DIAS Project: Inorganic polymers as advanced and sustainable materials for sensible heat storage

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Cyprus tomorrow RECOVERY AND RESILIENCE PLAN

Republic of Cyprus

RESEARCH & INNOVATION FOUNDATION

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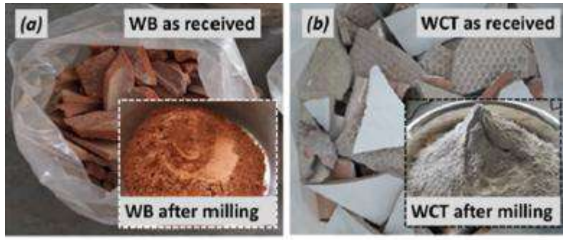
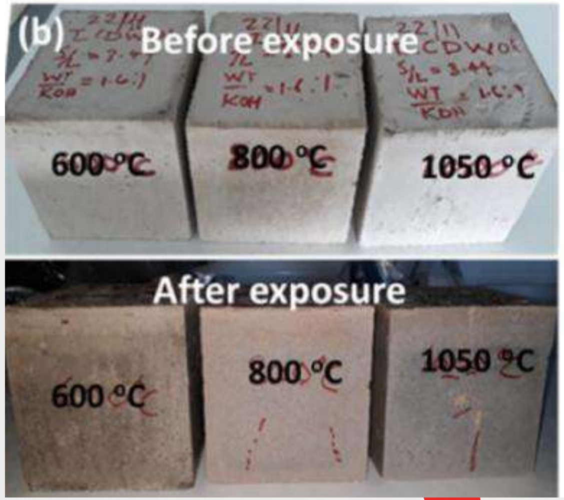
Introduction

- Increasing renewable energy sources causes grid instability.
- ***Thermal energy storage (TES)*** can stabilize energy supply and demand.
- **Sensible heat storage** is the most economical and technically straightforward method for thermal energy storage.
- Materials Currently used Face Limitations.
- High Demand for scalable, cost-effective, and durable TES materials.

EnergyNest *- Thermal Energy in Concrete. (1)*

Hypothesis and Aims:





Hypothesis:

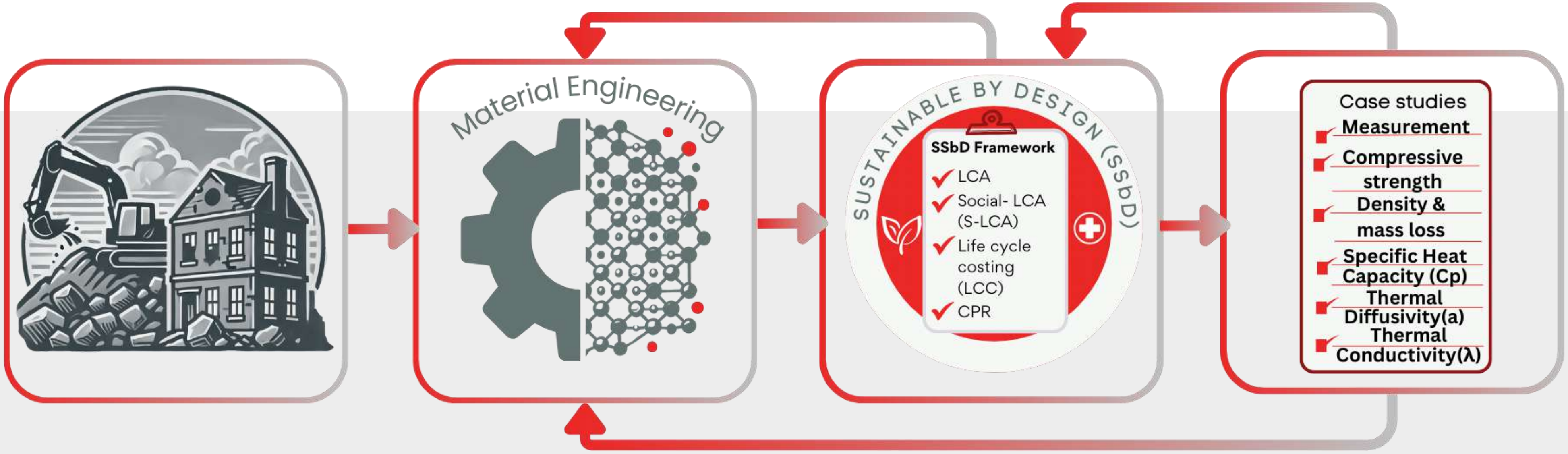
- **Background (DEFEAT results):** CDW-derived geopolymers reached **15 – 30 MPa** compressive strength, **1 500 – 1 700 kg m^{-3}** density and stayed crack-/spall-free up to ≈ **800 °C**.
- **Research Question:** *Can these geopolymers maintain their thermo-mechanical performance after repeated 600 °C cycles and therefore serve as the core material for cost-effective, high-temperature TES blocks?*

Project Aims:

- **Optimise Mix Design**: Tailor CDW geopolymer formulations for ≥ 20 MPa strength and high heat-storage capacity.
- **Thermo-Mechanical Testing**: Quantify strength, density, specific heat & conductivity before/after ≥ 100 cycles (ambient ↔ 600 °C).
- **Prototype Demonstration**: Cast and 3D-print TES modules; measure round-trip efficiency and volumetric energy density.
- **Sustainability & Cost Benchmarking**: Compare embodied CO_2 and levelised cost with OPC concrete, ceramic and molten-salt TES media.

Methodology:

From Material Formulation…



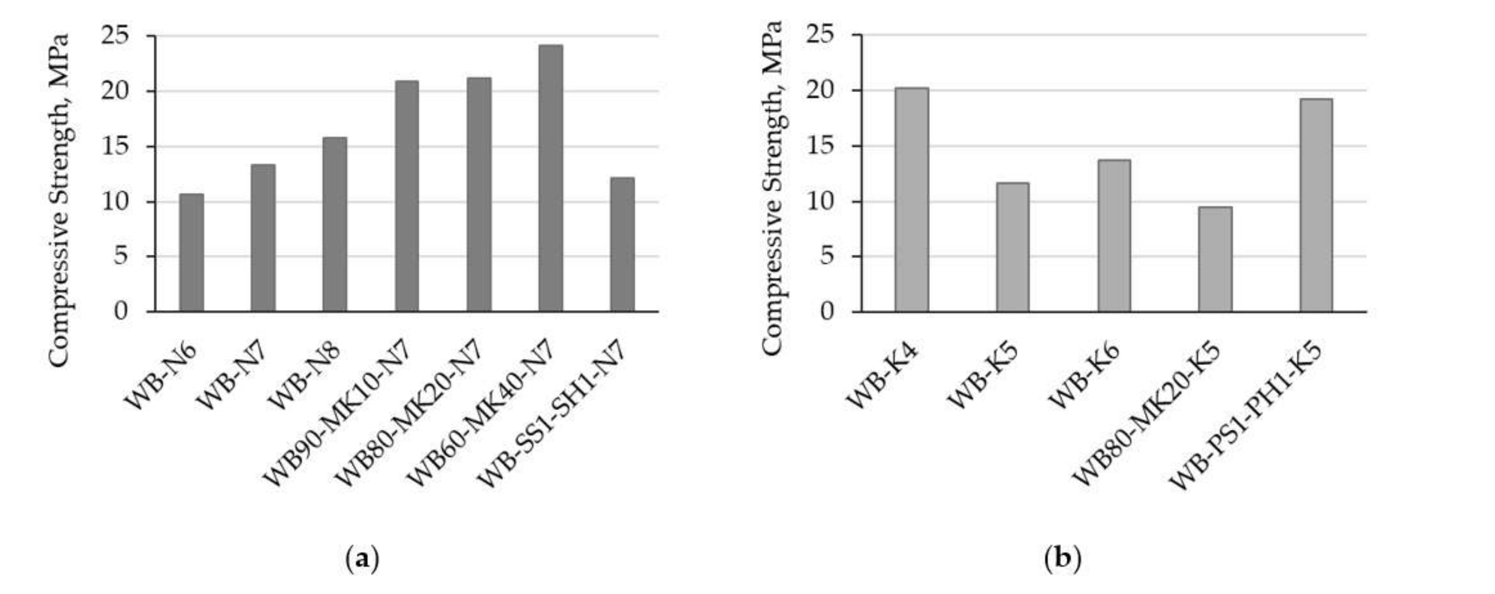
….to System Design!

Results: Compressive Strength

Experimental conditions: curing at 70 ^{0}C for 48 hours and hardening for 28 days at ambient temperature.

a) Compressive strength of the Na-based inorganic polymers;

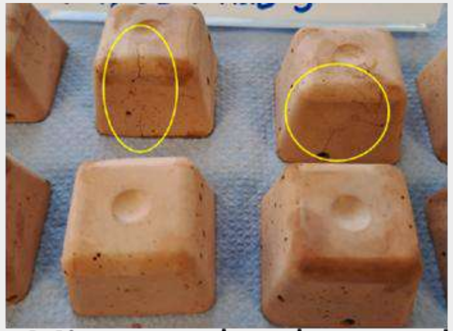
b) Compressive strength of the K-based inorganic polymers.



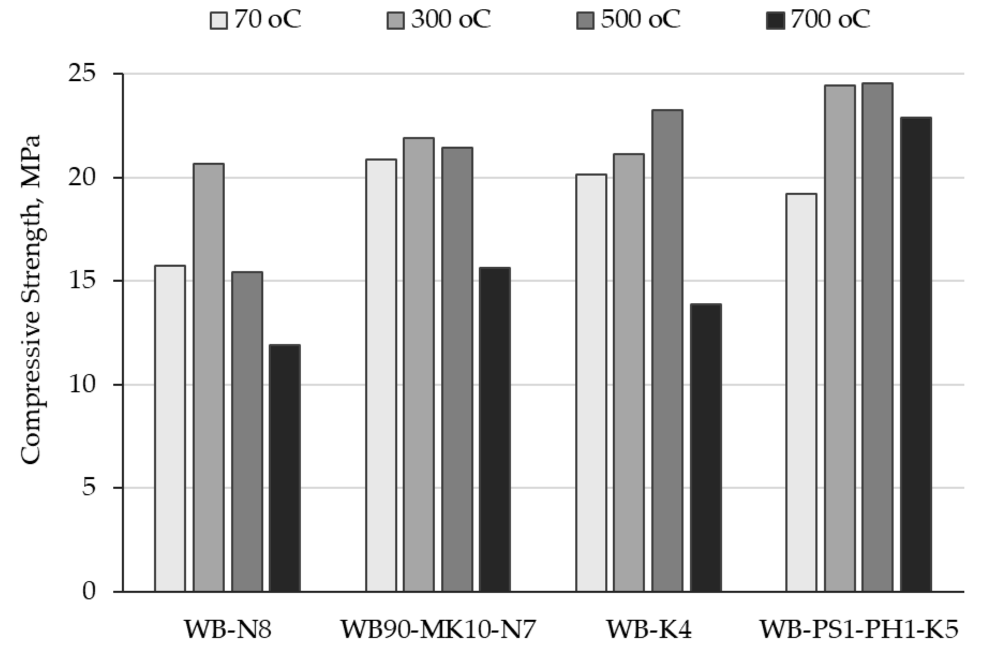
Results: Compressive Strength

Compressive strength of ***optimal inorganic polymers after exposure to elevated temperatures*** for 2 hours and cooling down at ambient temperature.

Heating the Samples



Microcracks observed on the surface



Results: ThermoPhysical Properties

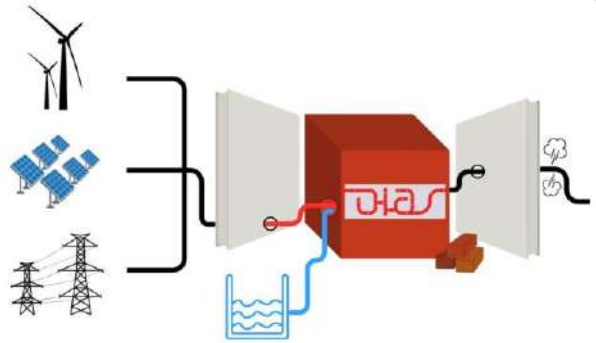
The **thermophysical properties** are similar to concrete, natural stones, bricks, ceramics, with concrete, natural stones, bricks, ceramics and glass.

At higher temperatures, the properties exhibited better.

- Higher **density** - volumetric energy storage Capacity.
- Higher **Specific heat capacity** - the material can store more thermal energy per kilogram
- **Thermal Diffusivity** - Rate of heat transfer: higher diffusivity is beneficial for fast charging/discharging cycles

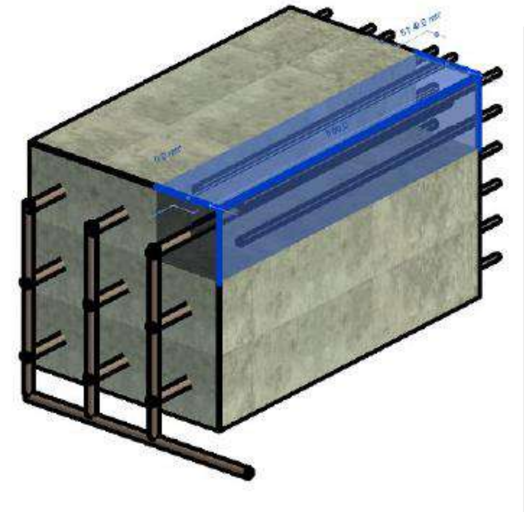
Temperature (°C)	Density ρ (kg/m³)	Specific heat capacity - Cp (J/kg°C)	Thermal diffusivity(a) × 10^{-7} (m²/s)
100.0	1968 – 2154	904 - 1090	4.7-5.3
300.0	1963 – 2105	641- 968	4.4-5.3
500.0	1913 - 2156	606 - 1049	4.7-5.6

Conclusion and Future Work



- ➢Investigate Further the inorganic polymers performance and efficiency.
- ➢**Casting** and **3D printing** processes.

3D printing patterns



3D Model of the prototype DIAS-TES system

- ➢Preparation of Prototype and Testing Operation
- ➢Final Report on Sustainability Assessment

Thank You

FOR YOUR ATTENTION!

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