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

*E-mail: alexnevesjr@gmail.com

Alex Neves Junior*a,b, Romildo Dias Toledo Filho*a, Eduardo de Moraes Rego Fairbairn*a, Jo Dweck*c
SUMMARY

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CO₂ absorption principle in cementitious materials:

- **Mainly hydration reactions:**

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

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

- **Mainly carbonation reaction:**

  \[ Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O \]

**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%

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

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.
4. METHODS
• 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
• CO₂ 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°C.min⁻¹ until 1000°C, using 100 mL min⁻¹ of nitrogen flow, after initial drying step for 1h at 35°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 – CaCO₃ content on initial cement mass basis
Fig 12 - Compressive strength x CO₂ 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.
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