

CARBONATION RESISTANCE OF IRON-RICH INORGANIC POLYMERS

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ABSTRACT

After curing in a CO₂-rich environment, the compressive strength of Fe-silicate inorganic polymer rises significantly; after 28 days the inorganic polymer reached 91 MPa at room temperature, 101 MPa at 40 °C. The increased compressive strengths are due to the formation of CaCO₃ during the carbonation process in the inorganic polymer, filling the pores of the material. No crack formation is observed, which was observed to be a problem in the tested CEM-II formulation.

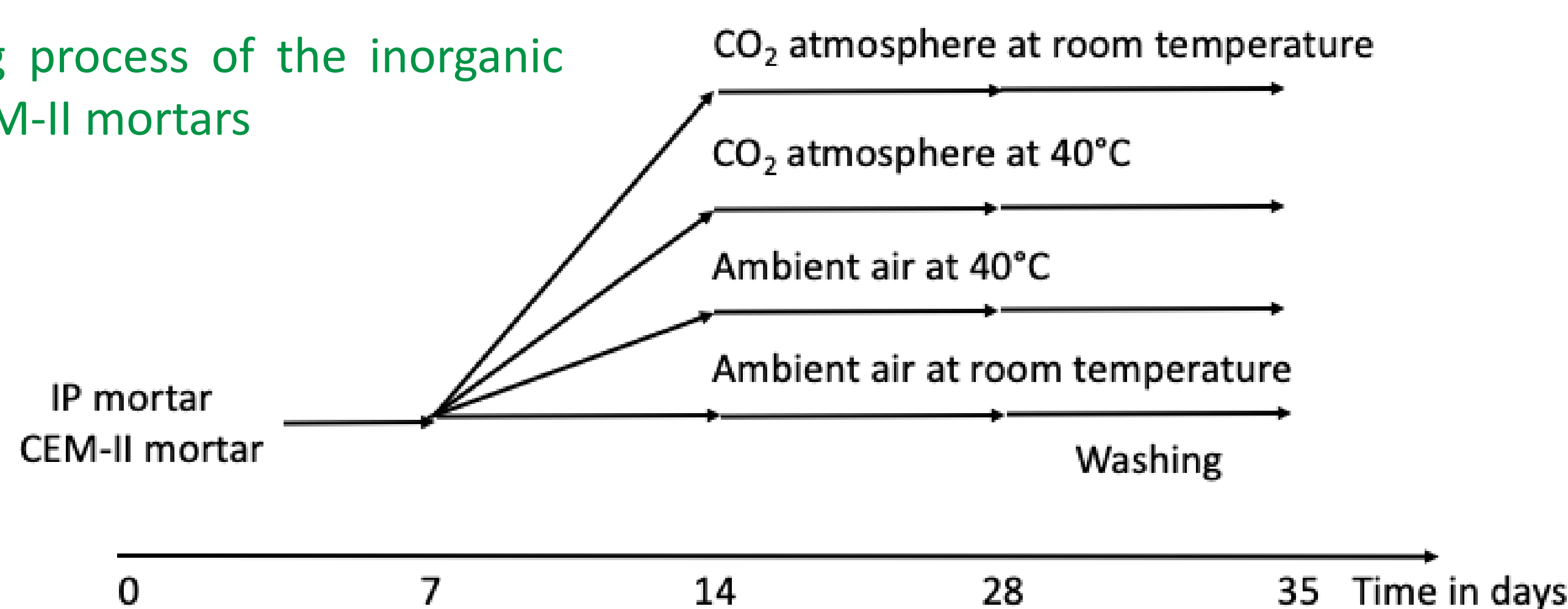
INTRODUCTION

In this paper, the influence of carbonation on the mechanical properties of an inorganic polymer (FeO_x-SiO₂-CaO slag with a sodium silicate activator) is tested for different curing times, curing temperatures and curing atmospheres (ambient air and a 2% CO₂ atmosphere). The results are compared with CEM-II samples which are processed under identical conditions. The effect on steel reinforcement is not considered, but is the subject of future work.

METHODS AND MATERIALS

Synthetic FeO_x-SiO₂-CaO slag with a composition close to slags in the non-ferrous metallurgy was produced by melting analytical grade oxides and casting molten slag into a container full with water. The chemical composition was measured with X-ray fluorescence: 54 wt% FeO, 31 wt% SiO₂, 14 wt% CaO, 1 wt% Al₂O₃. A X-ray diffraction analysis indicates an amorphous fraction of at least 95 wt%. The mortars were made by mixing 526 g of slag with 1350 g of CEN standard quartz sand and 206 g of sodium silicate solution. The curing process of the samples is described in Figure 1. The compressive strength measurements are carried out after 7, 14 or 28 days and compared with a CEM-II mortar cured for the same time and same conditions. The same procedure is followed for three point bending.

Figure 1: Curing process of the inorganic polymer and CEM-II mortars



RESULTS

The compressive strength of the inorganic polymer mortar and CEM-II mortar at ambient CO₂ concentrations are equivalent at room temperature and 40°C. The exposure to 2 vol% CO₂ drastically increases the compressive strength of the inorganic polymer samples, the OPC samples show a 20% increase in strength (Figure 2).

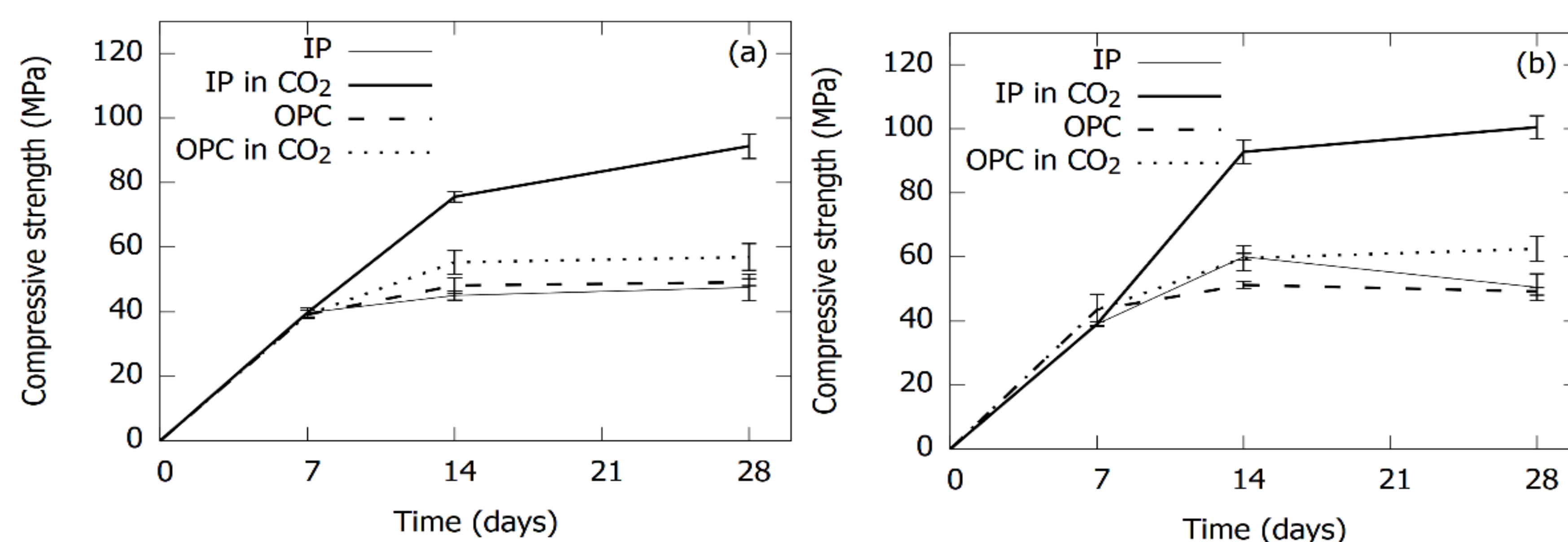


Figure 2: Compressive strength evolution of samples cured at (a) room temperature and (b) 40 °C.

No peaks are observed in XRD before and after the accelerated carbonation, the present carbonates are amorphous. A more detailed characterisation of the carbonation products was performed by comparing the results before and after a washing step. FTIR spectroscopy shows bands at 1450 cm⁻¹ before and after washing. The intensity seems to have declined after washing, indicating that at least part of the carbonates are water soluble Na-carbonates. The compressive strength results in Figure 3 do not show a statistically significant effect of the washing. The reinforcing effect is thus caused by water insoluble carbonates (Ca- or Fe-carbonates).

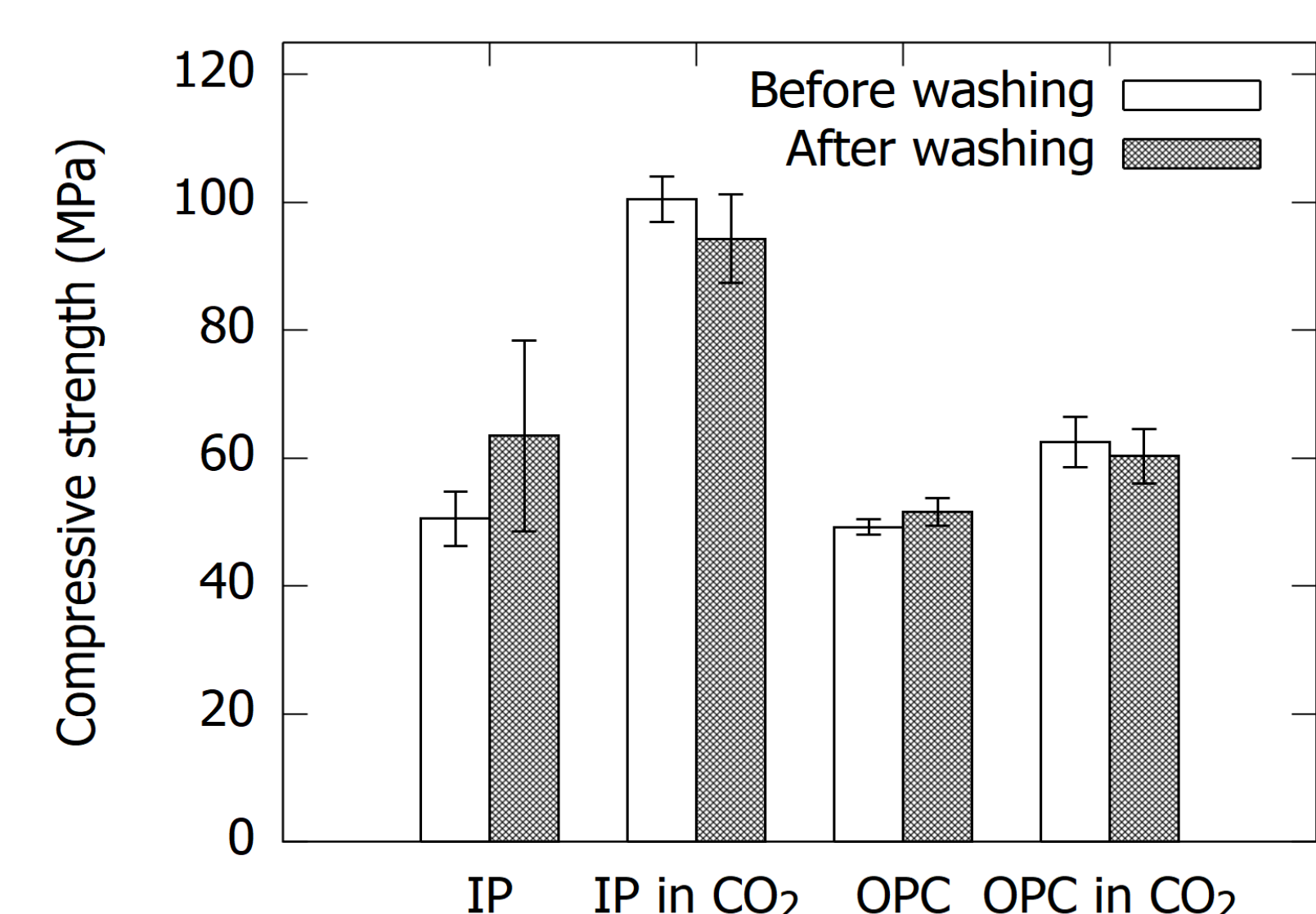


Figure 3: Compressive strength after 28 days at 40 °C and 2% CO₂, compared before and after washing the samples for 7 days in water.

CONCLUSIONS

After curing in a CO₂-rich environment:

- ✓ Compressive strength of Fe-silicate inorganic polymer rises
 - ✓ After 28 days inorganic polymer reaches 91±4 MPa at room temperature, 101±4 MPa at 40°C
- ✓ Formation of water insoluble carbonates during carbonation process in the inorganic polymer, filling pores of the material
- ✓ No crack formation is observed, which was observed to be a problem in the tested CEM-II formulation

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