18th International Conference
ENGINEERING MECHANICS 2012
Svratka, Czech Republic, May 14 – 17, 2012

pp. 316–317
Paper #232

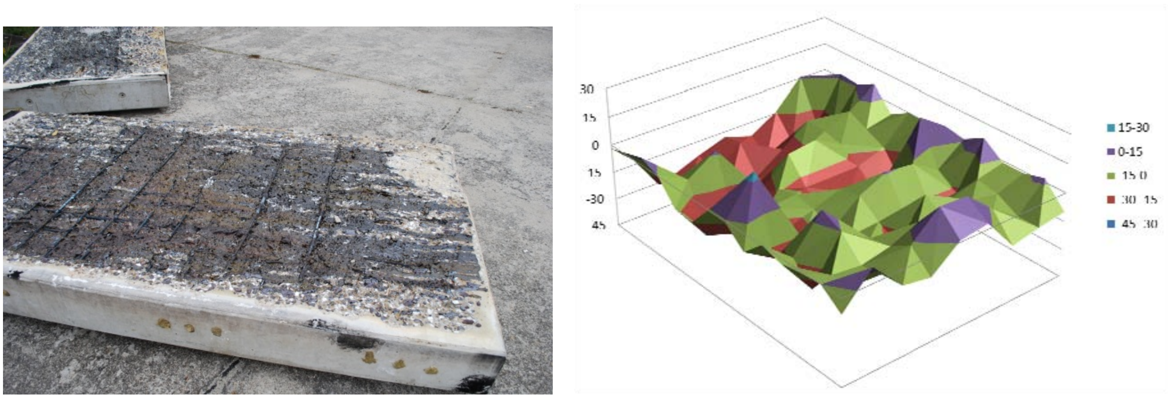
RESISTANCE OF CONCRETE WITH FLY ASH CONTENT UNDER THE RWS CURVE FIRE LOADING

M. Šejnoha[*], M. Brouček[**], E. Novotná[***], J. Sýkora[****]

Abstract: *The first part of the paper presents the results obtained from large scale fire experiments on reinforced concrete panels 1.5 x 3.0 meters and small scale high temperature experiments on cubes with a side length equal to 0.15 meters. Concrete mixtures with large content of fly ash as a binder were selected for large scale experiments whereas cubes were made of cement based mixtures as well as of alkali activated fly ash mixtures. The influence on polypropylene fibres, added into half of the specimens, on the fire resistance is also described. Second part of the paper is focused on the numerical modelling of the effect of fire using a simplified numerical approach. Experimental data are used for calibration of the models as well as for the comparison of results. The loading is governed by RWS Curve which assumes 50 cubic meters of petrol or oil fire in the tunnel.*

Keywords: ***Fire resistance, Heat transfer, Spalling, Fly ash, PP fibres***

Increased effort in the use of waste material as well as in decrease of CO_2 emissions powered by international agreements, increased taxation and subsidy from national and international agencies, and new challenges and improved standards on structural safety enable incorporation of materials which so far have been used only under specific circumstances. The idea of substituting fly ash for cement and thus reducing the heat from hydration has been successfully used in the past (e.g. Keil J., 1966) for massive concrete structures with low requirements on strength or strength increase rate.



(a) (b)

Fig. 1: Specimens after an experiment: (a) FAC2 mixture - photo, (b) Measured surface

Presented results are part of an extensive experimental program aimed at possible application of cement free (alkali activated) or cement reduced (fly ash replaced) concrete in the production of precast segmental linings for tunnels created by TBM. In particular, this topic is focused on fire resistance of enhanced mixtures including large and small scale experiments as well as numerical simulations of large scale tests. Requirements applied to mechanical parameters of tested mixtures

[*] Prof. Ing. Michal Šejnoha, Ph.D., DSc.: Czech Technical University in Prague, Faculty of Civil Engineering, Thákurova 7; 166 29, Prague; CZ, e-mail:sejnom@fsv.cvut.cz

[**] Ing. Miroslav Brouček: Czech Technical University in Prague, Faculty of Civil Engineering, Thákurova 7; 166 29, Prague; CZ, e-mail:miroslav.broucek@fsv.cvut.cz

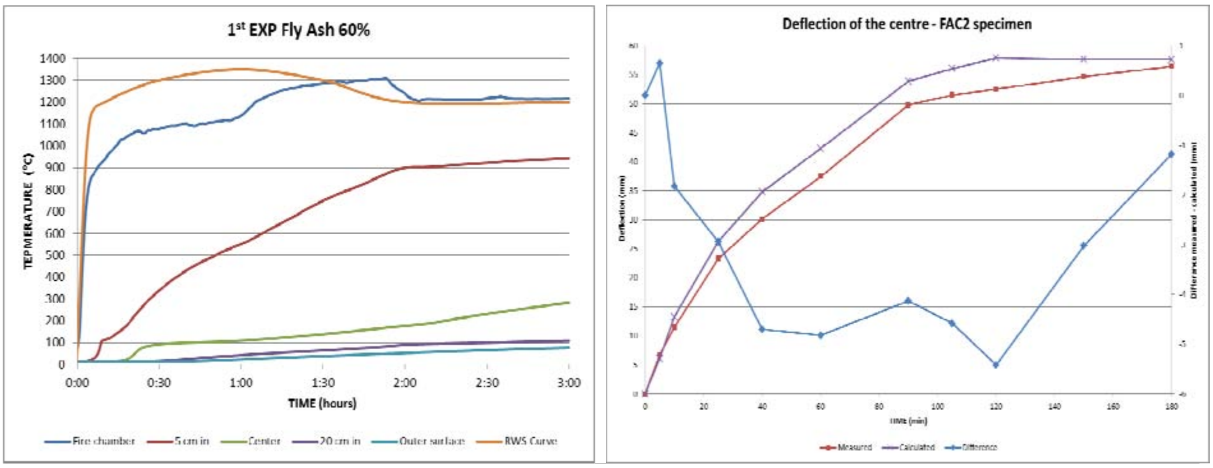
[***] Ing. Eva Novotná, Ph.D.: Czech Technical University in Prague, Faculty of Civil Engineering, Thákurova 7; 166 29, Prague; CZ, e-mail:novotnae@fsv.cvut.cz

[****] Ing. Jan Sýkora, Ph.D.: Czech Technical University in Prague, Faculty of Civil Engineering, Thákurova 7; 166 29, Prague; CZ, e-mail:jan.sykora.1@fsv.cvut.cz

correspond with concrete C50/60 with improved resistance against fire and hostile environment (mainly aggressive sulphate).

Fire outbreaks in tunnels differ from others especially in terms of the peak temperature and the rate of temperature increase. In recent years a great deal of research has taken place internationally to ascertain the types of fire which could occur in tunnel and underground spaces. Such research has taken place in laboratory conditions as well as in disused tunnels. In the presented experiments, RWS curve, which assumes 50 m^3 fuel tanker fire which last for 120 minutes, is considered.

The examples of results from the full scale physical experiments can be seen in Fig. 1. The measured temperature distribution in one of the specimens can be seen in Fig. 2 (a), while Fig. 2 (b) shows comparison between measured and calculated deflection of the centre of the specimen. The ATENA FEM code was adopted for the numerical calculation while simple elastic material model was used as the first approximations.



(a) (b)

Fig. 2: Full scale experiment: (a) temperatures, (b) calculated and measured deflection

While full scale experiments proved to be irreplaceable, when it comes to proper evaluation of the fire resistance of reinforced concrete panels, simple static simulations with appropriate loading distribution can still provide good results in terms of the total deflection of panels. Valuable experience obtained by examining small scale specimens will allow for improvement of the method for testing the enhanced mixtures.

Mixtures with increased amount of fly ash did not show significantly different behaviour unlike the mixtures with added plastic fibres. Even though the temperature in the 50 mm distance from the inner surface in all specimens have risen above 500°C, the specimens with the plastic fibres experienced smaller spalling and their reinforcement was not exposed after the experiment.

Numerical approximation of the impact of fire loading will be subjected to further research activities concentrating specifically on the heat transfer problem and spalling.

Acknowledgement

The financial support of the project No. TA01030245 provided by the Czech Technology Agency is gratefully acknowledged.

References

Beneš, M. and Mayer, P. (2007), Coupled model of hygro-thermal behavior of concrete during fire. *International Journal for Numerical Methods in Engineering*, (218):12–20.

Červenka, V., Jendele, L. and Červenka, J. (2007), ATENA Program Documentation - Part 1: Theory, *Cervenka Consulting*, Prague, Czech Republic.

Fraay, A.L.A., Bijen, J.M. and de Haan Y.M. (1989) The reaction of fly ash in concrete a critical examination, *Cement and Concrete Research*, 19(2): 235-246

Helmuth, R. (1987), Fly Ash in Cement and Concrete. *Portland Cement Association*, Illinois