Creep of the Cement Paste with Fly Ash in Time

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Abstract: - Different quantities of fly ash contained in the cement paste causes change properties of the final product. One of the properties is a creep. The size of creep may influence the size ratio of fly ash and cement in the cement paste. Furthermore, measurement results are presented and their comparison. Creep was observed in the specimen’s age of 1, 5 and 12 months.

Key-Words: Leave Cement paste, Creep, Shrinkage, Fly Ash, Compression Strength.

1 Introduction

The processing waste materials allows observing the properties of materials, where such waste material is occurring. One example is the fly ash, which is produced as a waste during combustion of the brown and black coal. According to the method, and in particular combustion reached temperature, the fly ash can be divided into two basic groups, free flowing and classical. Particulate the fluidized fly ash is produced by burning coal at high temperatures and ash capture using limestone. Conversely the classic ash is a result from burning the coal in conventional furnaces at temperatures of 1200-1700°C [1]. Its annual production in countries where electricity is produced from coal combustion is negligible.

One of the sectors where the waste finds application is the construction industry [2]. The fly ash has a number of suitable properties, which fit in the manufacture of building materials and in construction [3]. The classical ash is chemically the inert material with a very fine granulometry 0.001 to 1 mm. The ash has a low content of SO₃ and relatively low volume density.

Listed properties predispose to use the fly ash as filler in the concrete [4]. Fly ash in concrete is characterized by the so-called secondary hydration. This means that the fly ash reacts with gels which are formed after the hydration of cement and formation of CSH [5] gels. By reaction of the fly ash and gels are generated new types of gels in the cement matrix.

Due to the reaction between the cement gel and the fly ash, attention is focused on properties of the cement paste mixed with the fly ash. Between the primary properties such as compression and tensile strength, flexural strength and modulus of elasticity, is creep one of the essential characteristics for the design of structures [6], [7].

2 Specimens and their preparation

The length 70 mm was chosen for the tests of specimens. The size is limited for the use of measuring sensors. The diameter of the test specimens is 10 mm, the size is sufficient to ensure the homogeneity of the material. The cement paste was prepared with a water coefficient (w/c) 0.4 [8]. The coefficient in this case is the ratio of water to weight of cement and fly ash.

The ratio between the weight of cement and fly ash was 1:1. Water was added to the mixture of cement and fly ash and cement slurry created. The cylindrical moulds were filed by cement slurry. The hardened cement paste was removed and inserted to the water basin, where it was stored until to use after hardening. The specimens were cut to the required length for creep tests (Fig. 1) before their first testing.

Fig. 1: Specimens for the creep test.
The specimens were tested at the age of one month, then in 5 months and 1 year. At the age of 5 and 12 months, the same specimens were used. The material properties - compressive strength, modulus of elasticity - were measured on the same type of specimens produced simultaneously with the test samples for creep. Before testing, some specimens were dried and some were left in water.

3 Measurement of properties
The measurement principle was in the monitoring of the creep increase of dry and water-saturated specimens. Shrinkage of the cement paste with fly ash was measured together with the measurement of creep. Two dried specimens were used for measuring of the dried solid creep. The creep was measured on the two saturated specimens and on the other two specimens the shrinkage was measured. The shrinkage was measured on dried specimens.

Testing was carried out in every specimen leverage mechanism. The creep was measured by three sensors with a resolution of 0.1 microns. The specimens were loaded on size of the load 0.69 kN. Stress near to 8.82 MPa was originated in the cement paste. The average compressive strength is 40 MPa for the one month old cement paste. The load level corresponds to 22 % of the strength of the cement paste.

The time interval of testing was one month. The measurement procedure consisted in the establishment specimens to the test equipment. Furthermore, the lever mechanisms were loaded with weights in order to achieve a defined level of load. Then, the test of specimens ran for 25 to 30 days. After the testing time, the specimens were unloaded and then test finished. To ensure moisture conditions during the test, the specimens were wrapped in foil to prevent the admission and removal of moisture from the material.

3 Results of the measurements
The results of the creep cement pastes with addition of fly ash are presented in Fig. 2 and 3. In all cases there is the creep and the basic creep, which expresses the creep of the material without the influence of shrinkage.

Size of the creep was determined, so that influence of weight was deducted from the measurement. The basic creep of the cement paste of one month reached 27.4 and 35.3 microns. The length of period of the measurement was 25 days. The creep of the water saturated specimens reached of the size 245.6 and 183.6 microns. Length of measurement was 70mm. It is same like the length of the specimens.

Fig. 2 The basic creep of the cement paste in 1 month age.

Fig. 3 The creep of the cement paste in 1 month age.
The basic creep of the cement paste tested at the age of 5 months reached 15.6 and 15.3 microns after 25 days. Water-saturated specimens showed the size of creep 263 and 253 microns after 25 days.

In comparison with the younger specimens, the decrease of deformation of dried specimens and decrease of the deformation in a given time at the water-saturated specimens were not proved.

The deformation of the dried specimens was less 20 microns for the paste 5 month old. On the contrary creep of the water saturated specimens was greater in five month than at 1 month. The difference of size of the creep was 43 microns. All carried tests were held at a constant temperature of 20 °C.

Both one year old specimens achieved the creep size 22 microns after 25 days of measurement.
Water-saturated specimens had the deformation size 126 and 135 microns after 25 days of measurement. The values of deformation were deducted from graphs in all cases.

The deformation of the dried specimens is lower than 1 month old specimens. The deformation of the 1 year old specimens is little bit lower than the deformation of the 5 month old specimens.

![Graph](image)

Fig. 7 The creep of the saturated cement paste in 1 year old.

This difference is only 4 microns after 7 months. Other situation is in the case of the measurement of creep on the water saturated specimens. The average value of the creep is 130 microns for 1 year old specimens. This value of the deformation is nearly close to difference value 130 microns between 1 year and 5 month old specimens. The decreasing of creep of the saturated specimens is 84 microns for the specimens 1 year old to 1 month old specimens.

The important information is evolution of the temperature during the tests. At Figure 8 is displayed graph of temperature for the last measurement. In this case was average temperature 19 °C. But is possible see the every day’s night decreasing of the temperature about 2 °C. As is possible see at Figures 6 and 7, decreasing of temperature has not influence on the evolution of the creep and the basic creep.

The material properties are changed during one year too. The compression strength increased to 58.6 MPa after 1 year (Fig. 10). It is increasing nearly about 50 % from the strength value in the 1 month.

![Graph](image)

Fig. 8 The evolution of temperature during test of the 1 year old specimens.

![Graph](image)

Fig. 9 Compression test of the cement paste with fly ash.

![Graph](image)

Fig. 10 The stress- strain graph of the specimens No.2.

The material properties are important for the modeling of the creep [9]. Namely, necessary is...
knows the compression strength, Modulus of elasticity, age and water – cement ratio [10].

4 Summary
From the creep measurement in chronological observation of maturation cement paste it can be seen that the decisive factor for the deformation is the water content in the specimen. The dried specimens did not show changes in the creep development during the year. On contrary, specimens that have been saturated with water showed a trend of reducing the size distortion. Although after 5 months, the creep size was higher than at the beginning and end of the measurement. It is possible to notice that the increase of deformation for the same period is almost 0.1 mm lower after one year from the specimen maturation than after the first measurement.

The material properties changes during the year. The chemical reaction occurs between the fly ash and the cement gels in the cement paste.

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References: