Institute of Fundamental Technological Research
Polish Academy of Sciences

IMPACT OF GAMMA RADIATION ON BORON RETARDED MORTAR IN EARLY AGE OF HARDENING

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RADCON meeting, 11-14 March, 2019, Smolenice – Slovak Academy of Sciences

Outline

1. Intoduction
2. Research program
3. Results
4. Concluding remarks
5. Supplementing of research

Introduction

Impact of gamma radiation:

- reduce setting time
- escape of moisture
- increase strength
- reduce shrinkage
- reduce prosity

CARBONATION

Formation vaterite and aragonite instead od calcite in micropores near to C-S-H

I. I. Maruyama et al., IMPACT OF GAMMA-RAY IRRADIATION ON HARDENED WHITE PORTLAND CEMENT PASTES EXPOSED TO ATMOSPHERE, CCR 2018

II. S. Ishikawa et al., CARBONATION OF CEMENT PASTE USING HIGH EARLY STRENGTH PORTLAND CEMENT UNDER GAMMA-RAY IRRADIATION, CSCT 2017

Objectives

Using of gamma radiation field to control of setting time in 3D printing

1. influence of gamma radiation dose on early age properties
2. Impact of boron retarders on properties of early age hardened mortar
3. Controlling setting time and rate of hydration

Cooperation with the CTU

Assumption:

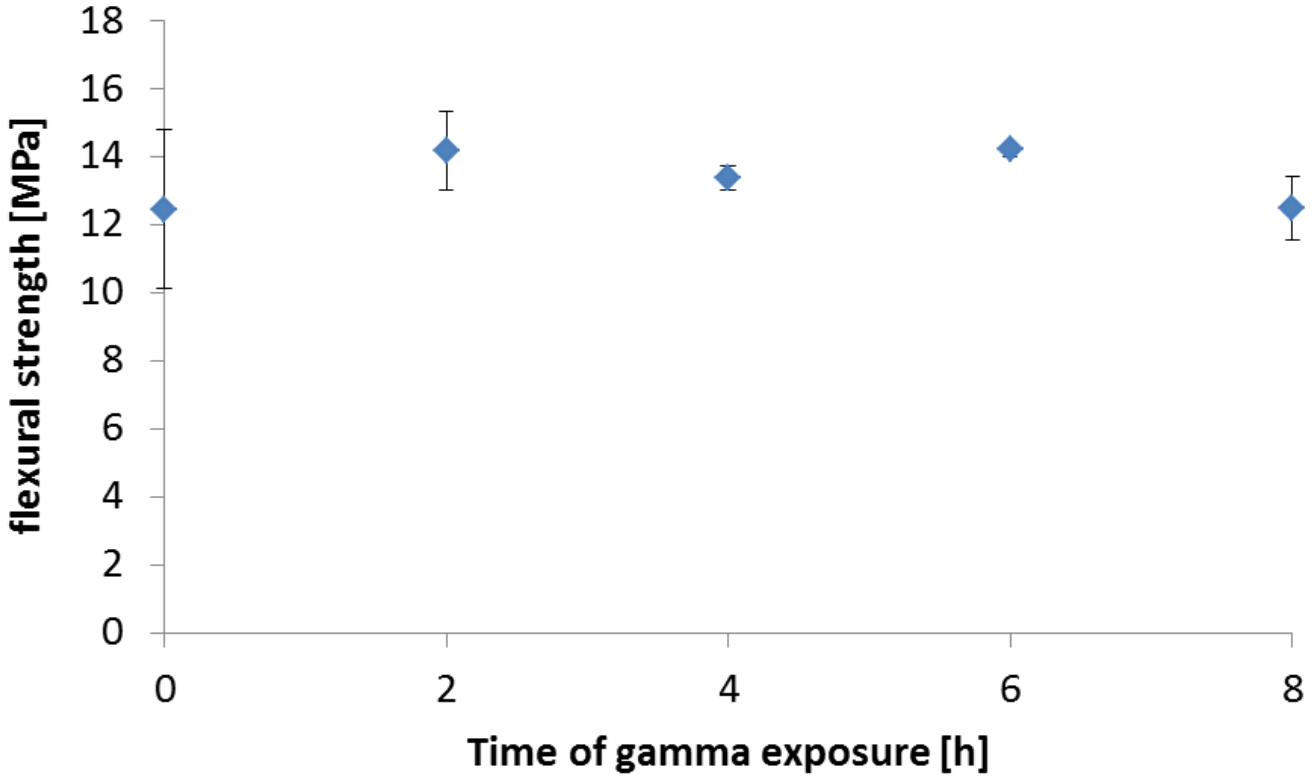
- cement paste specimens - 10 x 10 x 80 mm
- Portland cement and w/c=0.38
- time of gamma exposure:
  - non-irradiated – „0h”
  - 2h
  - 4h
  - 6h
  - 8h

Gamma radiation source:

60Co Irradiation Facility UGU-420 of The Joint Institute for Power and Nuclear Research - Sosny of the National Academy of Sciences of Belarus

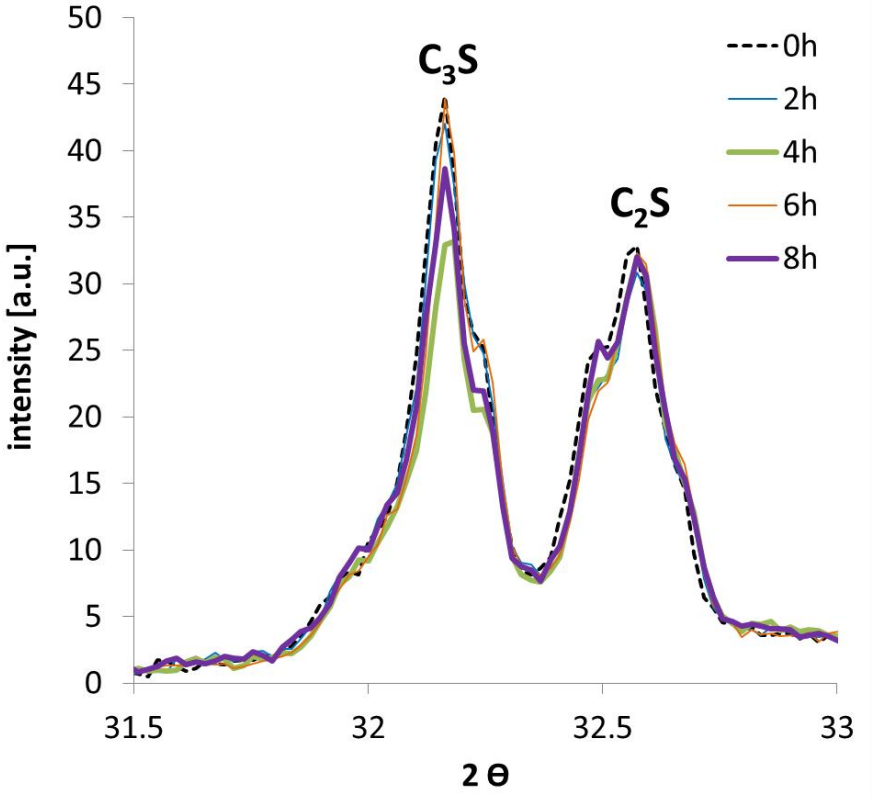
Flexural strength

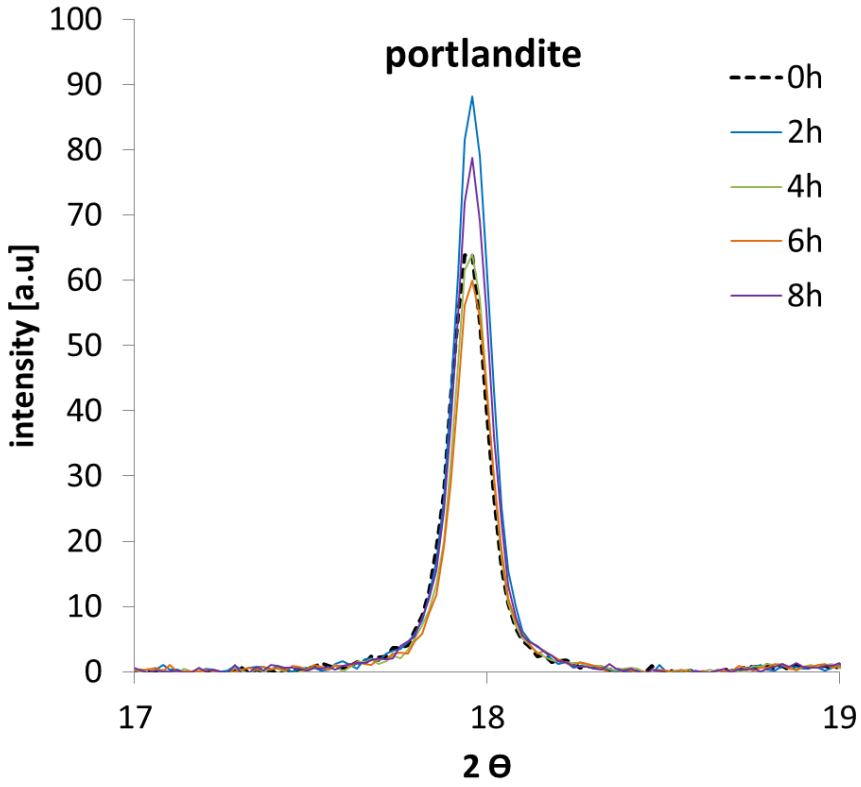
- Three-point bending test
- LLOYD EZ 50 – up to 500 N
- The span – 60 mm
- Specimens – 10 x 10 x 80mm
- 24h drying at 50°C befor test



X-ray diffraction (XRD)

- Bruker D8 DISCOVER
- voltage ratio – 40 kV
- Copper lamp current – 40 mA
- Step - 0,02 deg.
- 24h drying at 50°C before crushing (<45 μm) and testing





Objectives

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1. influence of gamma radiation dose on early age properties
2. Impact of boron retarders on properties of early age hardened mortar
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Research program

Assumption:

- mortar specimens - 15 x 15 x 100 mm
- cement/sand/water ratio:
  - 1/2/0,45 – mortar with Portland cement
  - 1/2/0,50 – mortar with CSA cement
- Boron additives:
  - ulexite (U)
  - colemanite (Col)
  - boric acid (BA)
- time (dose) of gamma exposure – 8h (dose 35-39 kGy)
- temperature: 8-13 °C and RH: 40-50%
- storage: in aceton

Gamma radiation source: 60Co Irradiation Facility UGU-420

Dosage of retardant additives

Mortar with Portland cement	Designation of mortar					
	I_0	I_0_γ	I_U0,50_γ	I_U0,75_γ	I_Col3_γ	I_Col6_γ
U [% c.m.]	-	-	0.50	0.75	-	-
Col [% c.m.]	-	-	-	-	3	6
BA [% c.m.]	-	-	-	-	-	-

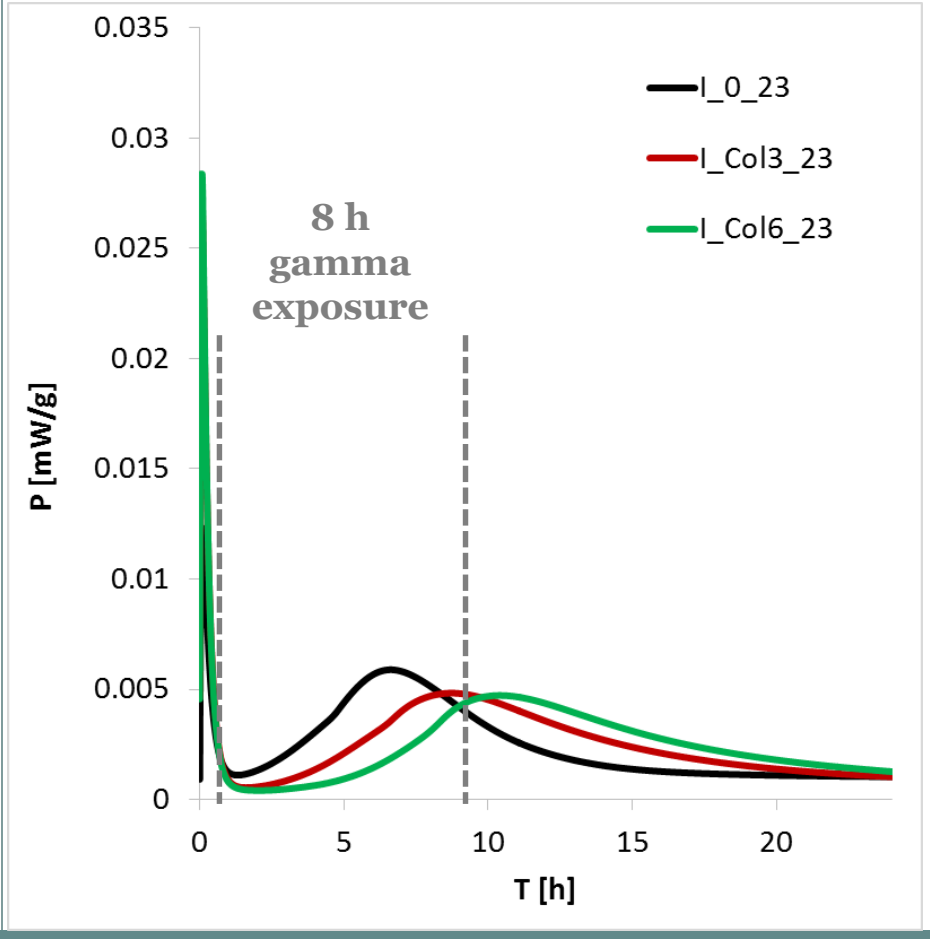
Gamma irradiation – 8 h

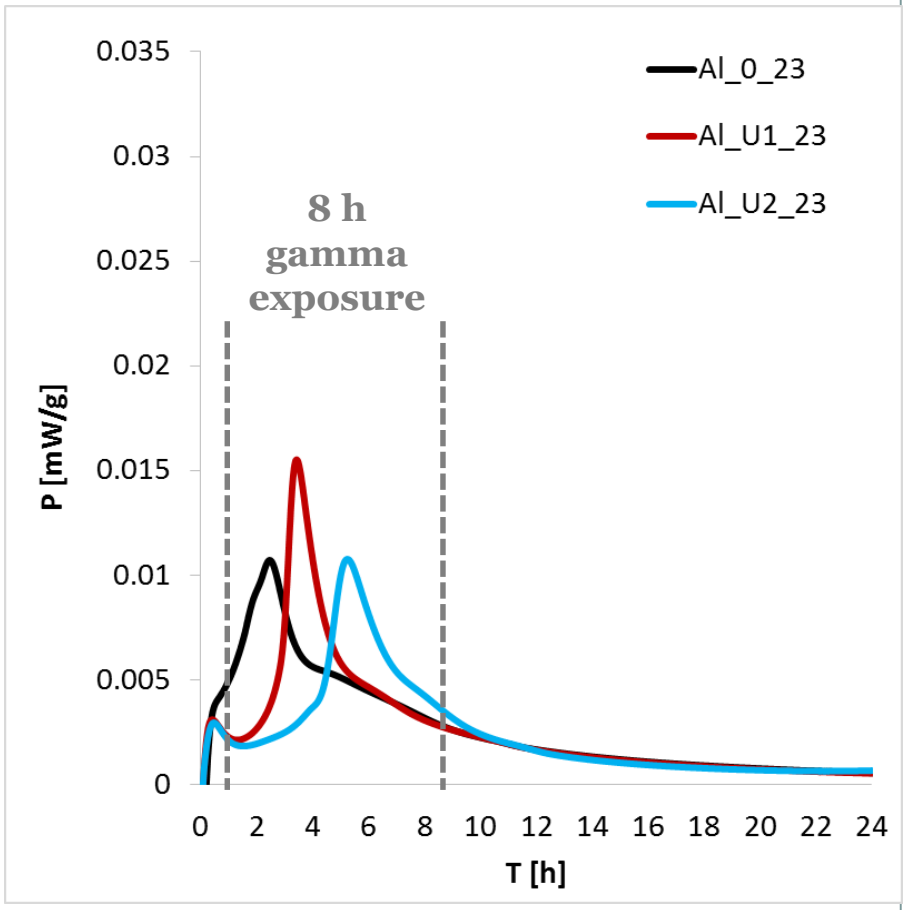
Mortar with CSA cement	Designation of mortar					
	Al_0	Al_0_γ	Al_U1_γ	Al_U2_γ	Al_BA0,2_γ	Al_BA0.4_γ
U [% c.m.]	-	-	1	2	-	-
Col [% c.m.]	-	-	-	-	-	-
BA [% c.m.]	-	-	-	-	0.2	0.4

Gamma irradiation – 8 h

Isothermal calorimetry

- Calmetrix I-Cal 2000 HPC
- temperature – 23 °C
- Mass of specimen – 125g





Flexural strength

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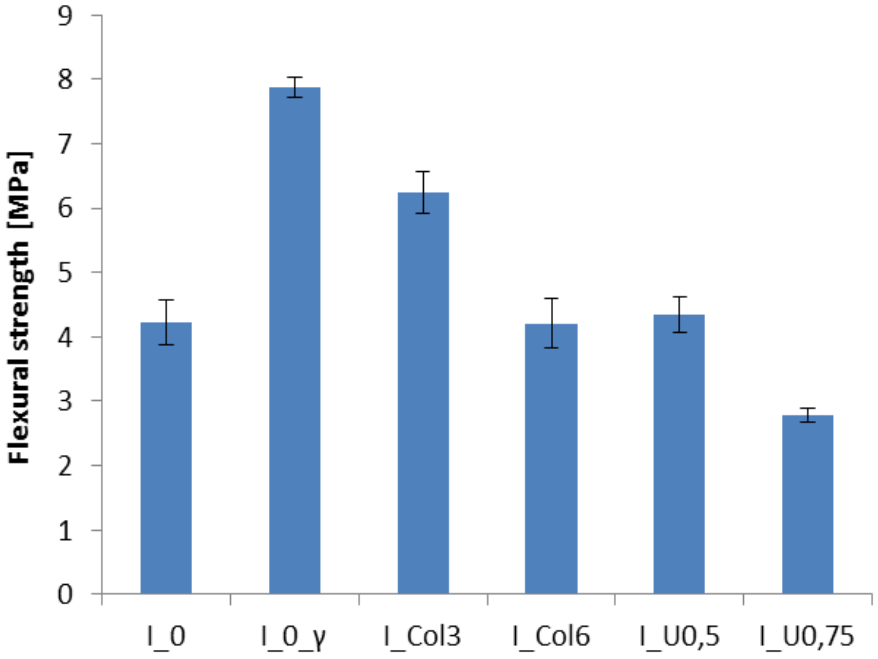
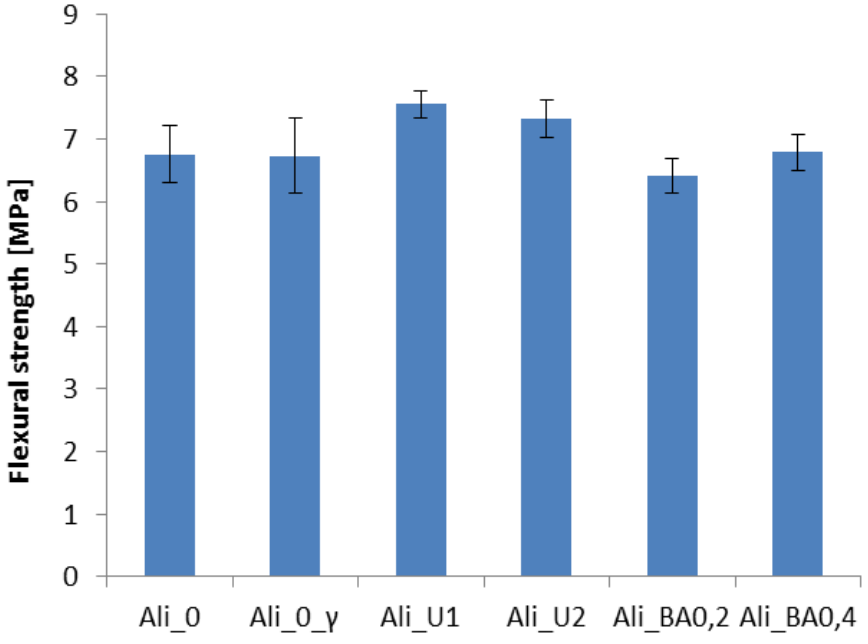
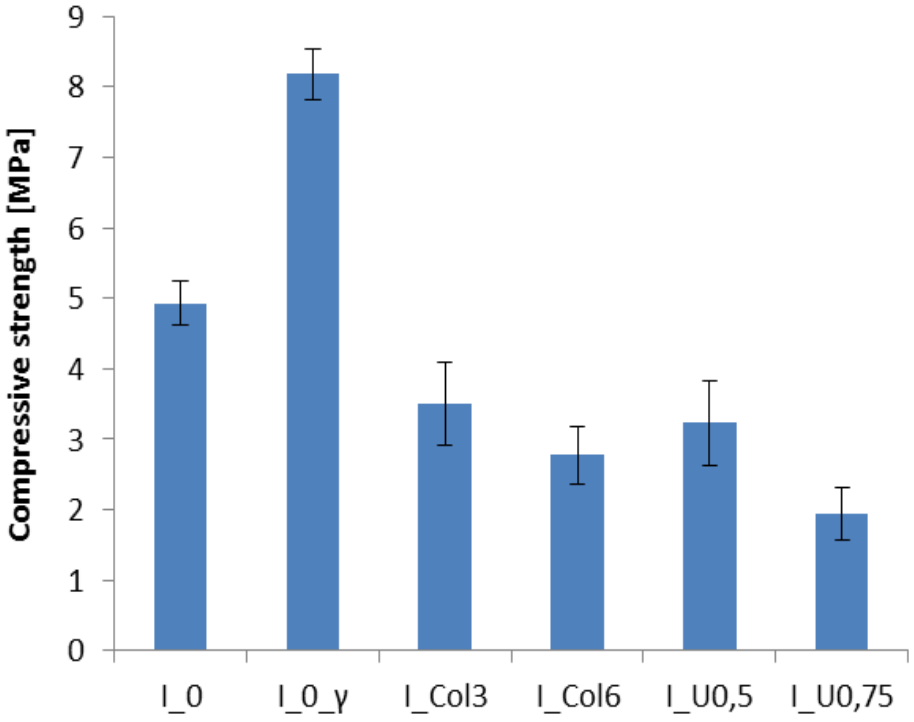
- the span – 60 mm
- specimens – 15 x 15 x 100mm
- 24h drying at 50°C befor test
- average of 3 specimens

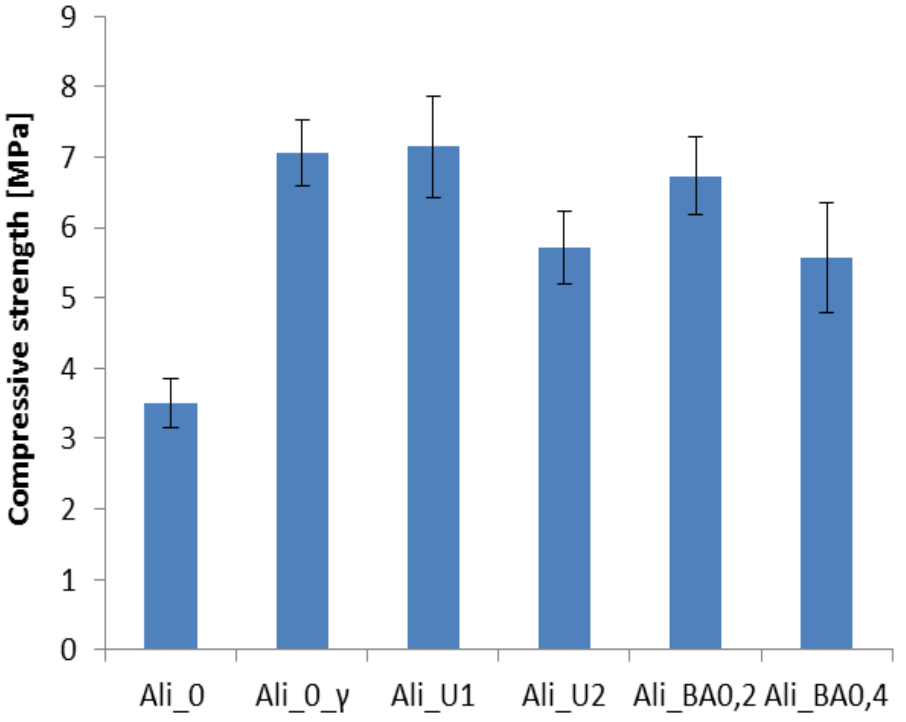




Compressive strength

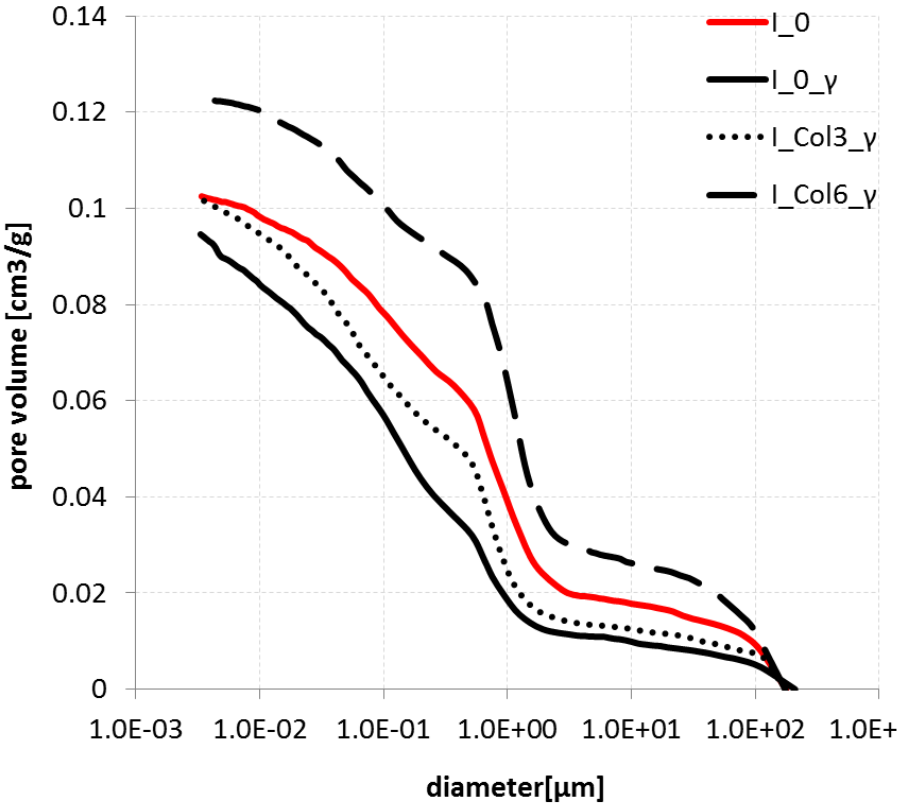
- LLOYD EZ 50 – up to 50 kN
- half of specimens – 15 x 15 x 50mm
- Immediately after three-point bending
- average of 5 specimens

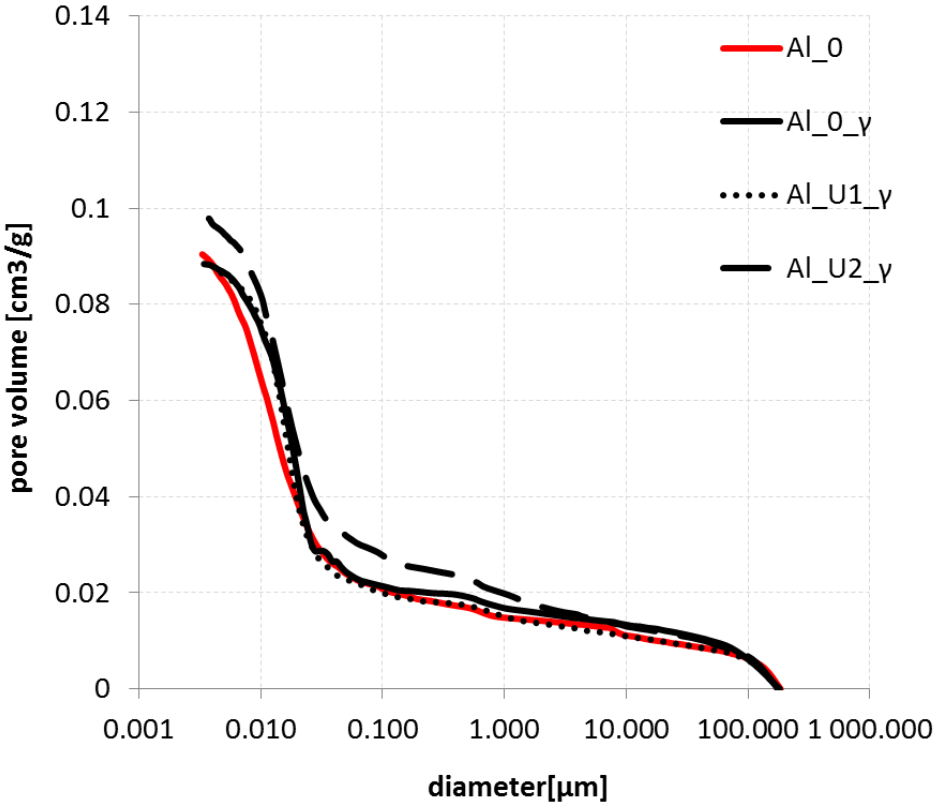




Mercuty intrusion porosimetry (MIP)

- PoreMaster 60 firmy Quantachrome Instruments
- 7days drying at 50°C





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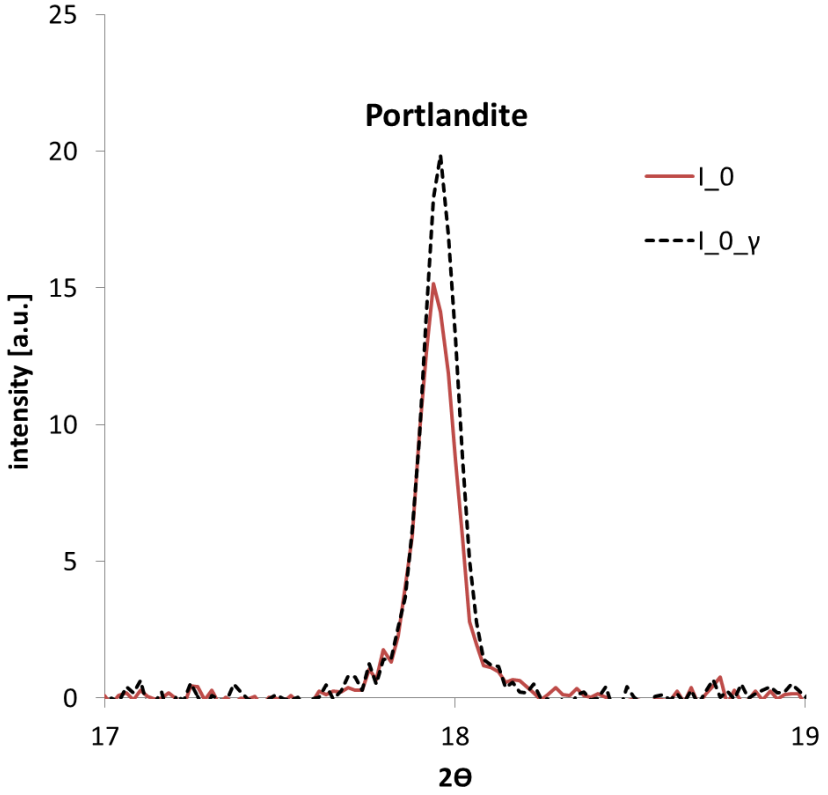
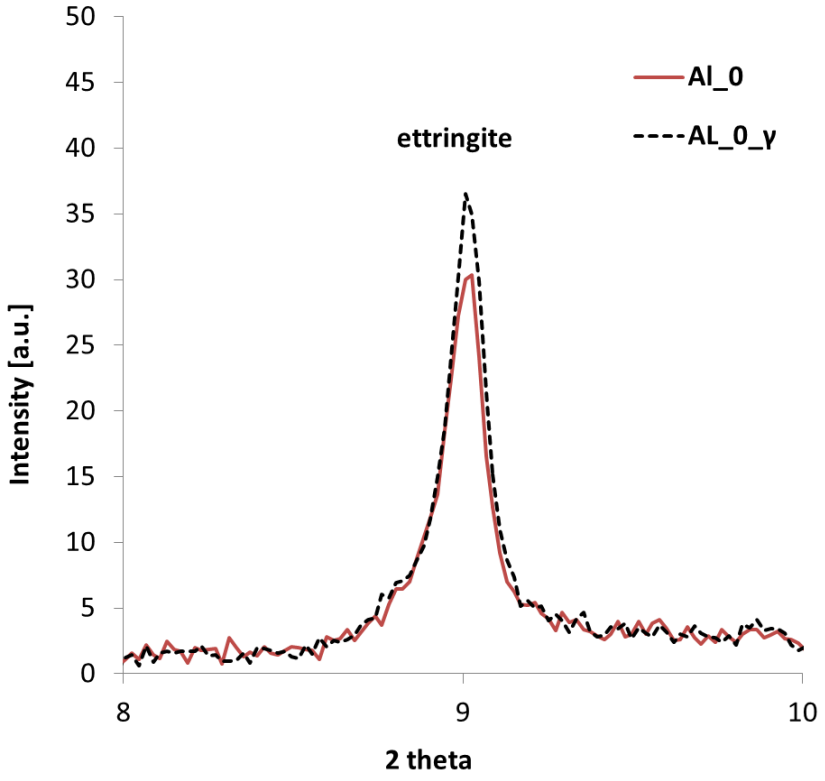
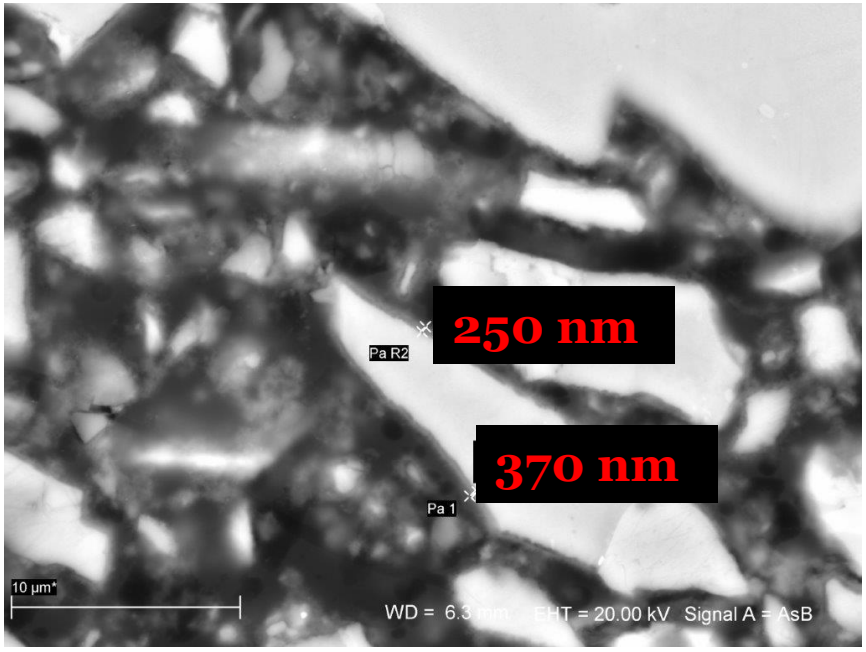


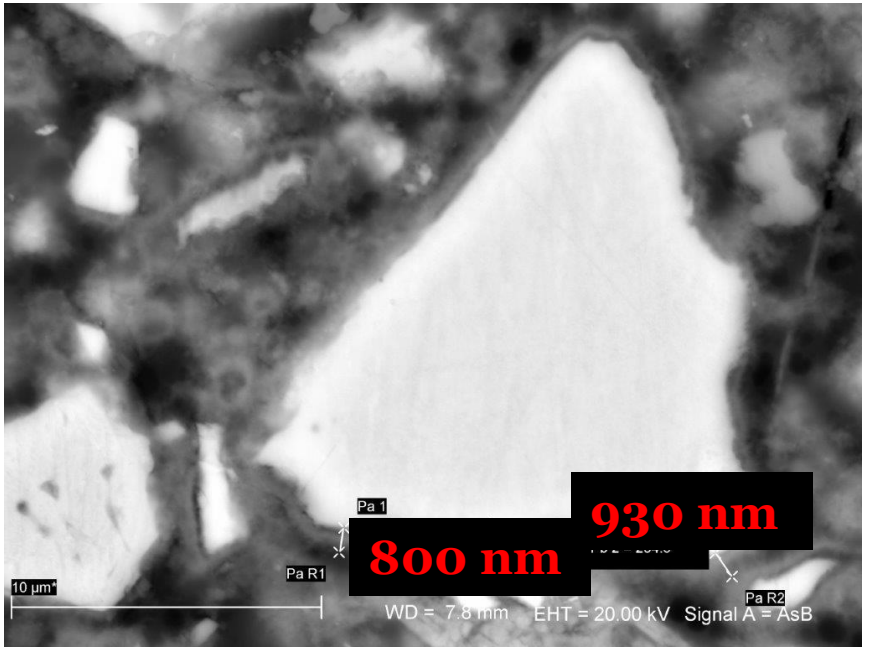


SEM – EDX observation

- Nova NanoSEM 200 with EDX microanalysis
- Preparation:
  - 7days drying at 50°C
  - impregnation in an epoxy resin
  - polishing surface of mortar beginning from the mold wall
- Observed – polished surface 2mm from surface



I_0



I_0_γ

Isothermal calorimetry at 10, 23 and 40 °C

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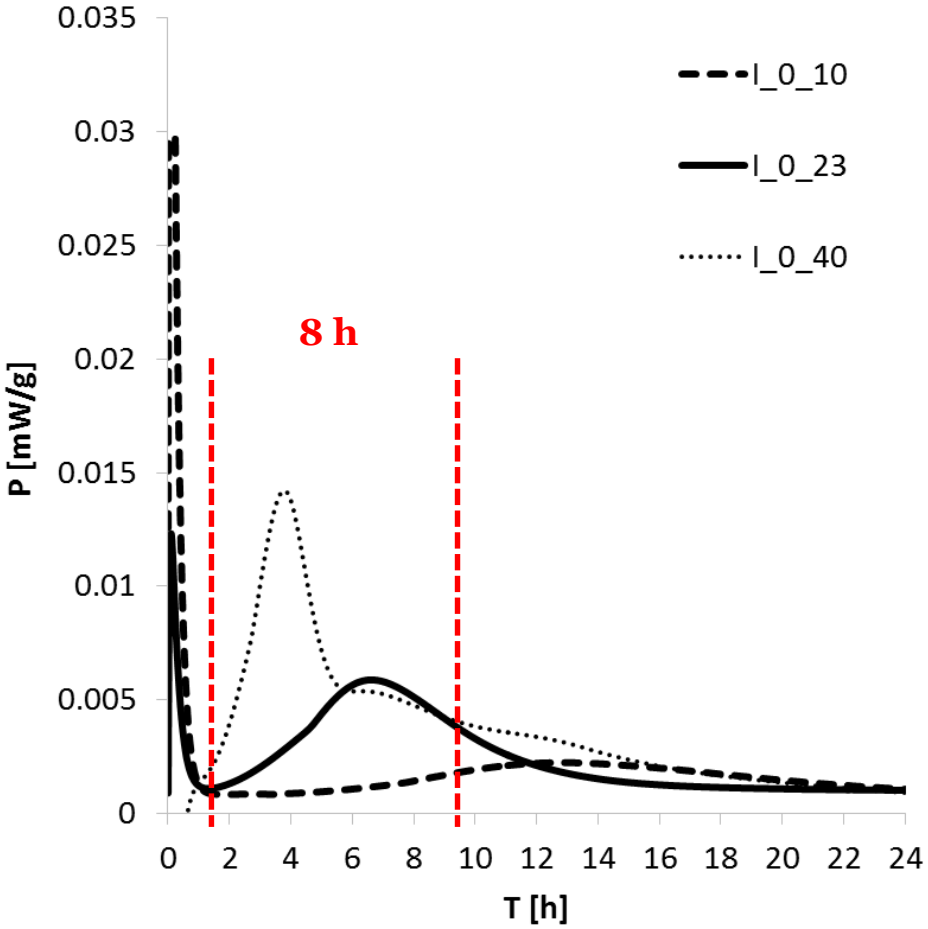

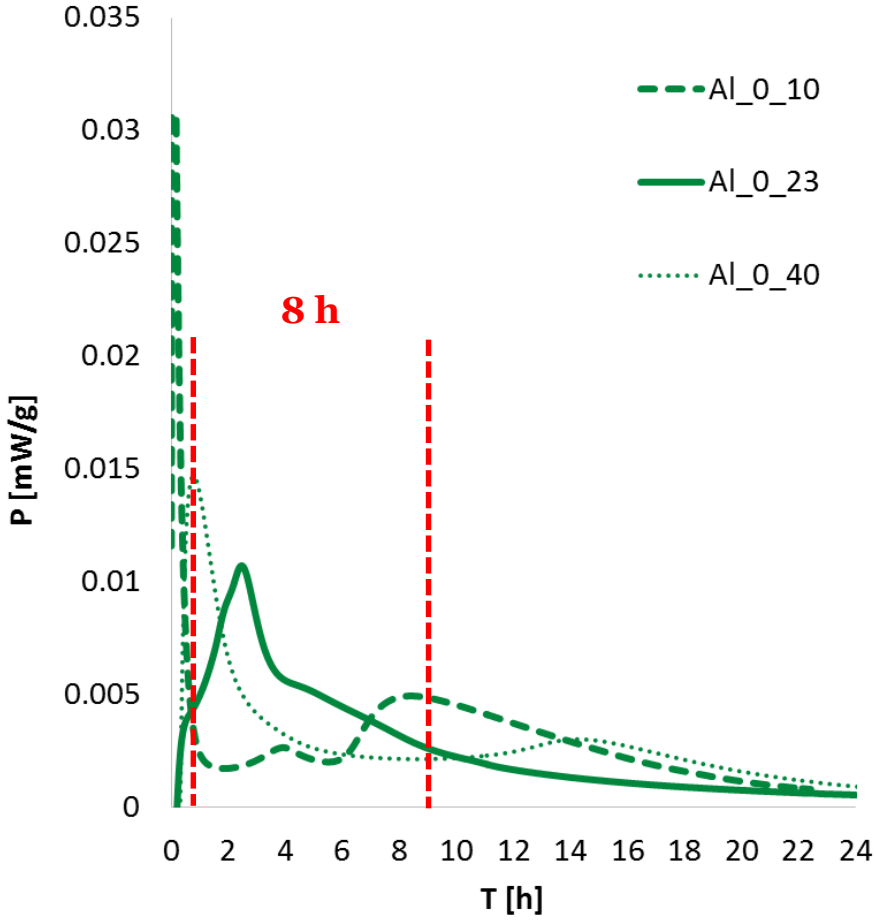

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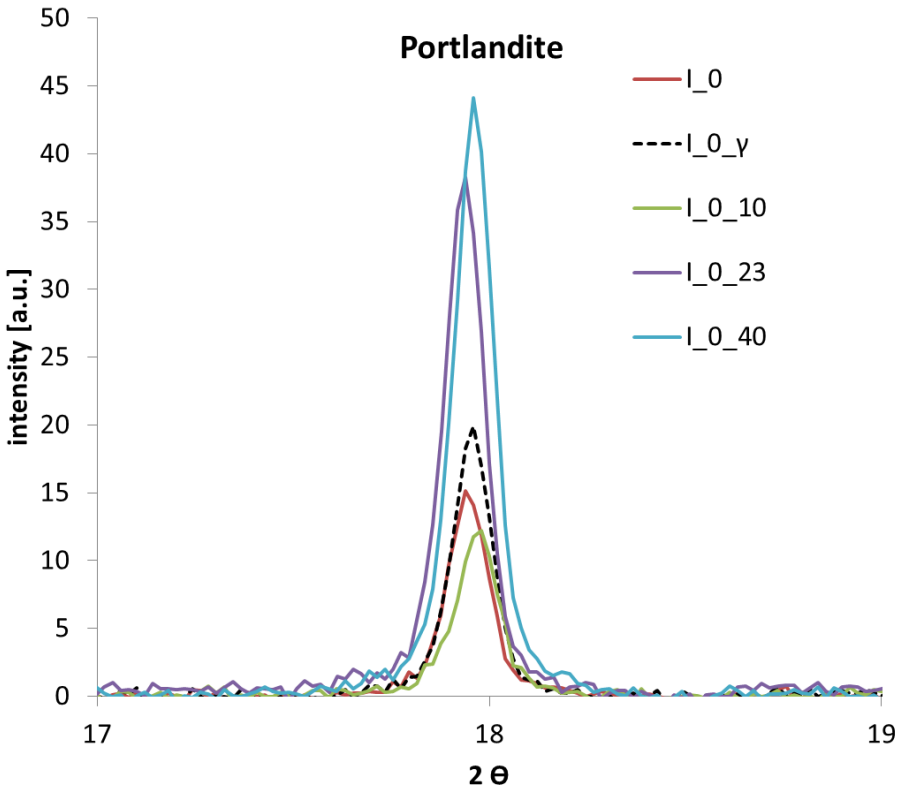

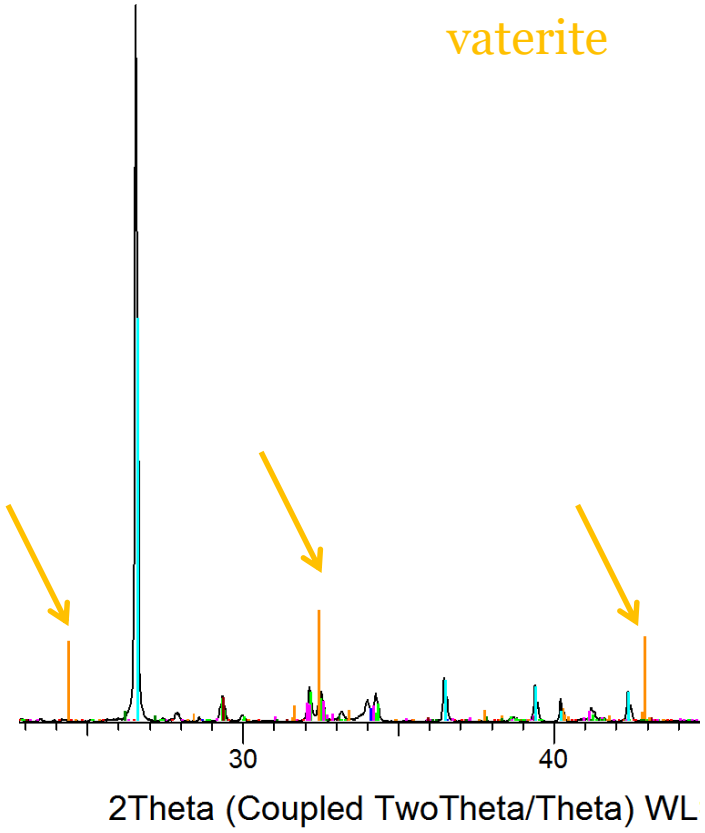

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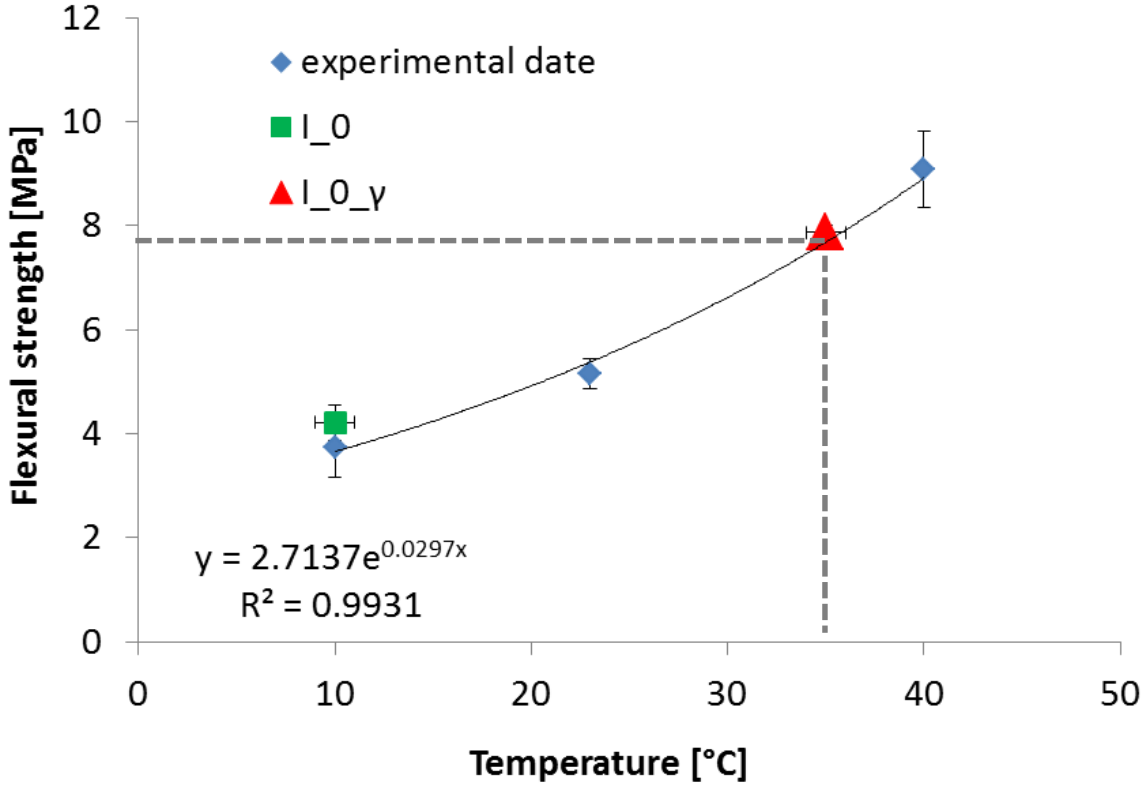

What is next

1. Collecting all measurement
2. Prediction of physical properties of mortars with boron retarders
3. experiment with coarse aggregate concrete

Thank you for your attention!

The research was founded by Polish National Centre for Research and Development (Project V4-Korea/2/2018, RADCON)