PERFORMANCE OF Fe-RICH INORGANIC POLYMERS IN A GAMMA RADIATION FIELD

Bram MAST*, Isabelle GERARDY, Yiannis PONTIKES, Wouter SCHROEYERS, Brigitte RENIERS, Pieter SAMYN, Bram VANDOREN, Sonja SCHREURS

*Hasselt University, CMK, NuTeC, Nuclear Technology - Faculty of Engineering Technology, Agoralaan Building H, B-3590 Diepenbeek, Belgium

ABSTRACT

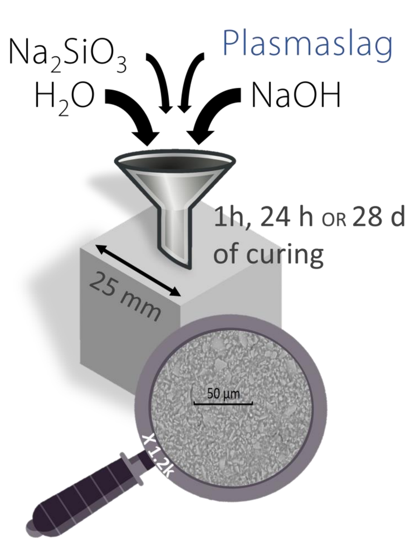
Calcium (alumino)silicate-based cements are currently used for shielding and nuclear waste storage. However, these materials can present several drawbacks concerning durability and immobilisation. Therefore, alternatives such as Inorganic Polymers (IPs) are increasingly being studied. The effects of gamma irradiation on mechanical properties of IPs were evaluated by means of compressive strength tests. A significant increase in compressive strength was observed for all the samples with a total absorbed dose above 5 kGy irrespective of the applied dose rate.

INTRODUCTION

Ordinary Portland cements are currently used to condition low and intermediate level radioactive nuclear waste[1]. However, several studies have already proven the detrimental effect of gamma radiation on ordinary Portland cement matrices, due to changes in average pore diameter, radiation induced carbonation and the formation of microcracks. Therefore, alternatives as inorganic polymers (IPs) are increasingly being studied.

Lambertin et al.[2] observed a densification of IP matrices due to the radiolysis of water when irradiated, leading to an increased strength. According to Deng et al.[3] and Leay et al.[4], gamma rays do not produce significant morphological changes, except for changes in the pore structure. Studies on IPs were however performed on hardened samples while in this study also non-cured samples were irradiated. The same experiment was executed by Craeye et al.[5] using cementitious samples. They found an overall strength reduction with increasing absorbed dose of gamma radiation.

METHODS AND MATERIALS



SiO_2/Na_2O = 2.0
H_2O/Na_2O = 29.0
S/L = 2.6 g/ml

γ - Irradiation

32 Gy – 624 kGy

Set-up	Source	Dose rate
1	^{60}Co	1.6 Gy/h & 7.1 Gy/h
2	^{137}Cs	152 Gy/h
3	^{137}Cs	2 kGy/h

Evaluation

- **Compressive Strength** (NBN EN 12390-3 ◦ ZWICK Z050)
- **Thermogravimetric analysis**

Additional tests (results not included in poster)

- Scanning electron microscopy
- Infrared spectrometry
- Mercury intrusion porosimetry

RESULTS

< 5 kGy: no significant change in strength
> 5 kGy: increase in strength

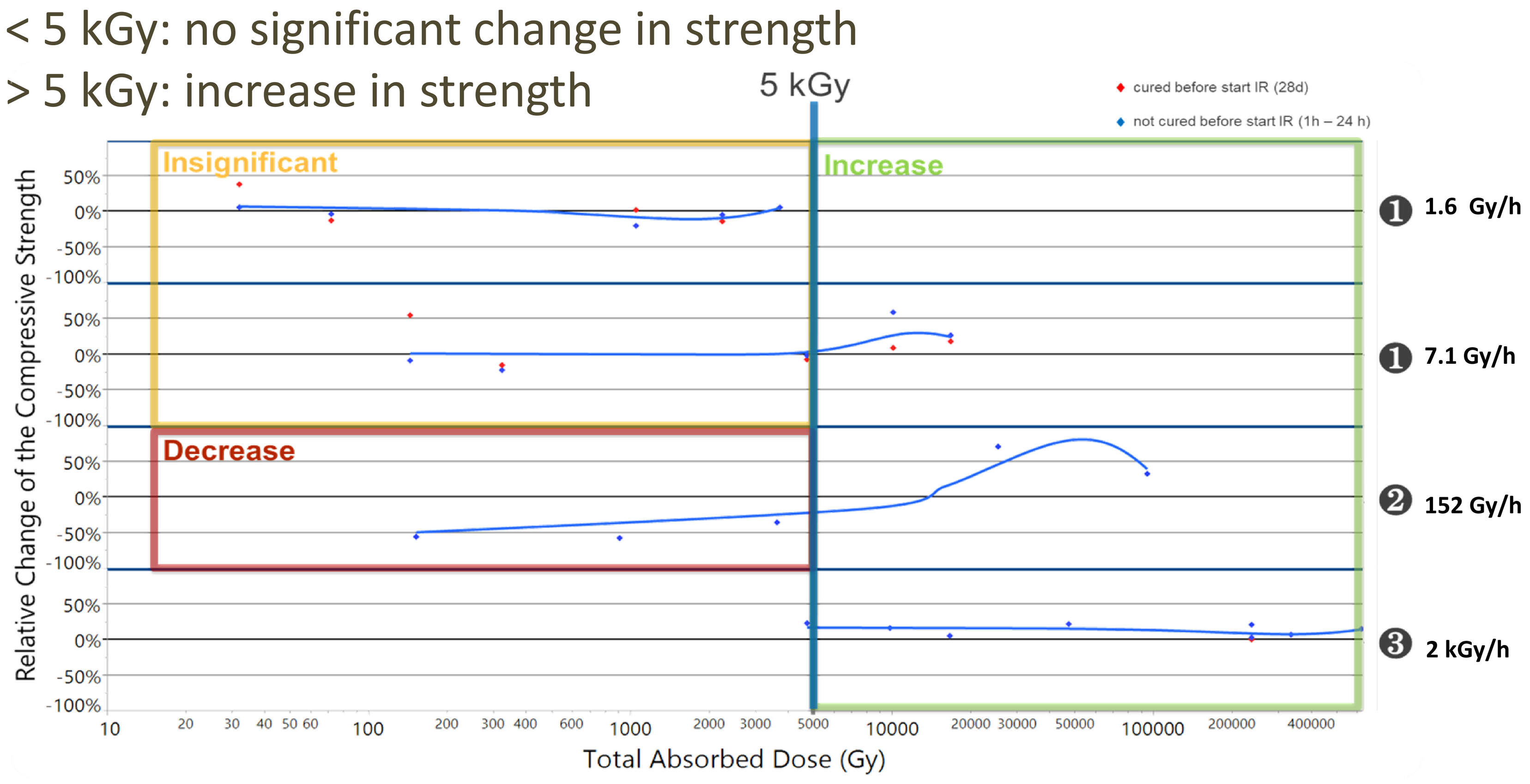


Figure 1: Rel. change in comp. strength of the irradiated samples compared to the reference samples in function of total absorbed dose (log scale).

Lower water content for IRs due to radiolysis of water [20 – 250] °C

Change in carbonates [600 – 630] °C

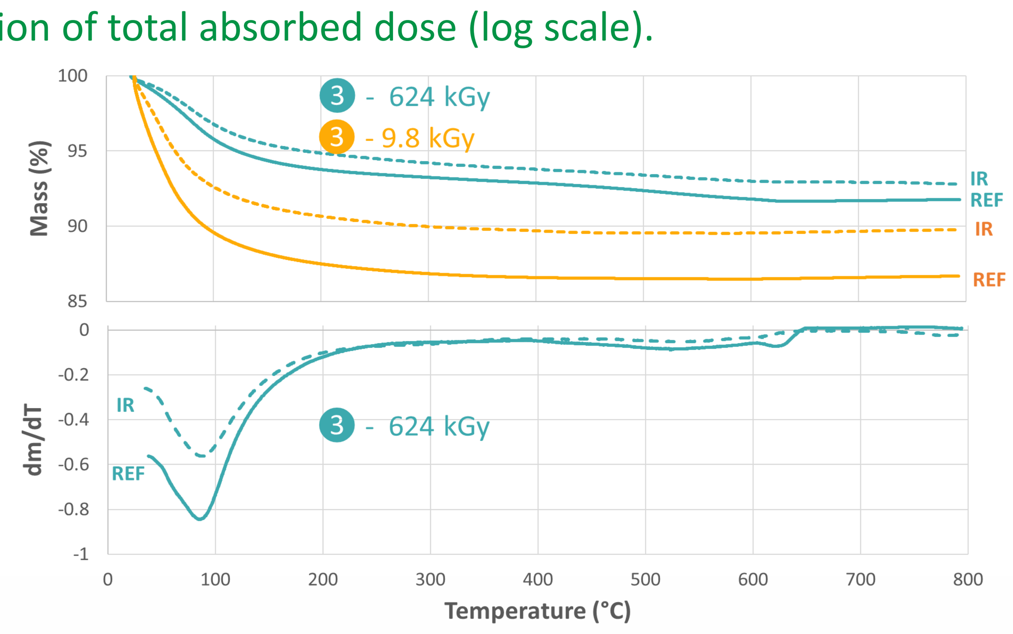


Figure 2: Thermogravimetric data of irradiated (IR) and reference (REF) samples

CONCLUSIONS

✓ Increase in compressive strength of IPs irradiated above 5 kGy.
✓ Threshold value of 5 kGy is independent from the dose rate.
✓ Radiolysis caused an accelerated mass loss of water and therefore to a lower density.
✓ Radiation altered carbonation is observed.

REFERENCES

[1]J. Koťátková, J. Zatloukal, P. Reiterman, and K. Kolář, "Concrete and cement composites used for radioactive waste deposition," J. Environ. Radalterioact., vol. 178–179, pp. 147–155, 2017.

[2]D. Lambertin, C. Boher, A. Dannoux-Papin, K. Galliez, A. Rooses, and F. Frizon, "Influence of gamma ray irradiation on metakaolin based sodium geopolymer," J. Nucl. Mater., vol. 443, no. 1–3,

[3]N. Deng et al., "Effects of gamma-ray irradiation on leaching of simulated 133Cs+ radionuclides from geopolymer wasteforms," J. Nucl. Mater., vol. 459, pp. 270–275, 2015.

[4]L. Leay, A. Potts, and T. Donoclift, "Geopolymers from fly ash and their gamma irradiation," Mater. Lett., vol. 227, pp. 240–242, 2018. pp. 311–315, 2013.

[5]B. Craeye, G. De Schutter, C. Vuye, and I. Gerardy, "Cement-waste interactions: Hardening self-compacting mortar exposed to gamma radiation," Prog. Nucl. Energy, vol. 83, pp. 212–219, 2015.

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