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Lightweight aggregates and functional fillers from recycled glass for construction applications

e-CODOMH Open Event

"The Green and Digital Transition of Construction: Innovation, Skills and Sustainability in the Built Environment"

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ESIEA, 1st Floor, "George Karantzas" Hall

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EUROPEAN PARTNERSHIP

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1 |Project’s Overview

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Objectives / Expected Results

- Optimized geopolymer compositions from recycled waste glass (since it undergoes a pretreatment stage in recycling plant) capable of expanding at the following process stage.
- Optimized expansion process of the innovative geopolymer formulations, that will result in innovative expanded glass fillers with thermal insulation and structural integrity.

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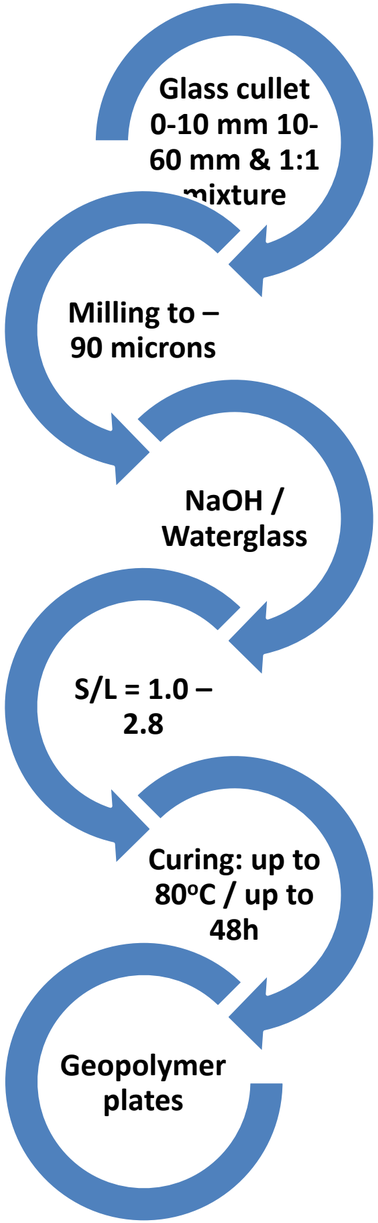
➢ Lightweight sustainable construction end-products with advanced physical properties

➢ Lab-scale process for lightweight material production ready for scale-up.

2 | Development of lightweight materials at laboratory scale

Task: Glass Waste Geopolymerisation – Challenges

- Selection of glass waste streams of:
  - controlled chemical composition
  - Adequate quantities
- Study of alkaline activators and curing conditions
- Parameters to optimize:
  - Milling process of waste glass
  - Na/Si ratio,
  - S/L ratio
  - Molarity of alkaline activator solution
- 28 different formulations have been prepared up to date



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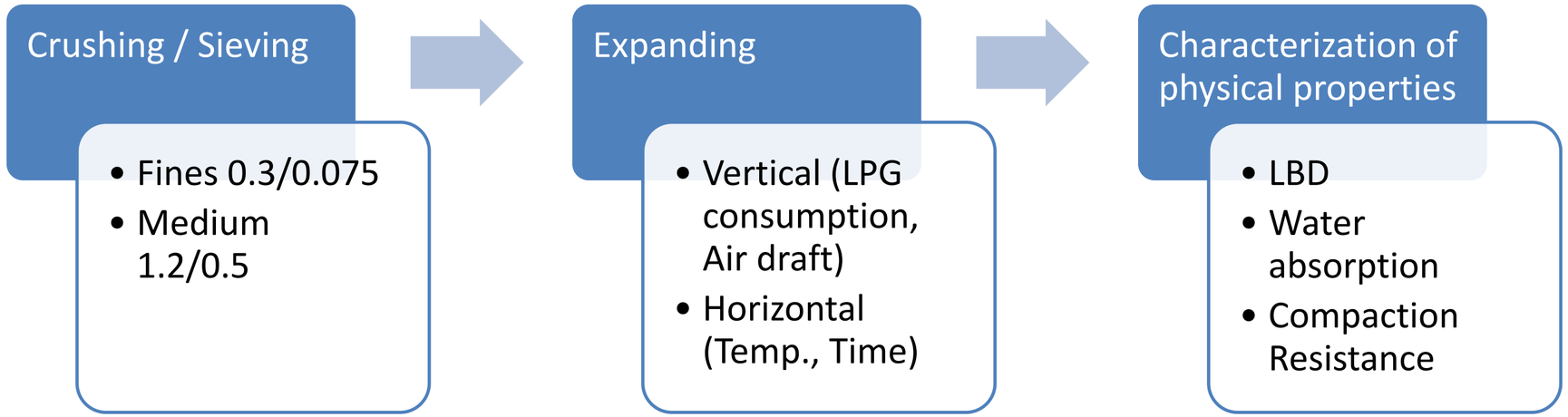
2 | Development of lightweight materials at laboratory scale

Task: Expandability Study of Geopolymer Compositions - Challenges

- Crushing – Preparing raw polymer grades having a PSD of the expanded comparable to the industrial practice

- Evaluate vertical (LPG) and horizontal (electrical induction) furnaces for expansion
  - Control parameters: expansion temp, residence time, particle size

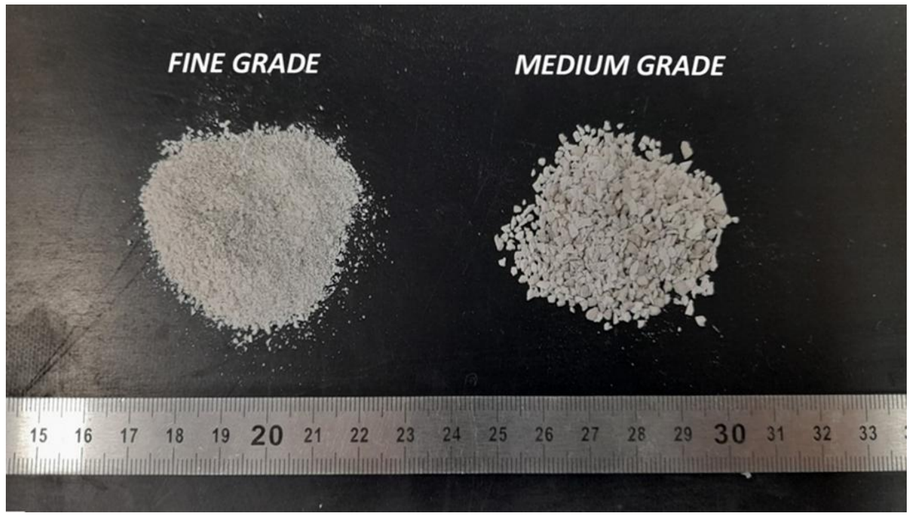
- Characterization of physical properties



2 | Development of lightweight materials at laboratory scale

Task: Expandability Study of Geopolymer Compositions - Conventional Vertical Furnace

- LPG consumption, air draft
- The expansion conditions depend on the employed grade
- T (^{o}C) range 580 to 670 ^{o}C (per 20 ^{o}C)
- LBD's varying from 544 to 150 kg/m^3
- Optimum LBD ~150 kg/m^3 at ~590^{o}C for both grades



2 | Development of lightweight materials at laboratory scale

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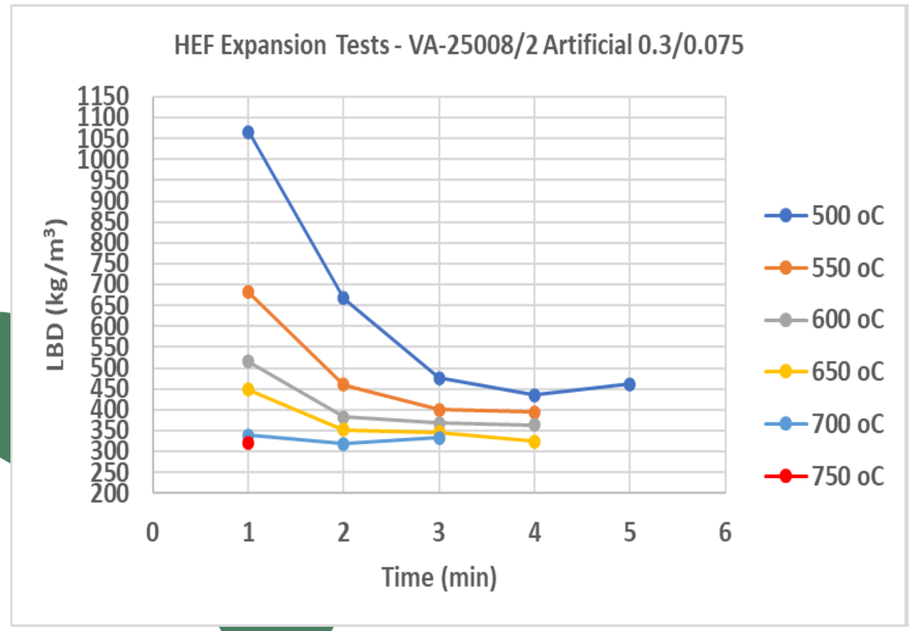
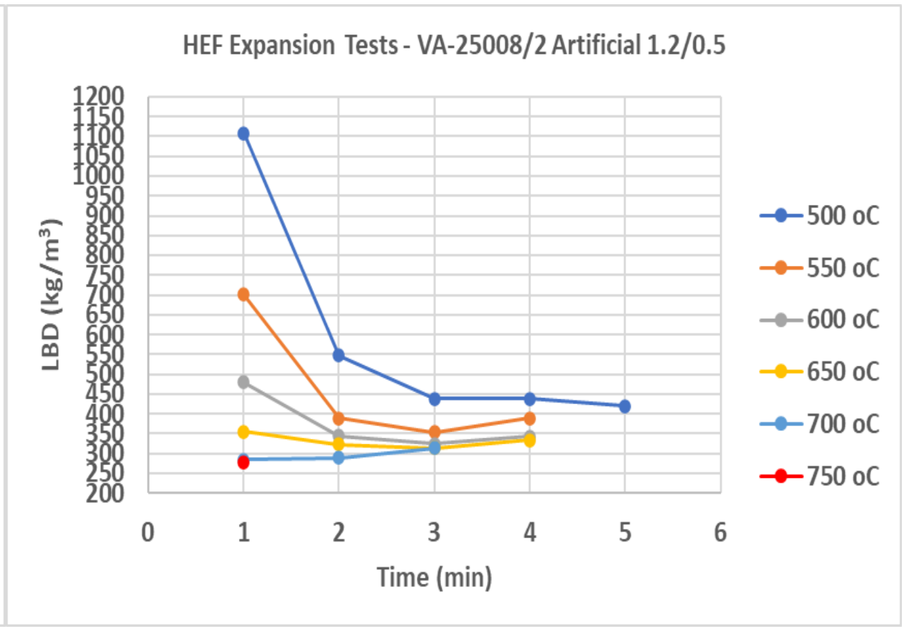
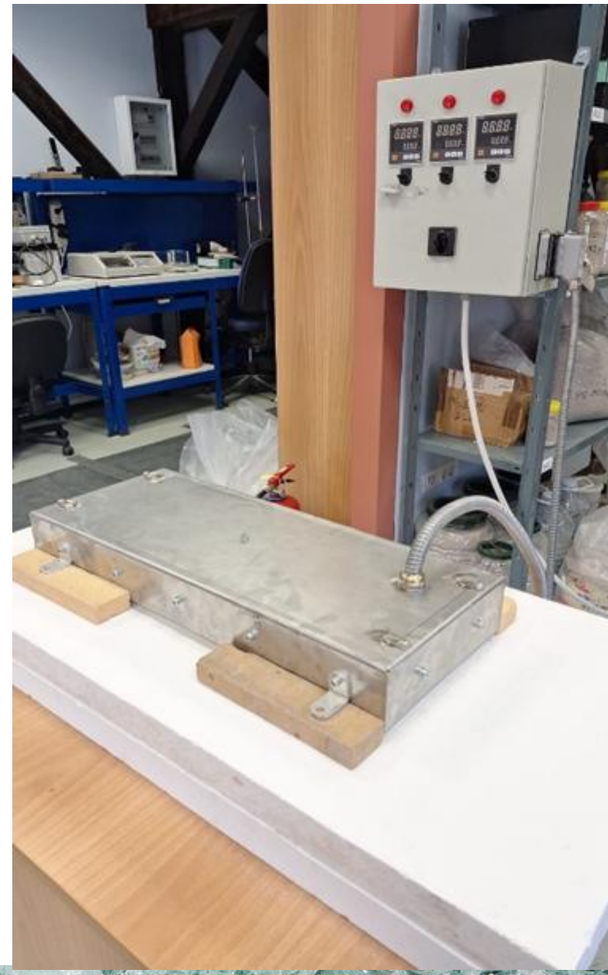
Task: Expandability Study of Geopolymer Compositions - Horizontal Electrical Furnace

- Temperature and retention time
- T (°C) range 500 - 800 °C (every 50 °C)
- Optimum LBDs to ~300 kg/m³ for both grades







2 | Development of lightweight materials at laboratory scale

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Task: Expandability Study of Geopolymer Compositions - Technoeconomic Study

- Reduced energy cost in comparison to conventional perlite lightweight aggregate (~30% savings)
- LPG vertical furnace is more efficient than the horizontal one.

Fine Graded Samples	Perlite	Geopolymer
LBD (kg/m³)	151	148
Yield (m³/MT)	6.5	5.8
Estimated Variable Energy Cost (€/m³)	9.25	6.59
Medium Graded Samples	**Perlite**	**Geopolymer**
LBD (kg/m³)	128	150
Yield (m³/MT)	7.4	5.7
Estimated Variable Energy Cost (€/m³)	10.13	7.64

Fine Graded Samples	CVF	HEF
LBD (kg/m³)	148	309
Yield (m³/MT)	5.8	2.9
Estimated Variable Energy Cost (€/m³)	6.59	15.37
Medium Graded Samples	**CVF**	**HEF**
LBD (kg/m³)	150	252
Yield (m³/MT)	5.7	3.5
Estimated Variable Energy Cost (€/m³)	7.64	12.79

2 | Development of lightweight materials at laboratory scale

Task: Surface Treatment of Lightweight Fillers and Aggregates

- Hydrophobic surface treatment of fine grades
  - Apply silicone emulsion (e.g., Wacker type) to selected glass fractions
- Optimize silicone ratio for full surface coverage
  - Reference mortar according to EN 196-1
  - Replacement of reference sand by 3% w/w of lightweight aggregate
  - Evaluate workability according to EN- 13279-2 by water addition

Hydrophobation agent	Water Load	Workability	
(%)	(ml water / g perlite)	ml water	Mortar Diameter (mm)
0.0	3.16	162.6	17.0
0.2	2.16	150.1	16.8
0.4	1.45	154.4	17.5
0.6	0.94	147.1	17.8

3 | Development of lightweight construction components at laboratory scale

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Task: Development of a BASECOAT RENDER comparable to production batches

- Replacement of expanded perlite by ReGlass medium lightweight aggregate
  - On weight/weight basis
  - On volume / volume basis

BASECOAT RENDER	1:1 w/w replacement			1:1 v/v replacement		
	Prod. Batch	Lab Batch	Lab. ReGlass	Prod. Batch	Lab Batch	Lab - ReGlass
Mixing Ratio (%)	35.0%	32.5%	32.0%	35.0%	32.5%	32.0%
Density on a dry basis (kg/m3)	967	1007	1015	959	958	982
Fresh mortar density (kg/m3)	1473	1538	1584	1467	1503	1539
Adhesion (N/mm2)	0.14 FP:A	0.16 FP:A	0.19 FP:A	0.12 FP:A	0.15 FP:A	0.17 FP:A
Bending strength (N/mm2)	1.7	1.8	2.0	1.5	1.6	1.8
Compressive strength (N/mm2)	4.2	4.4	5.6	4	4.5	5.2
Consumption (kg/m2/mm)	1.09	1.16	1.18	1.09	1.13	1.17

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The results are within the specs.
Fine tuning of the formulations will result in further optimization

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Conclusions

- Development of lightweight aggregates from waste glass cullet via a sustainable environmentally friendly process
- Development of construction products with similar properties as the industrially produced lightweight aggregates

Future Work

- Pilot scale production of render is on going.
- FTO /LCA is under consideration.
- Looking for other waste glass streams to be evaluated.

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Thank you

for your attention!

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