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The application of fluidized fly ash a new kind of waste material in concrete technology

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CONTENTS

- Fluidized fly ash, what is it?
- Aims of research
- Examples of test results
- Conclusions

Reduction of harmful emission to the atmosphere
Directive 2001/80/WE
(reduction of sulphur and NO_x)

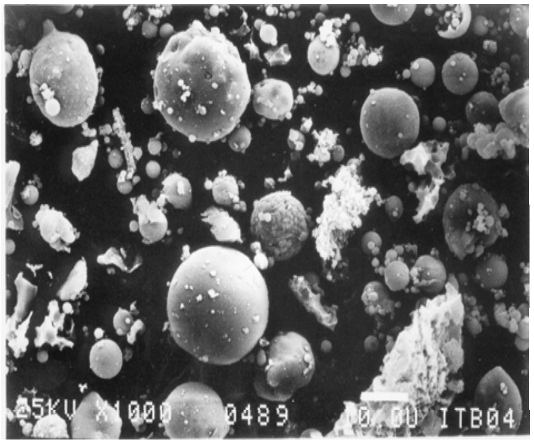
↓

New coal combustion technique in power industry
Fluidized bed coal combustion

↓

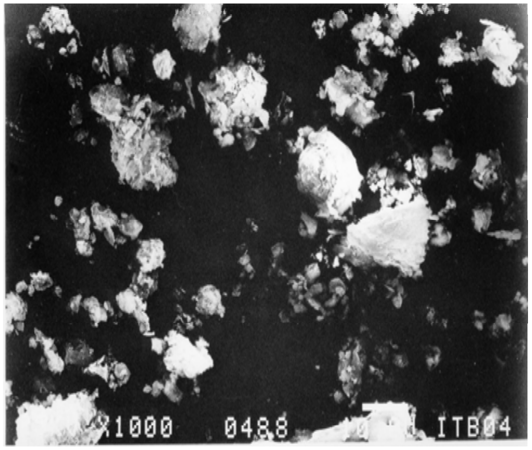
New kind of fly ash
Circulating Fluidized Bed Combustion Fly Ash
CFBCFA

Conventional fly ash



- Temp. of combustion ok. 1400ºC
- Grains spherical
- Glassy phase is present

CFBC fly ash



- Temp. of combustion ok. 850ºC
- Grains non-spherical
- Glassy phase is not present

Properties of CFBCFA:

- high content of different calcium sulphur compounds
- high content of free lime
- higher loss of ignition compared to standard fly ash

Chemical compounds	PC type I	Fly ash	CFBC fly ash	
			from hard coal K	from lignite T
SiO_2	21.4	50.8	47.18	36.47
Fe_2O_3	3.5	8.6	6.8	4.4
Al_2O_3	5.7	23.9	25.62	28.4
TiO_2	NA	1.11	1.08	3.84
CaO	64.1	4.0	5.84	15.95
MgO	2.1	2.8	0.15	1.65
SO_3	2.1	0.8	3.62	3.8
Na_2O	0.5	0.8	1.18	1.64
K_2O	0.92	2.9	2.36	0.62
Cl^-	0.029	0.02	0.1	0.03
CaO_{free}	0.9	0.6	3.4	4.75
Specific gravity [g/cm^3]	3.15	2.16	2.68	2.75
Loss on ignition, 1000°C/1h	1.1	2.9	3.4	2.73

Circulating Fluidized Bed Combustion Fly Ash does not meet the requirements defined by European Standard EN 450 or ASTM C618 to be used for cement or concrete production

CFBC FA does not conform to standard requirements as a concrete additive

Accordingly, it has to be treated on a case-by-case basis in relation to its application

Current applications of fluidized fly ash in the infrastructure:

- Highway engineering and road construction (a stabilizer - soil reinforcement by injection at the site)
- Geotechnics (hardening slurries)
- Hydrotechnics (filter diaphragms in soil foundations protecting underground water against contamination)

also

- Filling underground structures (old coal mines) in land reclamation
- Macro levelling

Soil stabilization by means of 'jetgrouting' method with application of Flubet® (mechanically activated CFBCFA) at the A4 highway section near Ruda Śląska

Glinicki, Nowak, Maslanka

Crevice ditch with slurry containing

Flubet® (mechanically activated CFBCFA)

Glinicki, Nowak, Maslanka

Portland cement concretes with addition of fluidized bed combustion fly ashes

Project 2006-2010

Research project is oriented at determination whether and how CFBC fly ash may be used as partial replacement for Portland cement in structural concretes

Arguments for such investigation:

- reduction of waste material deposits
- replacement of Portland cement (lower cost and reduction of powder and gas emissions related to cement production)

} **Sustainable development**

Research project 2006 – 2010

- mixture composition and workability
- mechanical properties (strength, Young's modulus, etc.)
- stability of the pore microstructure in the fresh mix
- resistance against carbonation
- corrosion of steel reinforcement
- resistance against chloride ions penetration
- frost resistance and scaling resistance
- bond to steel and non-metallic reinforcement

Mixture composition

Concrete A, ordinary concrete - XC3, XD2, XF1, XA1

Concrete B, high strength concrete - XC4, XD3, XF1, XA1

Concrete C, air-entrained concrete for bridges - XC4, XD3, XF4

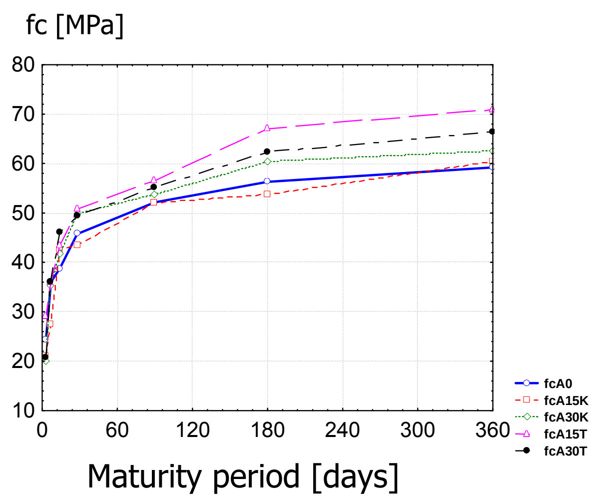
XC - corrosion caused by carbonation
XD - corrosion caused by chlorides not originated from sea-water
XF – frost-salt aggression
XA - chemically aggressive environment

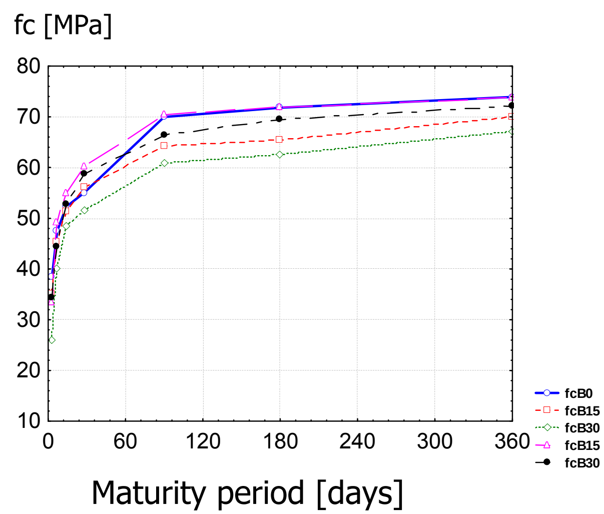
Mixture composition

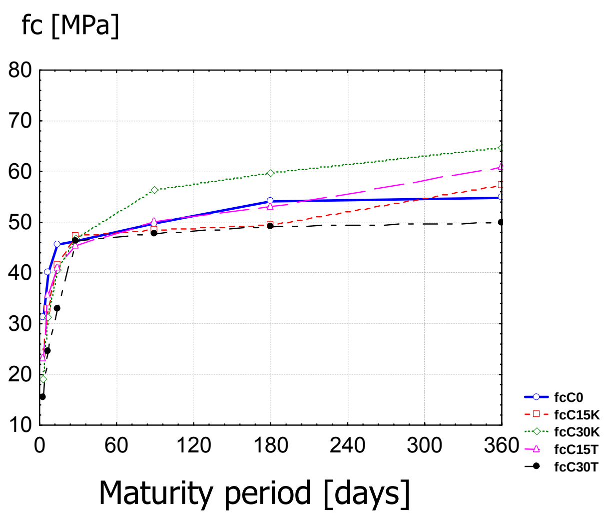
A	B	C
OC	HSC	air-entrained
w/b = 0.55	w/b = 0.45	w/b = 0.45
C=320 kg/m^3	C=360 kg/m^3	C=380 kg/m^3

Replacement of 0%, 15% and 30% of cement mass by CFBC fly ash from hard coal and from lignite

A0	B0	C0
OC	HSC	air-entrained
w/b = 0.55	w/b = 0.45	w/b = 0.45







max: A15T
min: A0 i A15K

max: B0 i B15T
min: B30K

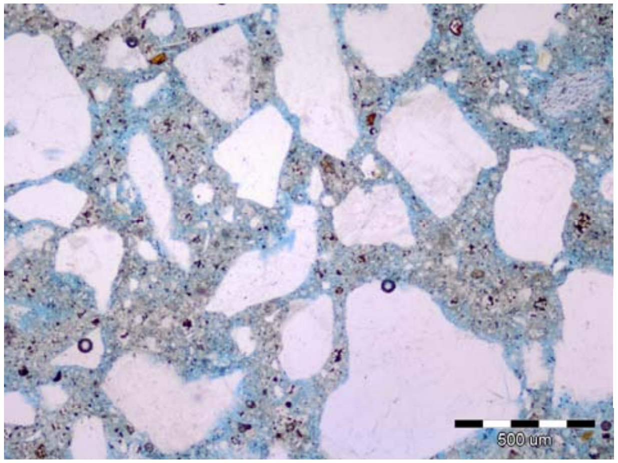
max: C30K
min: C30T

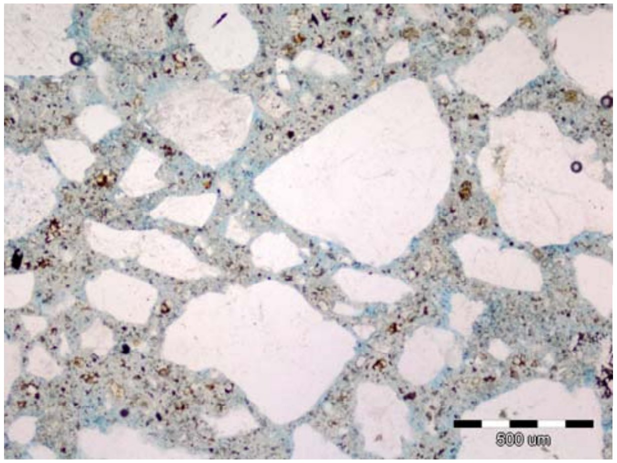
Śliwiński et al.

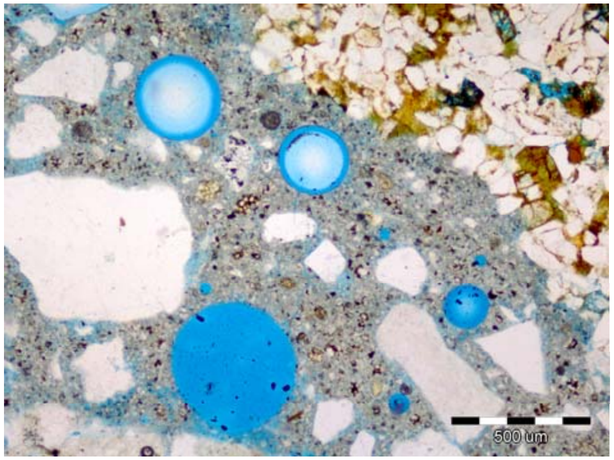
A0	B0	C0
OC	HSC	air-entrained
w/b = 0.55	w/b = 0.45	w/b = 0.45

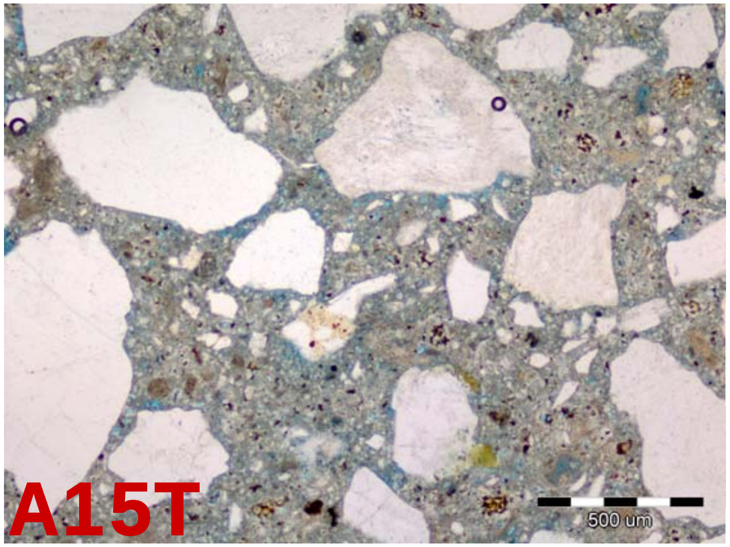
PLANE POLARIZED LIGHT

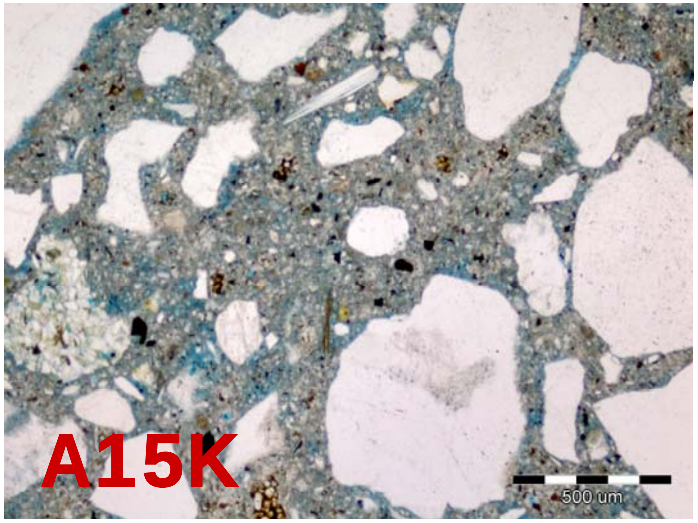
blue dye, magnification 40x

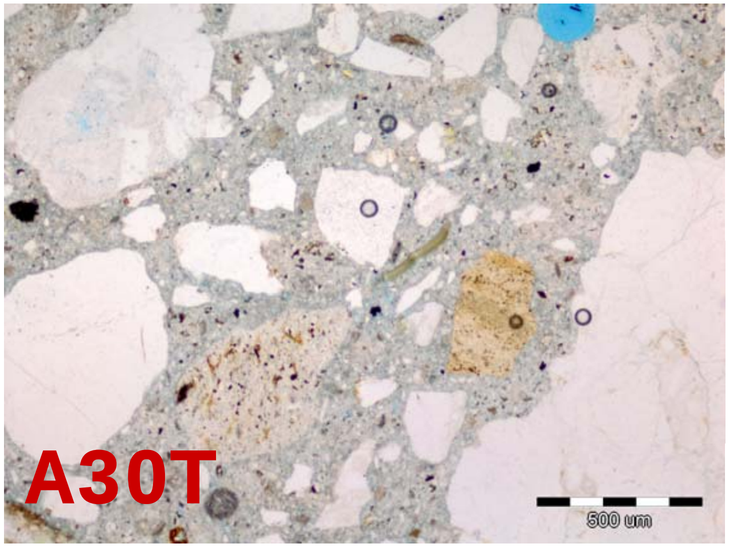


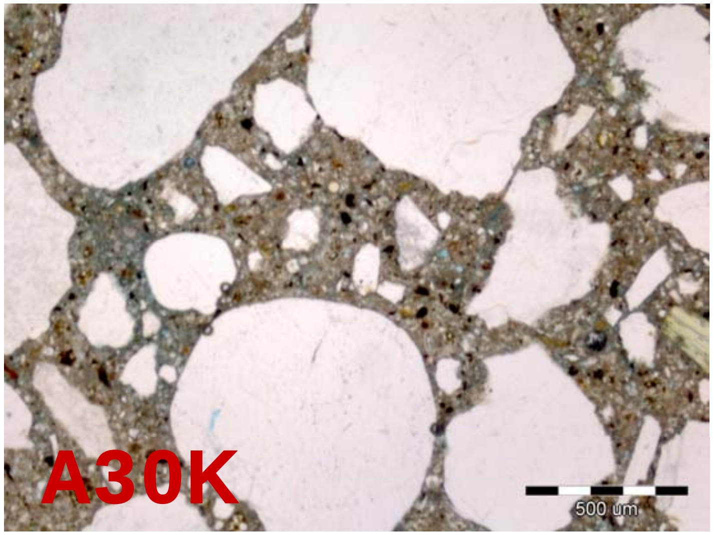






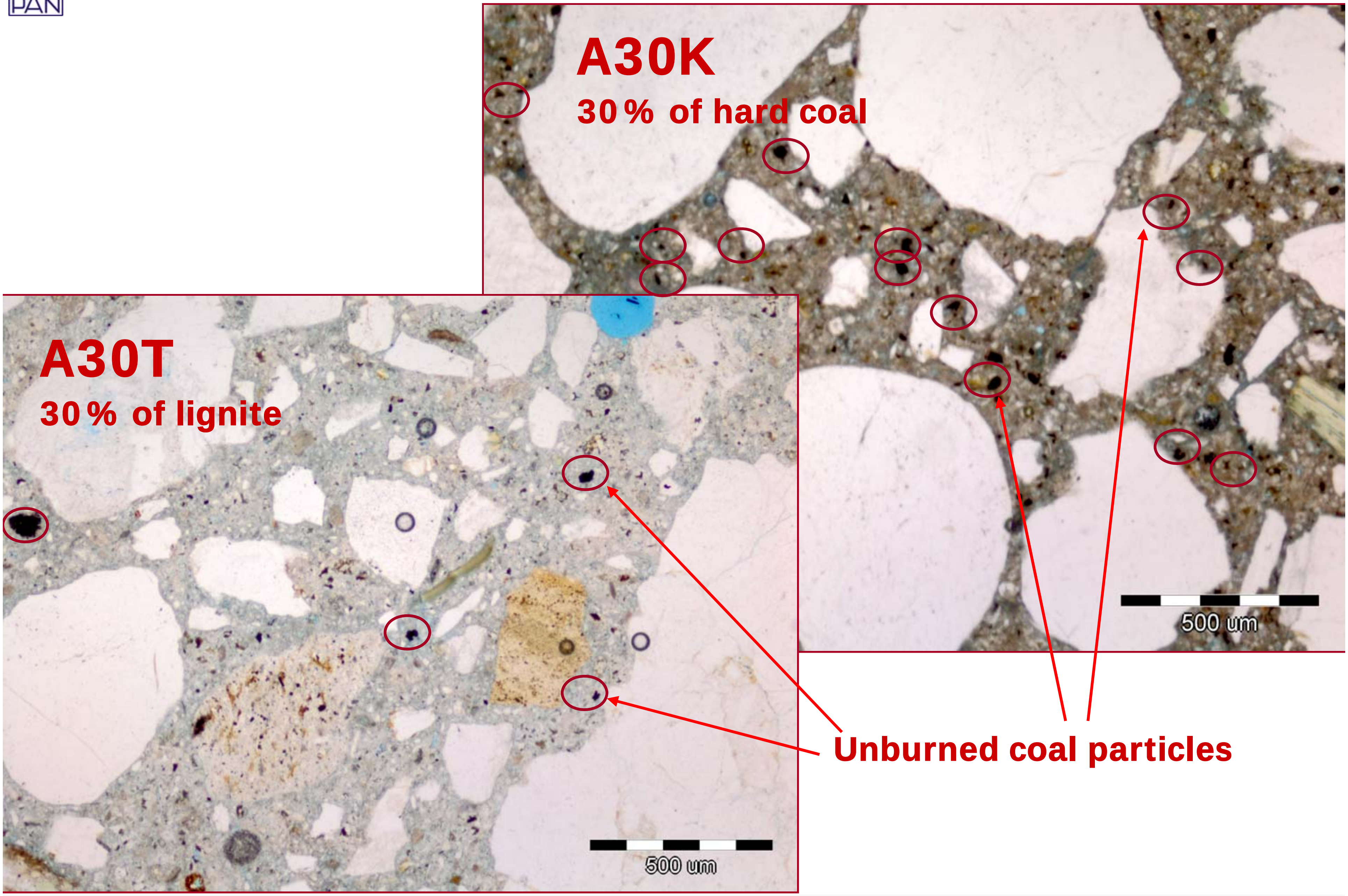






15 % and 30 % of lignite

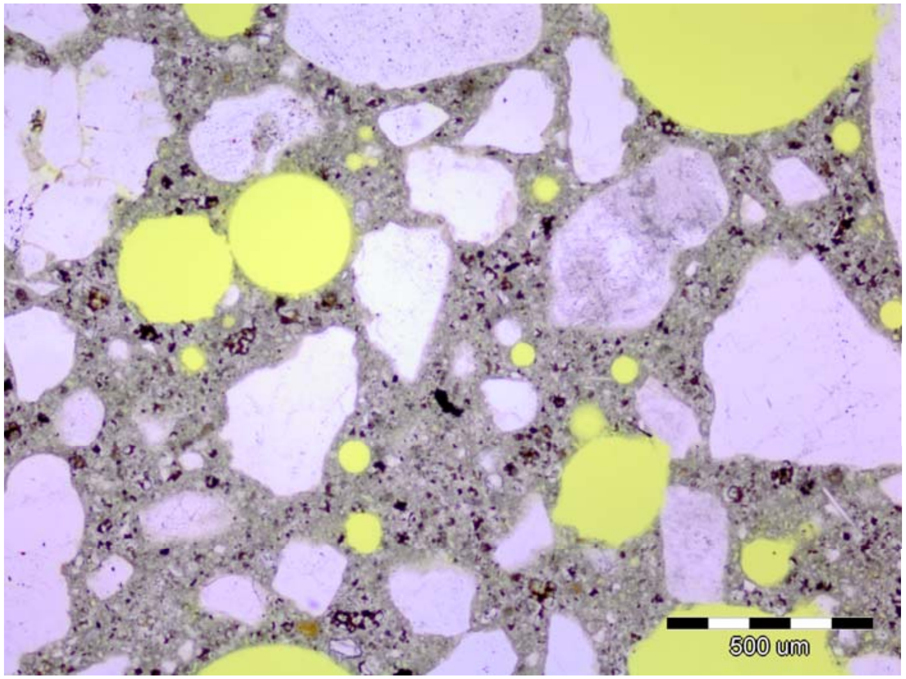
15 % and 30 % of hard coal


A30K
30% of hard coal
500 um
A30T
30% of lignite
500 um
Unburned coal particles

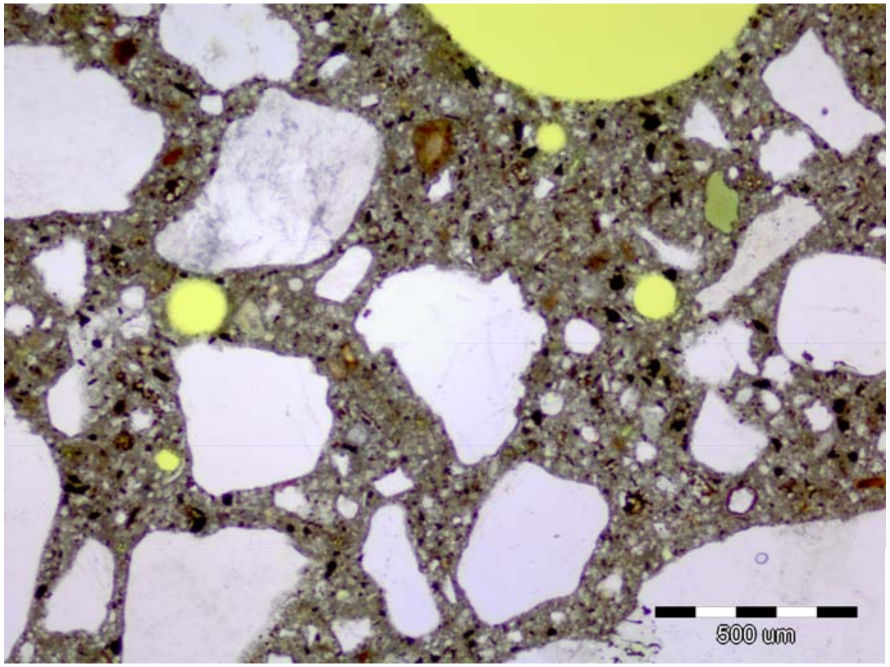
PLANE POLARIZED LIGHT
yellow dye, magnification 40x

Air-entrained concretes, w/b = 0.45

C0, without CFBCFA



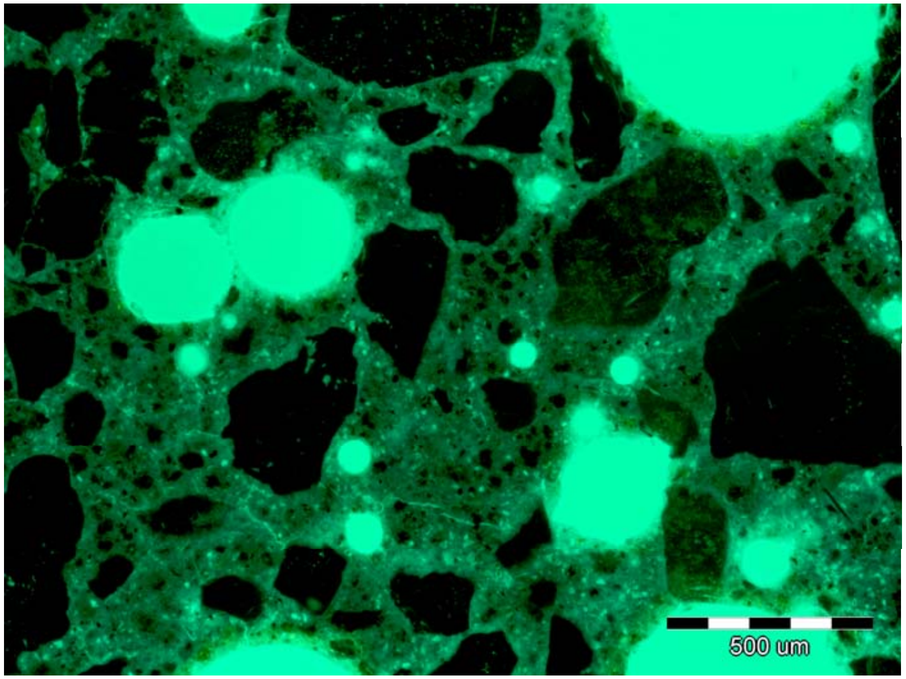
C30K, 30% of CFBCFA from hard coal



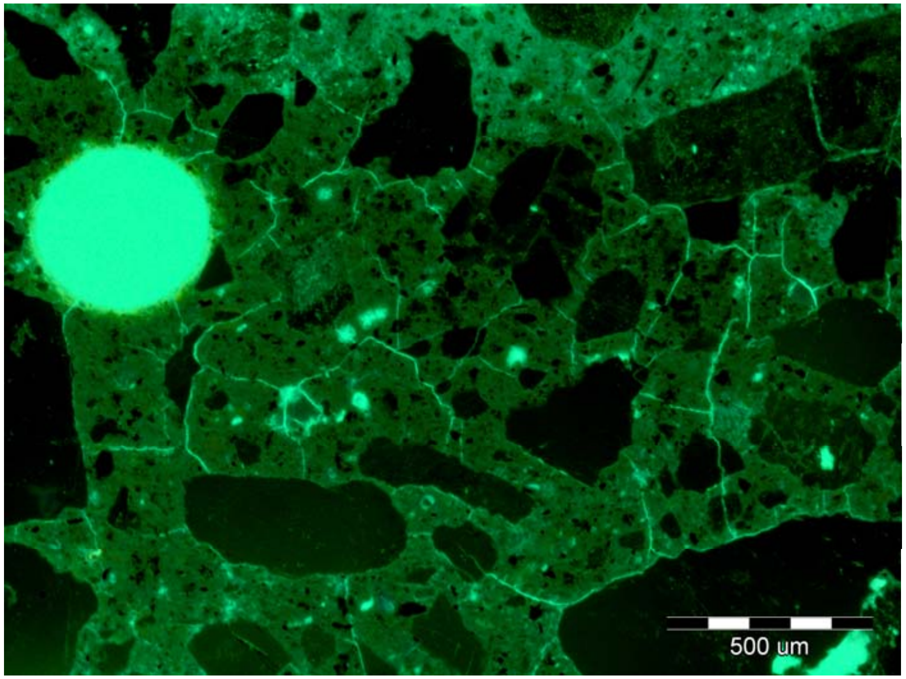
UV LIGHT
yellow dye, magnification 40x

Air-entrained concretes, w/b = 0.45

C0, without CFBCFA

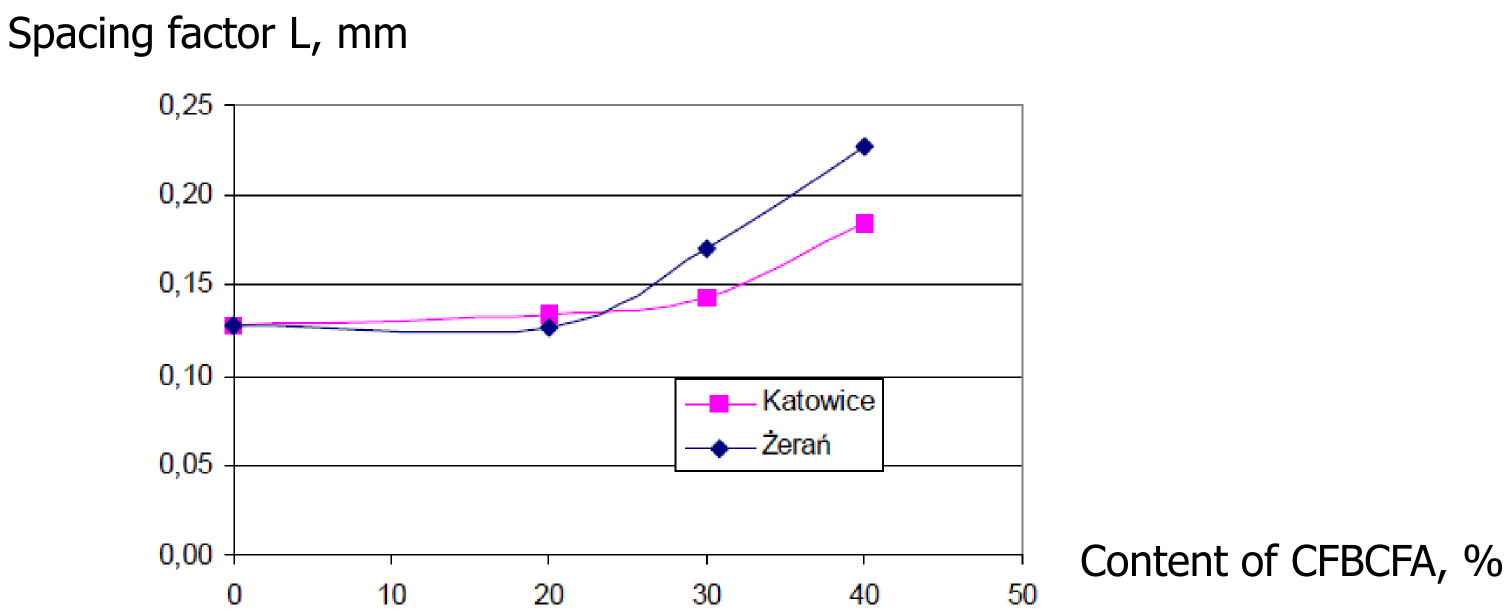


C30K, 30% of CFBCFA from hard coal



Test of air content in fresh mix revealed a proportional increase of the dosage of AEA, to achieve the target air content (6%), along with increasing content of CFBCFA

The spacing factor of air void system vs the content of CFBCFA

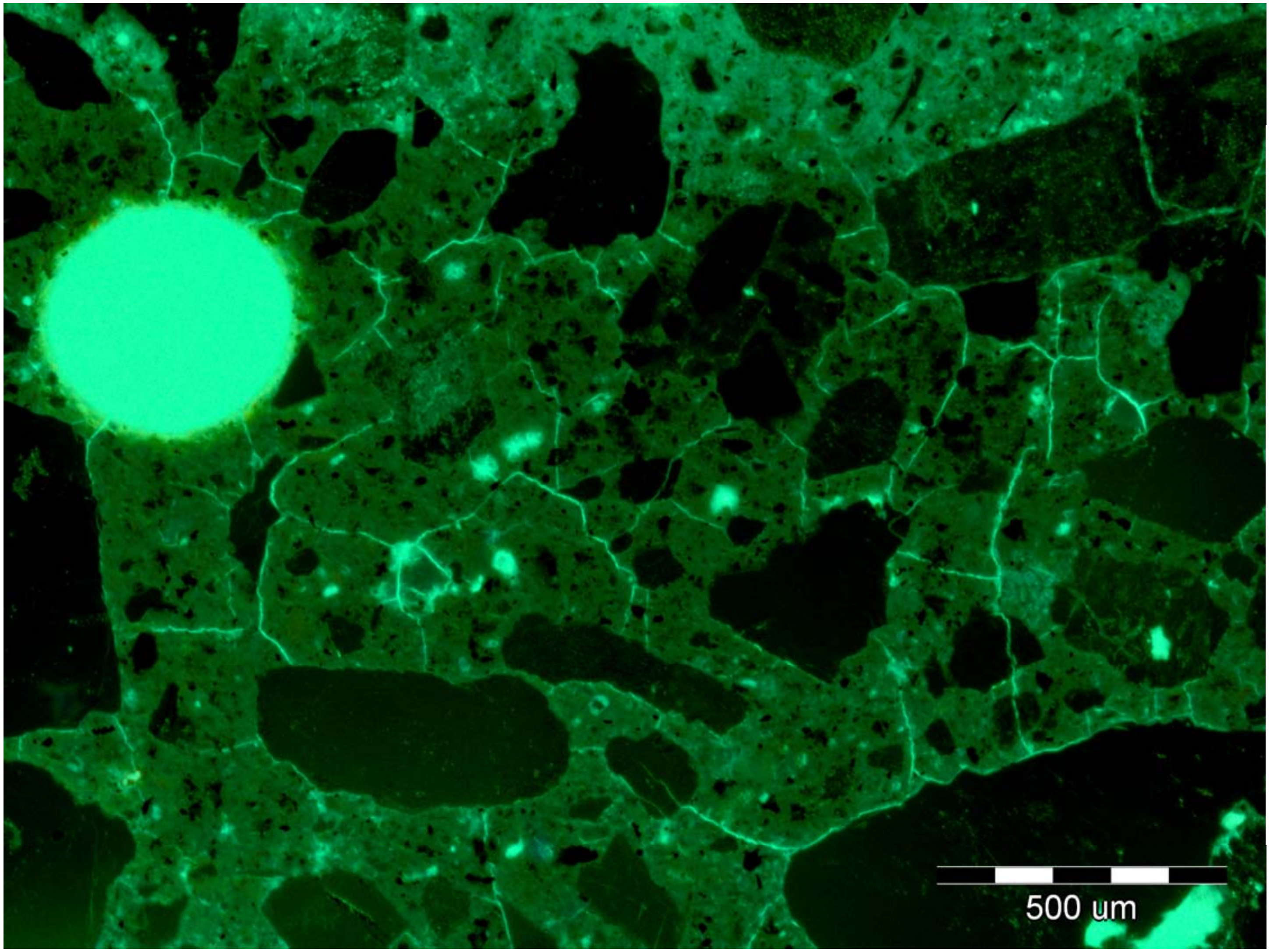


The content of CFBCFA > 30 % strongly influences on the microstructure of air-voids by missing the micro pores which play the major role in the frost resistance of concrete

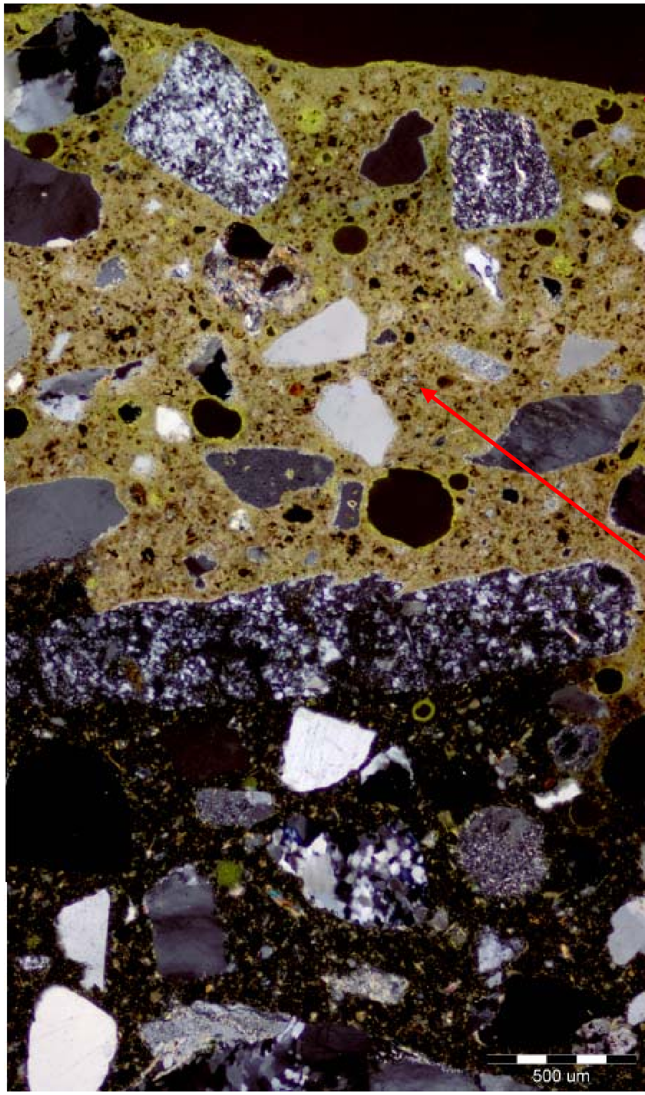
Glinicki, Zieliński

UV LIGHT, yellow dye, magnification 40x

C30K, 30% of CFBCFA from hard coal

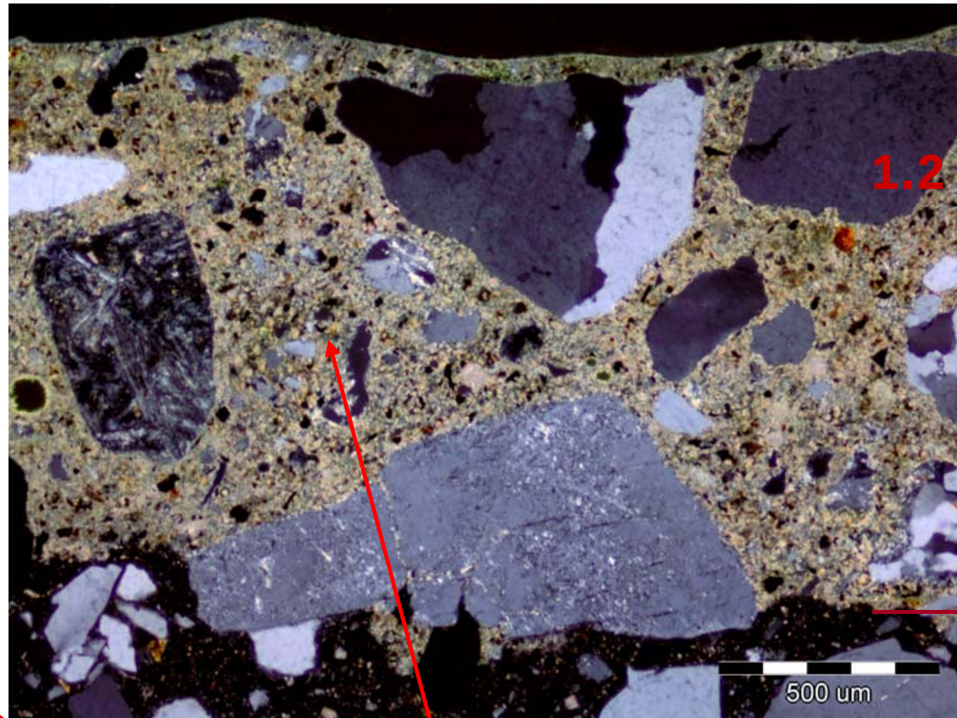


Crossed polarized light, yellow dye, magnification 40x



2 mm

C0, without CFBCFA



1.2 mm

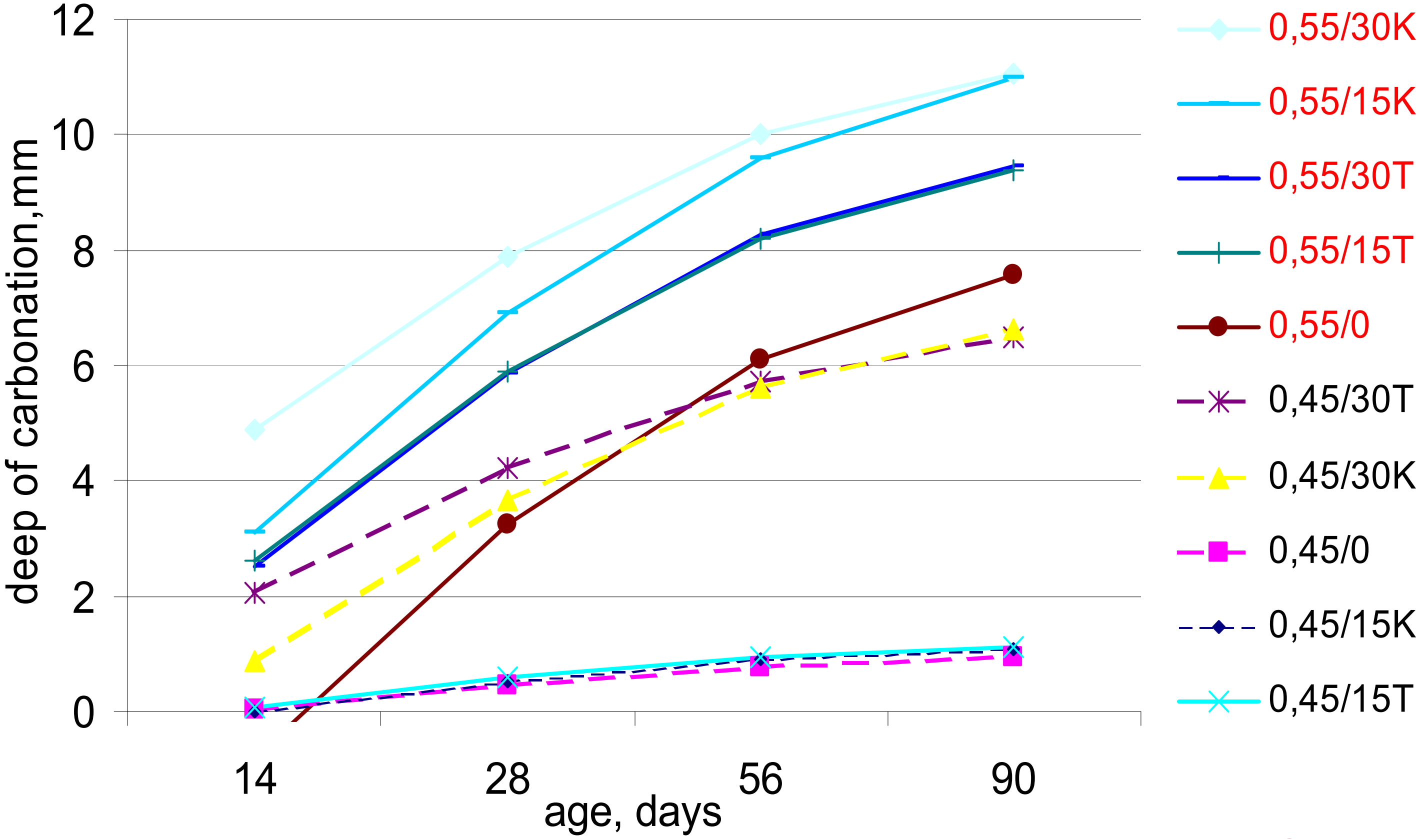
C30K, 30% of CFBCFA from hard coal

Carbonation zone

EN 13295:2004

specimens 100x100 mm, 1% CO_2

0.55/30K = w/b=0.55, 30% of CFBCFA from hard coal
0.45/15T = w/b=0.45, 15% of CFBCFA from brown coal

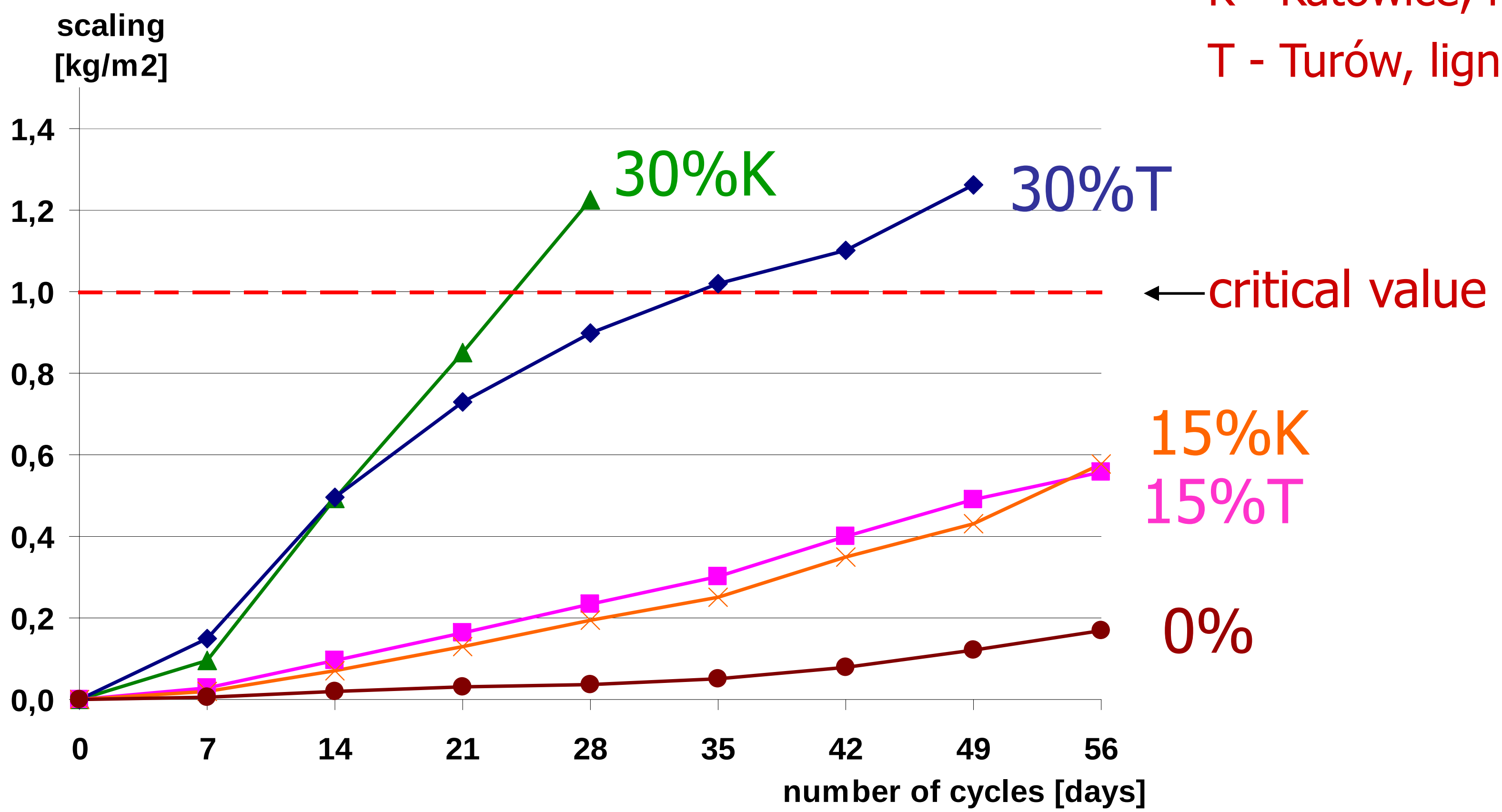


Czarnecki, Woyciechowski

CEN / TS 12390-9:2007, slab test

K - Katowice, hard coal

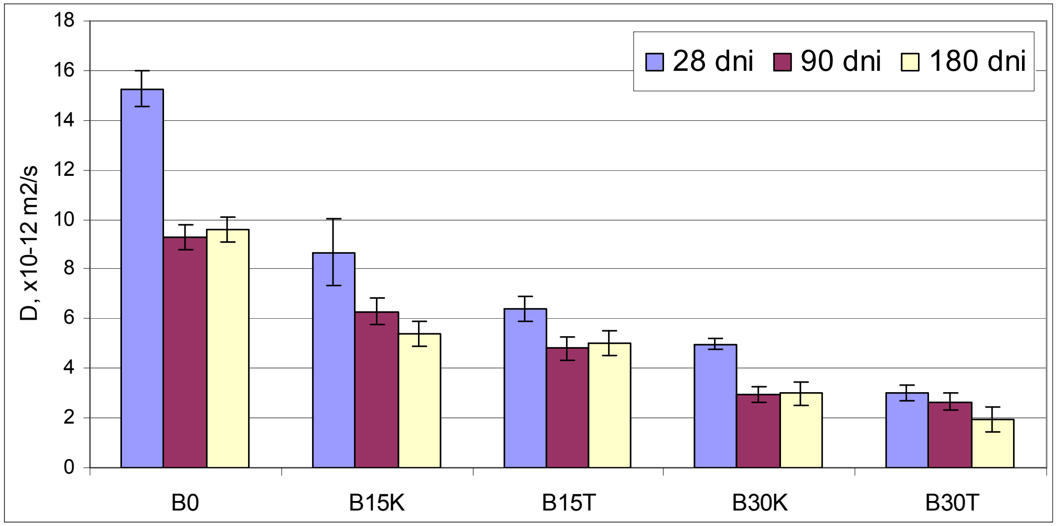
T - Turów, lignite



Scaling resistance is decreasing with increased CFBCFA content and unburned carbon content

Nordtest Method BUILD 492

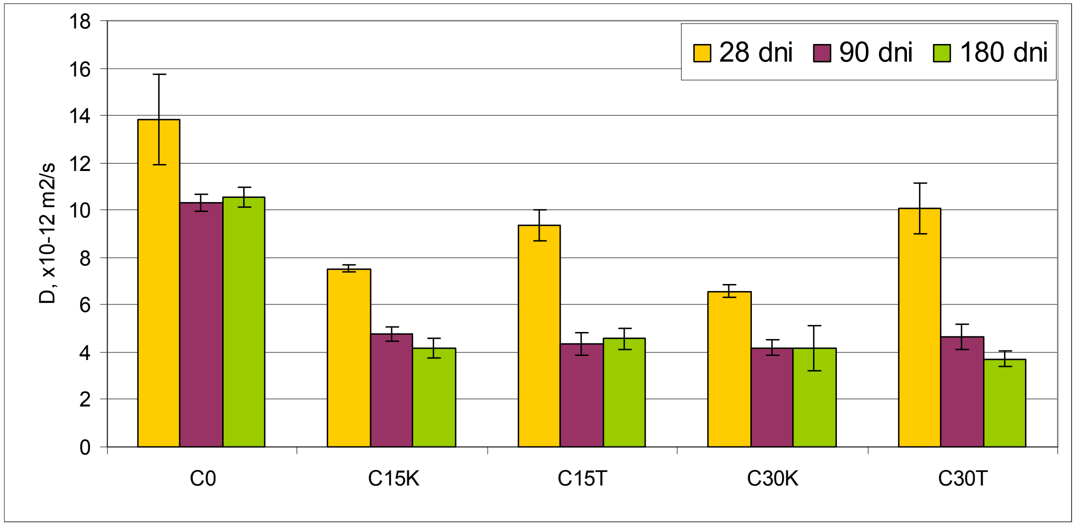
non air-entrained concretes



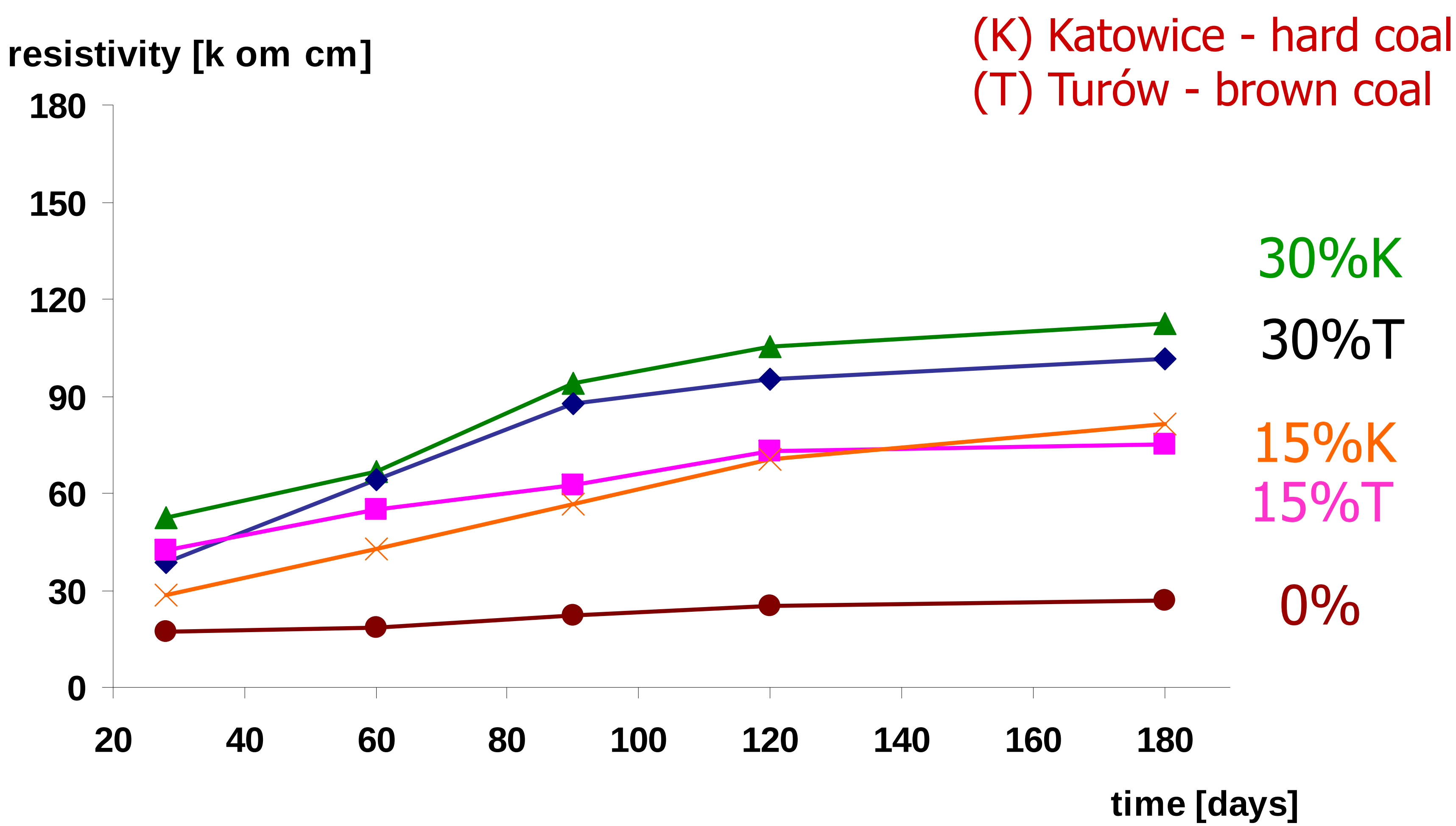
w/b = 0.45

K - hard coal
T - lignite

air-entrained concretes



Results – resistivity



Conclusions:

Positive effects:

- Increase of long term compressive strength by 10%
- Non-steady chloride migration coefficient is decreasing with CFBCFA content
- Concrete resistivity is increasing with CFBCFA content

CFBCFA has compacted the microstucture of concrete

Negative effects:

- Scaling resistance is decreasing with increased CFBCFA content and unburned carbon
- Addition of CFBCFA slightly increases the depth of carbonation
- Required microstructure of air entrained voids is more difficult to be obtained but possible

Conclusions:

After preliminary test results, it seems admissible to use Circulating Fluidized Bed Combustion Fly Ash for structural concretes, with some restrictions

Thank you for attention