and higher resistance for aggressive influence of environment.

Specimens were made with water-cement ratio 0.3, 0.4 and 0.5. Water cement ratio (w/c) is the weight proportion of water and cement. The second series of specimens was made from Portland cement CEM II with w/c = 0.4, see Fig 1. The third series was made from Portland cement and water too, but with w/c ratio 0.3. Cement mixture was sufficiently liquid (w/c = 0.5) and it was possible pour to the moulds. Better properties were achieved by using the plasticizer during the production, namely for w/c ratio 0.3 and 0.4. Content of plasticizer was 1.3 % of weight of cement. Cement paste with water-

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cement ratio 0.3 was prepared by using the plasticizer too, namely Spolstan with quantity of 3 % from cement weight.

All specimens were before testing heated in the temperature cube. Temperature was applied to the specimens by below described procedure. Specimens were heated to 300 °C during 1 hour. After then specimens were heated at 300 °C during 2.5 hours. The specimens were then 20 hours cooled at temperature 20 °.

Lever mechanism (Fig. 2) is the equipment for creep measuring and shrinkage of cement paste and it was developed as a special equipment for creep tests of homogenous materials. Stationary load is applied to the specimen. The size of the applied load depends on the weight of plumb and location of plumb at the lever. The measurement of deformation is realized by using three optoelectronic probes. The length of deformation is the whole length of specimen which is placed into the lever mechanism. Axial deformations are measured by the three optoelectronic gauges. The average deformation is calculated after termination of measuring.

In executed experiments, there were used specimens with diameter 10 mm. The applied loads were approximately between 740 and 760 N. For the measuring of the specimens shrinkage was applied load 76 N. Applied loads on specimens were invariable for whole measuring period. Specimens were firstly placed into the lever mechanism and after then systems were loaded by plumb. Measuring the deformation was started after specimen placing into the lever mechanism. Period of measuring was from 27 to 30 days. The plumbs were taken off before finishing of measuring. After then, all specimens were taken out of lever mechanisms and prepared for compression testing.

Parameters of material properties were measured during the testing continuously. The modulus of elasticity and compression strength was computed from data of measured data (Kala, 2010). Young's modulus of elasticity was calculated like a secant, linking the start and value at stress-strain curve which correspond to 1/3 of the strength. An extensometer with measurement length 25 mm was used for measuring of strain. The extensometer was placed in axial direction at the middle part of the specimen (Van Mier, J.).

2. Results of creep tests

Results of creep and shrinkage were achieved from tests in lever mechanism. The 6 specimens were tested in the whole series. Specimens tested in creep tests were loaded by load 740 N. Creep tests were executed in two conditions. The first condition was represented by water saturated specimens. The second one was represented by drying of water from specimens. The first set of specimens was placed back into the water basin for 24 hours after their temperature loading. The specimens were placed into the lever mechanisms after their water saturation.

Two specimens were tested in the water saturated condition. Next two specimens were tested in water dried conditions (after temperature heating). The shrinkage was tested in saturated and dried condition, too. Only one specimen saturated and one specimen dried was tested for shrinkage. The cement paste prepared with w/c ratio 0.4 was tested on shrinkage in wet condition only.

Specimens were covered by plastic wrap before the creep and shrinkage tests. Before covering, some specimens were placed into the water basin. All specimens were 1 year old.

Tab. 1: Deformation of specimens from creep and shrinkage tests.

Specimen	w/c 0.3	w/c 0.4	w/c 0.5
1	70 *	30.66	137.7
2	49.56	-0.16	251.8
3	-44.3 *	-30.13	-21.9 **
4	-93.63	-36.3	-73.7 ***
5	39.2	-24	0.2
6	64.83	-29.46	14.4

*Test finished 13^{th} day, ** Test finished 4^{th} day, ***, Test finished 24^{th} day.

In the next figures Fig. 1, there are presented typical graphs of creep test. In last graphs, it is possible to see comparison of experimental results of basic creep and simulation in OOFEM (Patzák).

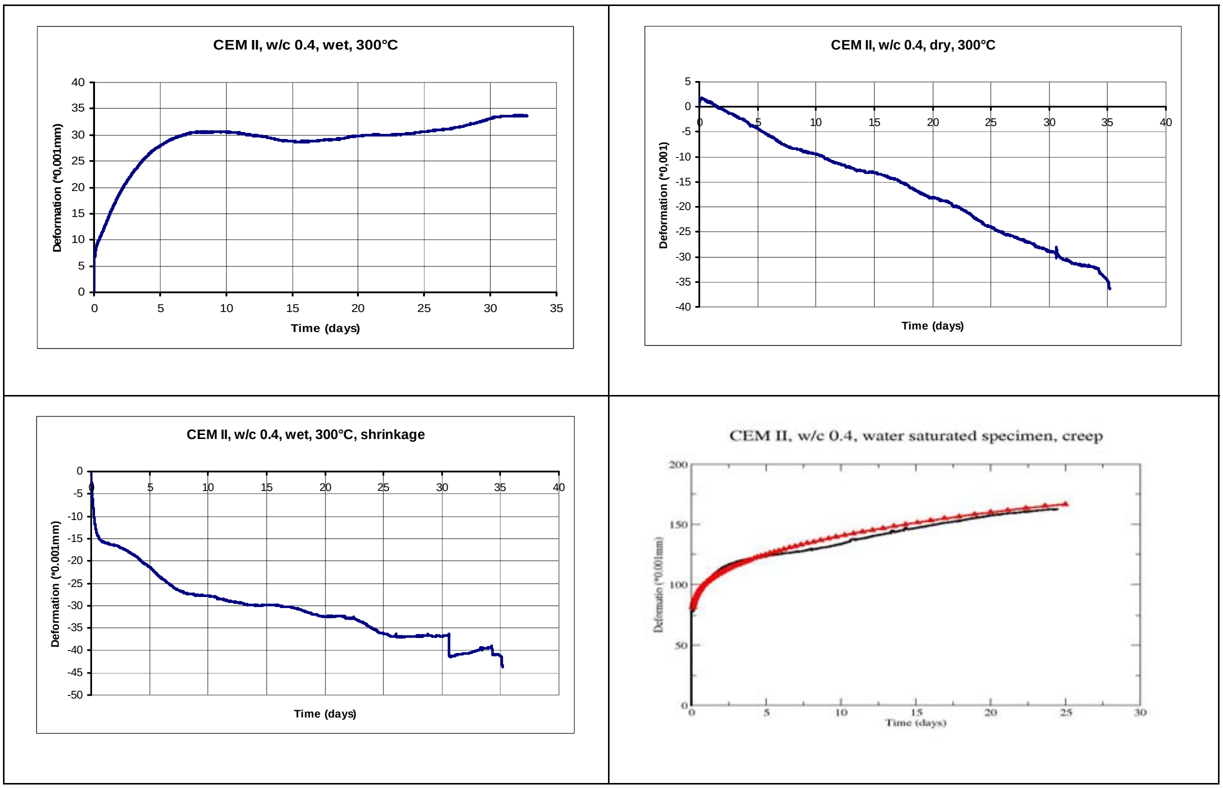

Fig. 1: Creep and shrinkage of cement paste prepared with w/c 0.4.

3. Results of compression tests

Values of compressive strength were obtained from stress- strain diagrams of specimens. Measuring was executed after finishing creep tests. Weights of the specimens were checked before start of compression tests. Average weight of the specimen prepared by w/c 0.3 was 10.308 g, with standard deviation 0.267. Cement paste prepared with w/c 0.4 had average weight 10,725 g, and standard deviation was 0.287. Specimens had average weight 8.897 grams with standard deviation 0.269 in the third series (w/c 0.5).

In Tab. 2, there are displayed results of compression tests of the specimens. 5 specimens were tested in the first series (w/c 0.3). In the next two series, 6 and 5 specimens were tested. Specimens in w/c 0.3 series had values of strength from 74.5 MPa to 150.3 MPa. The lowest values of compression strength were achieved for specimens tested in shrinkage test and water dried specimens tested in creep test. The second series (w/c ratio 0.4) had closer values; from 70.4 MPa to 129.4 MPa. Specimens No. 4 and 6 had extreme values of strength to the average value of strength 101.3 MPa

Tab. 2: Deformation of specimens from creep and shrinkage tests.

Specimen	w/c 0.3	w/c 0.4	w/c 0.5
1	140.0	100.9	80.5
2	153.3	106.8	78.7
3	77.1	105.9	-
4	74.5	94.6	53.8
5	136.5	70.4	60.2
6	-	129.4	78.3

Five tested specimens in third series had the average value of strength 70.3 MPa. The lowest value of strength was stated for specimen No. 4, it was the dried specimen tested in shrinkage test, before. Cement paste prepared by w/c ratio 0.5 had lower strength than cement pastes including lesser content of water (Fig. 6). Average strength was 143.26 MPa, 102.05 MPa and 74.42 MPa for specimens prepared by content of water in the mixture 0.3; 0.4 and 0.5. Standard deviations for results of compressive strength were 9.531, 5.603, and 8.863 (w/c ratio 0.3, 0.4 and 0.5).

4. Conclusions

The values of compression strength were determined in experimental part of work. Curves of creep and shrinkage were determined for three types of cement pastes, too. The first series (average strength was 143.2 MPa) was the strongest in the compression tests, and it was prepared by w/c ratio 0.3. The third series (w/c = 0.5) achieved only half value (74.4 MPa) of average strength of the first series. Content of water in cement paste mixture influences the strength of hardened cement paste. The values of compression strength depend on the type of cement, too.

If the content of water in cement gel is increasing, deformation of the water saturated specimens is increasing, too. Shrinkage of the all types of water saturated cement pastes was between 22 and 44 μm. Shrinkage of water in dried cement paste specimens was 93.6 μm, and 73.7 μm for cement paste prepared with w/c 0.3 and 0.5. The size of shrinkage influences both the rate and size of creep

Conformity between simulation and experiment illustrate that the model B3 (Patzák, 2000) is suitable for analysis of the creep of cement paste.

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