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Geopolymers including CDW for application as a building material

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GEOPOLYMERS INCLUDING CONSTRUCTION AND DEMOLITION WASTE (CDW) FOR APPLICATIONS AS A BUILDING MATERIAL

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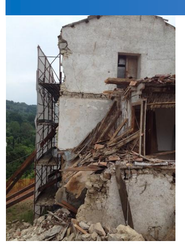
InnoWEE: Aims and Strategy



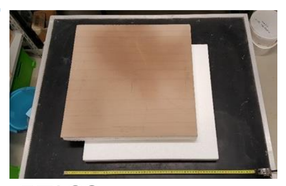
Project cost: **3.36 M€**
Starting date: **Oct. 2016**
Duration: **4 years**
http://innowee.eu/

Development of an optimized **reuse of Construction and Demolition Waste (CDW)** in **geopolymer materials** producing **prefabricated insulating and radiating panels** to be used in **Energy-Efficient Buildings.**

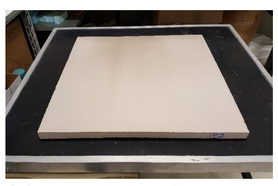
- **Identification of the waste typologies** and their use in new construction material
- **Development of new materials** and performance evaluation in laboratory
- **Production** definition and scale up of new panels
- **Selection** of the best technical solutions
- **Demonstration and validation** in field, performance and scenarios
- **Business models**, **market** introduction plan and future **impact**
- **Dissemination**, **exploitation** and **communication** activities

CONSORTIUM

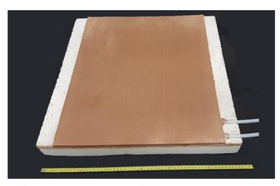
- CONSIGLIO NAZIONALE DELLE RICERCHE – **CNR**, *ITALY*
- PROIGMENES EREVNITIKES & DIAHIRISTIKES EFARMOGES – **AMSOLUTIONS**, *GREECE*
- R.E.D. SRL – **RED**, *ITALY*
- FUNDACION TECNALIA RESEARCH & INNOVATION – **TECNALIA**, *SPAIN*
- GUIDOLIN GIUSEPPE - ECO. G. SRL – **ECO**, *ITALY*
- PIETRE EDIL SRL – **PIETRE EDIL**, *ROMANIA*
- IZNAB SPOLKA Z OGRANICZONA ODPOWIEDZIALNOSCIA – **IZNAB**, *POLAND*
- ZAVOD ZA GRADBENISTVO SLOVENIJE – **ZAG**, *SLOVENIA*
- MAGNETTI BUILDING SRL – **MAGNETTI**, *ITALY*
- DIMOS VARIS - VOULAS - VOULIAGMENIS – **VOULA**, *GREECE*



ETICS-LIKE



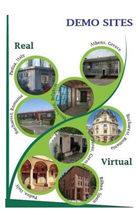
VENTILATED FAÇADE



RADIANT ELEMENT

PROTOTYPE PANELS GEOPOLYMER + INSULATION

INSTALLATION TEST AND DEMO SITES



Construction and Demolition Wastes

INORGANIC CDW FROM SELECTIVE DEMOLITIONS, processed and milled to obtain suitable Secondary Raw Materials (SRM)

CDW

METAKAOLIN

FURNACE SLAG

K-SILICATE

MIXER

GEOPOLYMER BINDER

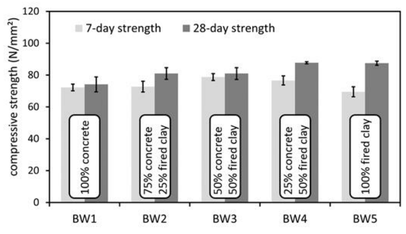
Mechanical and physical characterization

BLEND OF WASTE TYPES

The influence of the aggregate types was studied by comparing the compressive strength of similar mixtures with different blends of Concrete (C) and Fired Clay (FC) waste.

C:FC ratios: **1:0**; **3:1**; **1:1**; **1:3**; and **0:1**.

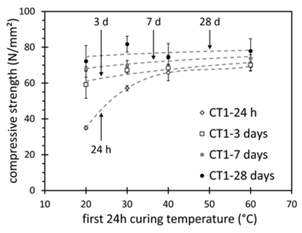
Overall aggregate content: 40% of dry weight.

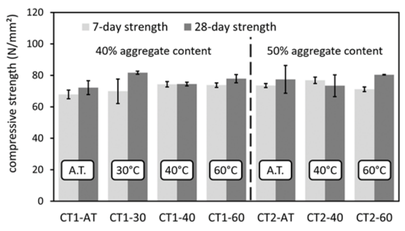


CURING TEMPERATURE (FIRST 24 H)

Selected curing temperatures applied during the first 24 h of curing: **20°C** (AT), **30°C**, **40°C** and **60°C**.

Mixtures with either 40% or 50% of blended concrete and fired clay (1:1 ratio).

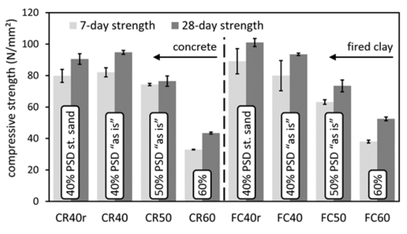




WASTE AGGREGATES CONTENT

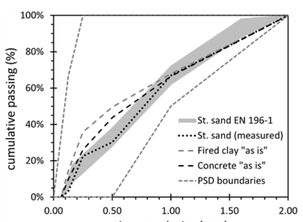
Maximization of the aggregate content investigated for cost optimization and increase of CDW reuse.

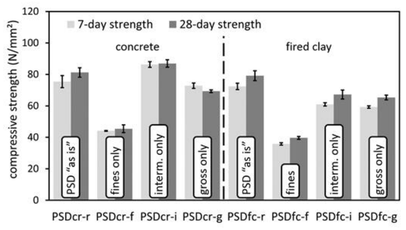
Three contents selected for both concrete and fired clay: (i) **40%**, tested in preliminary trials; (ii) **50%**; and (iii) **60%**.



AGGREGATES PSD

The Particle Size Distribution (PSD) of aggregates affects the behavior of both fresh paste and hardened material. Adopted limit distributions: (i) **fines** only (0-0.25 mm); (ii) **intermediate** particles (0.25-0.50 mm); (iii) **"coarse"** aggregates (0.5-2 mm).

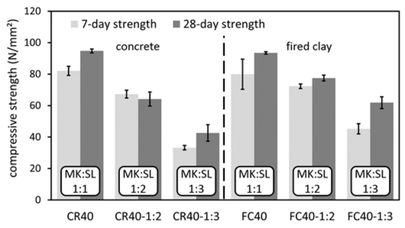




METAKAOLIN:SLAG RATIO

The cost of metakaolin (MK) is typically 3 to 4 times greater than that of ground blast furnace slags (SL). Consequently, the reference **1:1** proportion was modified into **1:2** and **1:3** to measure its influence on strength.

Overall aggregate content: 40% of dry weight.

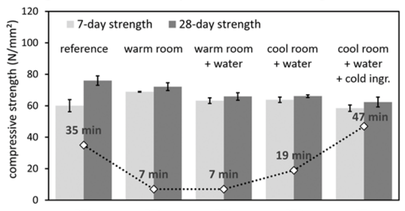


TEMPERATURE DURING PREPARATION

Conditions tested to study the impact of preparation temperatures on the open time: (i) cool room (19°C) and ingredients (19-21°C); (ii) warm room (28°C) and ingredients (29-31°C); (iii) warm room and ingredients with extra water; (iv) mildly cool room (21°C) and ingredients (21-23°C), with extra water; (v) mildly cool room and ingredients kept cold during the mix (8-11°C), with extra water.

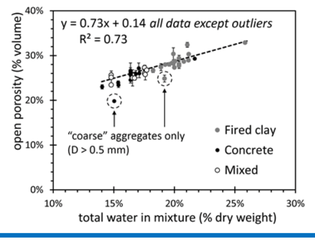
Overall aggregate content: 50% of dry weight.

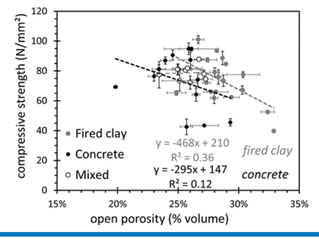
Aggregate tested: fired clay



WATER CONTENT OF THE FRESH MIX

Water in the geopolymer reaction is reagent and solvent at the same time. Additional water may be needed anyway to adjust workability, but exceeding quantities leave more pores in the binder and may affect the performance.



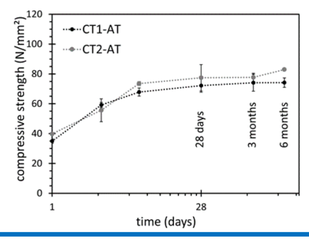


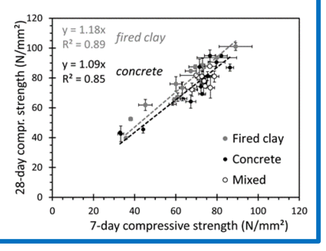
EVOLUTION OF STRENGTH DURING TIME

Since the mechanical performance needs to be assessed at conventional ages, the reliability of 28-day testing (typical reference age for building materials) was investigated.

The 28-day strength showed a fairly linear correlation to the 7-day strength.

In 28 days: more than 90% of the 6-month strength.



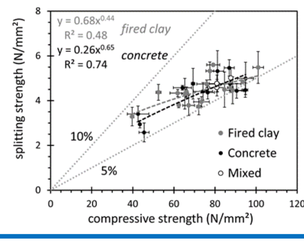


SPLITTING VS COMPRESSIVE STRENGTH

Possible correlations between compressive strength and splitting strength (which is a reliable estimator of tensile strength) were investigated. The ratio splitting vs compressive strength tends to reduce for greater compressive strengths, and most values are comprised in the range 5-10%.

Average ratio: about 6% regardless the aggregate type.

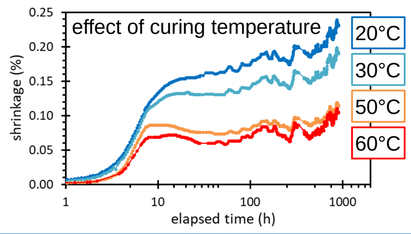
An empirical power law regression appears to describe adequately the observed trends.



WORK IN PROGRESS

DRYING SHRINKAGE

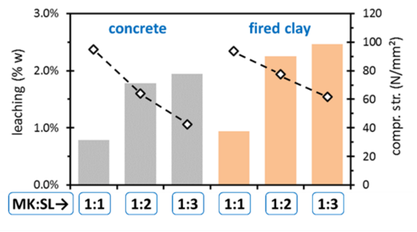
Measurements are ongoing to highlight possible relations with curing temperatures, type and content of aggregates, type of reagents, etc.

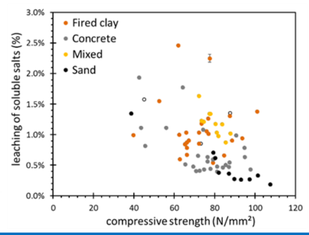


LEACHING OF SOLUBLE SALTS

Measure of the amount of salts expelled after 24 h in water (w/o analysis of the leachate).

Qualitative considerations can be drawn (e.g. development of the reaction).





PRELIMINARY FREEZE-THAW RESISTANCE

After 50 cycles in climatic chamber (between +20°C and –23°C), the weight loss was lower than 1%

Reference: Panizza, M., Natali, M., Garbin, E., Tamburini, S., & Secco, M. (2018). *Assessment of geopolymers with Construction and Demolition Waste (CDW) aggregates as a building material*. Construction and Building Materials, 181, 119-133. doi: 10.1016/j.conbuildmat.2018.06.018