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Effects in the short-term of combining an eco-friendly slag cement and several lightweight aggregates in relation to the microstructure and water ingress ability of mortars

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Outline

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

Introduction

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Sustainability of cement-based materials

- Improving the sustainability of the construction sector → Major issue at present
- Active additions → Ground granulated blast furnace slag:
    - Finer pore network of cement-based materials
    - Improves some of their service properties
- Lightweight aggregates:
    - Great interest for sustainability of construction industry
    - Development of new lightweight aggregates → Important topic of research
    - Potential of cork granulates as lightweight aggregate

Objetives

Effects at early hardening ages

↓

Combination of sustainable slag cement and different lightweight aggregates

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Microstructure

Ordinary Portland cement

Cement with high content of slag

Water absorption

Expanded cork

Natural cork

Expanded clay

Materials and methods

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Samples preparation

- Materials (mortars):
  - 50% of the volume of the sand has been replaced by and equivalent volume of lightweight aggregates
  - Types of cement:
    - Ordinary Portland cement CEM I 42,5 R
    - Ground ground granulated blast furnace cement III/B 32.5 N/SR → 70% slag content
  - Water to cement ratio = 0.5 (in weight)
  - For reference series without lightweight aggregates → Aggregate to cement ratio = 3 (in weight)
  - For lightweight series → Partial replacement of the natural sand by an equal volume of the studied aggregate

Samples preparation

- Series:
  - 1REF → CEM I without lightweight aggregates
  - 1ECK → CEM I with expanded cork
  - 1NCK → CEM I with natural cork
  - 1ECL → CEM I with expanded clay
  - 3REF → CEM III without lightweight aggregates
  - 3ECK → CEM III with expanded cork
  - 3NCK → CEM III with natural cork
  - 3ECL → CEM III with expanded clay
- Samples:
  - Prismatic → 4 cm x 4 cm x 16 cm
  - Stored submerged in water at 20^{o}C until the testing age

Experimental techniques

Effects at early hardening ages of combining sustainable slag cement and different lightweight aggregates

Microstructure

Mercury intrusion porosimetry

SEM microscopy

Water absorption

Absorption after immersion

- **Tests performed at 28 hardening days.**

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Mercury intrusion porosimetry

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

Scanning electron microscopy (SEM)

- Hitachi model S3000N microscope

Absorption after immersion

- ASTM Standard C642-06
- Pieces taken from prismatic specimens

Results and discussion

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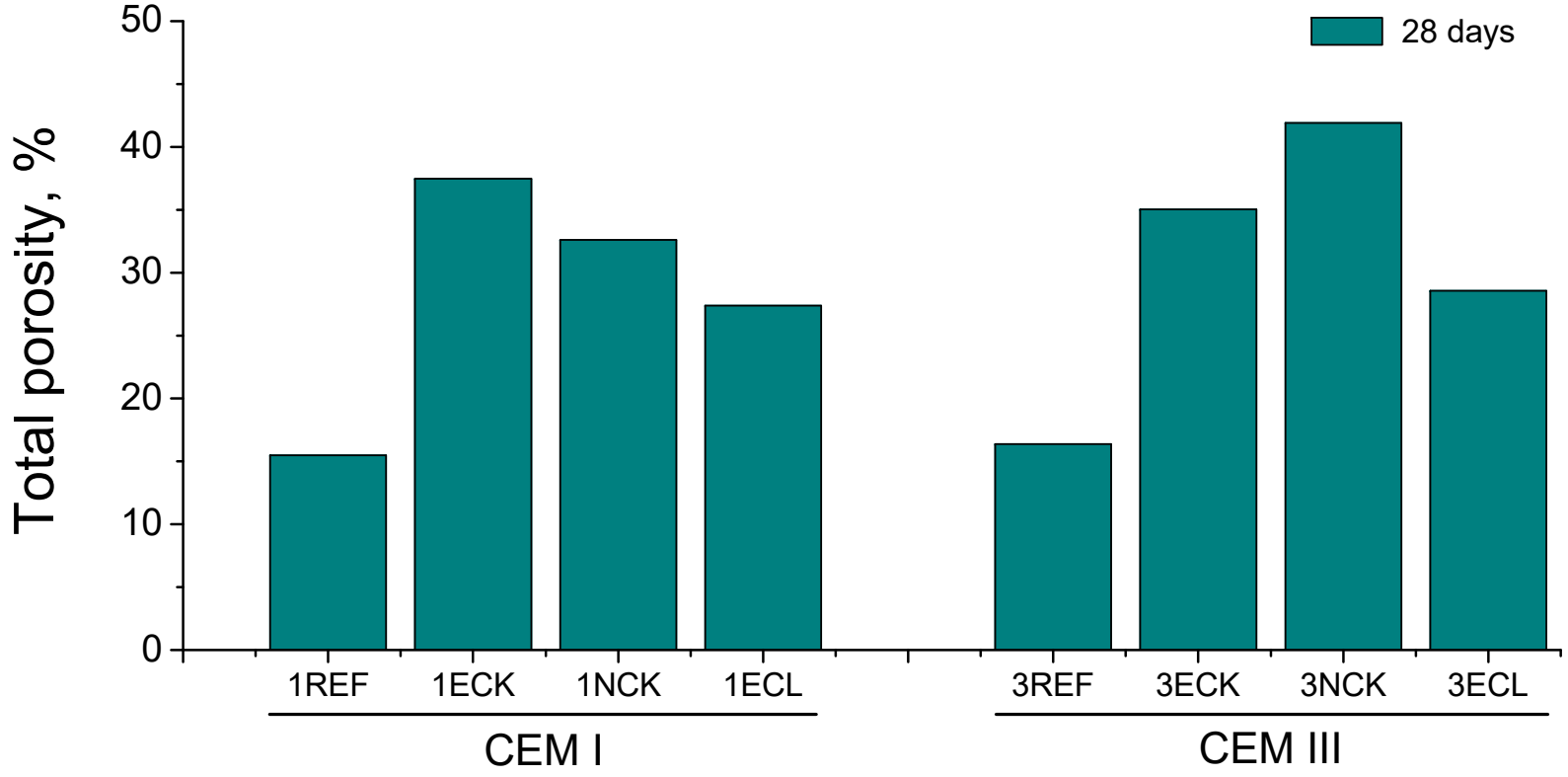
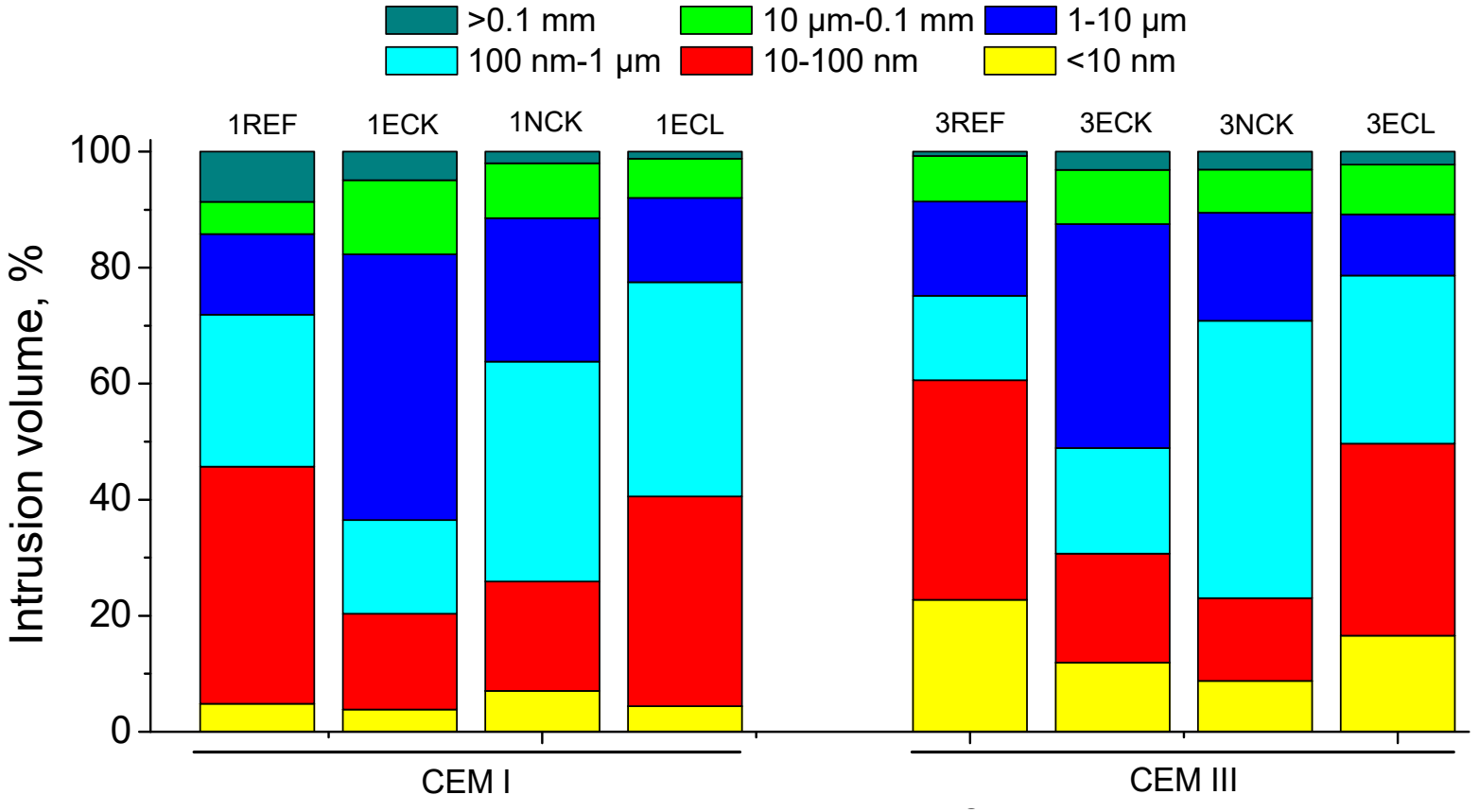
Microstructure



- Highest porosity → ECK and NCK specimens
- Slag cement → Reduction of porosity for ECK and ECL samples
- **Effects of slag hydration**

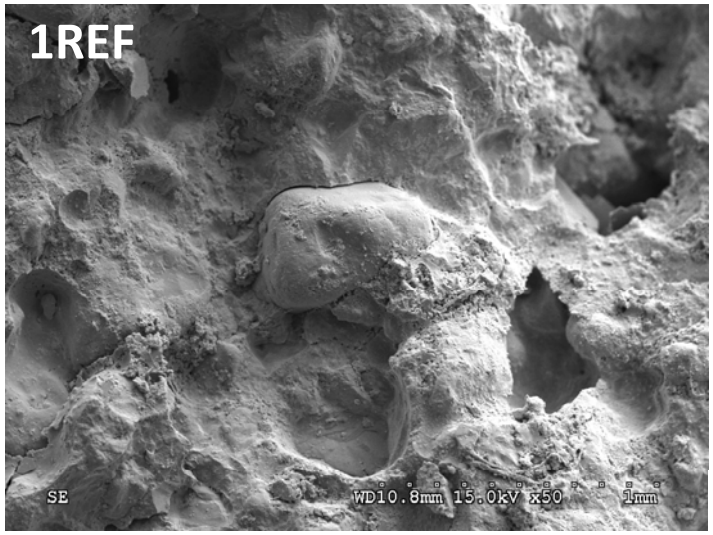
Microstructure

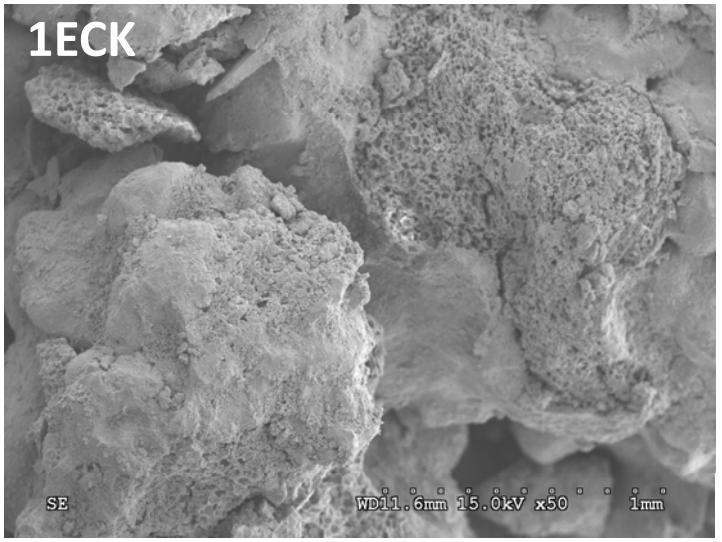


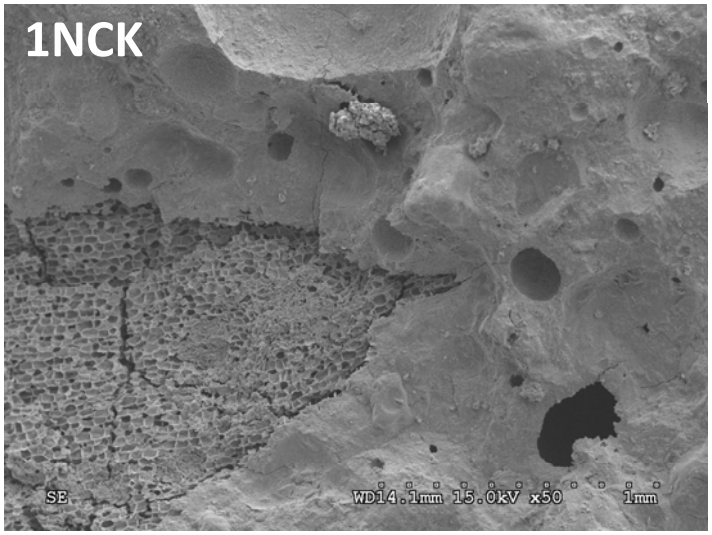
- Slag cement → Higher pore refinement for the same aggregate
- Lower pore refinement → ECK and NCK specimens
- **Slag hydration → Formation new solid phases → Finer microstr.**

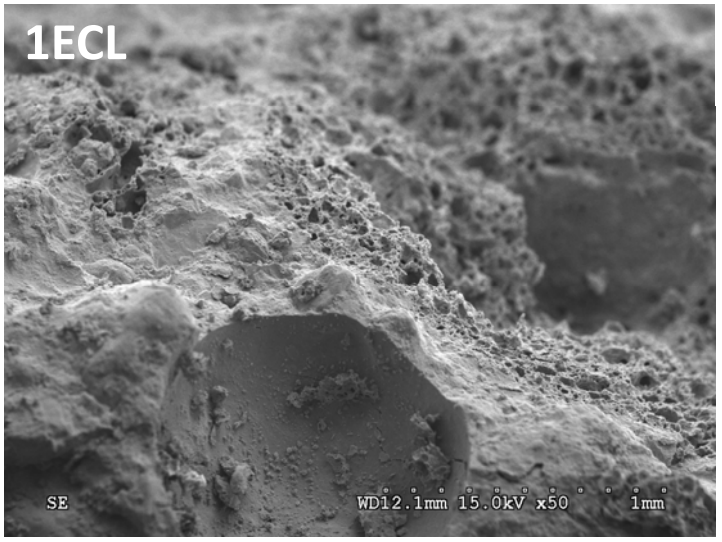
Results and discussion

Microstructure

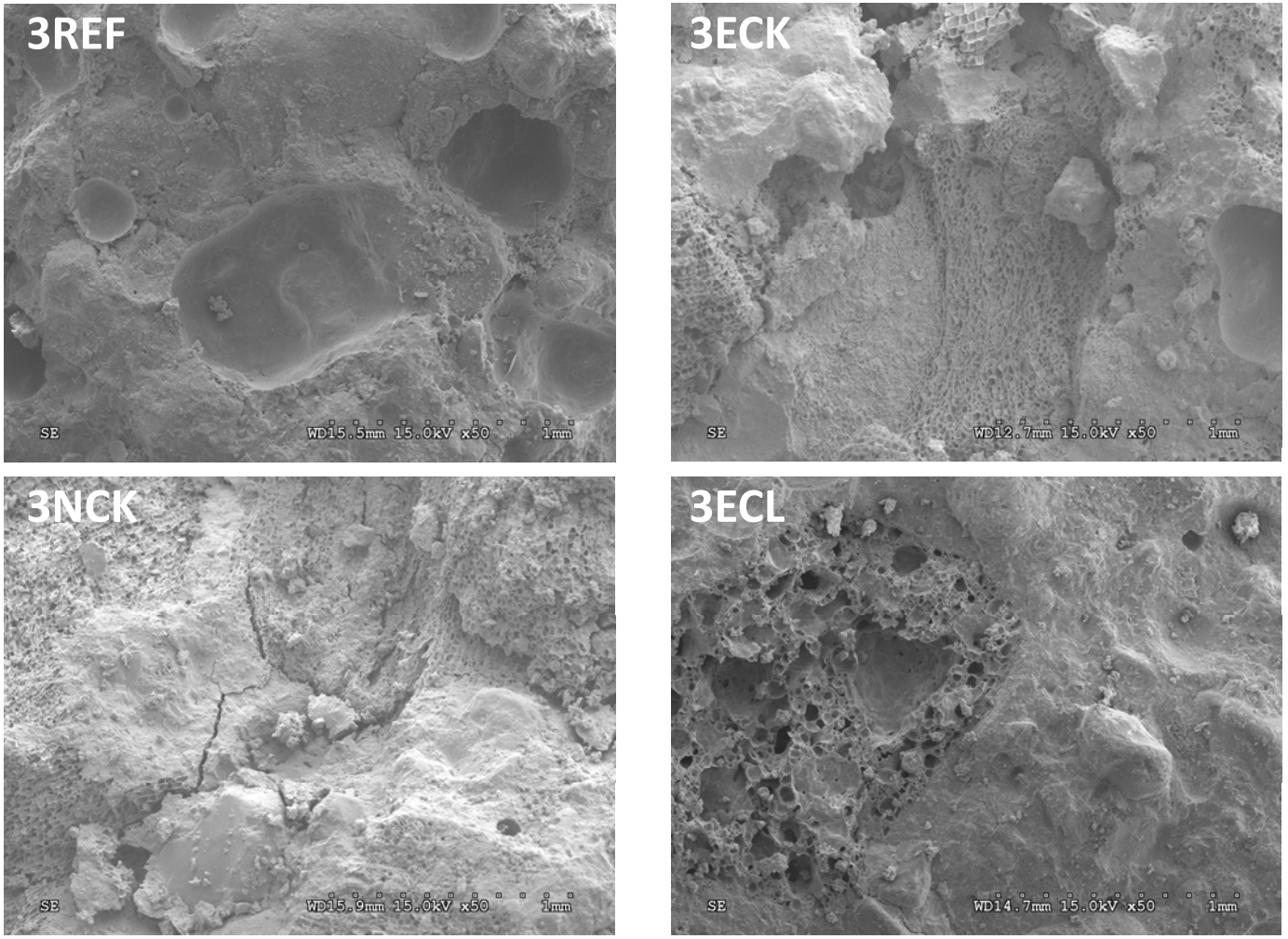






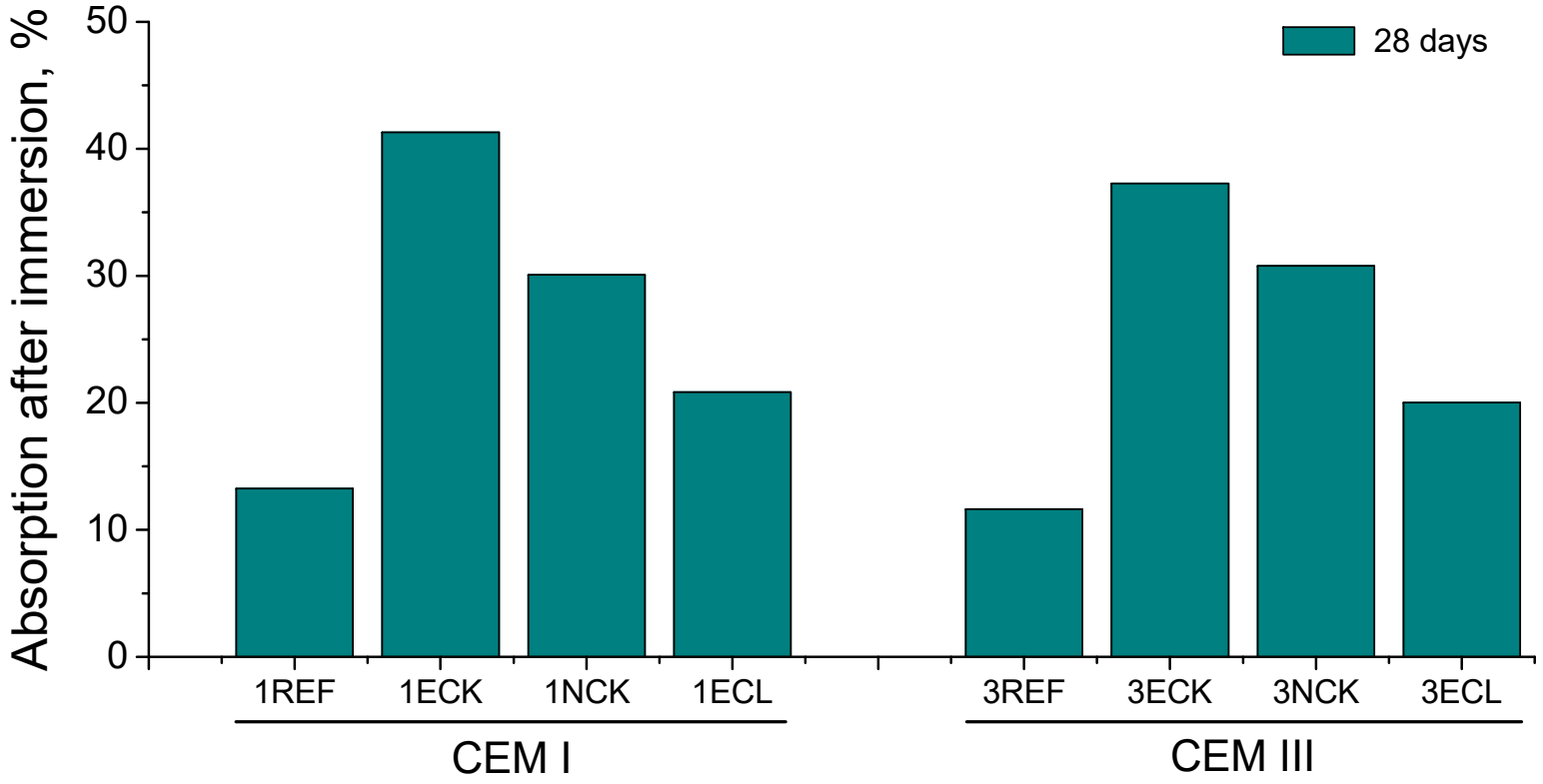


Microstructure



- **Cork aggregates → cement matrix was more compact and refined when slag cement was used**

Water absorption



- Lowest values → Reference specimens
- Highest absorption → ECK specimens
- **Slag cement → Lower absorption for the same aggregate**

Conclusions

Conclusions

- The use of sustainable cement with high content of slag overall produced a higher pore refinement and a reduction of absorption at 28 hardening days for all the mortars studied, independently of the aggregate used
- Mortars which incorporated expanded cork and natural cork showed higher porosities and water absorption than the other series, for both cements studied
- It would be interesting to follow the evolution of the microstructure and water absorption of these mortars with cork at later ages → More noticeable effects of slag will be expected

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