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Impact of fine aggregates replacement by fluidized fly ash to resistance of concretes to aggressive media

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Summary

Fluidized fly ashes constitute a part of industrial waste used in building material production on a small scale up to now. Concrete production is one of fluidized fly ashes application field. This paper presents findings concerning testing of concrete with addition of fluid combustion ashes as to aggressive media resistance - chlorides and sulphates in particular. Fine grained aggregate has been replaced by deposit ash (0 to 50 %). This ash originates from black coal fluid combustion in the TZ Trinec Power Plant. Concrete samples have been exposed for a period of 24 months.

KEYWORDS: fluidized bed ash combustion, concrete resistance, resistance to chlorides, sulphates, raw material.

1. INTRODUCTION

Industrial ashes exploitation for building material production continues permanently in the course of many years. One of wastes exploitable with concrete production is also fluid combustion ash. To use these ash concretes in practice there is necessary to know not only their basic physical–mechanical characteristics but also other properties, among others their resistance to aggressive media. Our research works have been focused on monitoring of concrete chloride/sulphate resistance after addition of deposit fluid combustion ash.

2. FLUIDIZED BED ASH CHARACTERISTICS

Fluid ashes originate in the course of flue gases desulphurization based on direct mixing of fuel with desulphurising reagent (generally lime or dolomite in some cases) before combustion or during it. There are many production processes; most of them are patent covered.

ISSN 1582-3024

Generally all these processes are based on calcination of present desulphurising reagent to CaO and its subsequent reaction with sculpture oxides along with oxidation of sulfur dioxide to sculpture trioxide. This reaction results in mixture of original fuel ash, unreacted desulphurising reagent (CaO with $CaCO_3$ remains, as the case may be), calcium sulfate, ash matter product reaction with CaO, and unburned fuel. Since fluid combustion temperatures are lower than classic combustion ones, unreacted CaO is present in the form of so called burned lime, therefore reactive lime. Fluid ashes are also typical for their low volume of melt.

As a result of flue gases transport from the furnace space particular fractions of this mixture are separated; fine parts are drifted by flue gases in the form of light ashes, remaining more coarse parts in the furnace space. Solid substances are removed using common technologic procedures (cyclone washers, filters).

That is why each fluid combustion unit products in principle fluid ashes of two kinds: furnace space ash (indicated as deposit ash for instance), and light ash (indicated as cyclone ash, filter ash, and so on). Characteristics of both these ashes are different as to physical properties (granulometry, specific surface, density, powder density) as well as chemical and mineralogical composition even if they originate from identical fluid combustion and desulphurization technologic procedure.

As well as with classic ash also both kinds of fluid ashes feature disadvantage of unequal properties namely chemical composition, density, and other parameters due to combustion process instability and variability of input component properties (coal and desulphurising reagent).

3. INPUT RAW MATERIAL AND CONCRETE COMPOSITION: BASIC DATA

Material used for concrete production:

Cement: CEM I 42.5 from the Mokra Cement Mill

Aggregates:
fine - mined; Bratčice Gravel Pit; fraction 0 to 4,
coarse - crushed; Olbramovice Gravel Pit, fraction 4 / 8, and 8 / 16.

Ash: deposit fluidized bed ash of black coal fluid combustion from the TZ Trinec Power Plant; see the Table 1 for ash chemical/physical composition.

Mixing Water: in agreement with EN 1008.

Table 1. Trinec ash chemical/ phase composition

ISSN 1582-3024

A. Chemical composition			
Tested components	Component share [%]	Tested components	Component share [%]
SiO_2	53.5	MnO	0.1
Al_2O_3	21.5	K_2O	2.6
Fe_2O_3	5.8	Na_2O	0.2
TiO_2	0.9	S	2.5
CaO	6.7	C	2.6
MgO	3.2	Annealing loss	0.46
B. Phase composition			
Ash contains considerable volume of β–silica. Only small volume of anhydride has been detected. That is why there is possible to assume low share of partly decomposed potassic feldspar (orthoclase) and lesser share of illite and hematite.			

Testing of concrete with deposit fluid ash as partial replacement of fine aggregates has been carried out using 3 kind of concrete with variable ash content and ashless concrete mixture as reference test sample. See the Table No. 2 for composition of particular concrete mixtures.

Table 2. Concrete mixture composition for experimental works

Concrete mixture composition per $1m^3$ of finished product	B0 Tr	B20 Tr	B30 Tr	B50 Tr
CEM I 42.5 R cement	330	330	330	330
Sand 0 to 4 mm from the Bratčice Gravel Pit	756	605	529	378
Ash from the Chvaletice Power Plant	0	151	227	378
Aggregates 8 to16 mm from the Olbramovice Gravel Pit	1069	1069	1069	1069
Mixing Water	199	199	199	199

4. WORK METHODOLOGY

To investigate concrete resistance to corrosion there were prepared test specimens (blocks 40 × 40 × 160 mm each) conformable to the CSN 73 1340 Standard.

After manufacturing the test specimens have been placed into moist environment for 24 hours followed - after form removal and before exposition to corrosive medium - by placing into water bath at 19 to 21 °C. After 28 hour hardening, the specimens have been exposed to corrosive medium action. Selection of parameters under evaluation is based on the CSN 73 1340 Standard.

Tested specimens will be monitored in light of parameters as follows:

- appearance (visually)
- density (EN 12390-7 Standard)

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- ultrasonic pulses velocity (EN 12504-4 Standard)
- dynamic modulus of elasticity E_{bu} (CSN 731371 Standard)
- compression strength f_{cc} (EN 196-1 Standard)
- tensile strength under flexure (EN 196-1 Standard)

Specimen strength has been destructive tested before exposition to corrosive medium and after 3, 9, 15, 18, and 24 months of exposition.

Corrosive environment effect during other time periods has been evaluated based on both ultrasonic pulse speed variation and dynamic moduli of elasticity.

Corrosive media:
- sulphates - sodium sulphate solution (10,000 mg of SO_4^{2-} in 1 litre)
- chlorides - 5 % solution of NaCl

5. FINDINGS OF CONCRETE RESISTANCE MONITORING

See the Figures 1 to 4 for variation in compression strength, and dynamic moduli of elasticity depending upon concrete kind, exposition time period, and corrosive medium.

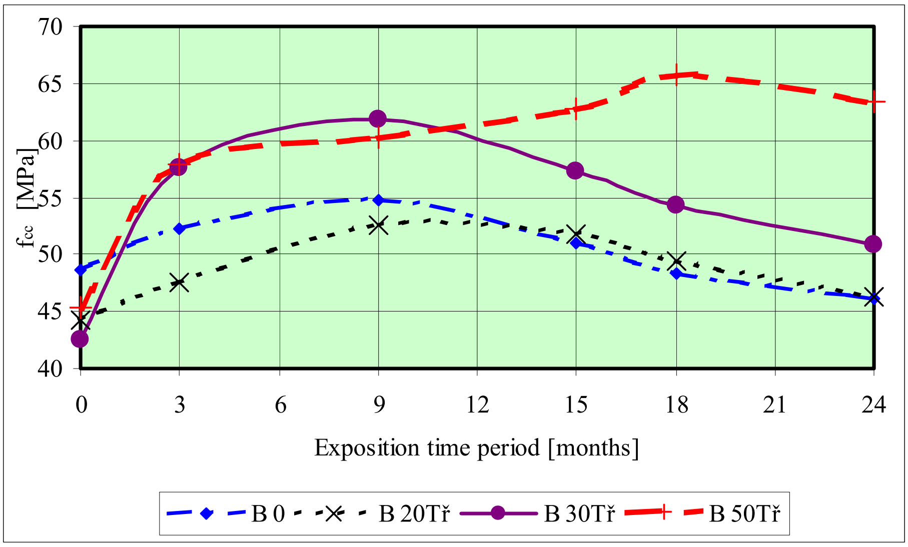

Figure 1. Compression strength curve depending upon exposition time period in aggressive chloride environment

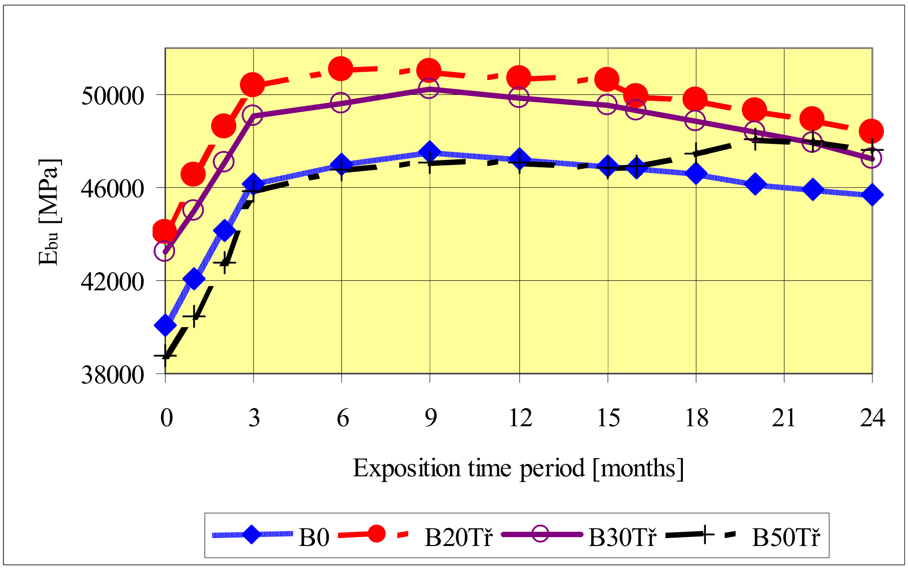

Figure 2. Concrete modulus of elasticity variations depending upon exposition time period in aggressive chloride environment

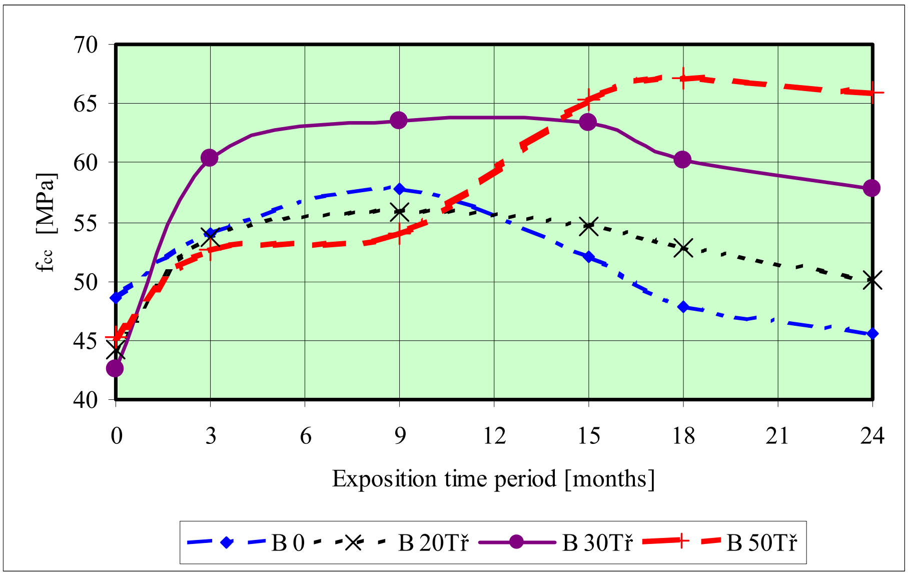

Figure 3. Compression strength curve depending upon exposition time period in aggressive sulphate environment

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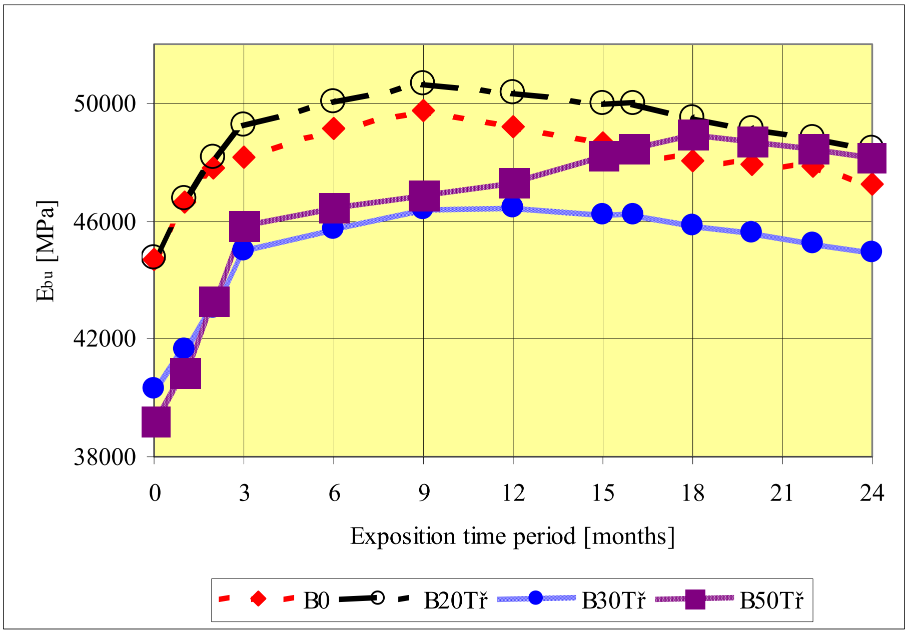

Figure 4. Dynamic modulus of elasticity curve depending upon exposition time period in aggressive sulphate environment

6. CONCLUSIONS

To evaluate concrete resistance to aggressive medium (chlorides in this instance - 12 months evaluation time period according to the CSN 73 1340 Standard) there is necessary to ensure that no one parameter under monitoring shall decrease during this interval.

6.1. Resistance to Chlorides

Based on monitoring results as mentioned above there is possible to state that tested concretes with 50 % of fluid combustion ashes (place of origin: TZ Trinec Co.) as replacement of natural aggregates are resistant to chlorides.

Other tested concretes including reference ashless concrete are unfit to stand up to chlorides by reason of monitored parameter deterioration before expiration of 12 months exposition (6 to 9 months). Concrete with 50 % of deposit fluid ash shown highest resistance; on the other hand concrete where 20 % of fine aggregates have been replaced with fluid combustion ash shown least resistance.

6.2. Resistance to Sulphates

There is possible to treat tested concrete with 50 % of fluid combustion ash (replacement of fine natural aggregates) as resistant to sulphates.

Other tested concretes including reference ashless concrete are unfit to stand up to sulphates by reason of monitored parameter deterioration before expiration of 12 months exposition (6 to 9 months). Concrete with 50 % of deposit fluid ash shown highest resistance; on the other hand concrete where 20 % of fine aggregates have been replaced with fluid combustion ash shown least resistance.

Acknowledgements

The work was supported by by the MSM 0021630511 plan: Progressive Building Materials with Utilization of Secondary Raw Materials and their Impact on Structures Durability and the GAČR 103/05/H044project.

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