A STUDY OF THE FLUIDIC MOVEMENT OF THE HYDRATED PRODUCTS FROM THE EARLY CARBONATION CURING IN CEMENTITIOUS PASTE AND THE EFFECTS ON THE MECHANICAL AND POROSITY PROPERTIES

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SUMMARY

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2. OBJECTIVES
3. MATERIALS
4. METHODS
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1. BACKGROUND

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CO_2 absorption principle in cementitious materials:

- *Mainly hydration reactions:*

$$3C_3S + 6H_2O \rightarrow C-S-H + 3Ca(OH)_2$$

$$2C_2S + 4H_2O \rightarrow C-S-H + Ca(OH)_2$$

Hydrated product

- *Mainly carbonation reaction:*

$$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$$

Reagent

CO_2 captured as carbonated product.

Conditions:

- *At early stages:*

-Porous water

-High porosity

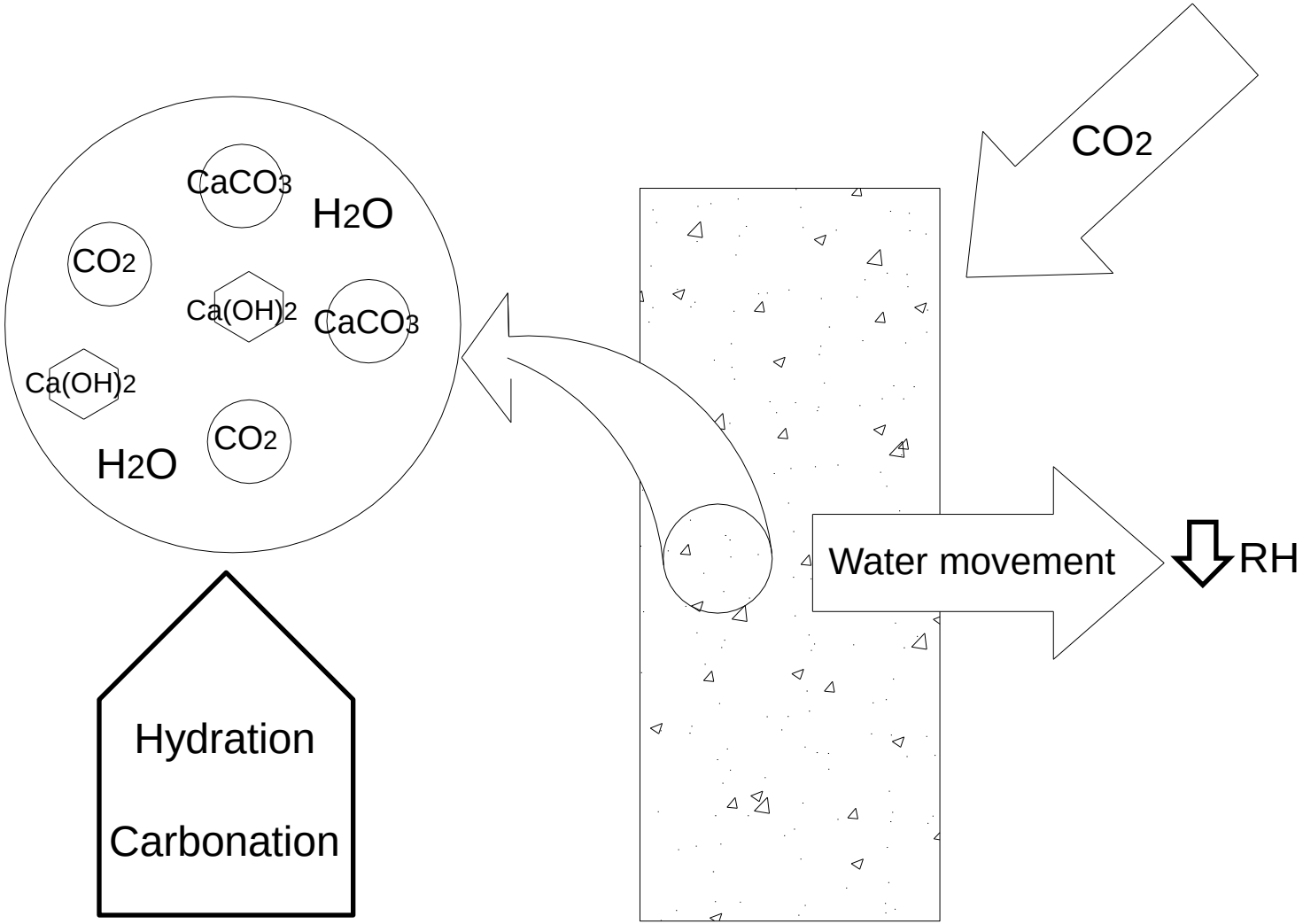


Fig.1 - Fluidic Movement x Hydration and Carbonation reactions

- In a previous work of the authors (*) the best conditions achieved to capture CO_2 in cementitious paste were:
- water to cement ratio: 0.7
- initial hydration time: 6h
- relative humidity: 60%
- temperature: 25°C
- CO_2 concentration in volume: 20%

(*) **"CO_2 sequestration by high initial strength Portland cement pastes"** *Journal of Thermal Analysis and Calorimetry (Online), v. 112, 2013* - DOI 10.1007/s10973-013-3117-0

CARBONATED SAMPLES for 24 hours

prepared at the best conditions

Were compared with **NON CARBONATED REFERENCES**



- 4 Cylinders (25 x 50mm) for each case
- Compressive strength was measured after 28 days.

References X Carbonated Samples

- The compressive strengths of the carbonated cylinders were about 51% of the non carbonated references.

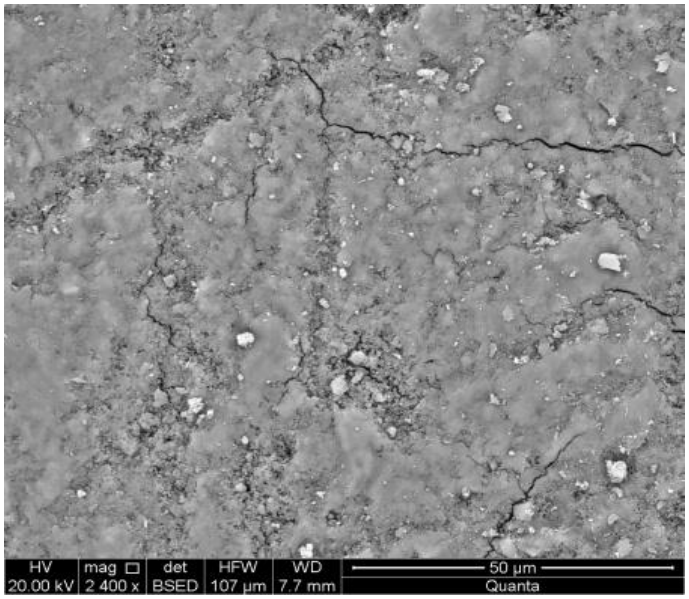


Fig.2 – Reference sample

SEM

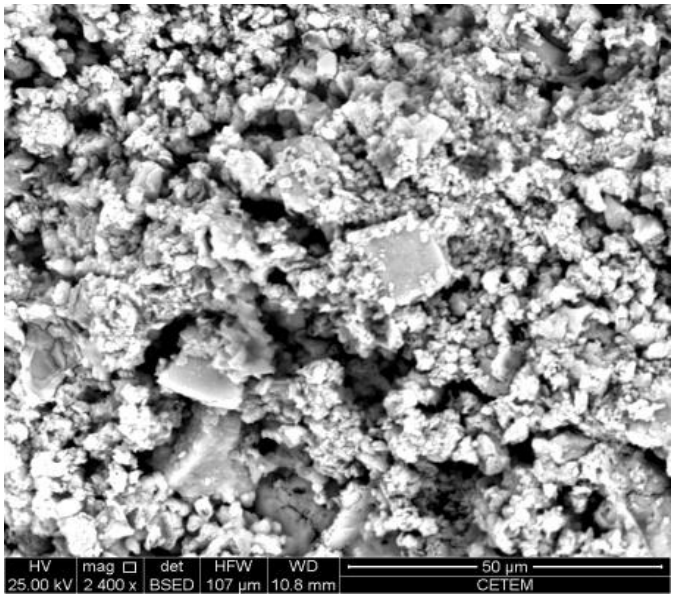


Fig. 3 – Carbonated sample

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- The purpose of this work was to evaluate by Thermogravimetry (TG) and Derivative Thermogravimetry (DTG), the evolution of the amount of hydrated products in cylinders treated with CO_2 in different times of carbonation and its relationship with the compressive strength.

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- High Strength and Sulphate Resistant Portland Cement (HS SR PC).
- Deionized Water.

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- 25 cylinders were prepared with 25mm of diameter and 50mm of height.

- 5 different times of carbonation: 1, 2, 4, 8 e 12h were used after 6h of non carbonated hydration.

During carbonation:

- relative humidity: 60%
- temperature: 25°C
- CO_2 concentration in volume: 20%

Performed analyses

Compressive strength

- 4 cylinders for each time.
- Cured at RH=100% after carbonation.
- At 14 days.

Thermal analysis

- 1 cylinder for each time.
- analysis after the carbonation time.
- Aliquots from 4 different regions.

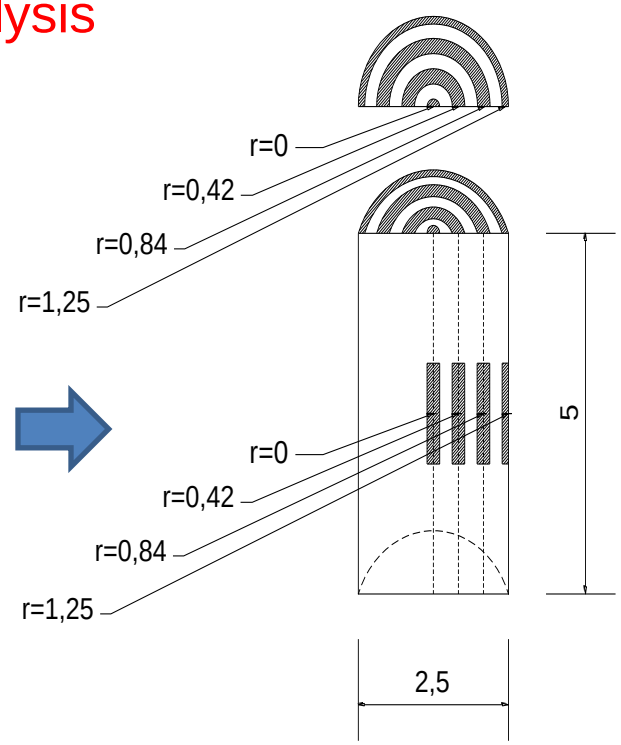


Fig 4 – Detail of the cylinder's studied regions by thermal analysis (distances in cm)

- The Thermal Analyses were performed in a TA Instruments, SDT Q600 Model, TGA/DTA/DSC Simultaneous equipment;

- The Heating Rate was $10^{o}C.min^{-1}$ until $1000^{o}C$, using 100 mL min^{-1} of nitrogen flow, after initial drying step for 1h at $35^{o}C$;

- Platinum pans for reference and samples.
- Hydration process was stopped using acetone after carbonation time.
- The compressive strength was performed in a SHIMADZU machine, model UH – F1000kN with a loading speed of 0,01mm/min

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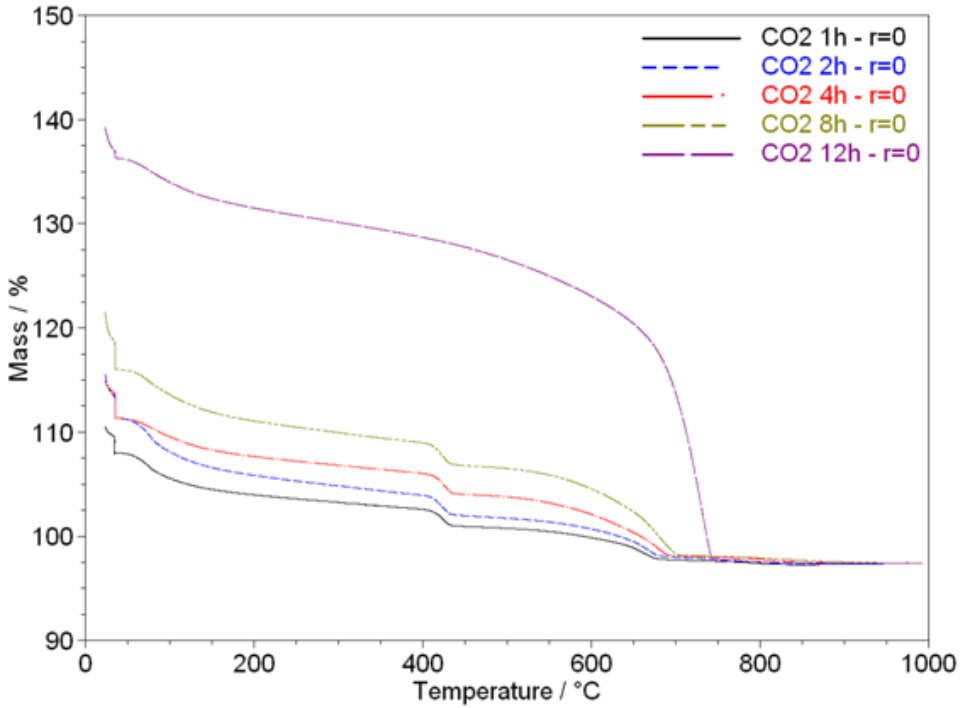


Fig 5 – TG curves on initial cement mass basis of carbonated samples for the r=0 region

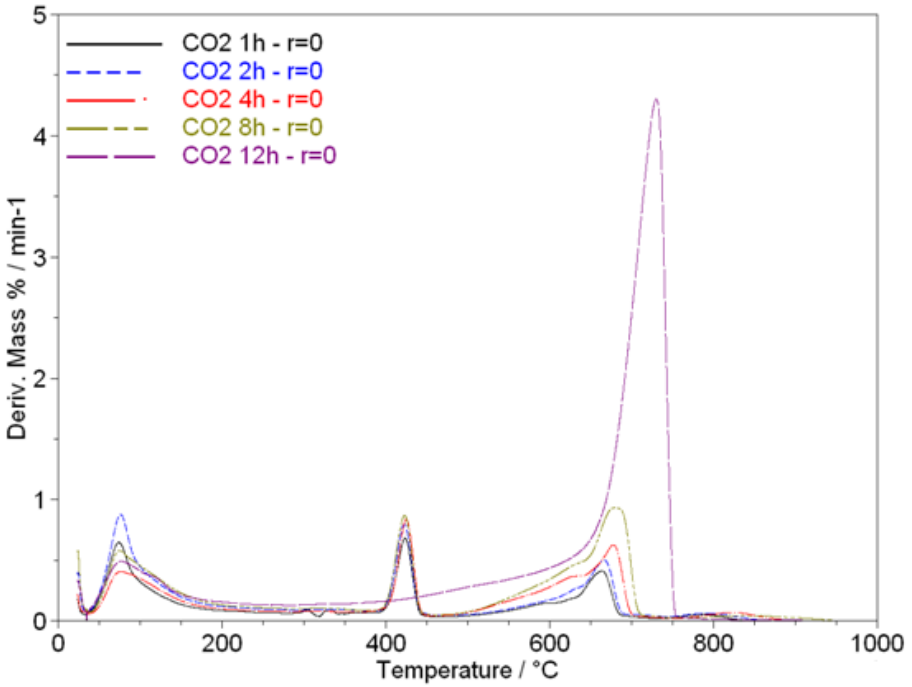


Fig 6 – DTG curves on initial cement mass basis of carbonated samples for the r=0 region

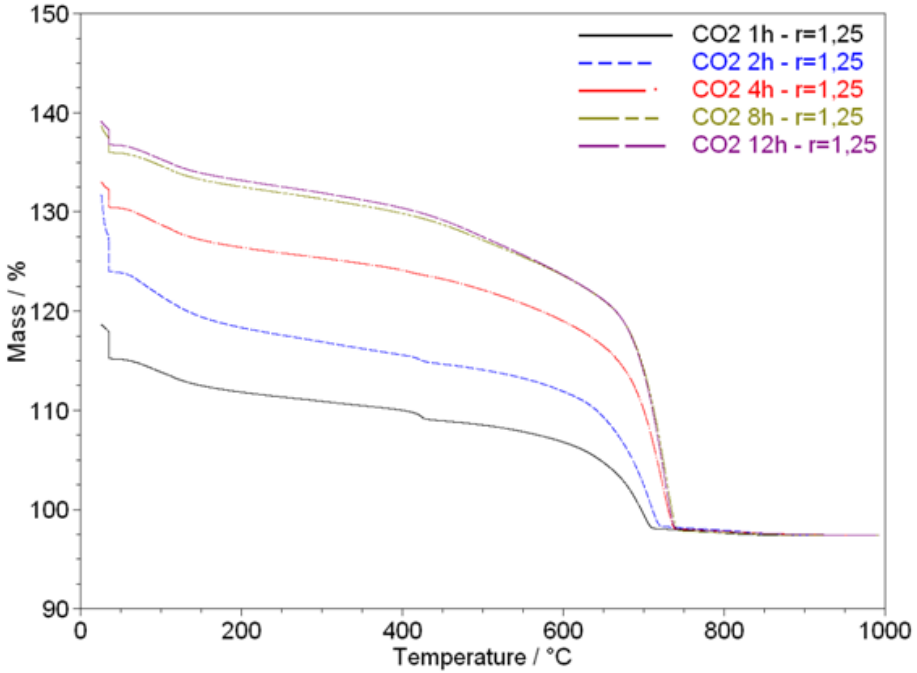


Fig 7 – TG curves on initial cement mass basis of carbonated samples for the r=1,25 region

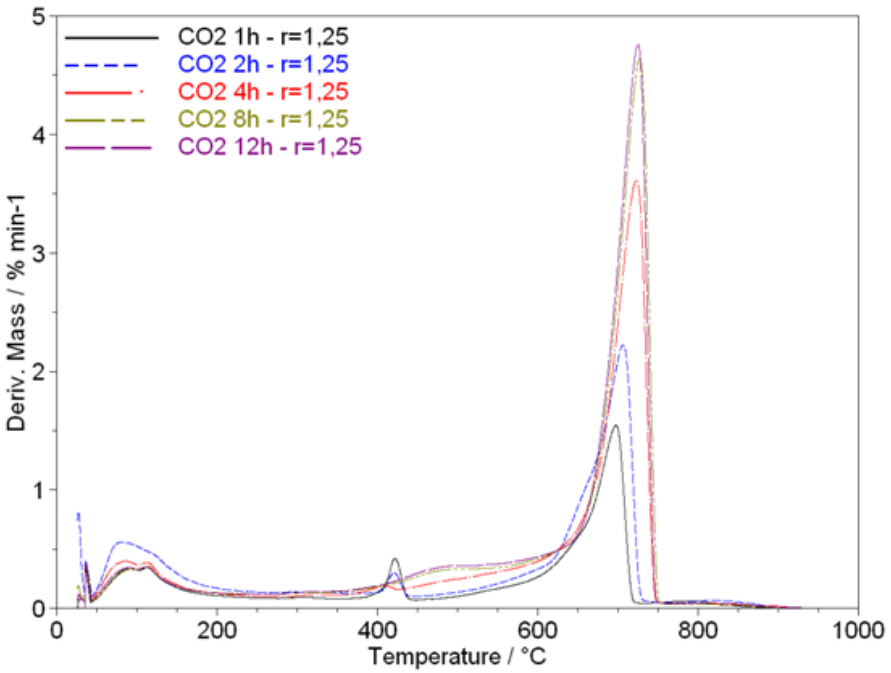


Fig 8 – DTG curves on initial cement mass basis of carbonated samples for the r=1,25 region

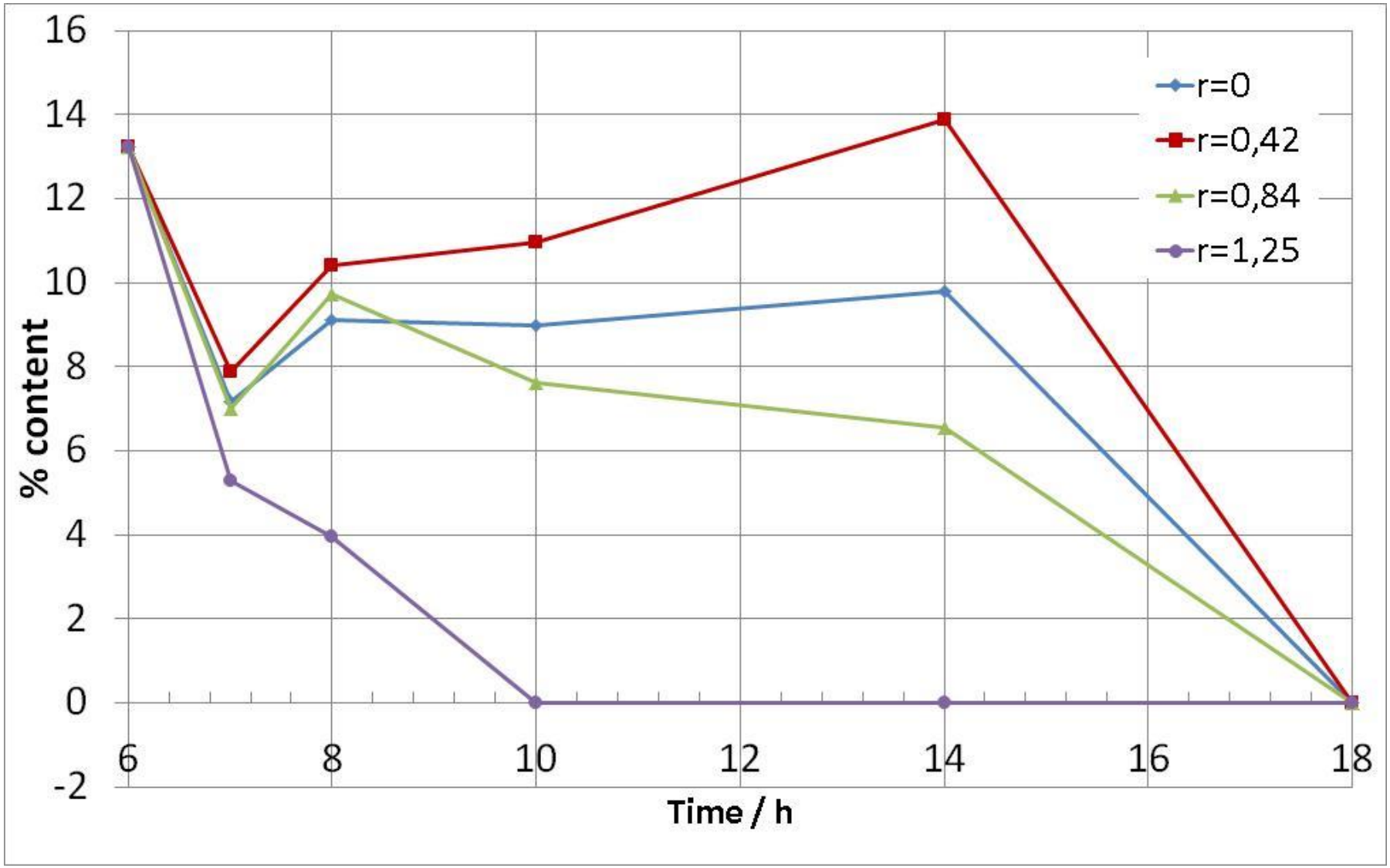


Fig 9 – $Ca(OH)_2$ content on initial cement mass basis

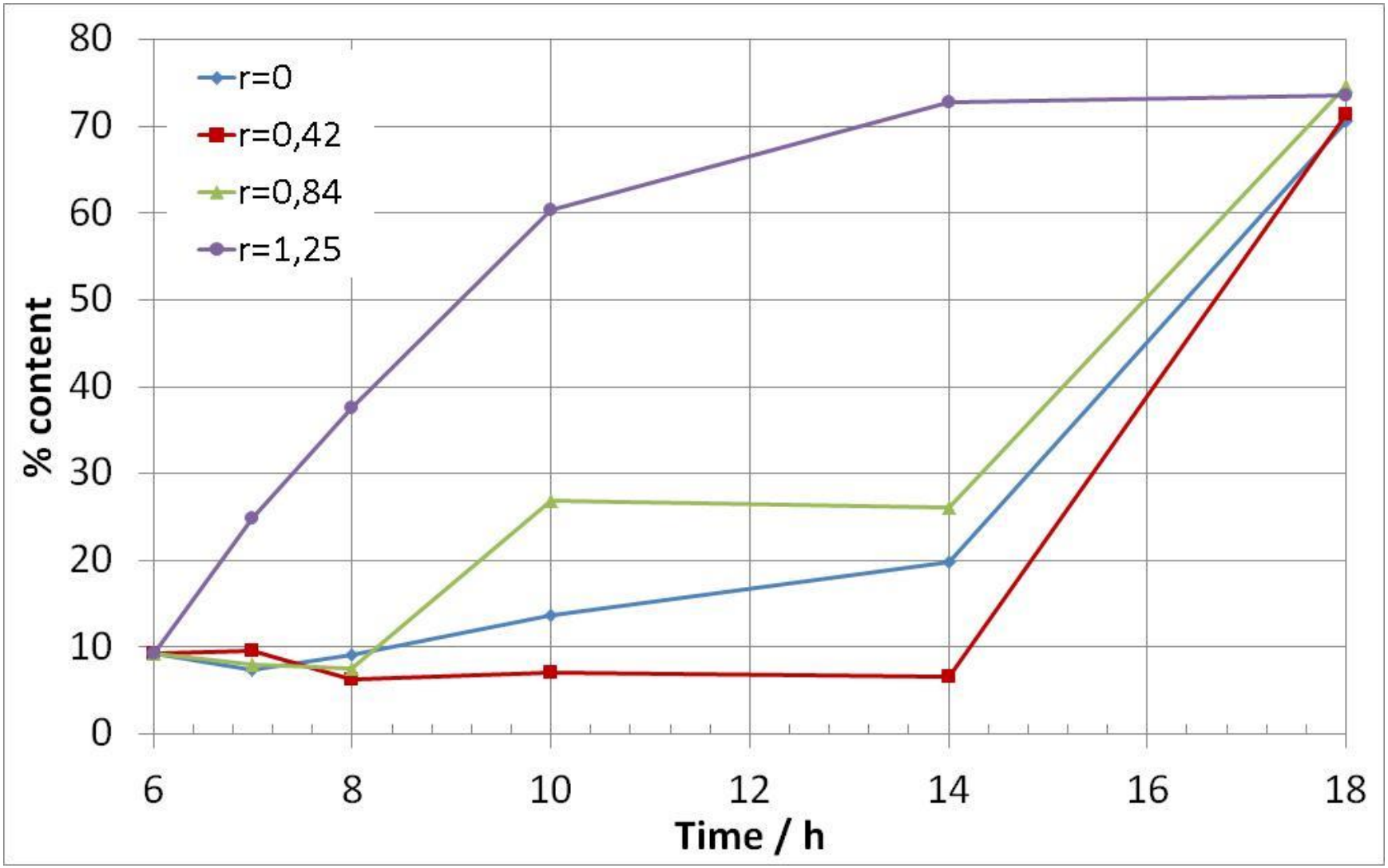
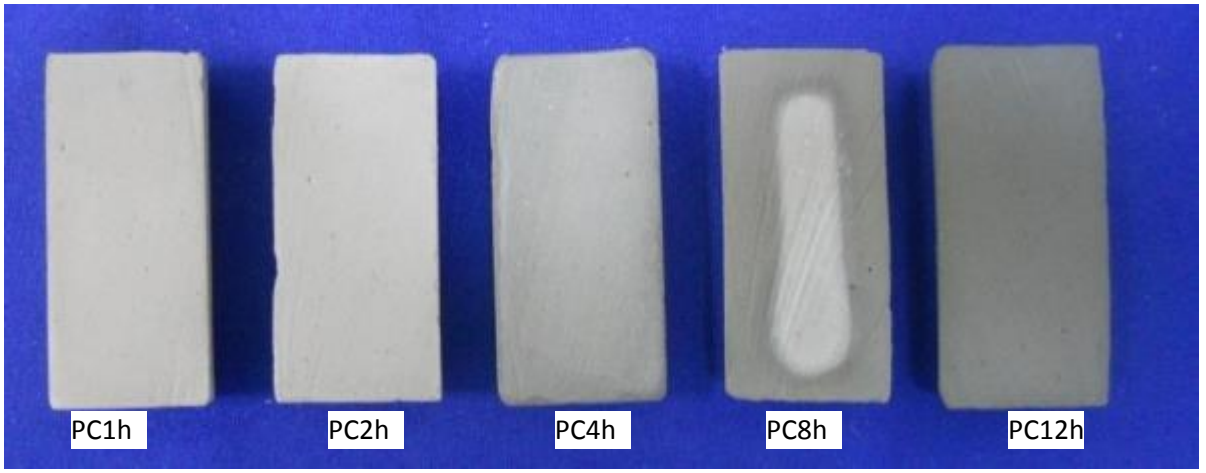


Fig 10 – $CaCO_3$ content on initial cement mass basis



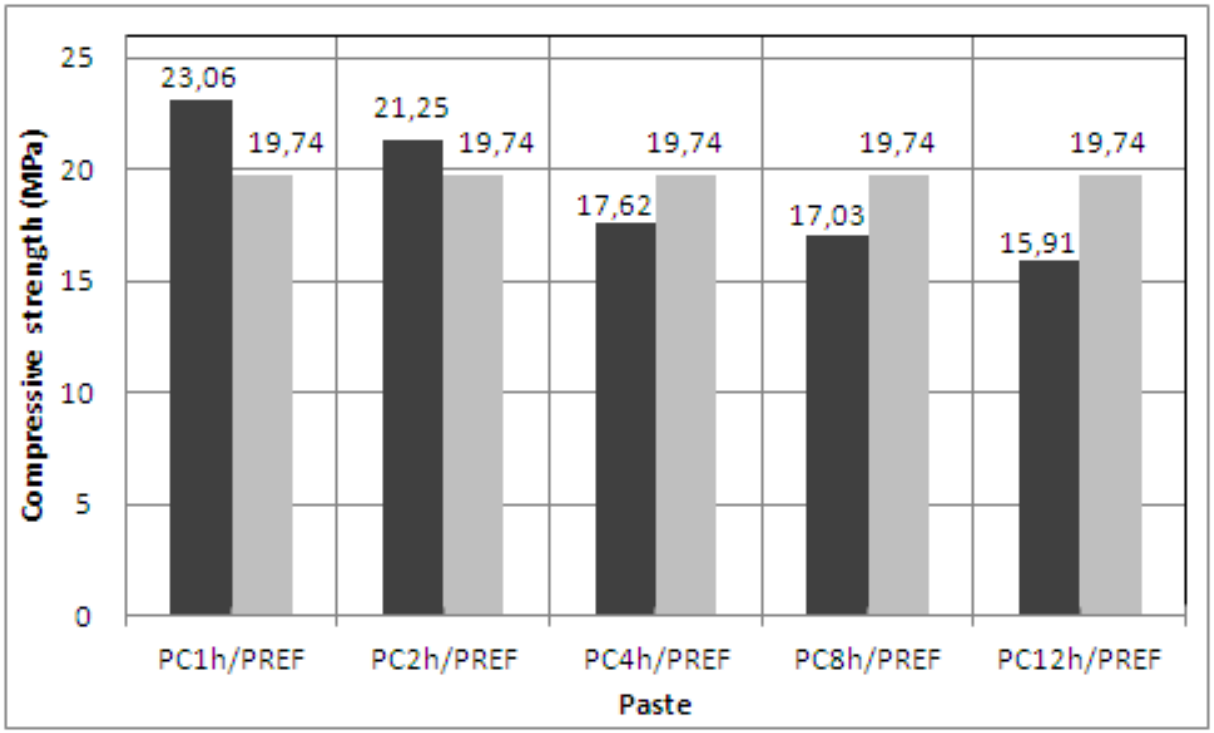


Fig 12-Compressive strength x CO_2 time exposure

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- With 1 and 2h of carbonation treatment, the compressive strength of the carbonated specimens was higher than the reference;
- The increase of the carbonation time decreases the compressive strength;
- The mechanical resistance of the carbonated paste is lower than that of the reference after 2h of carbonation because carbonation of the C-S-H phase occurs, as indicated by the respective DTG peaks;

- 12h of carbonation treatment is enough for the complete consumption of the $Ca(OH)_2$;

- In spite of the CO_2 exposure time increases its capture, it is not recommended, because it affects negatively the resulting mechanical resistance.

Acknowledgments

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Thanks you!