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Thermal Performances Assessment of a Biocomposite Building Material Based on Cement Mortar and Esparto Fibers

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Abstract

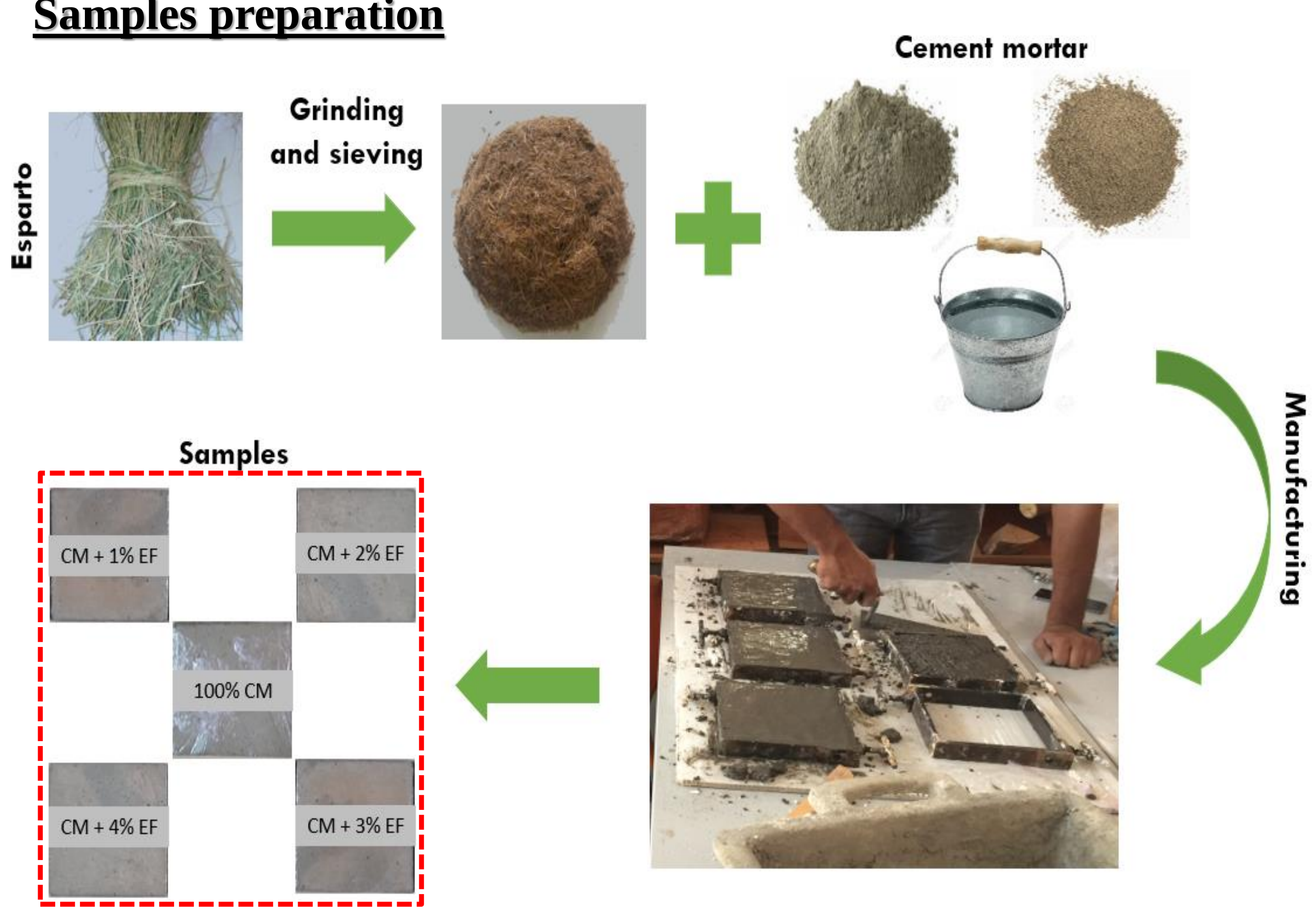
This work concerns the elaboration and characterization of biocomposite material based on cement mortar and esparto fibers. The main objective is to move towards a more **energy-efficient** and **environmentally friendly** construction method. Experimental measurements were performed in the laboratory in order to determine apparent density, thermal conductivity, thermal diffusivity, heat capacity and thermal effusivity. Thermophysical characterization results show the prominence of using these composite materials in building construction to ensure **thermal comfort** while **minimizing energy consumption** and **reducing greenhouse gas (CO_2) emissions.**

1- Introduction

The building sector is an energy-consuming system and emits greenhouse gases. The actions taken to reduce this consumption and to establish the building's energy efficiency are reflected in the adoption of the **Moroccan Construction Thermal Regulation (RTCM).** To support this regulation, two guides are proposed concerning the standardization of building materials and the building insulation solutions. Indeed, the usual building materials (**concrete**, **mortar**, **cement**, **clay bricks**, **concrete blocks**...) are characterized by low thermal performance and negative environmental impact. The current trend shows an increased use of composite materials to construct **sustainable** and **ecological buildings** due to the attention and awareness of society towards the **environment** [1,2].

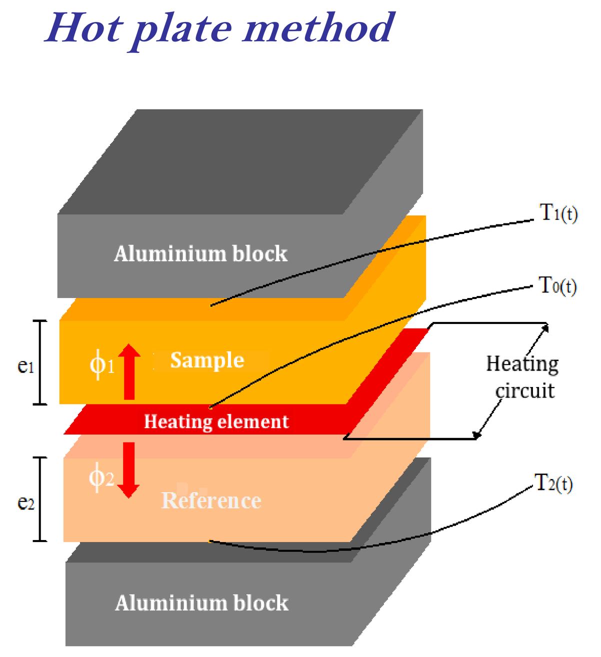
2- Materials and Methods

Samples preparation

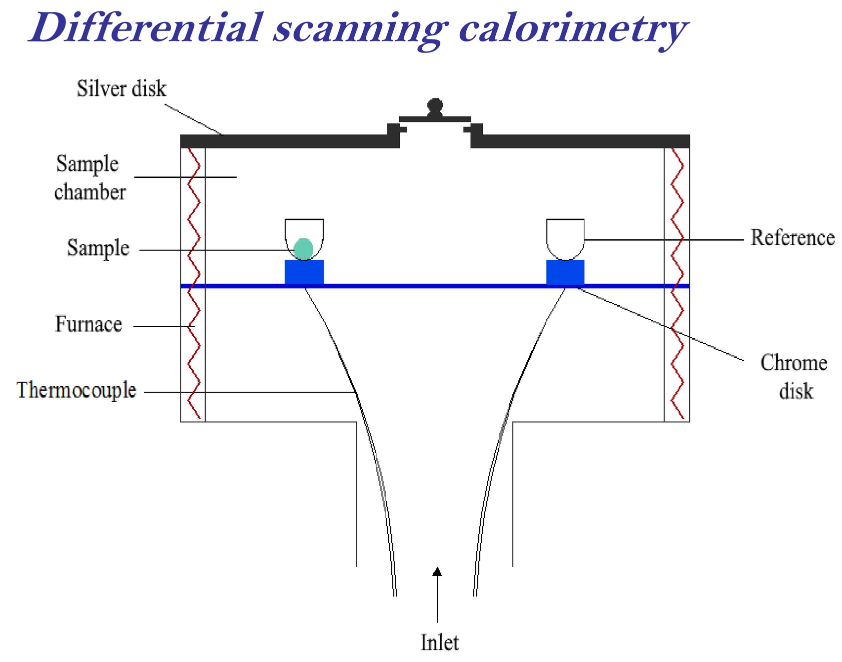


Characterization methods

Hot plate method



Differential scanning calorimetry



$$\lambda_1 = \frac{e_1}{T_0 - T_1} \times \left[\frac{U^2}{R.S} - \frac{\lambda_2}{e_2} \times (T_0 - T_2) \right]$$

$$c(T) = c_r(T) \times \frac{\phi_e(T) - \phi_b(T)}{\phi_r(T) - \phi_b(T)} \times \frac{m_r}{m_e}$$

$$E = \sqrt{\lambda.\rho.c}$$

$$c = \frac{\lambda}{\rho.a}$$

Future work

- Characterization of mechanical and acoustic properties
- Investigation of moisture effect on the thermal performances.
- Study of the durability and life-cycle.
- Perform dynamic thermal simulations on a typical residential building.

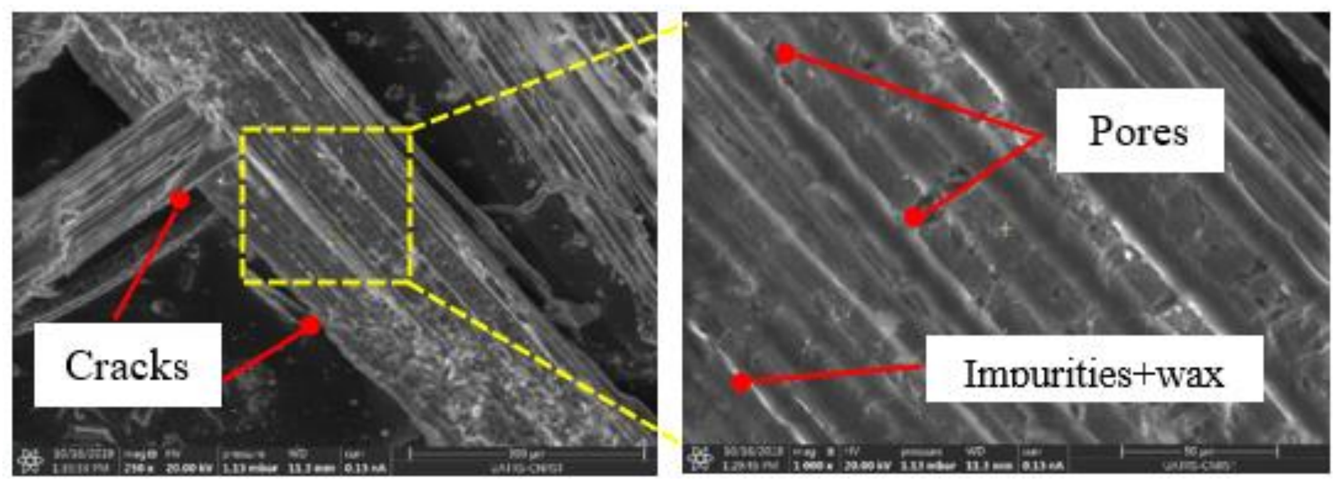
References

[1] Affan, H., Arairo, W. and Arayro, J., **2023**. Mechanical and thermal characterization of bio-sourced mortars made from agricultural and industrial by-products. Case Studies in Construction Materials, 18, p.e01939.

[2] Horma, O., Charai, M., El Hassani, S., El Hammouti, A. and Mezrhab, A., **2022**. Thermo-physical and mechanical characterization of cement-based mortar incorporating spent tea. Journal of Building Engineering, 52, p.104392.

3- Results and discussion

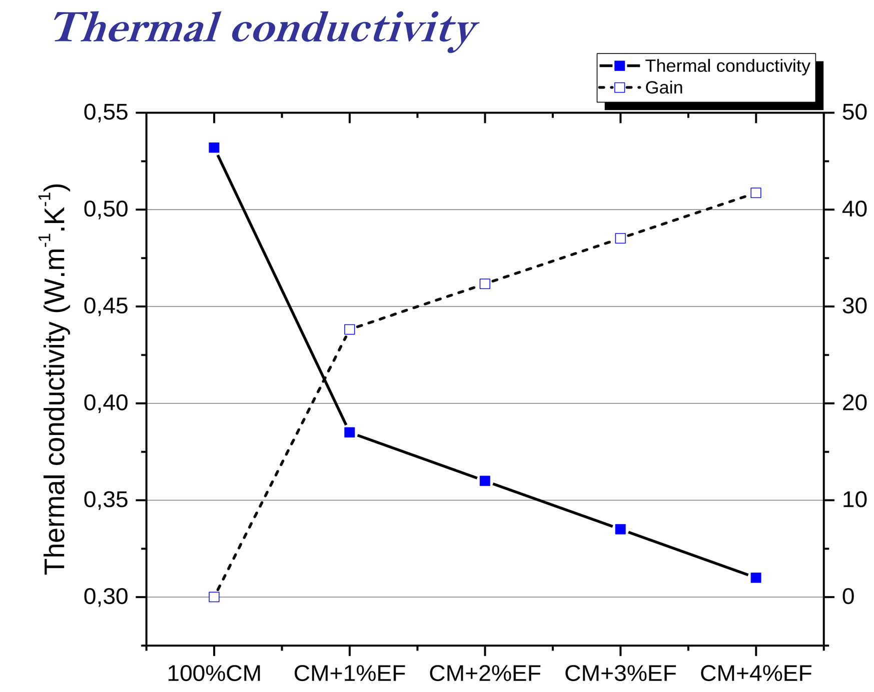
Mineralogical and chemical characterization



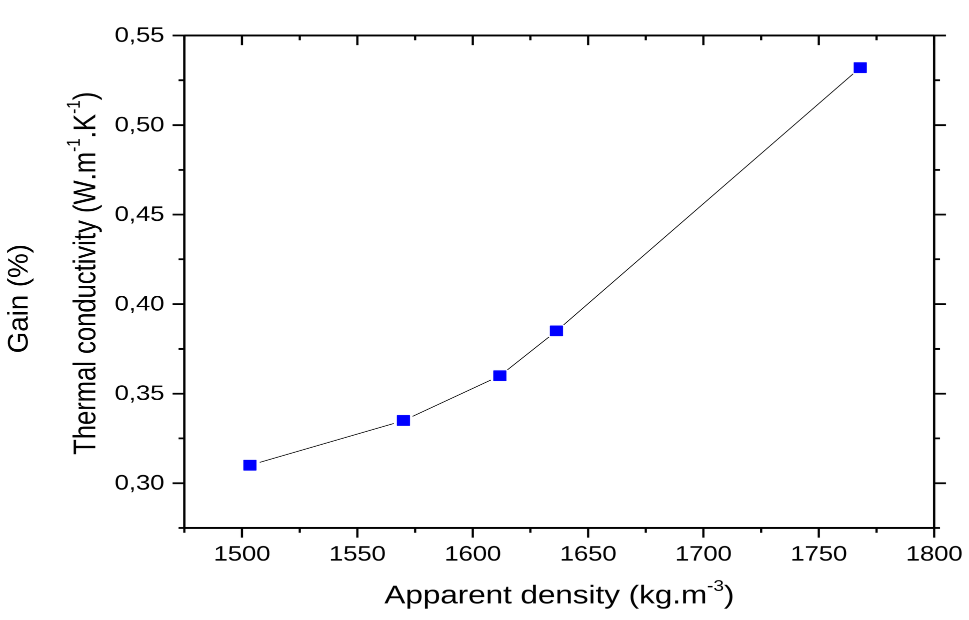
Element	Wt%
Carbone (C)	58.48
Oxygen (O)	31.15
Silicate (Si)	2.04
Calcium (Ca)	1.54
Aluminum (Al)	0.42

Thermal properties

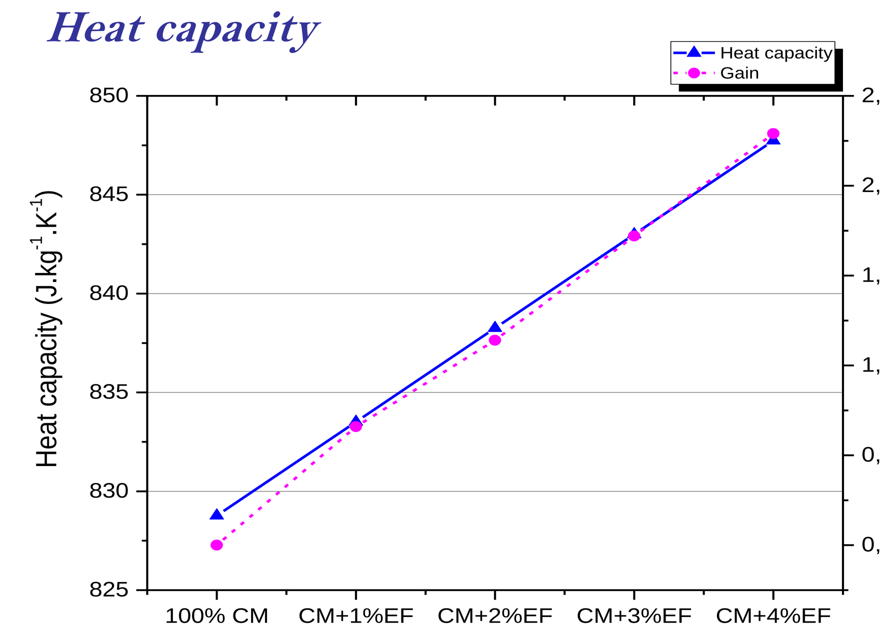
Thermal conductivity



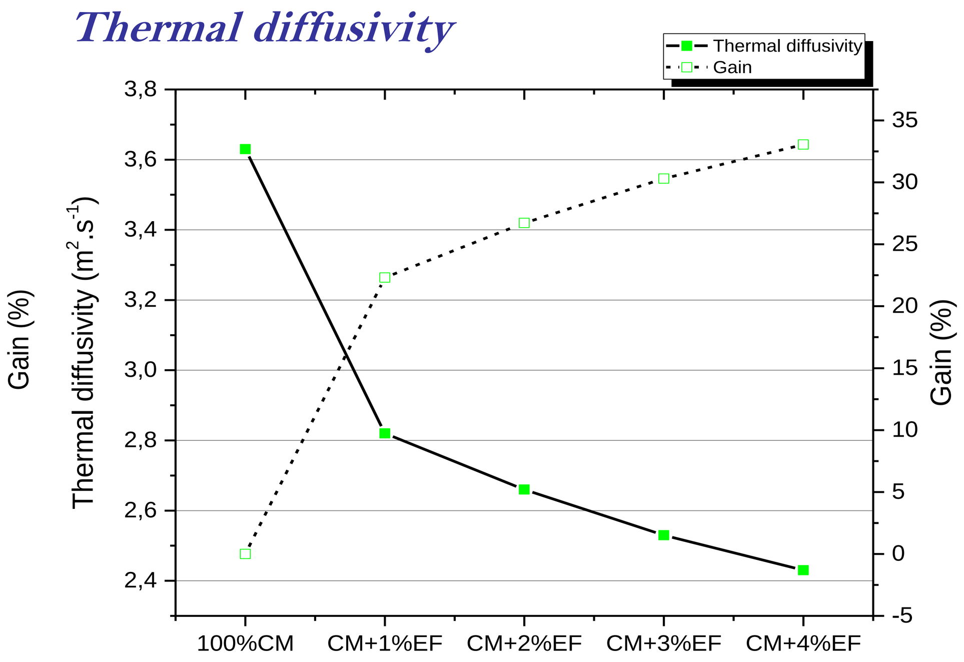
Thermal conductivity vs apparent density



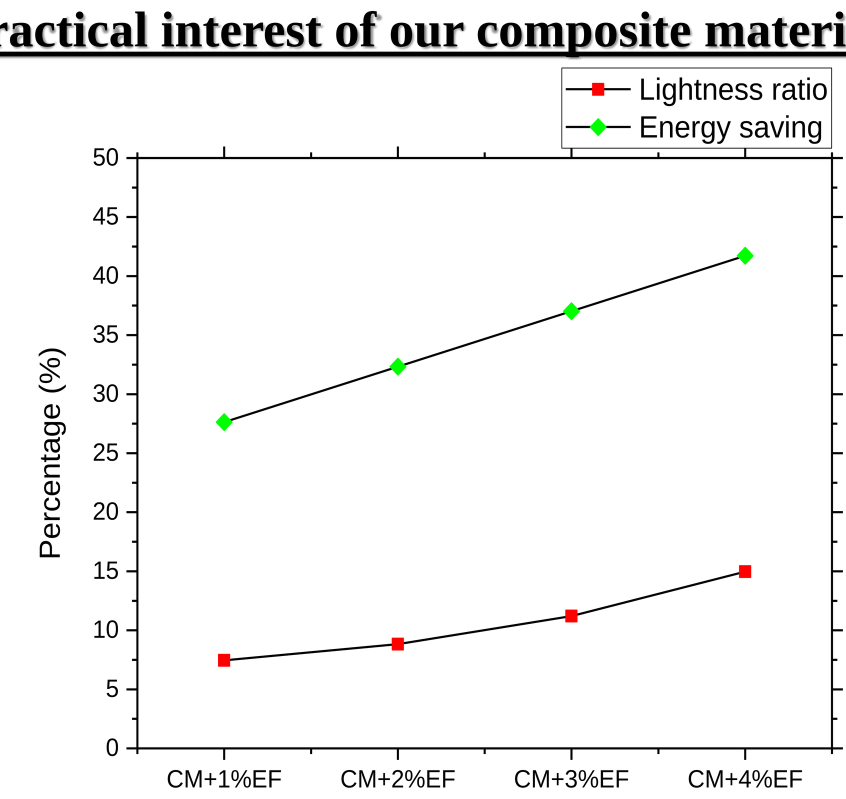
Heat capacity



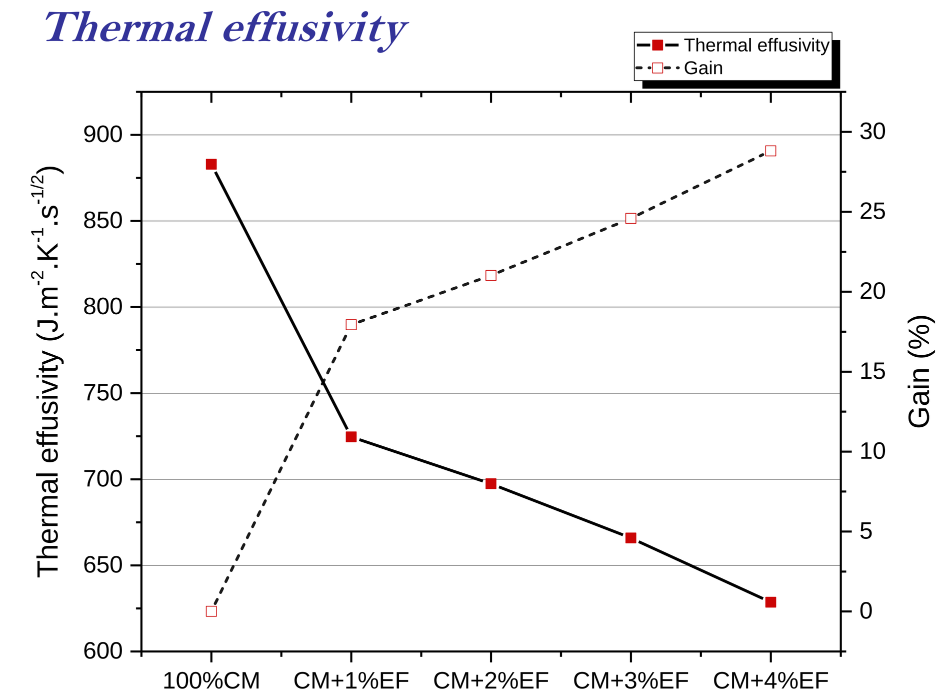
Thermal diffusivity



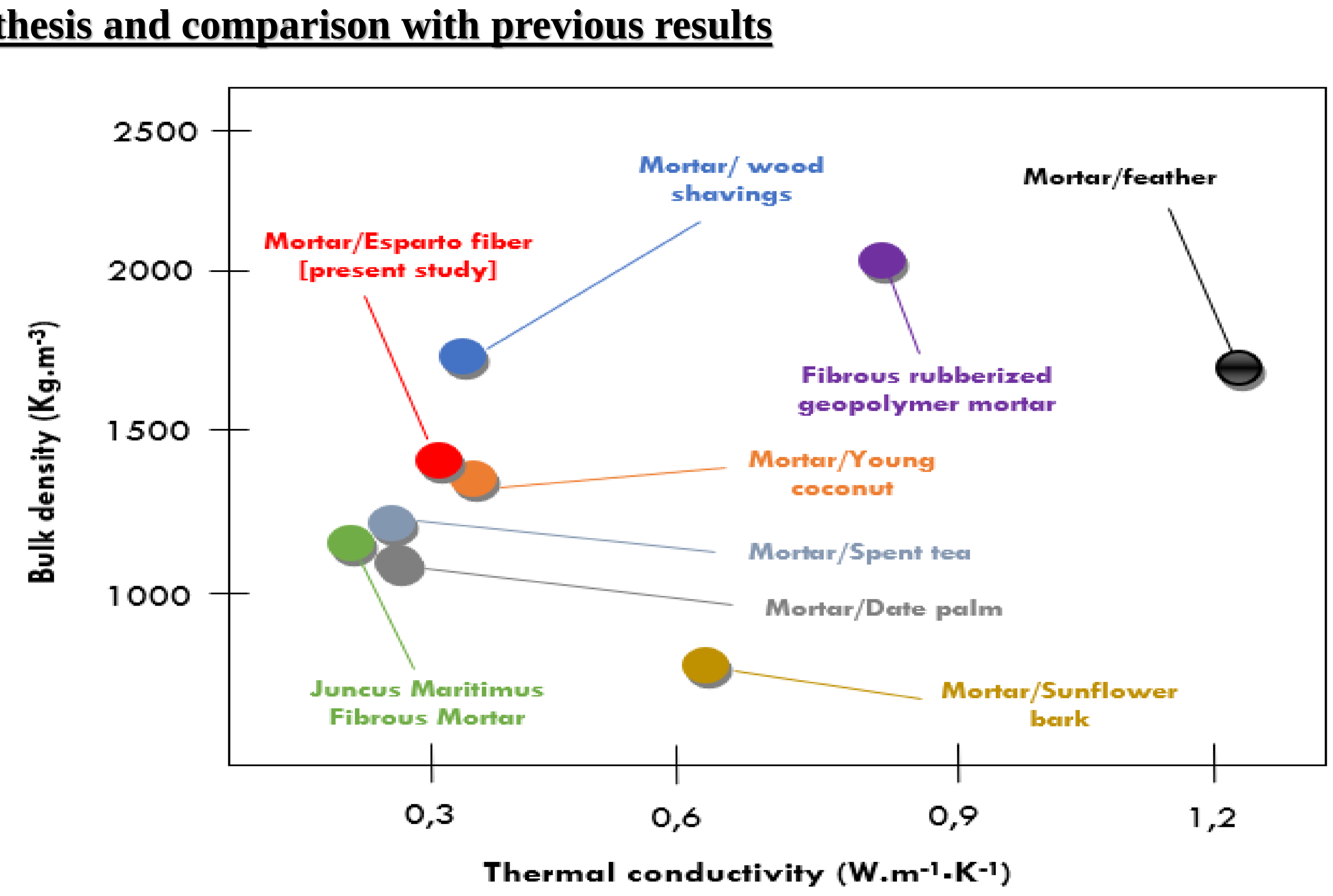
Practical interest of our composite material



Thermal effusivity



Synthesis and comparison with previous results



4- Conclusion

It emerges from this work that it is possible to manufacture ecological construction materials using natural fibers that can be competitive with other thermal insulation materials and allow a large amount of waste to be recovered and therefore protect our environment. The results obtained reveals that the incorporation of 4% of esparto fiber has a significant improvement on thermal properties of cement mortar (42% for λ ; 2.29% for c ; 33.06% for a ; 28.81% for E). Indeed, when we increase the percentages of fibers, the energy economy and the report of lightness increases so that the sample becomes more and more insulation with the energy economy maximum. This can reduce heating consumption in the winter period and cooling requirements in the summer period. The greenhouse gas emissions can be also sequestered.