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Influence of waste glass powder addition in the microstructure and durability of mortars in the very long term

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Outline

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1. Introduction
2. Materials and methods
3. Results and discussion
4. Conclusions

Introduction

Introduction

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Glass powder

- It could be used to **reduce environmental impact** in cement industry
- It could have a good performance as addition for cement-based materials
- Nowadays, the majority of existing studies analyzed the effect of glass powder as addition at relatively short hardening ages

Introduction

Objetive

To study the very long-term properties of mortars that incorporate 10% and 20% of glass powder as clinker replacement.

↓

1500 hardening days

↙ ↘

Microstructure | **Durability properties**

Materials and methods

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Materials and methods

Samples preparation

- Materials (mortars):
  - Glass powder from recycling containers
  - Crushing and dry grinding of the glass residues
  - Reference mortar → CEM I 42,5 R
  - Mortars incorporate glass powder as a replacement of cement CEM I 42,5 R
    - GP10 → 10 % of replacement
    - GP20 → 20% of replacement

Materials and methods

Samples preparation

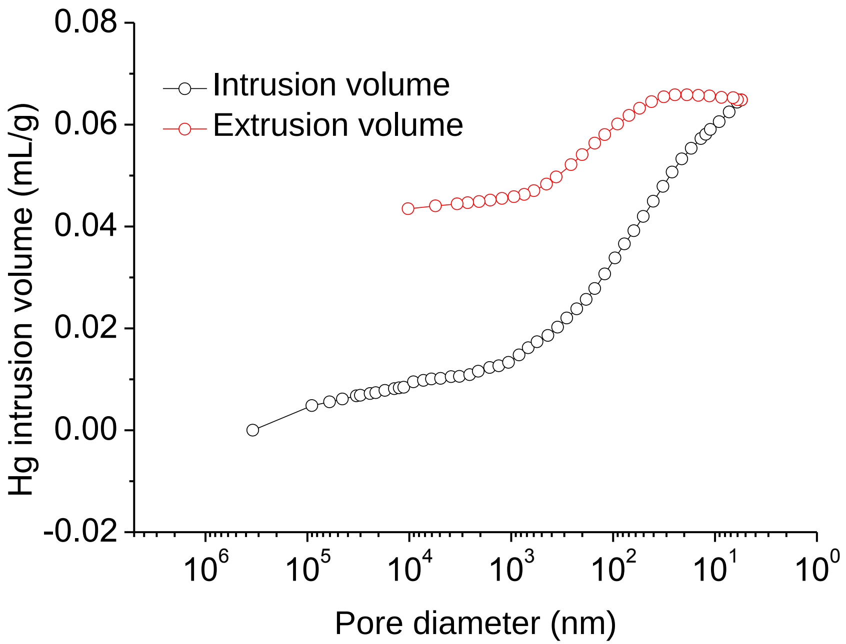
- Samples:
  - Cylindrical → 10 cm diameter and 15 cm height.
  - Chamber at 20 ºC and 95% RH during first 24hours
  - After, de-moulded and cut obtaining disks with 1 cm thickness.
  - They were kept in optimum laboratory condition (20°C and 100% RH)
  - Testing age → 1500 hardening days

Materials and methods

Microstructure

Mercury intrusion porosimetry

- Poremaster-60 GT porosimeter
- Total porosity
- Pore size distributions
- Pieces taken from disks

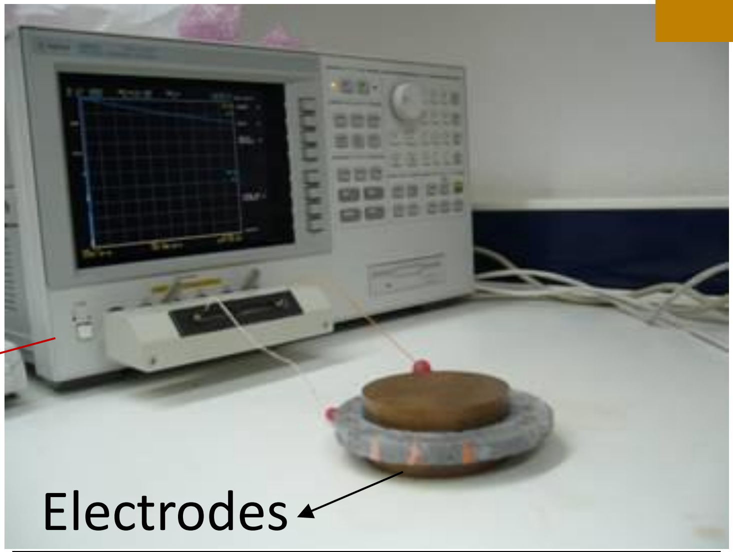


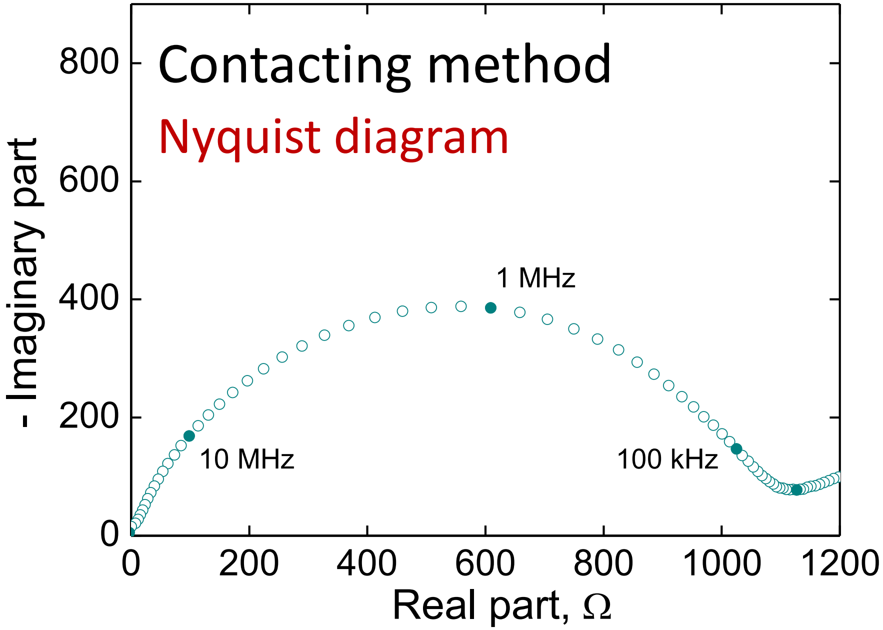
Materials and methods

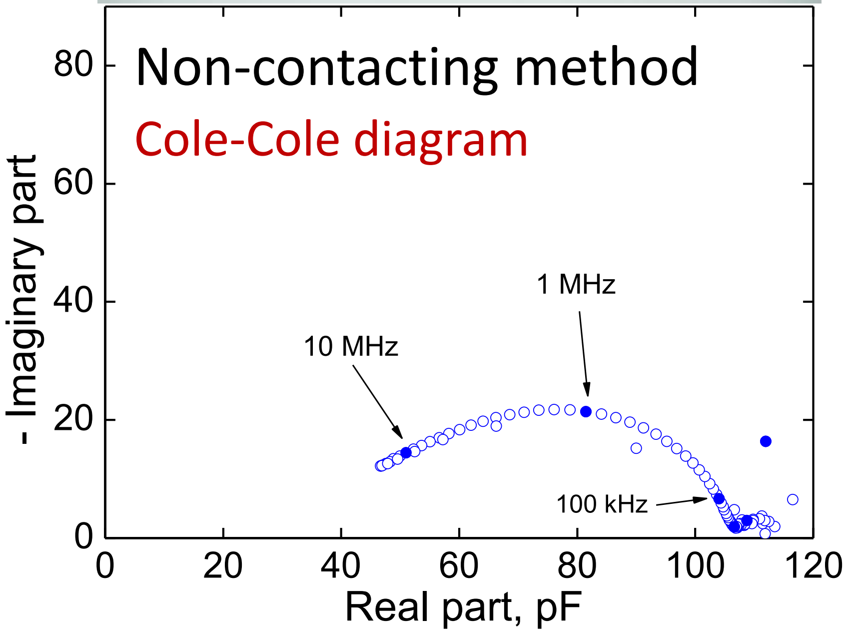
Impedance spectroscopy

Impedance analyzer
Agilent 4294A
100 Hz-100 MHz

Impedance spectra







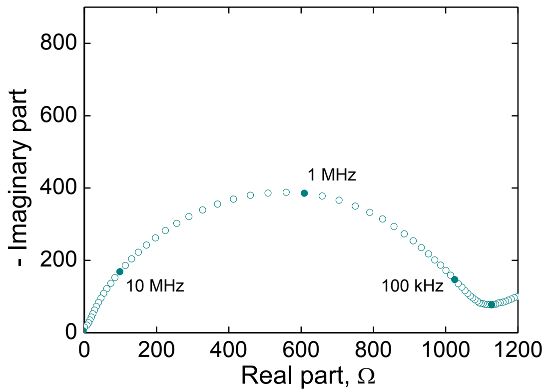
Materials and methods

Impedance spectroscopy

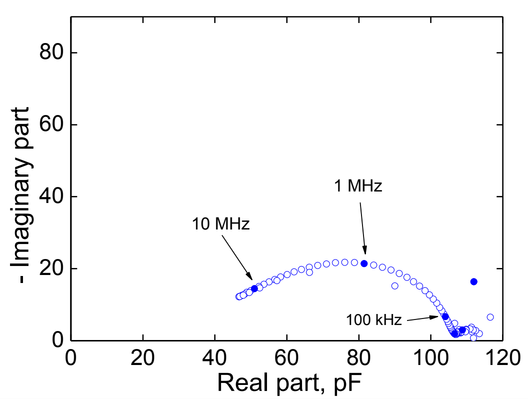
Equivalent circuits (Cabeza et al. 2002; Sánchez 2002)

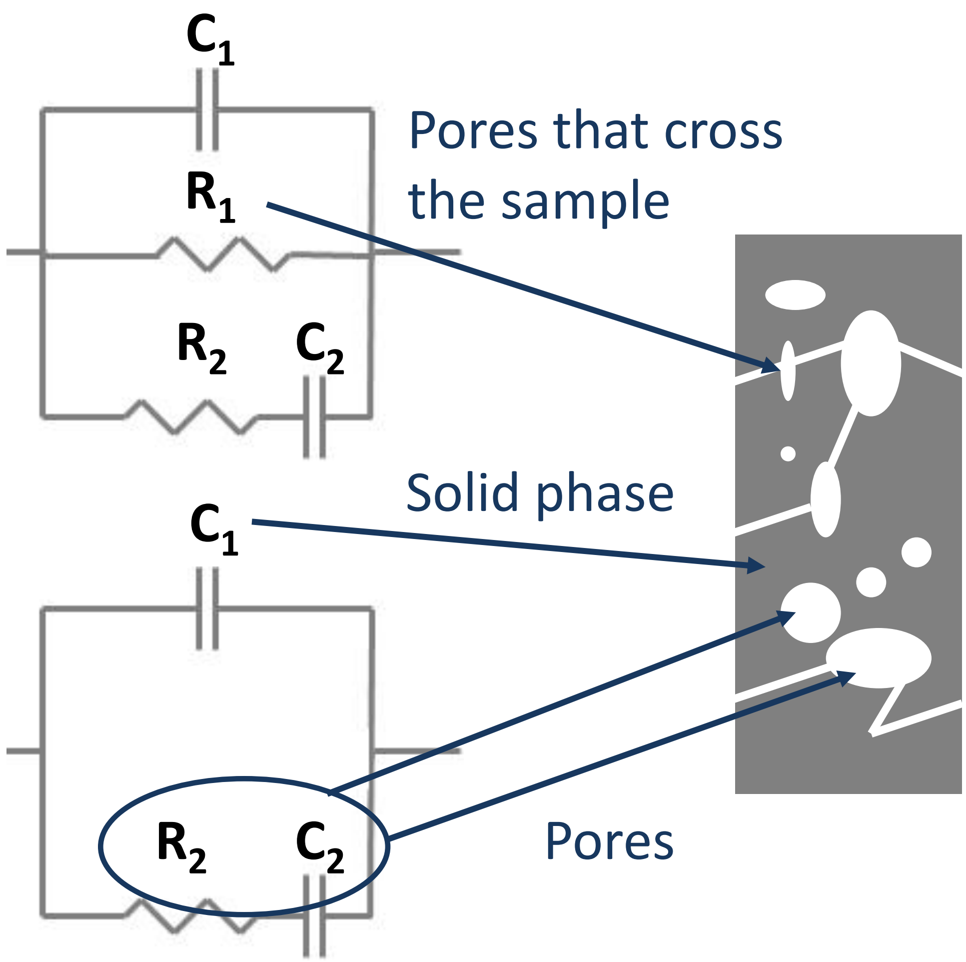
Represent **MICROSTRUCTURE**

Contacting method



Non-contacting method





Materials and methods

Durability-related parameters

Absorption after immersion

- ASTM Standard C642-06
- 6 samples were tested

Chloride diffusion coefficient

- Obtained from electrical resistivity of saturated sample
- Resistivity was calculated from the R_1 impedance spectroscopy of the samples
- Steady-state diffusion coefficient expression

$$D_S = \frac{2\times10^{-10}}{\rho}$$

Results and discussion

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Results and discussion

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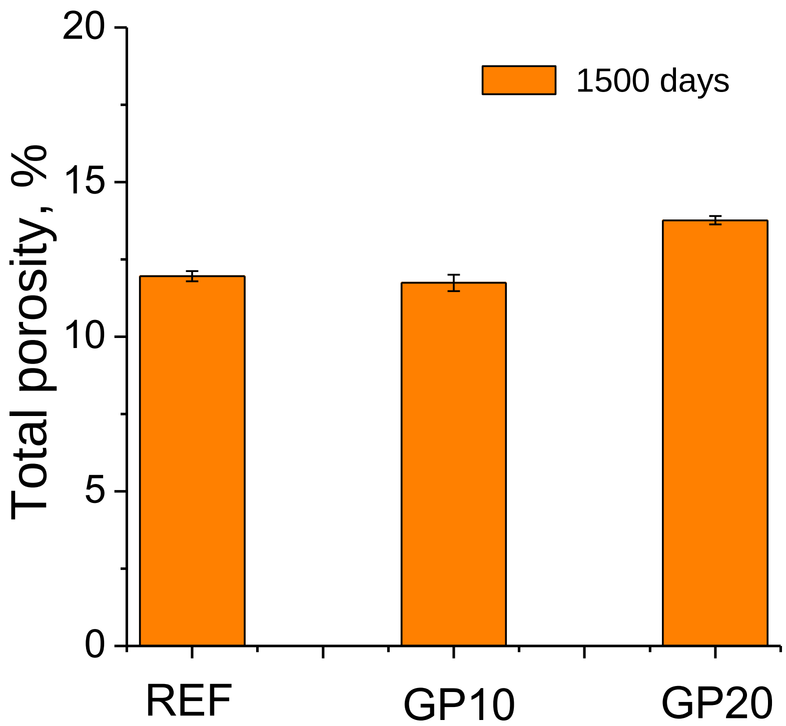
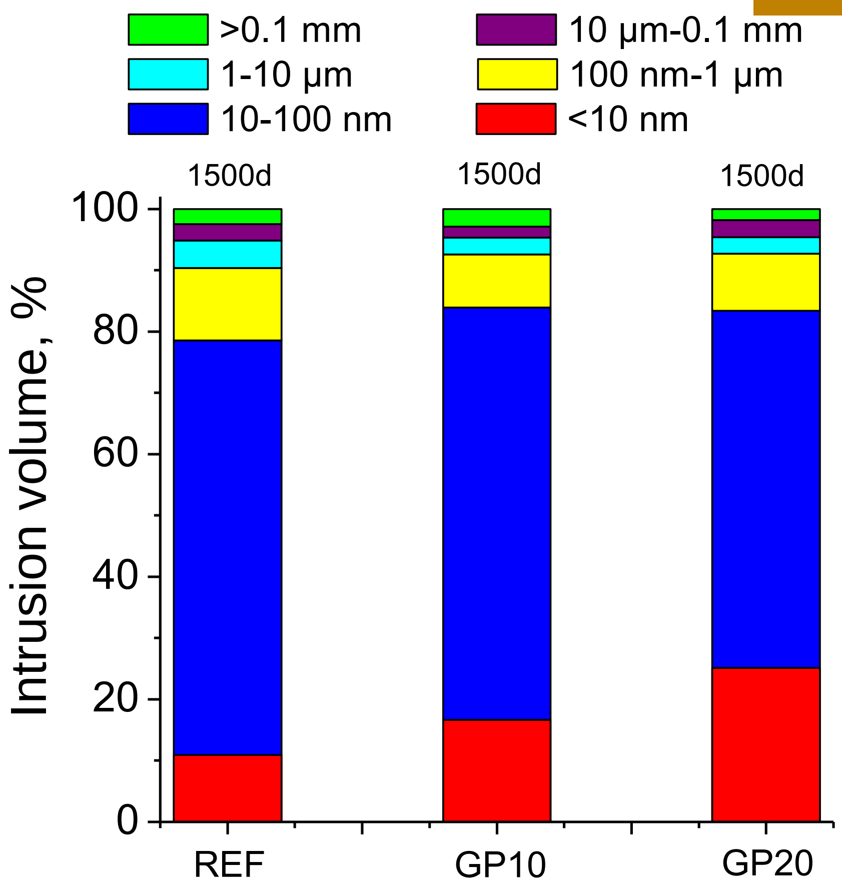
Microstructure

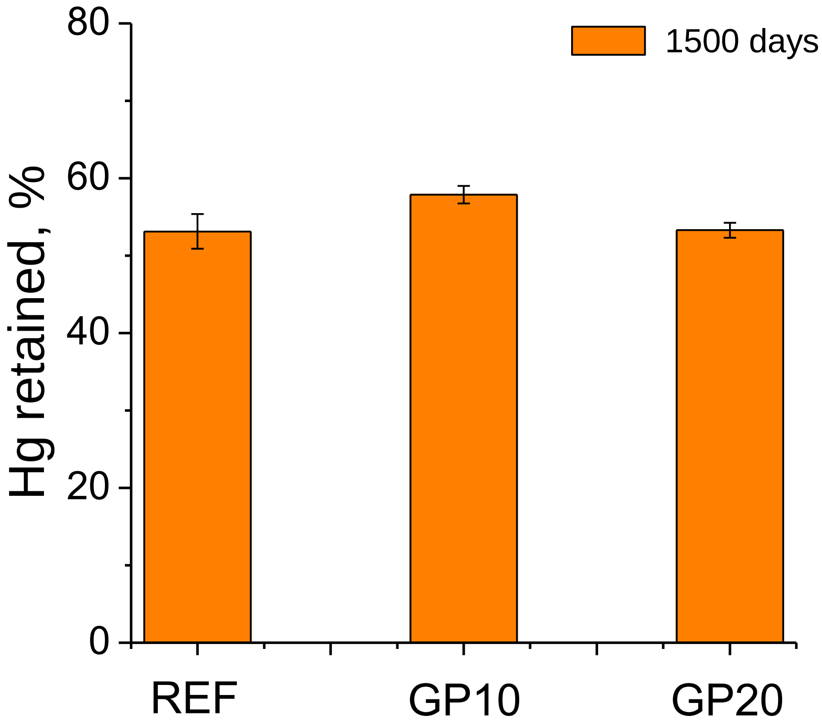


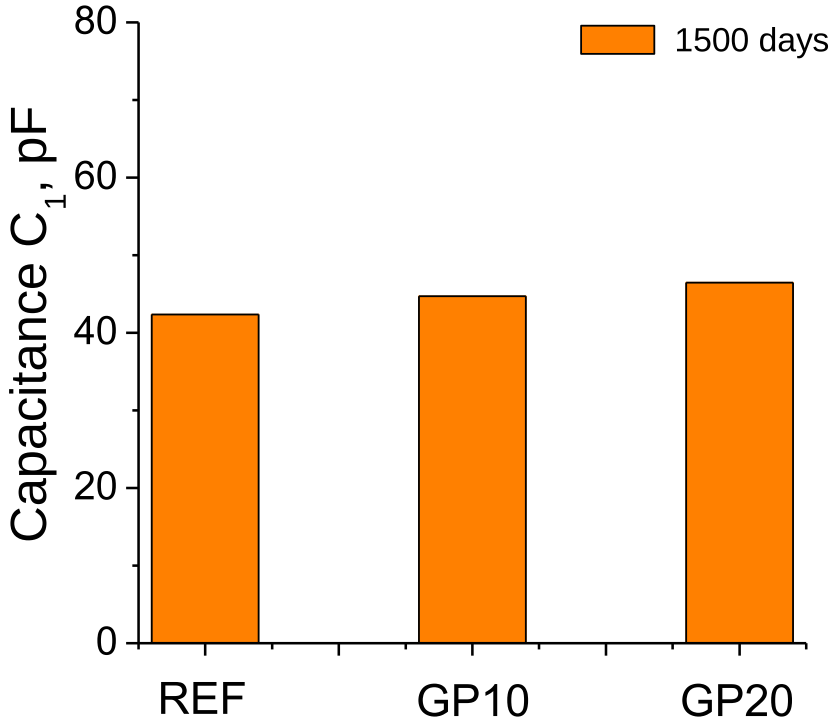


- Porosity GP10 mortar very similar to reference mortar
- Porosity GP20 mortar slight higher than reference mortar
- Porous structure→ **More refined in GP10 and GP20**

Results and discussion

Microstructure

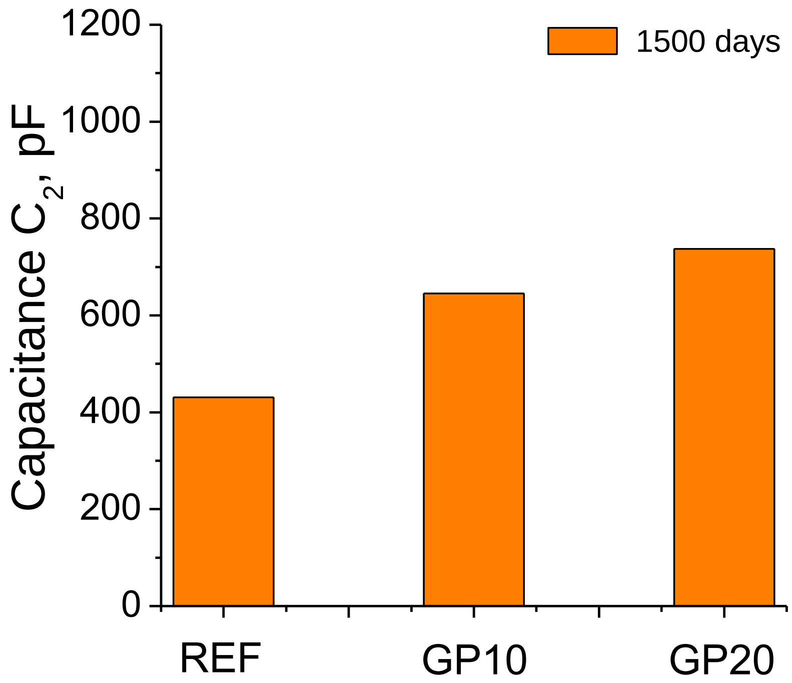


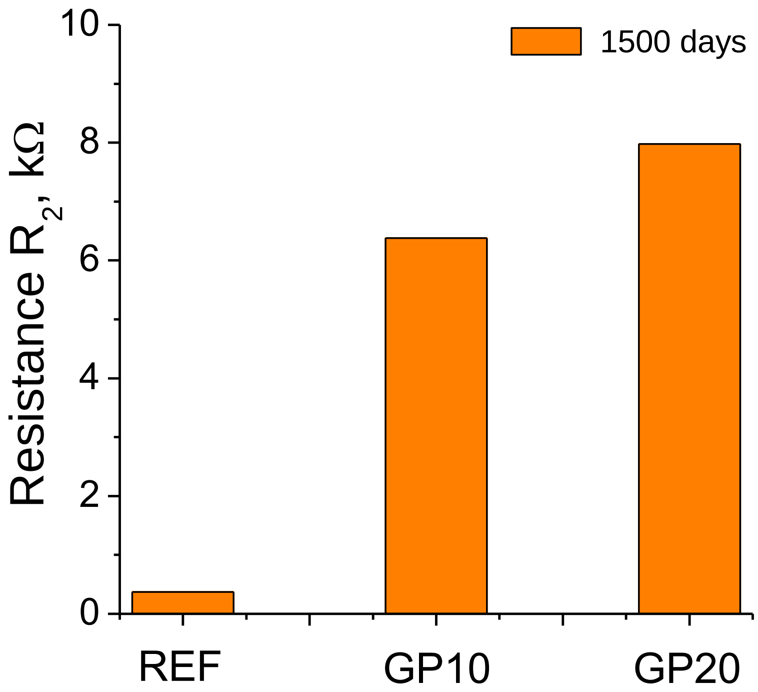


- Greater Hg retained in GP10 mortars
- Capacitance C_1 → Very similar values for GP10, GP20 and REF
- At 1500 hardening days → Very similar solid fraction in GP10, GP20 and REF

Results and discussion

Microstructure

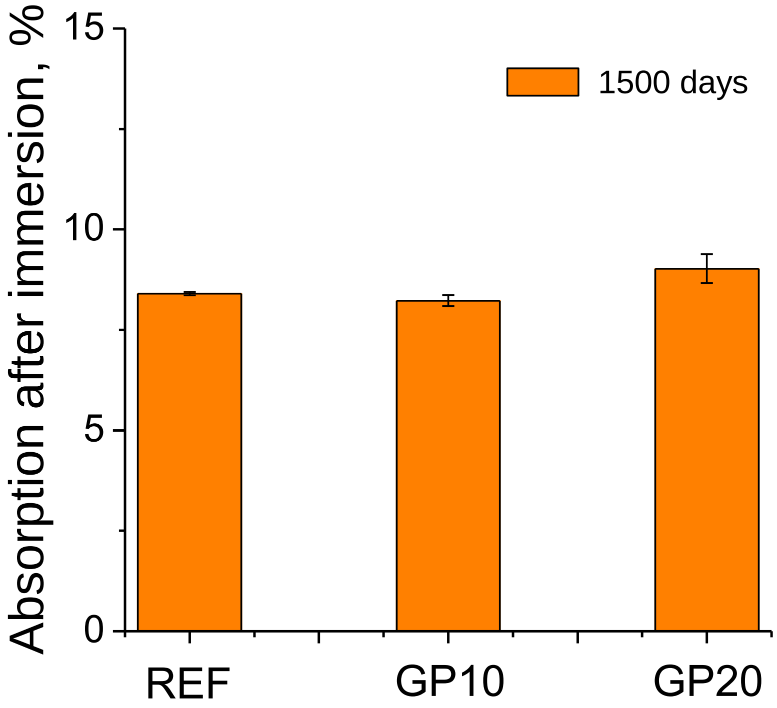


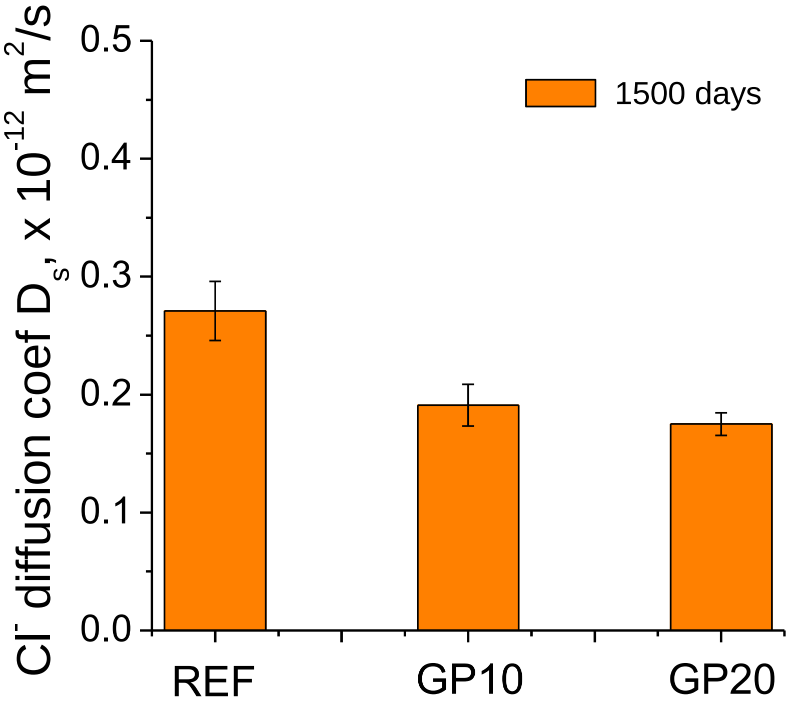


- Higher values for GP10 and GP20 than REF
- Results in keep with the higher pore refinement for GP mortars
- The addition of GP increased the relative volume of smaller pores

Results and discussion

Durability-related parameters





- Absorption % → Very similar for all the bindera
- Cl⁻ diffusion coef. → GP samples lower values than REF mortars
- **Very good performance of GP addition in Cl⁻ ingress resistance**

Conclusions

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Conclusions

Conclusions

- After 1500 hardening days, mortars with **glass powder** showed a **greater refinement** of the pore structure in comparison with the reference ones. This would show the **positive effects in the very long term of this addition**, produced by the formation of new solid phases as products of pozzolanic reactions of glass powder.

- The global solid fraction and pores volume of the mortars was very similar after 4 years, independently of the incorporation of waste glass powder in the binder, as suggested the total porosity results and impedance spectroscopy capacitance C_1.

Conclusions

Conclusions

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- The **durability-related properties** in the very long term analyzed in this work were **generally adequate for GP mortars**, highlighting their **very good performan**ce regarding **chloride ingress** resistance.

Acknowledgments

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Cementos Portland Valderrivas, S.A.

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