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MECHANICAL PROPERTIES OF CEMENT PASTE WITH VARIOUS CONTENT OF FLY ASH AFTER 6 MONTHS

O. Zobal*, P. Padevět**

Abstract: *Nowadays there is a heated discussion about using fly ash as an important concrete binder. It is therefore essential to define properties of this material. This paper presents results of an experiment which deals with mechanical and material properties of cement paste with different proportion of fly ash. More specifically, the compressive strength and tensile strength in bending of individual mixtures after 6 months will be presented.*

Keywords: ***Cement, fly ash, compressive strength, tensile strength in bending.***

1. Introduction

Worldwide and in the Czech Republic building industry is currently affected by several aspects. Among the most important ones there are economic and ecological aspects of construction. This means saving money while protecting the environment. Concrete and reinforced concrete are still the most widely used construction materials. Regarding concrete, money can be saved on the binder, the cement. There is an opportunity to use fly ash to a greater extend. This would positively influence the environment because of efficient waste disposal. It is widely known that the Czech Republic is among the greatest fly ash producers (Fečko, 2003).

Fly ash has already been used as an essential part of concrete for several decades. This fact is demonstrated by construction of one of the most significant structures in the Czech Republic, which is a water reservoir Orlík built and opened in 1961. The concrete used for construction of the massive dam body contains almost 30% of fly ash. One of the most important properties of fly ash was made use of. This property is the fact that larger quantity of fly ash in a concrete mixture reduces heat of hydration. In the graph, Fig. 1 summary of measurement during construction and measurement after 50 years, excellent durability of this concrete is shown. (Bittnar at al., 2011).

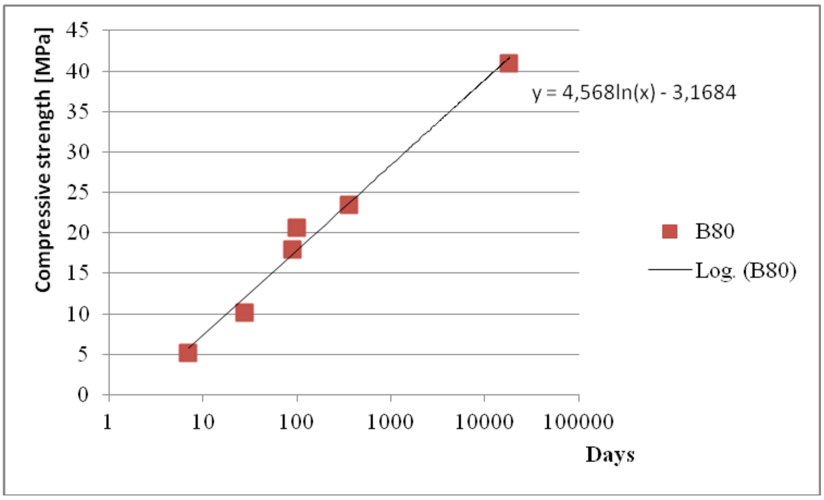

Fig. 1: The increase in compressive strength of concrete B80 dam Orlik (Bittnar at al., 2011)

* Ing. Ondřej Zobal: Faculty of Civil Ingineering, CTU in Prague, Thakurova 7, 166 29, Prague; CZ, e-mail: ondrej.zobal@fsv.cvut.cz

** Ing. Pavel Padevět, Ph.D.: Faculty of Civil Ingineering, CTU in Prague, Thakurova 7, 166 29, Prague; CZ, e-mail: pavel.padevet@fsv.cvut.cz

This secondary energy product is currently used when constructing significant structures such as Washington Dept. of Transportation, USA, in 2006 and Liu Center U.B.C, Canada, in 2000 (Schmidt & Fast, 2000). It is possible to produce alkali-activated fly ash and make it part of the concrete hydration process (Němeček at al., 2010). Fly ash has been used in construction industry for many years but there is still a considerable number of issues and problems to be dealt with. The paper deals with mixtures of concrete, water and fly ash free of alkaline agents and development of material properties over time.

2. Types of mixtures for production of test specimens

Water ratio of all mixtures - cement – fly ash – water - reaches up to 0.4. Cement was acquired from Radotín locality and it is Portland cement labelled CEM I 42,5R. Fly ash was acquired from Mělník and is commonly added in blended cements. Several types of mixtures with different ratio of fly ash in comparison to cement content were produced. Individual sets are described in Table 1 which shows density development of individual sets of mixtures. The larger content of fly ash, the sparser the density.

Tab. 1: Types of mixtures and their density

Type of mixture [-]	Cement [%]	Fly Ash [%]	Density [kg/m^3]
I	100	0	2059 ± 89
II	60	40	1820 ± 22
III	50	50	1844 ± 19
IV	40	60	1749 ± 32
V	30	70	1650 ± 29

3. Test specimens and testing methods

There were two groups of specimens designed for the purposes of the experiment. Planned measurements could thus be carried out:

- cylinders – diameter of 10 mm, length of 100 mm
  → produced for the compressive strength test
- beams – dimensions of 20 × 20 × 100 mm
  → produced for the tensile strength in bending test

Cylinder specimens were made in special plastic moulds. Beam specimens were made in classic steel moulds. After 48 hours they finally became hard and were placed in water for long-term storage at 20°C.

There were two mechanical tests carried out – determination of compressive strength and tensile strength in bending. Electromechanical testing machine, MTS Aliance RT-30, was used to perform both tests. Maximum loading force of the machine is 30 kN in compression and tension. The compressive strength test was carried out on adjusted cylinders. Cylinders were shortened at 40 mm of length. Diameter of the specimens remained the same; thus, the load area covered 78,5 mm^2. During performing the test, a strain gauge which recorded figures of transformation was fixed to each specimen. A three-point ending test to obtain tensile strength in bending figures was performed on beams. The beams were not adjusted before the test was initiated. Load affected the middle of the span, supports were placed 10 mm from the specimen edges and the span between individual supports (effective length) was 80 mm.

4. Experiment results

Graphic summary of measured figures is shown in Fig. 2 where development of compressive strength over time is shown. Fig. 3 displays tensile strength in bending over time. Description of trends resulting from the experiment is listed in the conclusion.

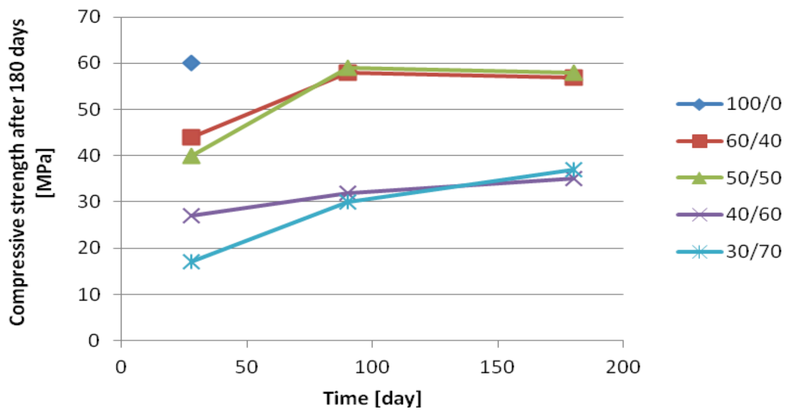

Fig. 2: Average compressive strength of cement pastes after 180 days

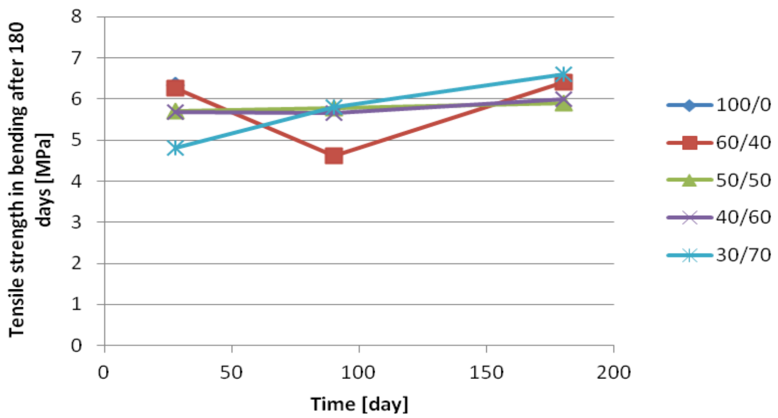

Fig. 3: Average tensile strength in bending of cement pastes after 180 days

5. Conclusions

Thanks to measurement results of observed mechanical properties of cement and fly ash mixtures blended in different proportion with water coefficient of 0,4 without any other additives we attained the knowledge as follows (all measurement results were statistically evaluated and a standard deviation ranging up to 10% was determined).

The density of mixture with higher ratio of fly ash in it decreased. Compressive strength with higher content of fly ash in it decreased as well after the period of 28 days. After the period of 90 days, the figures increased evenly and after the period of 180 days, the increase in strength was observed only in mixtures with higher ratio of fly ash. The figures of pure cement paste measured after several days were unfortunately not available at the time of completing this paper. Compressive strength of pure cement measured after 28 days was about 60 MPa. When there was only 30% of cement and 70% of fly ash in the mixture, the compressive strength figure rose to its third. After the period of 180 days the compressive strength figure regarding mixtures with higher fly ash content reached 60% of those mixtures with lower fly ash content; at the beginning it was only 50%. Increasing fly ash content in the mixture had no significant effect on tensile strength in bending under bend after 28 days. The figures ranged between 5 and 6 MPa. After 90 as well as 180 days there was only a slight increase of this strength (value of pure cement paste was unfortunately not available at the time of completing the paper). As far as the set II was concerned, a decrease in value occurred, which might have been associated with an error made during measuring.

Another aim of our work is to further observe the development of material properties over time and focus on other properties such as statistical flexibility module, heat of hydration, fracture energy etc. We would like to pay attention to material structure at micro level as well.

Acknowledgement

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