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Microstructural and durability effects in mortars after 1500 hardening days regarding the addition of volcanic powder of the Calbuco volcano (Chile) as clinker replacement

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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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Volcanic 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 volcanic 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 volcanic powder as clinker replacement.

↓

1500 hardening days

↙ ↘

Microstructure | **Durability properties**

Materials and methods

Materials and methods

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Samples preparation

- Materials (mortars):
  - Volcanic powder from Cabuco volcano (Chile)
  - Eruption on April 22-23,2015
  - Reference mortar → CEM I 42,5 R
  - Mortars incorporate volcanic powder as a replacement of cement CEM I 42,5 R
    - VP10 → 10 % of replacement
    - VP20 → 20% of replacement

Materials and methods

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Materials and methods

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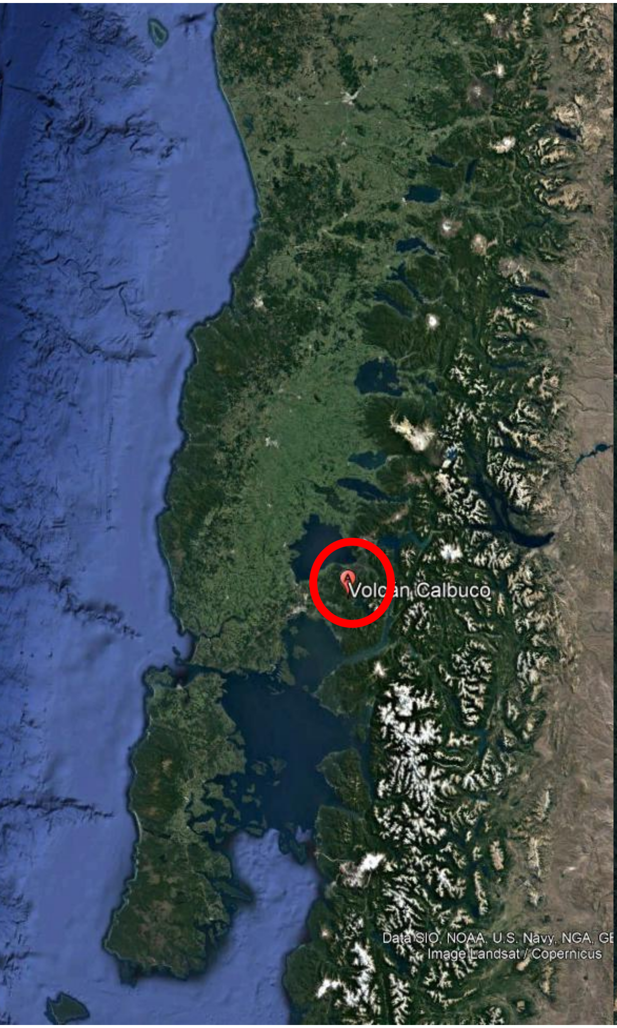

Materials and methods

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Samples preparation

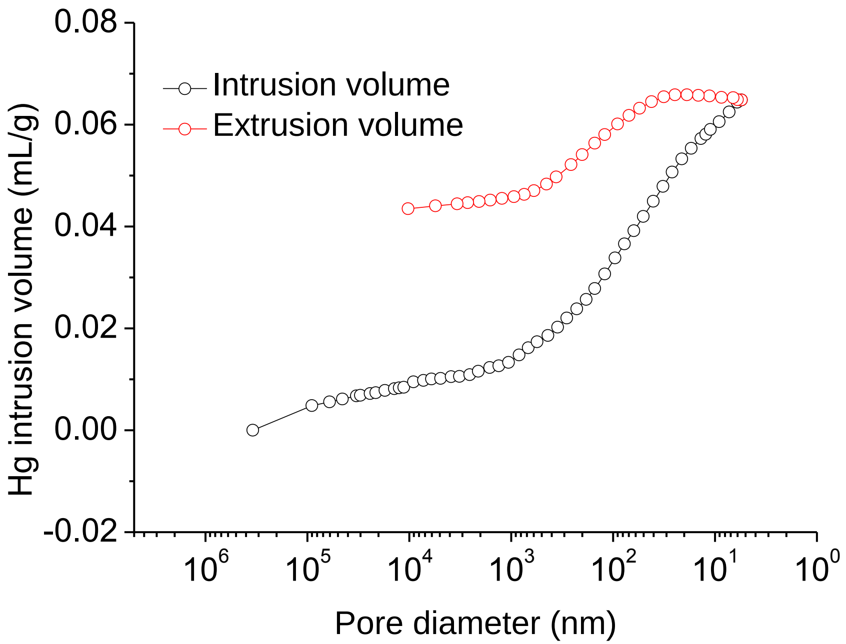
- Samples:
  - Cylindrical → 10 cm diameter and 15 cm height.
  - Chamber at 20 ºC and 95% RH during first 24hours
  - After, de-moulded and cut obtaining disks with 1 cm thickness.
  - They were kept in optimum laboratory condition (20°C and 100% RH)
  - Testing age → 1500 hardening days

Materials and methods

Microstructure

Mercury intrusion porosimetry

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

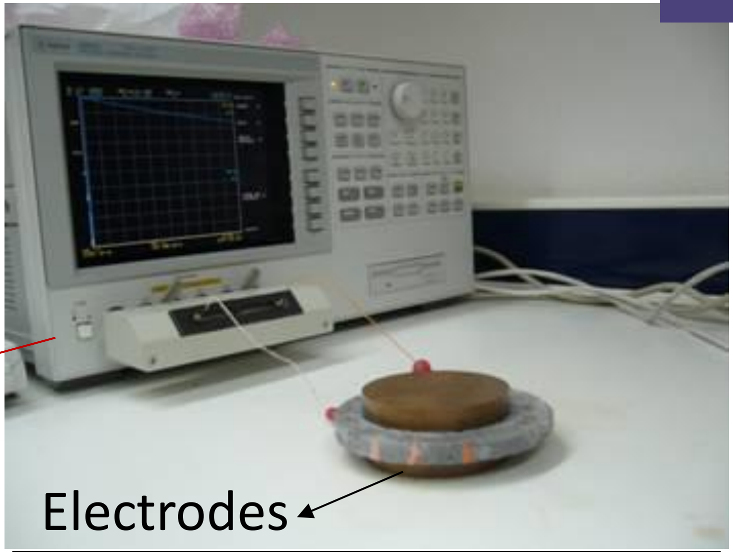


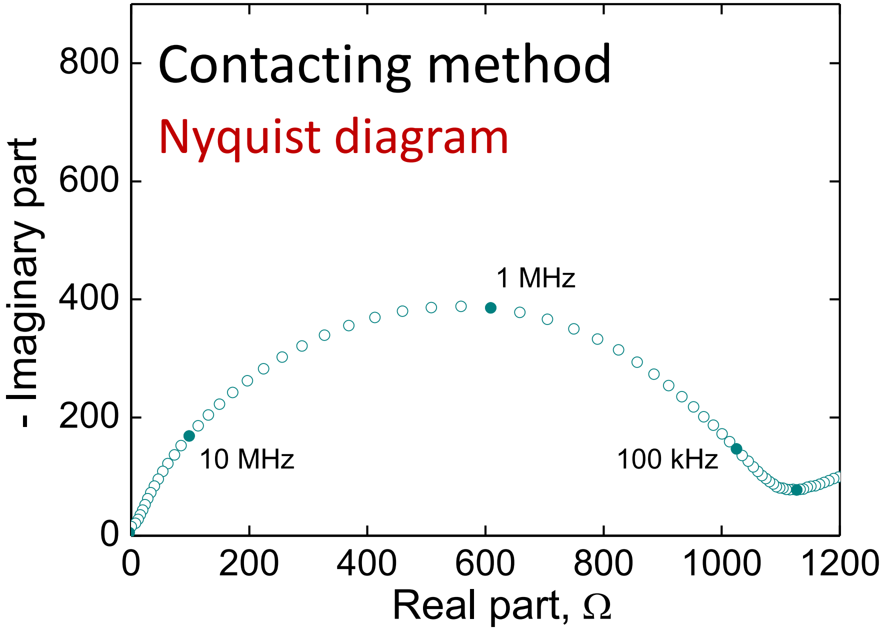
Materials and methods

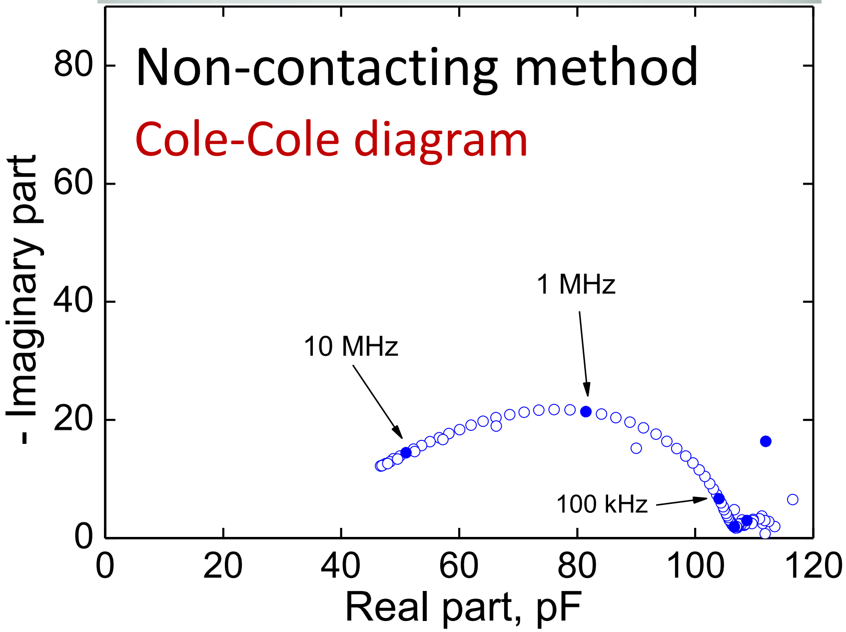
Impedance spectroscopy

Impedance analyzer
Agilent 4294A
100 Hz-100 MHz

Impedance spectra







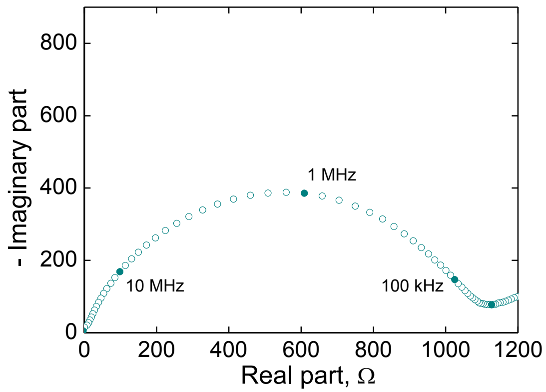
Materials and methods

Impedance spectroscopy

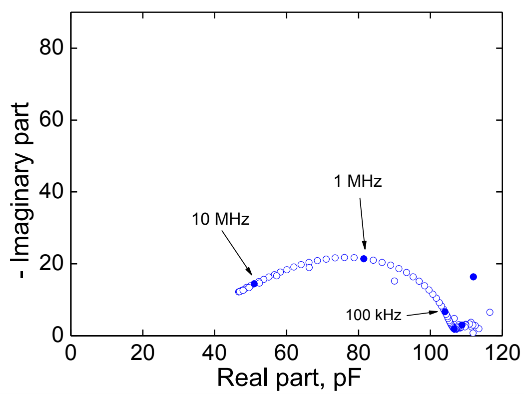
Equivalent circuits (Cabeza et al. 2002; Sánchez 2002)

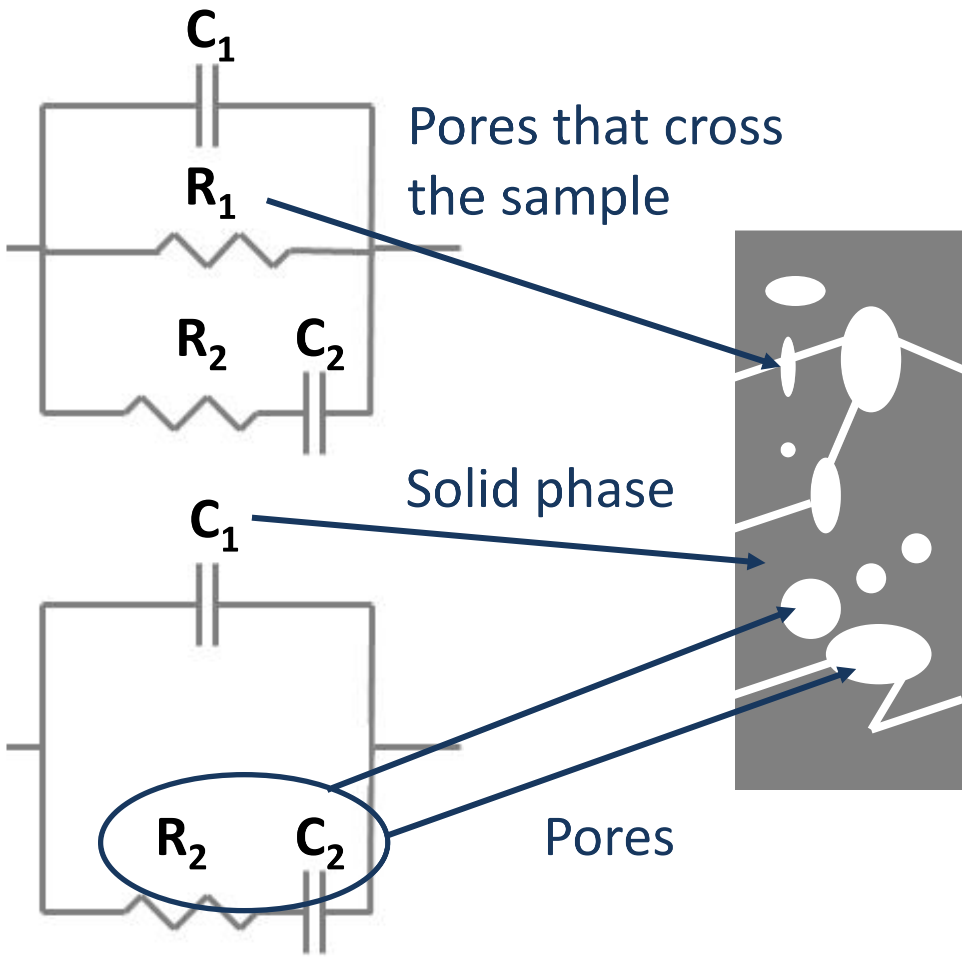
Represent **MICROSTRUCTURE**

Contacting method



Non-contacting method





Materials and methods

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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 samples
- Steady-state diffusion coefficient expression

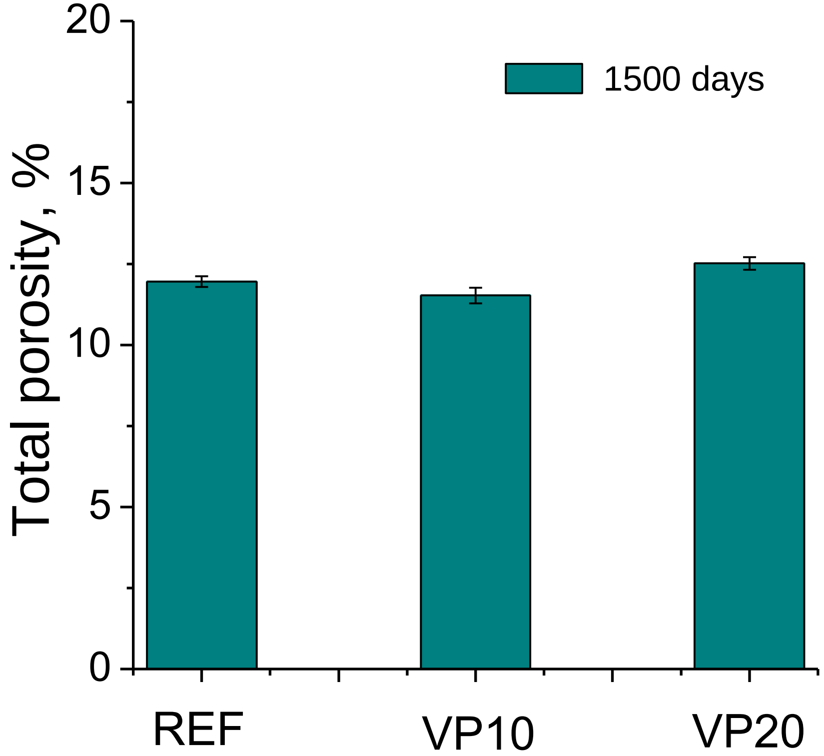
$$D_S = \frac{2\times10^{-10}}{\rho}$$

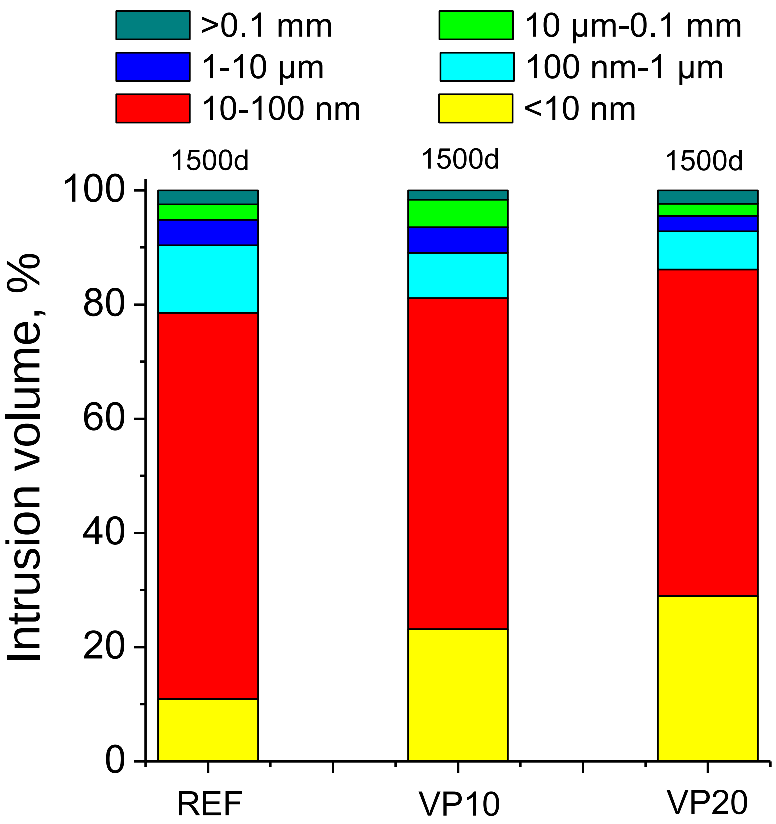
Results and discussion

Results and discussion

Microstructure

(b)





- Porosity VP10 mortar very similar to reference mortar
- Porosity VP20 mortar slight higher than reference mortar
- Porous structure→ **more refined in VP10 and VP20**

Results and discussion

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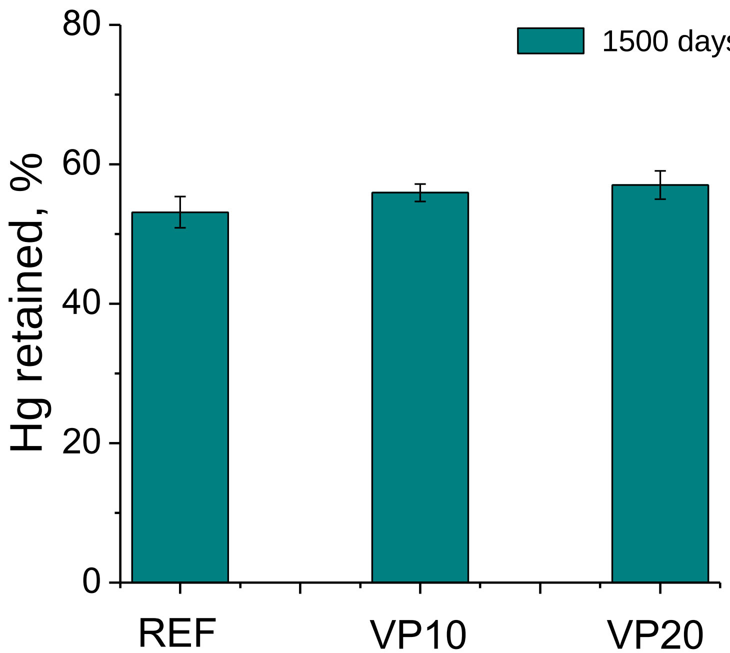
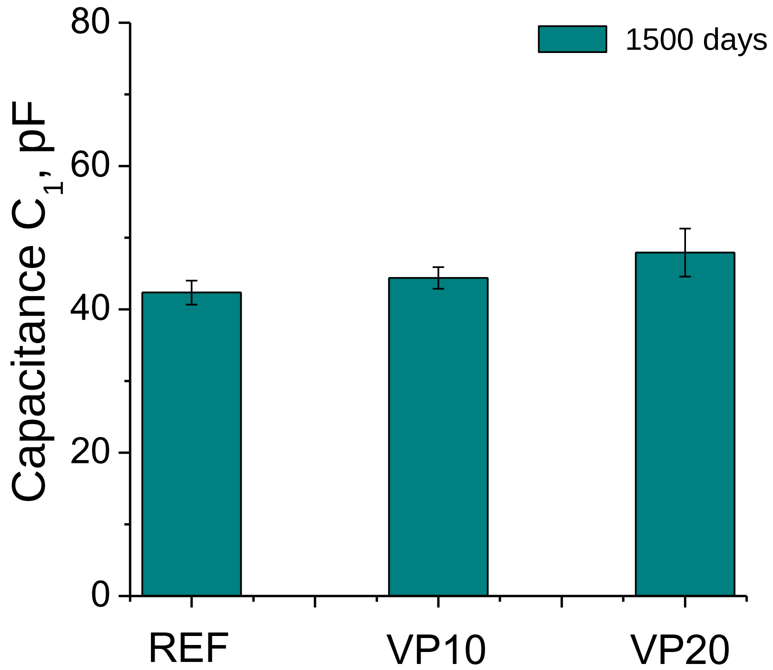
Service properties

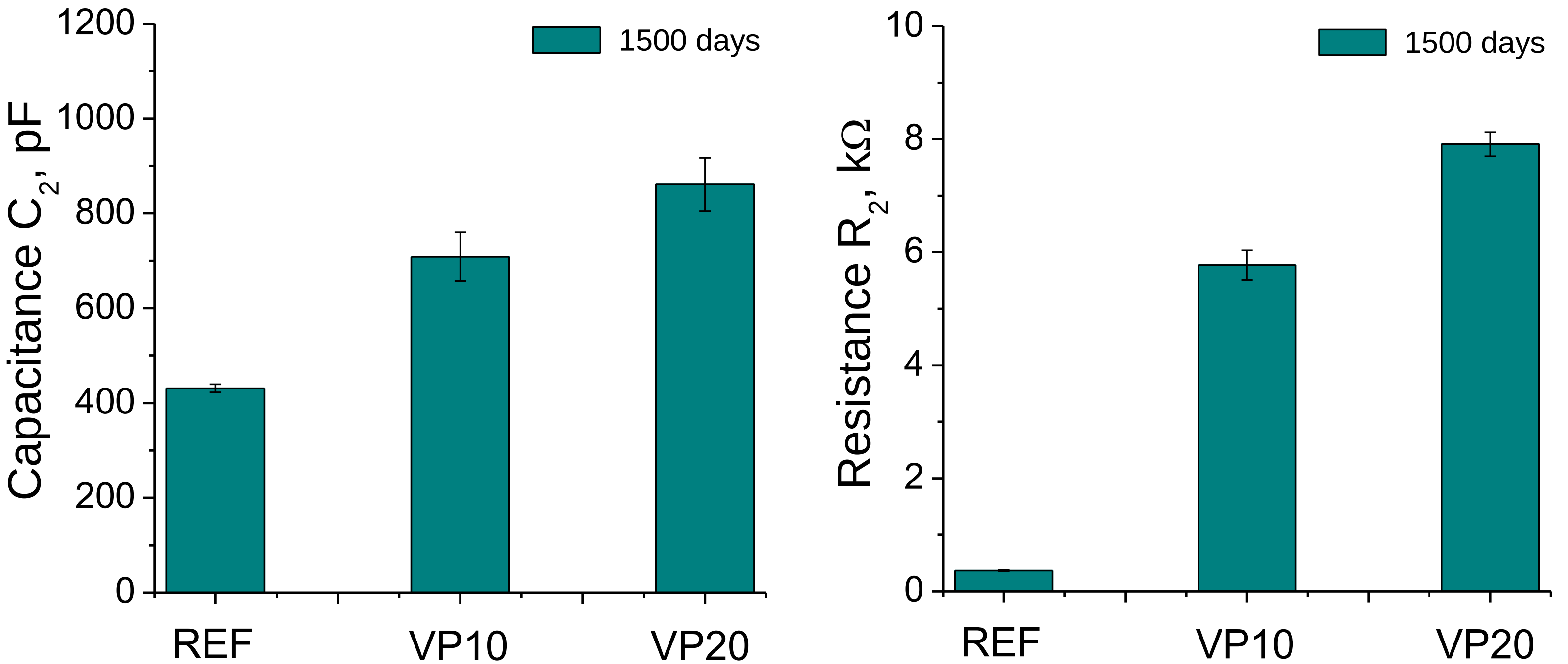




- Greater Hg retained in VP mortars
- Capacitance C_1 → Very similar values for VP10, VP20 and REF
- At 1500 hardening days → Very similar solid fraction in VP10, VP20 and REF

Results and discussion

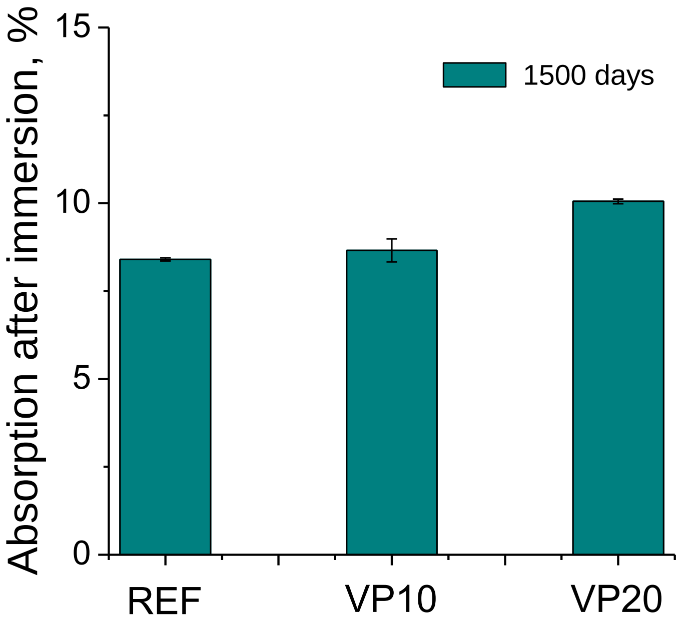
Service properties

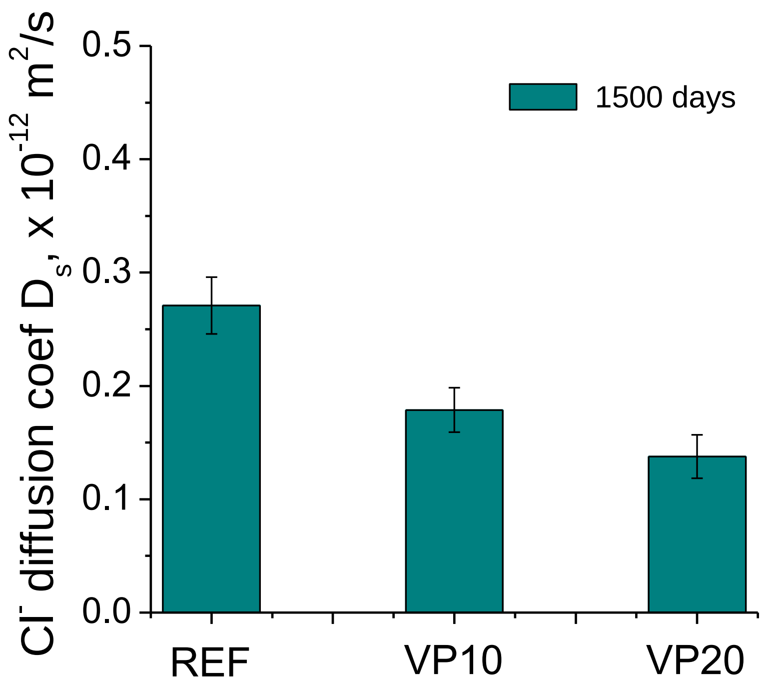


- Higher values for VP10 and VP20 than REF
- Results in keep with the higher pore refinement for VP mortars
- The addition of VP increased the relative volume of smaller pores

Results and discussion

Service properties





- Absorption % →VP10 and REF very similar
- Cl^- diffusion coef. → VP samples lower values than REF mortars
- **Very good performance of VP addition in Cl^- ingress resistance**

Conclusions

Conclusions

Conclusions

- At 1500 hardening days, the **VP mortars** showed a **greater refinement of the pore structure** in comparison with the reference mortars. This fact would be indicative of the **beneficial effect** in the very long term of this addition, produced by the formation of new solid phases as products of pozzolanic reactions of volcanic powders.

- The results at 1500 days obtained using the non-destructive impedance spectroscopy technique were overall in agreement with the results obtained with mercury intrusion porosimetry.

Conclusions

Conclusions

- The durability **properties** in the very long term analyzed in this work were **overall adequate for VP mortars**, highlighting their very good performance regarding chloride ingress resistance.

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Acknowledgments

GRUPO CEMENTOS PORTLAND VALDERRIVAS

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