

# Activation of Fly Ash binder in POPbeton® without heating

Rostislav Šulc, Pavel Svoboda

CTU in Prague, Faculty of Civil Engineering, Department of Construction Technology, Thákurova 7, 166 29 Praha 6 - Dejvice

## Introduction

There are some production processes and possibilities of alkaline activation of fly ash are examined. This fly ash is used as a binder in new type of concrete without cement binder, called POPbeton. Program was focused on „cold way“ preparation of POPbeton without necessity of heating. In this program same types of so called „intenzifikaror“ were used. These „intenzifikátor“ causes hardening of POPbeton mixture. Samples of cold way prepared POPbeton were explored with electron microscope and they were compared with POPbeton samples prepared with heating. This technology is following step to use waste materials such as fly ash and slag. In 2003 the close cooperation between the Department of glass and VŠCHT was set. Since that the examination of usage fly ash from a main hearth has been conducted. The core of the study is the geopolymer reaction. Researchers from department of glass had started this study several years before. The aim of the research is the application of acquired results into praxis.

## Mixture proportion

### Fly Ash

Location	Type of Fly Ash	SiO <sub>2</sub>	Na <sub>2</sub> O	Al <sub>2</sub> O <sub>3</sub>
Opatovice	Brown coal	52,85%	0,36%	31,84%
Dětmárovice	Black coal	47,21%	0,53%	29,02%
EFA Fuller	Black coal	46,74%	1,12%	29,17%
Otrokovice	Brown coal	52,07%	0,31%	32,99%
Kladno	from fluidises combustion	42,25%	0,57%	32,79%

### Na Silicate „water glass“

SiO <sub>2</sub>	Na <sub>2</sub> O	H <sub>2</sub> O
25,73%	8,64%	65,50%

### Na(OH)

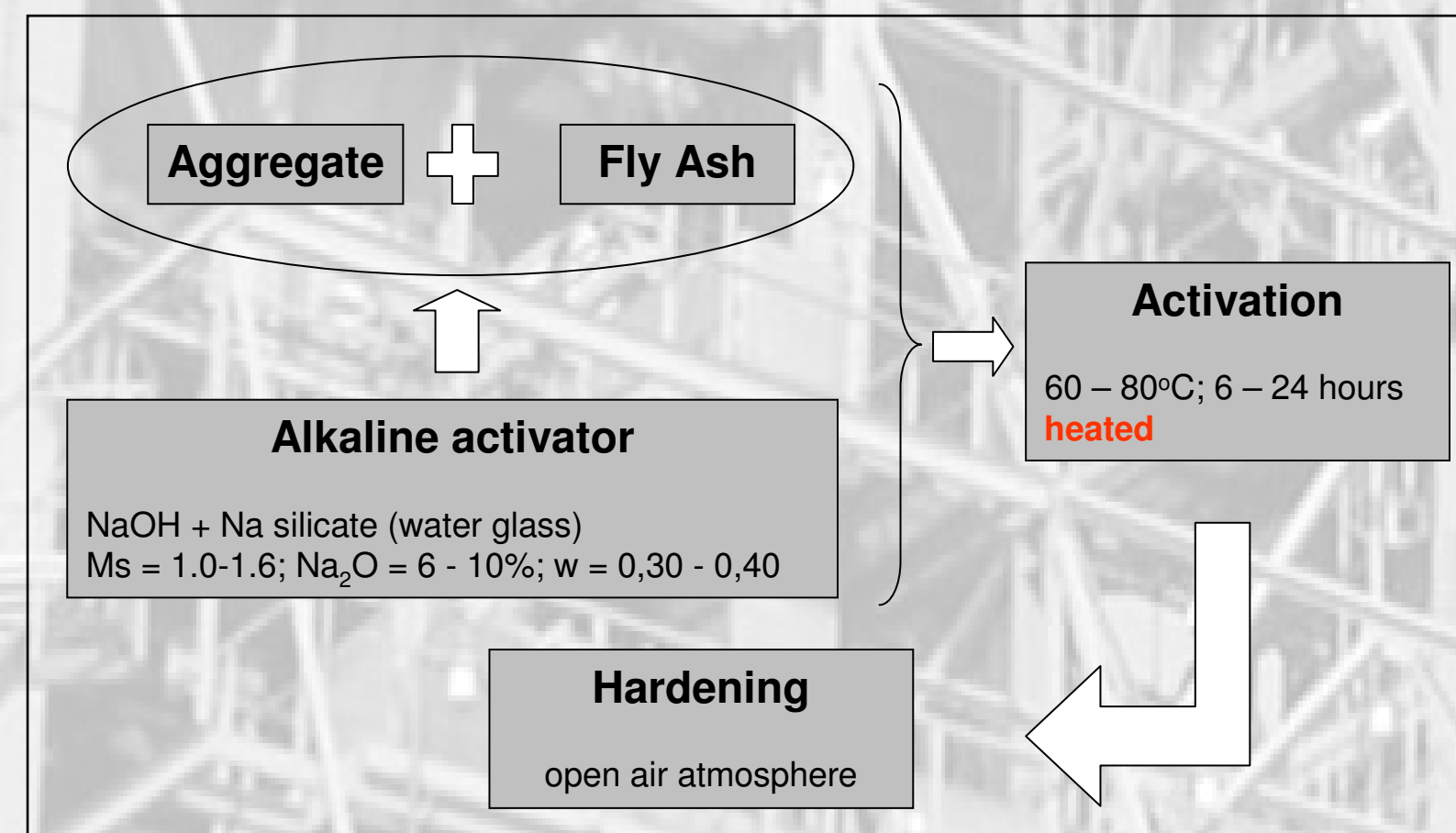
Na(OH)	H <sub>2</sub> O
100,00%	0,00%

### Sand and gravel fractions

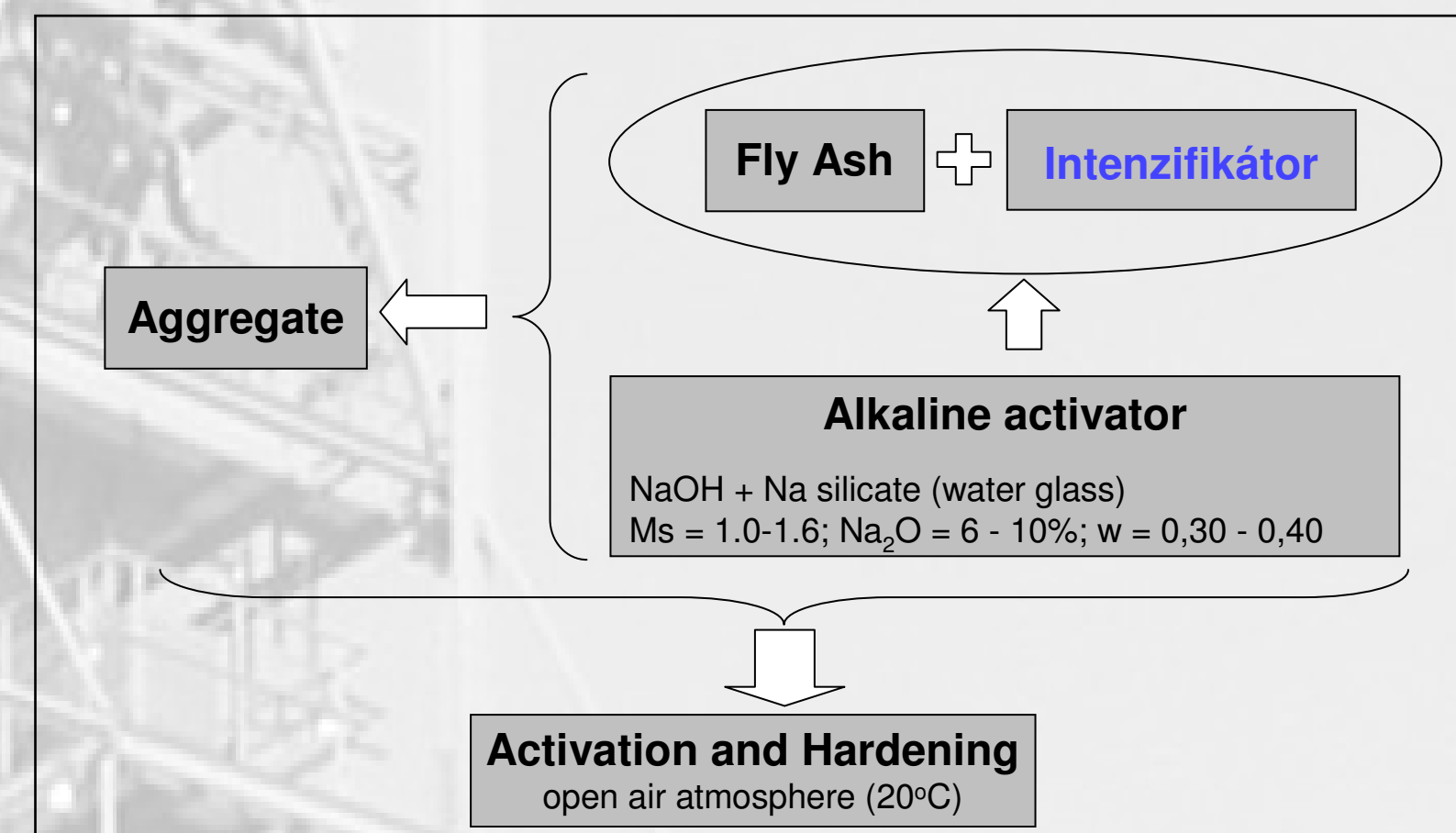
Type	Fraction	Location
Fines	0-4 mm	Dobříň
Gravel	4-8 mm	Zbraslav
Gravel	8-16 mm	Zbraslav

## Scheme of preparation of mixtures

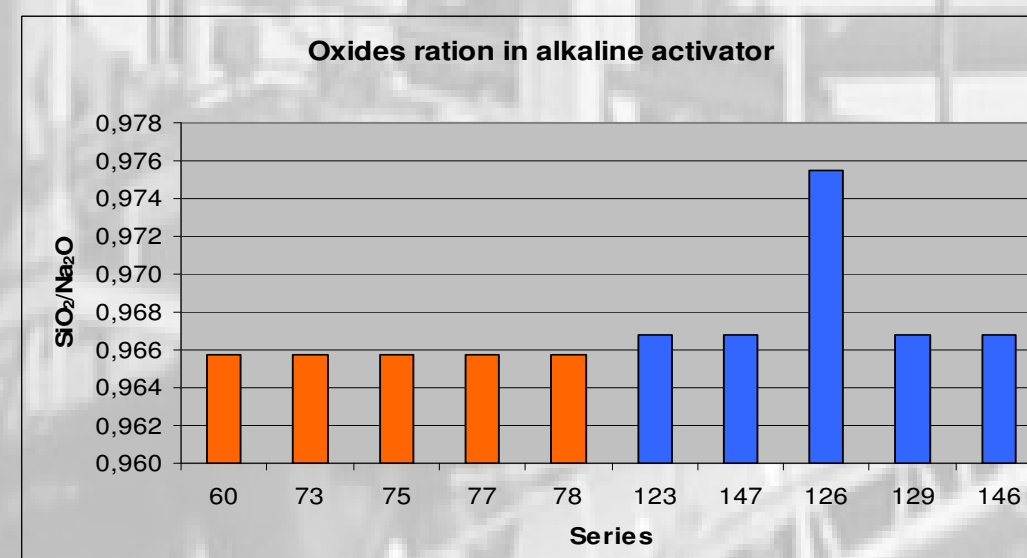
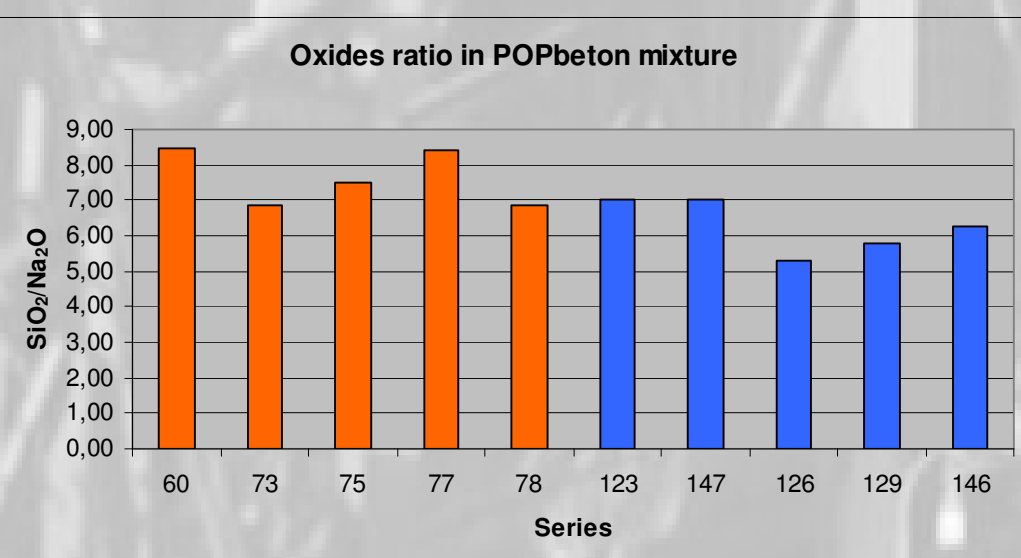
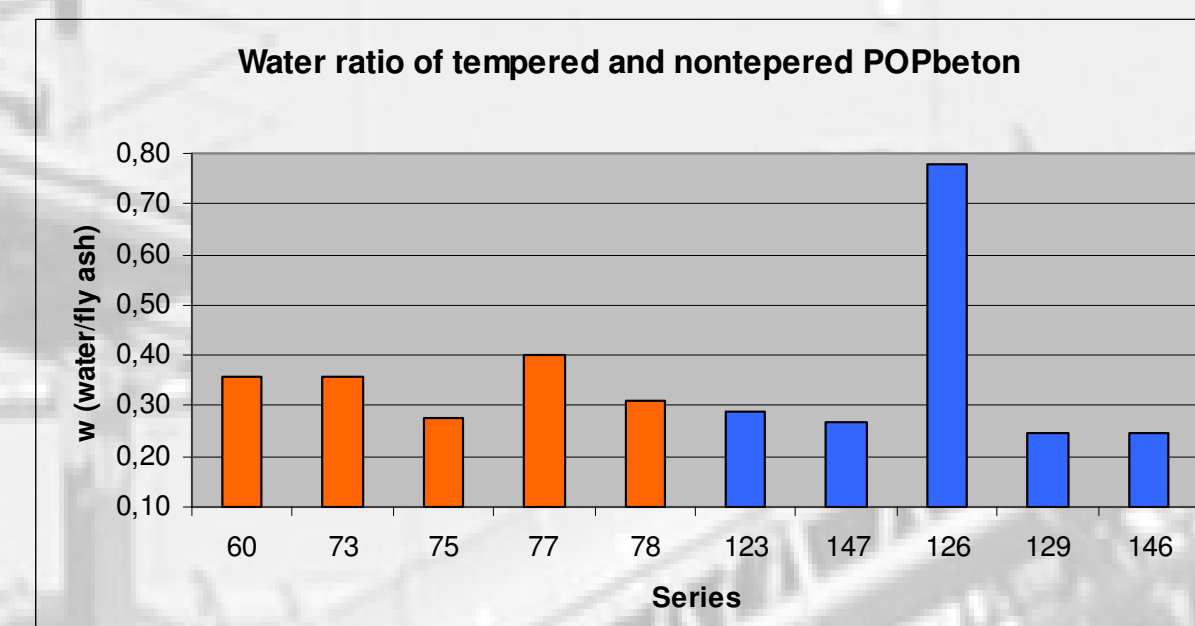
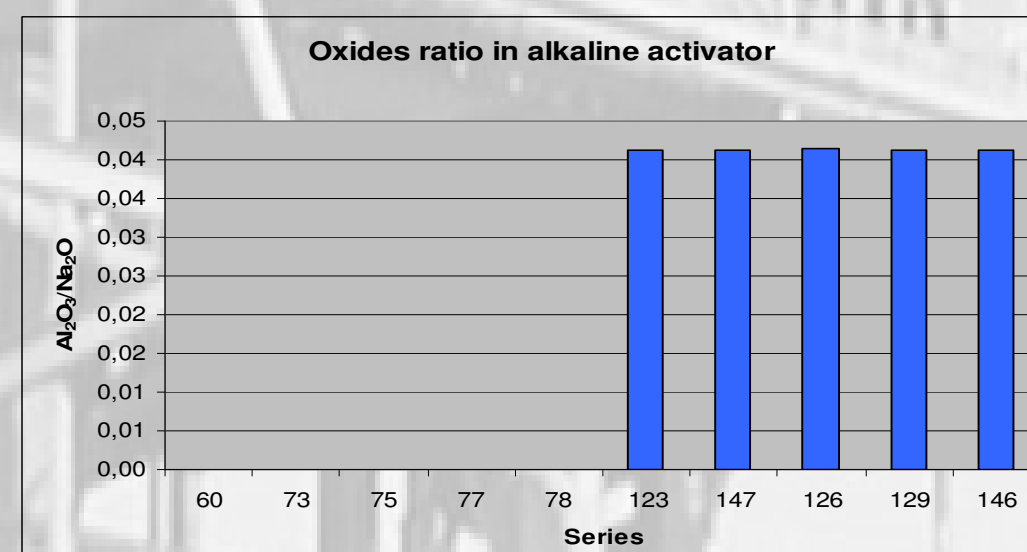
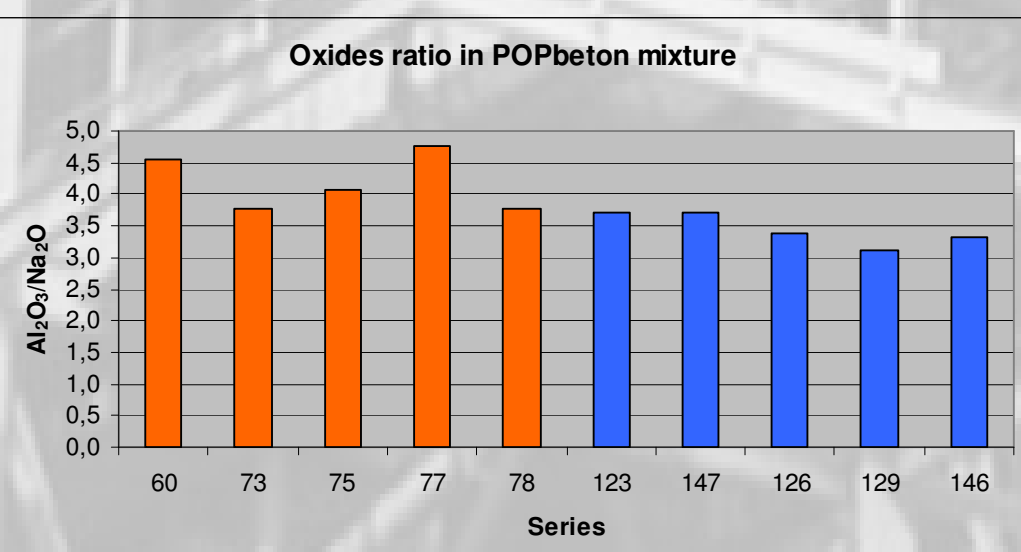
### Tempered mixtures



### Non-tempered mixtures



## Oxides ratio and water ratio



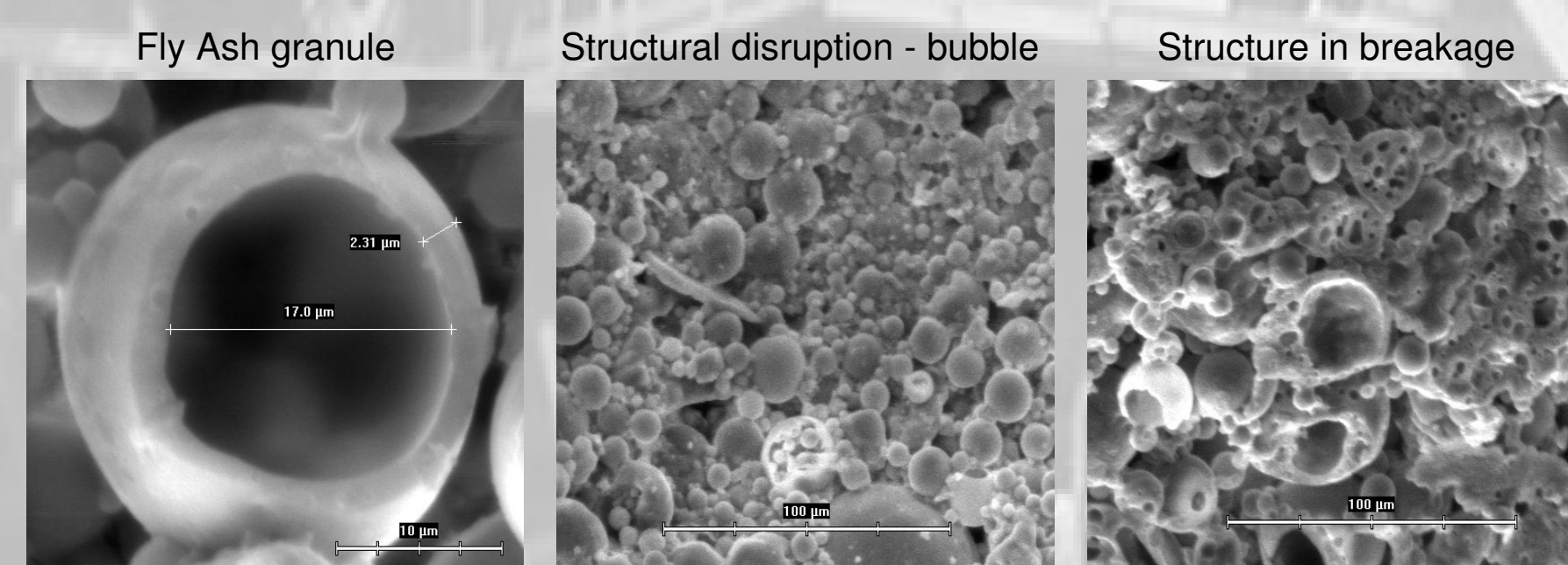
Tempered mixtures Non-tempered mixtures

• An amount of water in mixture highly influences the length of hardening of POPbeton® as well as the reached level of whole long term press strength. It seems therefore crucial to maintain the level on the minimum point to maintain a workableness of concrete mixture. A smaller amount of added water was used due to characteristics of black-coal fly ash. The effect of different amounts of water can be seen on the mixtures number 73, 76 which were the same in the rest of characteristics.

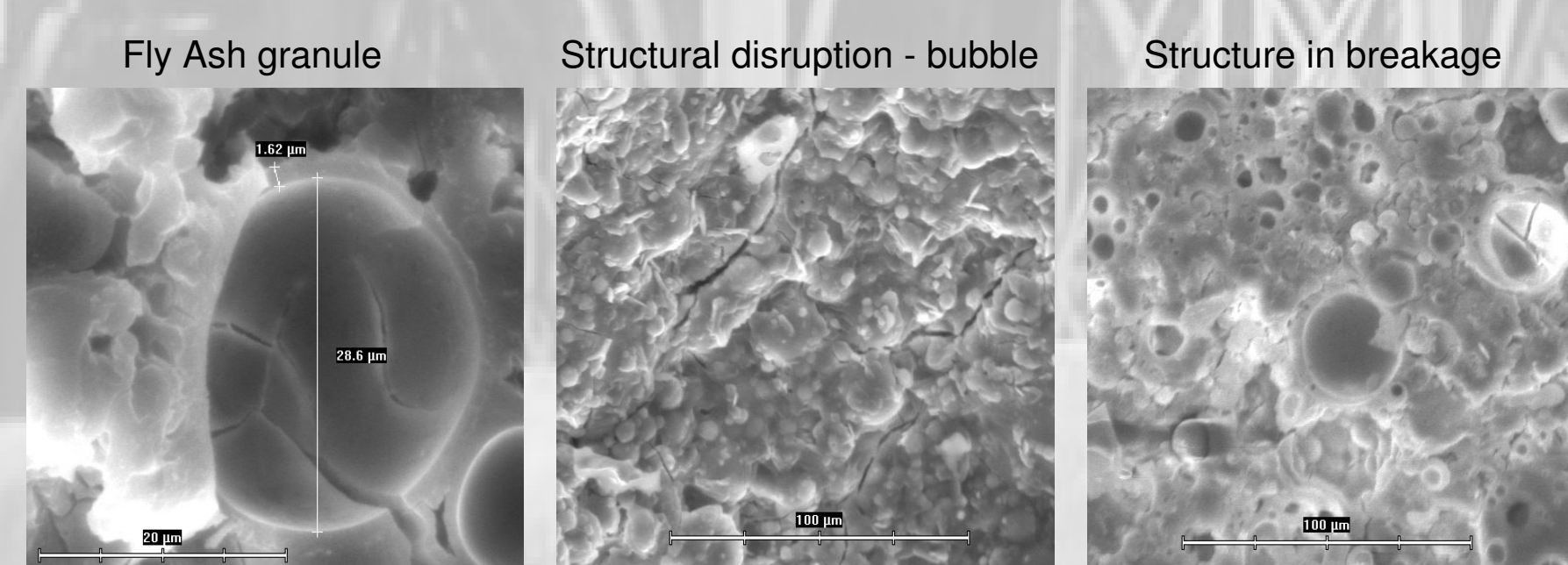
• Water ratios for non-tempered mixtures were chosen to fulfil a demand for the minimum amount of water in the mixture and to maintain the same workability for all of the series. Results from the set number 126 did not correspond with other results. The fluid fly ash from this set was therefore excluded from following examinations.

## Microstructure

### Non-tempered mixtures



### Tempered mixtures



## Types of mixtures

### Tempered series

60	Opatovice
73	EFA fuller
75	Dětmárovice
77	Otrokovice
78	EFA fuller

### Non-tempered series

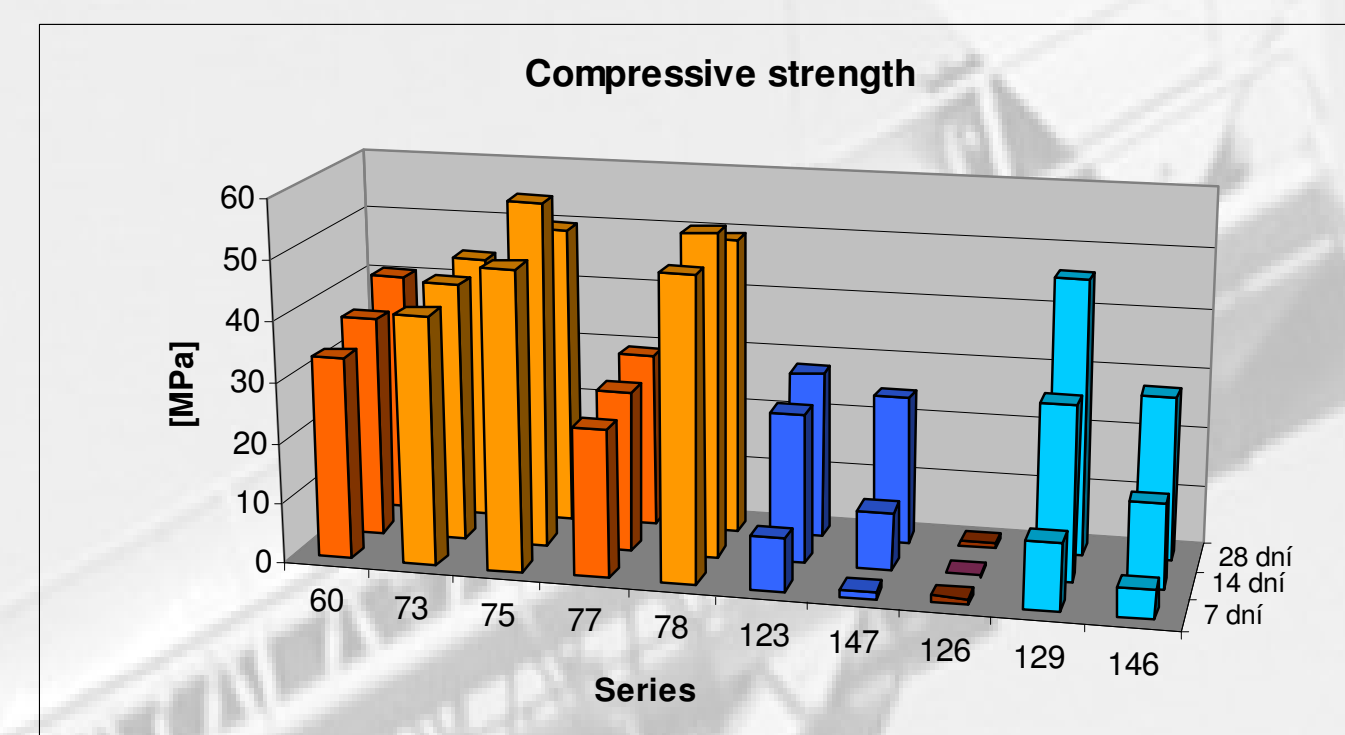
123	Opatovice
147	Opatovice
126	Kladno
129	EFA fuller
146	Dětmárovice



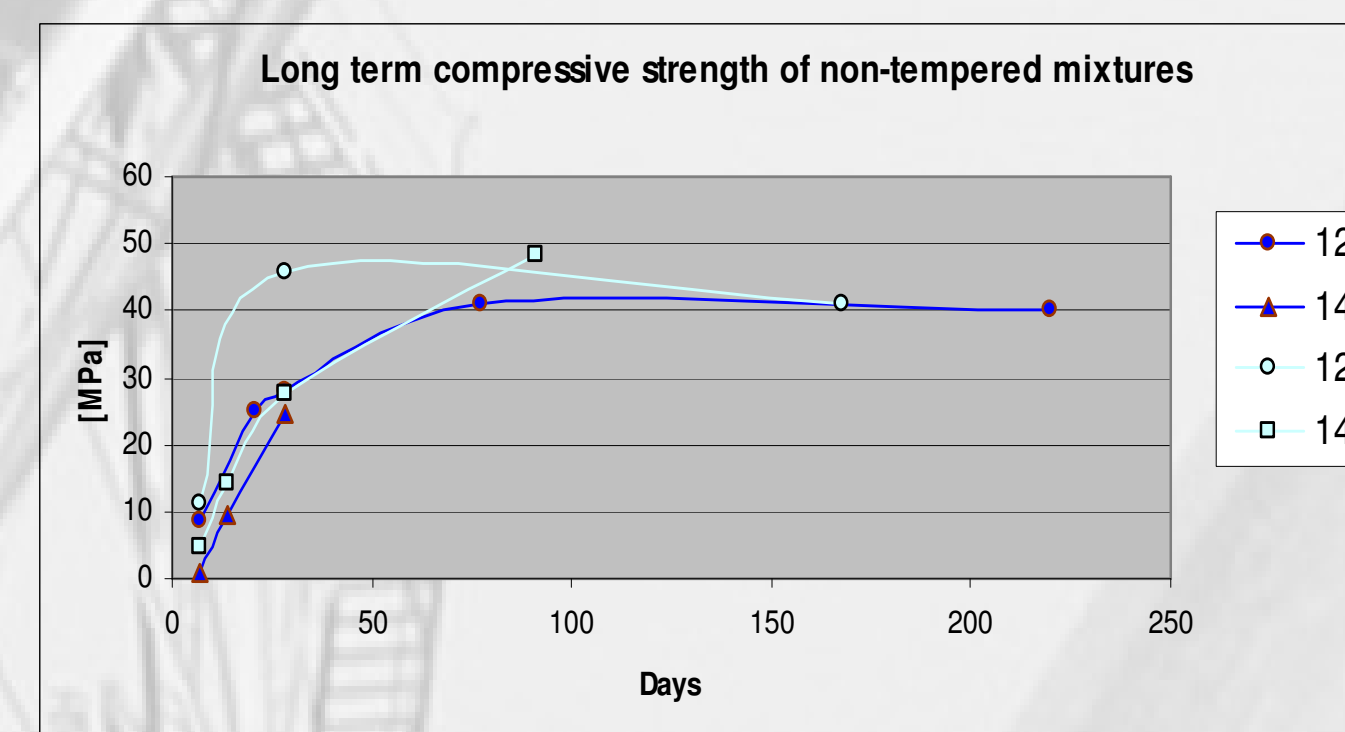
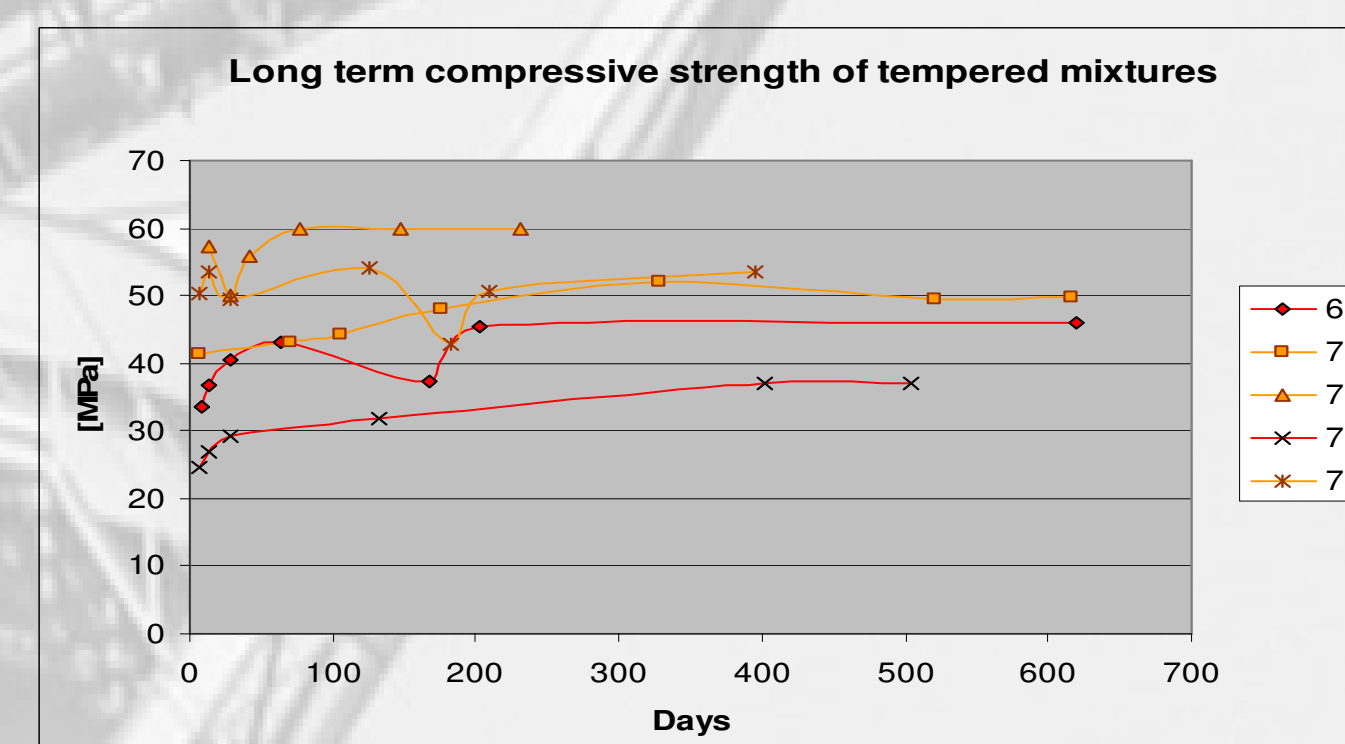
•The activation from black as well as from brown coal was investigated gradually. However, the necessity of tempering of new concrete mixture still remained an obstacle for broader application of activated ash as an agglutinant. POPbeton® prepared in this way could have been used just for building prefabricated smaller elements such as interlocking pavement.

•Thus it seemed necessary to develop the new technology of preparation of POPbeton® which would avoid temperation. Hence so called regulator of solidification was searched. A goal of implementation of this substance is to start the whole process of geopolymer reaction without the necessity to supply energy in the form of heat.

•Examinational cubes of size 100 x 100 x 100 were created. Press strength after 7, 14 and 28 days was examined on them. Long term press strength was examined as well. An amount of water in mixture highly influences the length of hardening of POPbeton® as well as the reached level of whole long term press strength.



Tempered mixtures Non-tempered mixtures



• The differences between black-coal and brown-coal POPbeton® are shown by press strength results. While press strength of black-coal fly ash are about 50 MPa press strength of brown-coal one are about 40 MPa.

• Press strengths of POPbeton® were examined 7, 14 and 28 days. Press strengths were measured over time as well. All of the mixtures showed more gentle grow than the mixtures prepared with tempering. The resulted press strength after 28 days are about 10 MPa lower comparing with the tempering alteration.

• Levels of long time press strength were observed on these series. Press strength increases by around 10 MPa over time. This increase proceeds till the 40th day.

• Investigating of long term press strengths provided us with interesting outcomes. The grow of press strengths is more gentle. To maintain the exact dosage of added water is very hard. Press strengths grow until 100th day. The reached press strengths are about 5 MPa lower than these of alteration prepared by tempering.

## Acknowledgments

The research is conducted within the grant of GAČR 103/05/2314 „Mechanické a inženýrské vlastnosti geopolymerních materiálů na bázi alkalicky aktivovaných popílků“ and a research aim MŠM 6046137302 „Příprava a výzkum funkčních materiálů a materiálových technologií s využitím mikro a nanoskopických metod“.

Other researchers cooperating within this research are: Josef Doležal<sup>1</sup>, Tomáš Strnad<sup>1</sup>, Jaroslav Jeništa<sup>1</sup>, Gabriela Tlapáková<sup>1</sup>, Pavel Houser<sup>1</sup>, František Škvára<sup>2</sup>, Lenka Myšková<sup>2</sup>, Simona Pawlasová<sup>2</sup>

<sup>[1]</sup> ČVUT v Praze, Fakulta stavební, K122 - Katedra technologie staveb, Thákurova 7, 199 29 Praha 6 - Dejvice, [pavel.svoboda@fsv.cvut.cz](mailto:pavel.svoboda@fsv.cvut.cz)  
<sup>[2]</sup> Vysoká škola chemicko-technologická, ústav skla a keramiky, Technická 5, 166 28 Praha 6 - Dejvice, [Frantisek.Skvara@vscht.cz](mailto:Frantisek.Skvara@vscht.cz)