ARISTOTLE UNIVERSITY OF THESSALONIKI

ΕΡΓΑΣΤΗΡΙΟ ΔΟΜΙΚΩΝ ΥΛΙΚΩΝ
LAB. OF BUILDING MATERIALS

# Exploitation of secondary products coming from the perlite process in building materials

M. Stefanidou[1], V. Pachta[1], G. Konstantinidis[2]

[1]Laboratory of Building Materials, School of Civil Engineering, Aristotle University of Thessaloniki, Thessaloniki, 54124, Greece

[2] Plant manager, Perlit Hellas Volos

# Introduction

- Building materials are detrimental for characterizing the construction technology of a civilization through history.
- The materials themselves, technics used, and their combination define the functional and aesthetical criteria of a structure.

- When designing intervention materials (mortars, grouts), for the restoration of historic structures, the individual characteristics of the authentic materials, based diachronically on lime / natural pozzolan and the environmental conditions of each site, are taken into account.
- The aim is to apply materials compatible with the old ones and meet the requirements of durability and performance

- Due to the absence of relevant specifications and criteria for certification of raw materials in the market a variety of ready mixed materials are available that although facilitate the restoration work are often of dubious quality and composition
- Secondary problems arise in the historical constructions from the use of incompatible intervention materials.

- The restoration of monuments and historic buildings is an important area of raw material management and natural resources, the application of low-cost materials and environmental footprint is considered imperative.

- In the context of the sustainability of constructions, the over-consumption of natural resources and the utilization secondary materials, the use of industrial by-products in construction has intensified internationally applications.
- At the same time, the growing awareness of society about its protection cultural heritage, as well as the need to protect the environment, drives strategies combining restoration principles with environmentally friendly materials and techniques.

# Perlite processing products

- The use of perlite processing products is an alternative exit, considering that Greece is internationally one of the largest productive countries perlite.
- Today only 1% of the world stock is mined.

- Perlite is a volcanic rock containing high amount of amorphous material as well as alumino-silicate minerals. The outcoming product (expanded perlite) is often used in construction, due to its light weight and insulating properties.
- During its industrial process, an increasing number of by-products results that mainly remains unexploited as the fineness of these materials renders them difficult to store.

- Use of perlite in building materials, proved its beneficial role, due to its low bulk density (32 - 150 kg/$m^3$), thermal conductivity (0.04-0.06W/mK), as well as its high heating resistance (melting point: 1260–1343 $^oC$)

In the studied plant (Perlite Hellas, Volos, Greece), the production line of perlite includes three stages (crushing, heating and expanding), during which a total amount of 10% of by-products is created. These by-products, obtained by air separation, are in a powder form and are usually deposited in the environment (in large areas near the plant)

# Perlite by-products

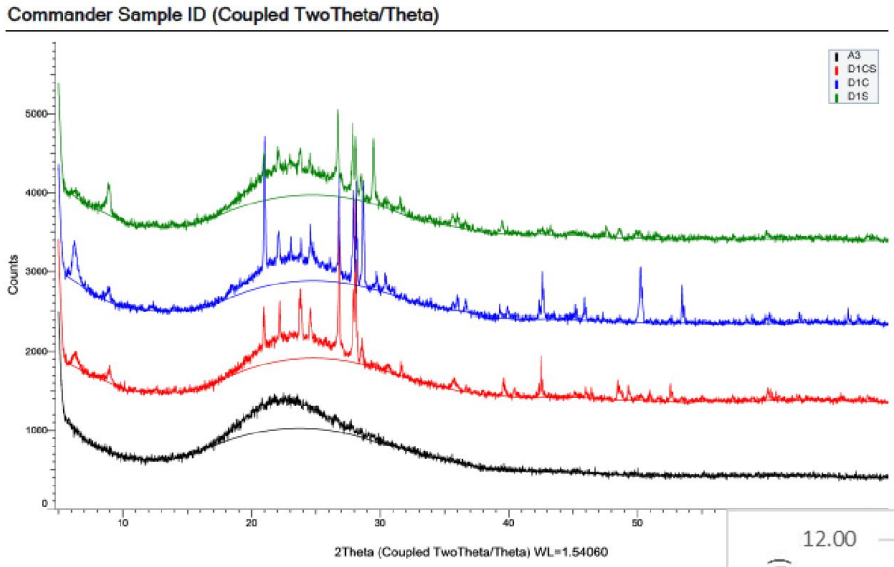

# Physical and mechanical properties of perlite by-products

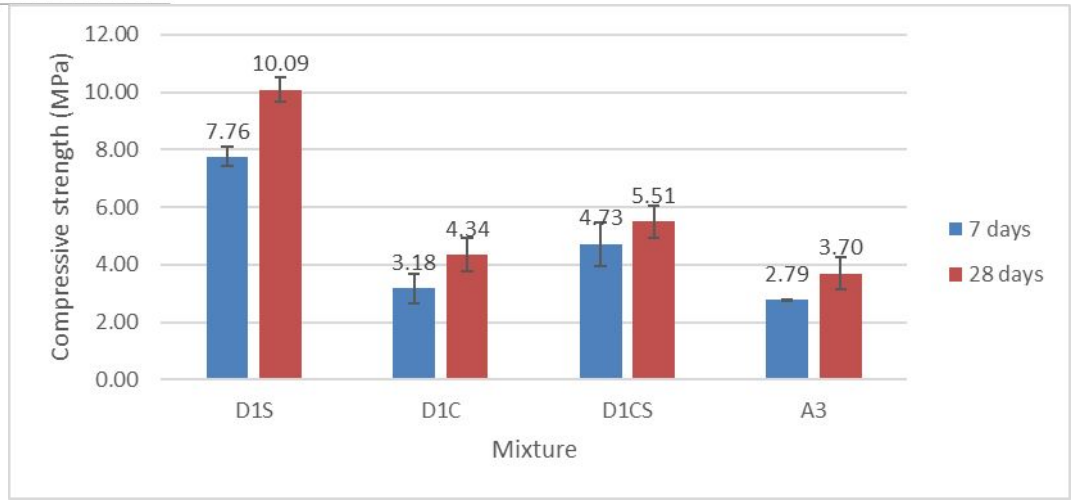
| Raw material | D(0.1) (µm) | D(0.5) (µm) | D(0.9) (µm) |
|---|---|---|---|
| D1S | 2.202 | 8.913 | 28.634 |
| D1C | 17.269 | 78.123 | 188.891 |
| D1SC | 6.082 | 51.388 | 171.347 |
| A3 | 3.810 | 12.417 | 32.197 |

| By-product | Specific gravity (g/ml) | pH | Moisture content (%) |
|---|---|---|---|
| D1S | 2.459 | 9.82 | <1% |
| D1C | 2.415 | 8.53 | <1% |
| D1CS | 2.343 | 9.02 | <1% |
| A3 | 1.462 | 8.80 | <1% |

| Sample | SOLUBLE IN ACIDS % w.t. | | | | | | | | SOLUBLE SALTS % w | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | $Na_2O$ | $K_2O$ | CaO | MgO | $Fe_2O_3$ | $Al_2O_3$ | $SiO_2$ | L.I.% | $Cl^-$ | $NO_3^-$ | $SO_4$ |
| D1S | 2.67 | 2.21 | 1.61 | 0.40 | 0.99 | 16.26 | 71.95 | 3.91 | 0.01 | - | 0.0 |
| D1C | 2.35 | 2.11 | 1.26 | 0.34 | 0.88 | 16.04 | 73.95 | 3.07 | 0.03 | <0.01 | <0.( |
| D1CS | 2.24 | 2.01 | 0.93 | 0.24 | 0.76 | 12.51 | 78.39 | 2.92 | 0.02 | <0.01 | - |
| A3 | 2.70 | 2.41 | 0.92 | 0.17 | 0.69 | 15.55 | 76.68 | 0.88 | 0.02 | - | <0.( |

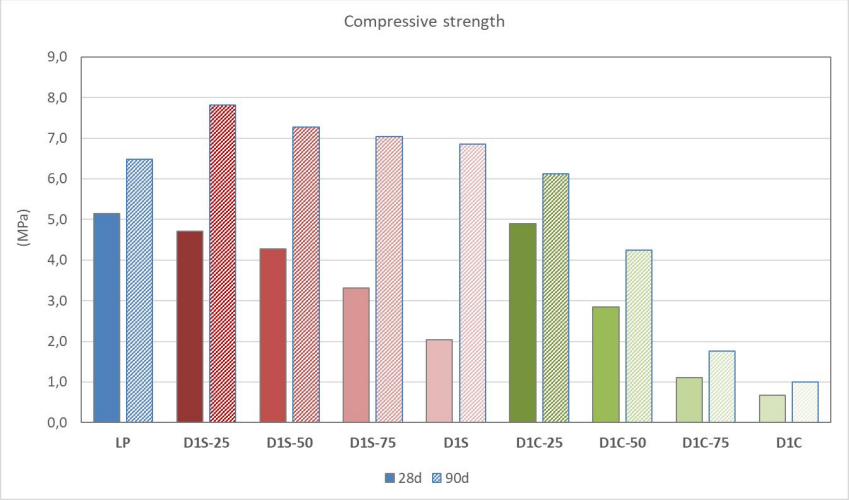
# Testing minerology and pozzolanicity of perlite by products

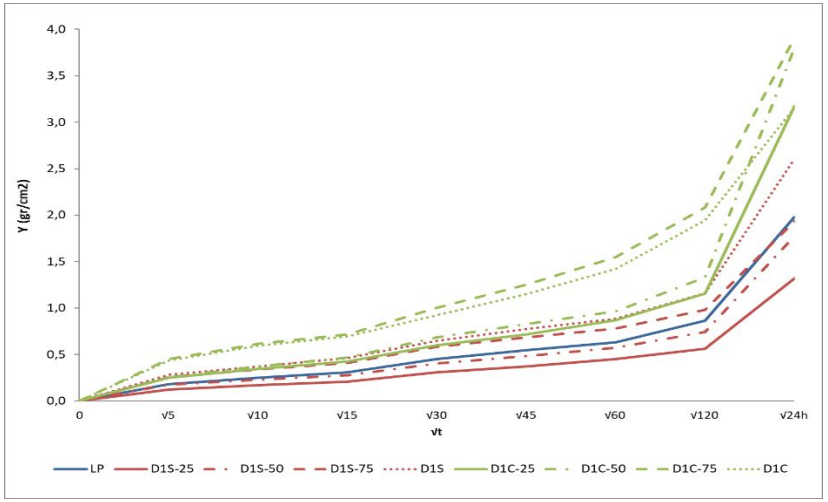


# Mortar production and testing

| Raw materials | Mortar compositions (parts of weight) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | LP | D1S-25 | D1S-50 | D1S-75 | D1S | D1C-25 | D1C-50 | D1C-75 | D1C |
| Hydrated lime powder | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Milos pozzolan | 1 | 0.75 | 0.5 | 0.25 | - | 0.75 | 0.5 | 0.25 | - |
| D1S | - | 0.25 | 0.5 | 0.75 | 1 | - | - | - | - |
| D1C | - | - | - | - | - | 0.25 | 0.5 | 0.75 | 1 |
| Siliceous sand (0-4mm) | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 | 4 |
| W/B ratio | 0.71 | 0.62 | 0.60 | 0.62 | 0.57 | 0.59 | 0.52 | 0.53 | 0.52 |
| Workability (cm) (EN1015-3:1999) | 15.4 | 14.6 | 14.9 | 14.7 | 15.0 | 14.9 | 14.5 | 14.8 | 15.0 |



# Outcomes for perlite byproducts

- The products from the perlite process show high hydraulicity fineness, low content in soluble salts and amorphous content
- The partial and even total replacement of natural pozzolan by perlite by-products, for manufacturing restoration mortars for historic building, seems to be a feasible and an environmental beneficial approach.
- The produced materials could be characterized by a low environmental footprint due to the limitation of the mining of natural pozzolan needed for their manufacture, as well as the exploitation of perlite by-products that would be otherwise deposited outdoor.

# Outcomes for mortars

- Reduction of the W/B ratio around 15-30%. The higher proportion of by-products the lower was the water demand in all cases.
- Reduction of porosity, absorption and capillary absorption, especially for the pozzolan partial substitution by D1S (up to 75%).
- The low strength development rate of the modified mortars, led to enhanced 90d mechanical characteristics that should be further envisaged.
- 90d Dynamic Modulus of elasticity was increased by the pozzolan substitution (up to 75%) by D1S, as well as flexural and compressive strength.

# Benefits

- Development of innovative use of perlite by-products in Greece.
- Management of the environmental impact of perlite by-products.
- Setting eligibility criteria for industrial perlite processing products in structural applications.
- Development of innovative, high quality local materials (mortars, coatings, grouts) for restoration of monuments and historic buildings with ecological profile and low cost, which will meet the principles of compatibility and performance
- Reduction of natural pozzolan extraction, especially in areas of high environmental beauty, as perlite processing products can effectively replace natural pozzolan

**Acknowledgements**

- The study was implemented during the Project ‘PerliMat - Exploitation of industrial products from the perlite process for the development of increased added value, ready mixed restoration materials’, Co-financed by the European Regional Development Fund of the European Union and Greek national funds through the Operational Program Competitiveness, Entrepreneurship and Innovation, under the call RESEARCH – CREATE - INNOVATE (project code: T2EDK-01105)

**Thank you for your attention**