



# REHABENDO 2022

## Euro-American Congress

CONSTRUCTION PATHOLOGY, REHABILITATION  
TECHNOLOGY AND HERITAGE MANAGEMENT

Granada (Spain)

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## ADVANCED TECHNOLOGIES FOR NATURAL STONE | INOVSTONE 4.0 - IMPORTANT RESULTS FROM A RESEARCH PROJECT ON NATURAL STONE CONSTRUCTION MATERIALS SELECTION AND PERFORMANCE ANALYSIS

**Vera Pires\***; José Mirão; Fabio Sitzia; Carla Lisci; José Duarte; Luis Dias; Tiago Alves; Luis Lopes;  
Ruben Martins

\* Speaker | Vera Pires | [vlcp@uevora.pt](mailto:vlcp@uevora.pt) | HERCULES laboratory | Évora University - Portugal



# SCOPE

Natural stone construction products....

...from structural 1000 mm thick....



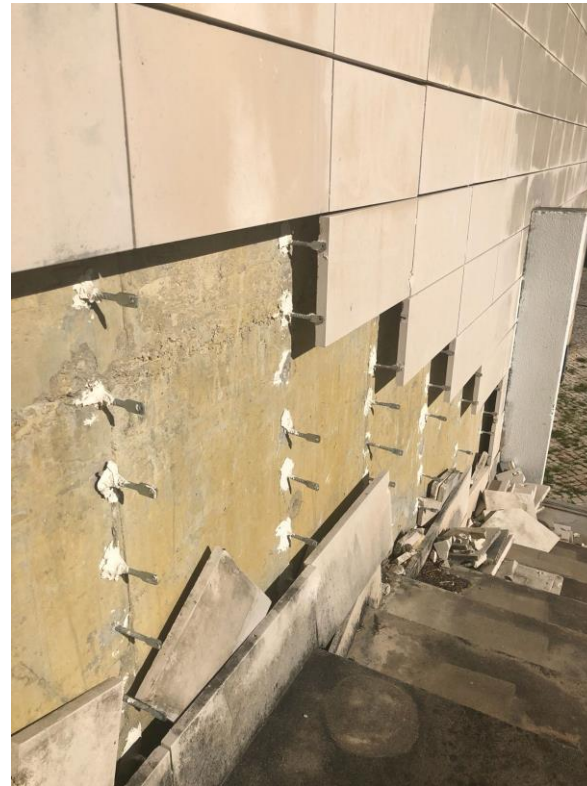
....to facade cladding elements with 20 – 50 mm





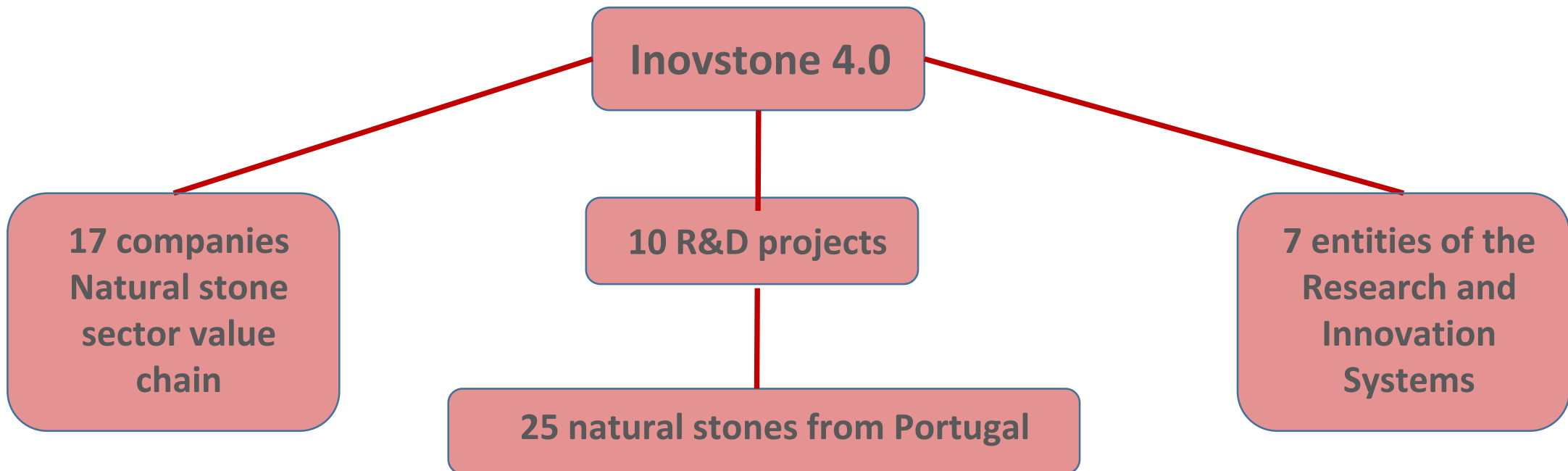
# SCOPE

| Even though most stones performed satisfactorily, durability problems begun to appear at an increasing rate sometimes after 10 years or less of using thin elements either in cladding or floor applications.



# Inovstone 4.0 | PROJECT

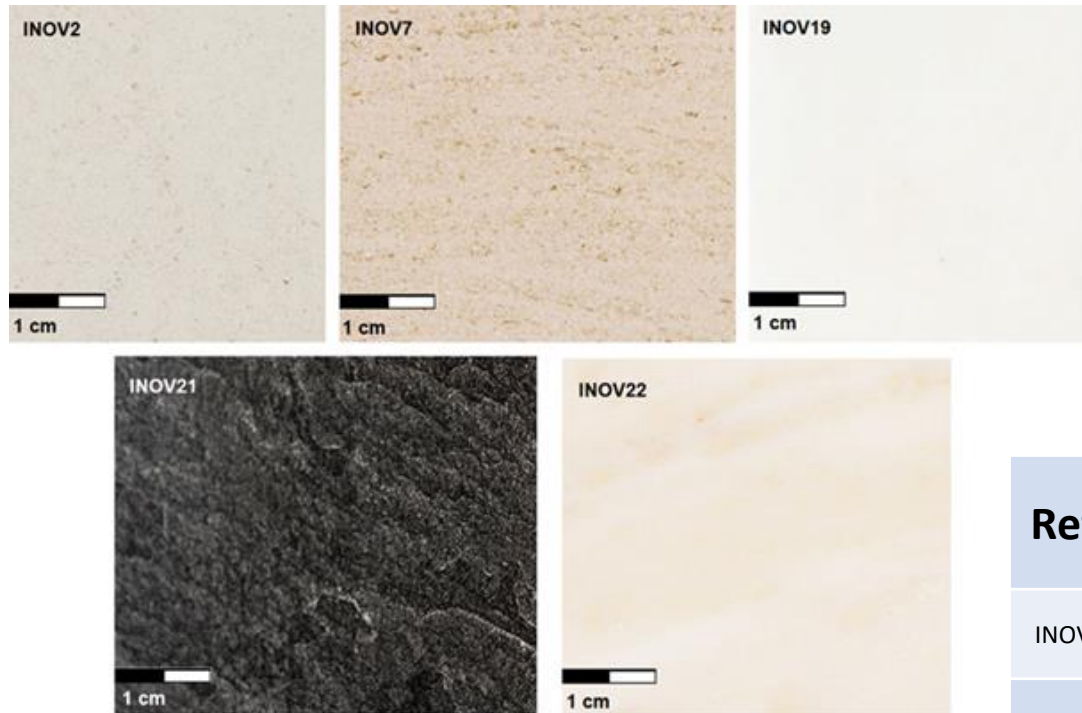
| This project arises from the need to highlight the dynamic capacity of the Portuguese natural stone sector and, at the same time, to strengthen its competitiveness in relation to the new digital procurement models, namely in the context of the Building Information Modelling (BIM).



# Inovstone 4.0 | PROJECT GOALS

- i) Provide resources to the stone industry professionals, offering a catalogue of Portuguese natural stone products in the world-leading platform BIM object.
- ii) Classify the stones by petrographic, mineralogical, physical-mechanical and geochemical analysis
- iii) Understand and provide explanation and classification on the loss of strength mechanisms caused by several ageing types
- iv) Study the effect of biodeterioration - through three different strains that are commonly found on colonization in stone-constructed buildings and artefacts
- v) Develop a concept for assessment of Portuguese natural stone products, including personalized BIM object application and a monitoring tool to predict decay and improve safety and reliability.

# SELECTED STONE MATERIALS



| Ref.   | Stone commercial name     | Origin and quarry location                               | Stone type |
|--------|---------------------------|--|------------|
| INOV2  | Branco real               | Vale da Moita, Arrimal, Porto de Mós, Leiria, Portugal   | Limestone  |
| INOV7  | Creme Savage - Moca Creme | Cheira, Pia do Zé Gomes, Alcanede, Santarém, Portugal    | Limestone  |
| INOV19 | Branco                    | Olival do Texugo, Bencatel, Vila Viçosa, Évora, Portugal | Marble     |
| INOV21 | Lousa de Valongo          | Campo, Valongo, Porto, Portugal                          | Slate      |
| INOV22 | Creme JPL                 | Encostinha nº 4 - JPL, Borba (Matriz), Évora, Portugal   | Marble     |



# TEST METHODS



## All RESULTS WERE USED IN THE STONE BIM OBJECTS ATTRIBUTES

mineralogical composition | thin section analysis & XRD

chemical composition | EDXRF

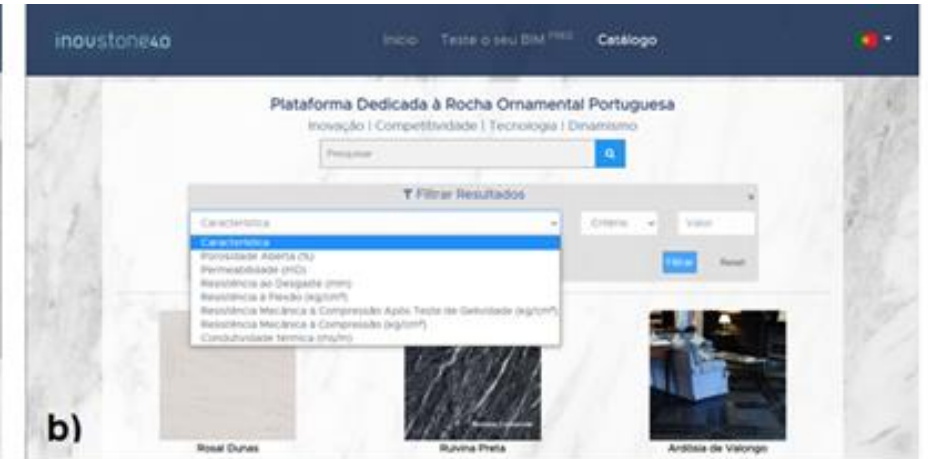
physical properties | colour (CIELAB), water vapour permeability, density, porosity, water absorption, capilarity, bio...

mechanical properties | uniaxial compression, bending, anchorage rupture, abrasion, impact, elastic modulus, ultrasound

ageing properties | termal ageing tests - frost and termal shock

# INOVSTONE PLATFORM | BIM OBJECT

- INOVSTONE platform main page;
- Natural stone research by properties;
- Example of a technical sheet for a limestone in which all properties are available;
- Linking a stone to a BIM object to be included in an architectural project or product design.



<https://www.inovstone.pt/>





# BIM OBJECT APPLICATION

**UNIVERSIDADE DE ÉVORA** **HERCULES**

**ANTECIPA**  
Modelos de previsibilidade de Rochas Ornamentais em obras e em exploração.  
(ALT20-03-0246-FEDER-000070)

**CATÁLOGO**  
**PESQUISA**  
**BIM**  
**TESTAR AR**  
**CONTACTAR**  
**SOBRE**

**Catalogo de rochas**

**Lioz Abancado**

**Informações**  
Nome comercial: Lioz Abancado  
Litotipo (EN12440): Abancado  
Local: Sintra

**Descrição**  
Petrografia: Calcário bioclástico a bioconstruído muito esparitizado (Biopelosparite)  
Teste de gelo-degelo: Resistência superior a 144 ciclos  
Resistência ao Desgaste: 3.4 mm  
Minerologia: Essencial: Calcite ~100%; Acessórios: -  
Geoquímica: Al<sub>2</sub>O<sub>3</sub> 0.18%; CaO 55.60%; Fe<sub>2</sub>O<sub>3</sub> (total) 0.04%; K<sub>2</sub>O 0.04%; MgO 0.12%; MnO 0.00%; Na<sub>2</sub>O 0.05%; P.R. (L.O.I.) 43.79%; SiO<sub>2</sub> 0.10%; TiO 0.00%

**Especificações**  
Massa volúmica aparente: 2690 kg/m<sup>3</sup>  
Porosidade: 0.4 %  
Absorção de água: 0.2 %  
Resistência ao desgaste: 3.4 mm

Rocha 1 de 14



# CONCLUSIONS

- | Inovstone 4.0 project – address the need to highlight the capacity of the Portuguese natural stone sector.
- | Inovstone 4.0 tool contributes to the increase of companies competitiveness concerning the new digital procurement modes, in the context of the Building Information Modeling (BIM)
- | In-depth characterization is fundamental for BIM objects parametrization; A complete and updated study originates reliable stone specifications that can easily be compared to product specifications defined in national codes or other relevant technical documents
- | Natural stone business is changing, and clients are evolving from buying first stage product to complete facade solutions
- | Product digitalization is becoming more relevant every year and the access to freeCAD and integrated natural stone databases are an advantage for the Portuguese natural stone industry



# FUTURE WORKS

- | Add more stones and more properties to the database
- | Link the current INOVSTONE BIM platform to a mobile APP
- | Add new functionalities to the INOVSTONE APP - augmented reality – complex objects

# THANK YOU | OBRIGADA | GRACIAS | GRAZIE

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