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Thermo-mechanical analysis of a new cement mortar based on marine waste for a low environmental impact

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INTRODUCTION & AIM

Seashells waste is a real environmental problem for most countries that consume seafood products. The problems lie in the difficulty of biodegradation, the emission of toxic gases due to the decomposition of organic matter on the surface, and the additional costs imposed on the state for their disposal. For all these reasons, many people are interested in recycling this or other types of waste. Recycling seashell waste in building materials is a relevant and attractive solution for eliminating this waste while at the same time reducing its environmental impact (Hasnaoui et al., 2021), (Martínez García et al., 2020) and (Souidi et al., 2024) . Our study focuses on the use of Mytilus galloprovinciallis shell waste in mortars of cement as a partial replacement of sand. A granular range similar to that of fine sand was used with the extraction of fine powder < 0.08 mm, in order to reduce the effect of organic matter on material properties, we used percentages of 0%, 15%, 20%, 25%, 30%, and 45% according to mass. The physical properties in the fresh and in the hardened state were examined, also the mechanical and thermal properties were studied. We also carried out a microstructural analysis of the mortars in relation to the various properties studied.

METHOD

Once the waste has been collected from the beach, it undergoes a cleaning and crushing process, then sieved through an 80 µm sieve, followed by physical and chemical characterisation. The cement mortars prepared are characterised mechanically and thermally after 90 days of hardening. Then, we complete by observing the fracture faces using scanning electron microscopy.

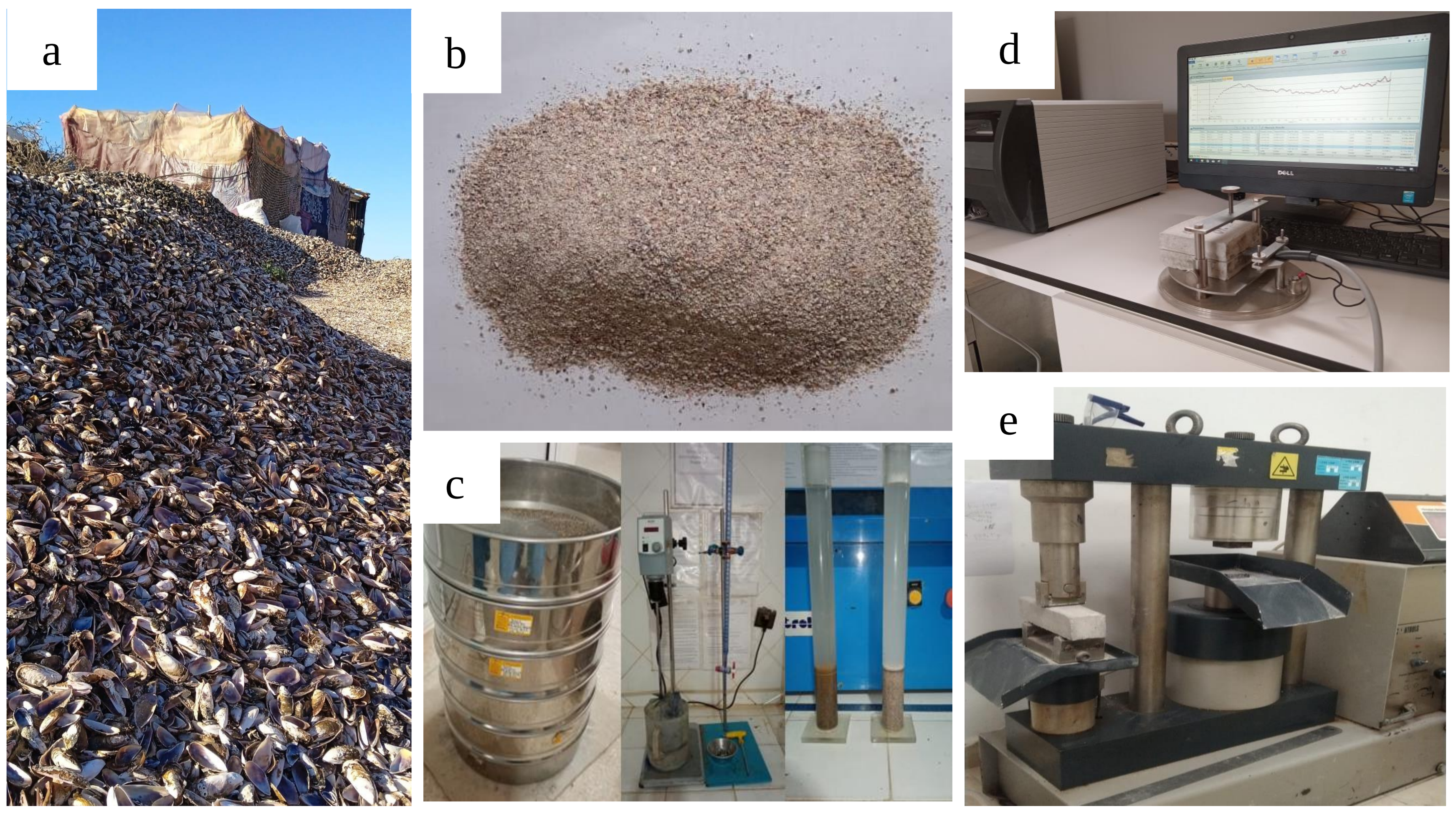

Figure 1. a) Seashells, b) Shell sand, c) Granulometry test, Methylene blue test, and Sand equivalence test, d) Thermal test, e) Mechanical test

RESULTS & DISCUSSION

Figure 1 shows the evolution of the fresh and dry hardened densities of cement mortars and their errors. The density in the fresh state decreases while increasing the percentage of replacement, the same evolution is observed in the dry state. This reduction reaches 7.78% for MC45 compared with MC0 in the dry state. Although the densities of the two types of sand are almost comparable (1.521 g/cm^3 for shell sand and 1.565 g/cm^3 for natural sand), replacing cement mortar with shell sand has reduced the density of the composites, which can be explained by the presence of pores within the volume. **Figure 2** shows the evolution of conductivity and thermal diffusivity as a function of the rate of substitution of natural sand by shell sand. A quasi-linear decrease in the two thermal parameters is observed as the substitution rates increase. Thermal conductivity is a setting that directly reflects the thermal insulation of materials, replacing 45% of shell sand (MC45) provides an estimated gain in thermal insulation performance of 21.7% compared to standard cement mortar.

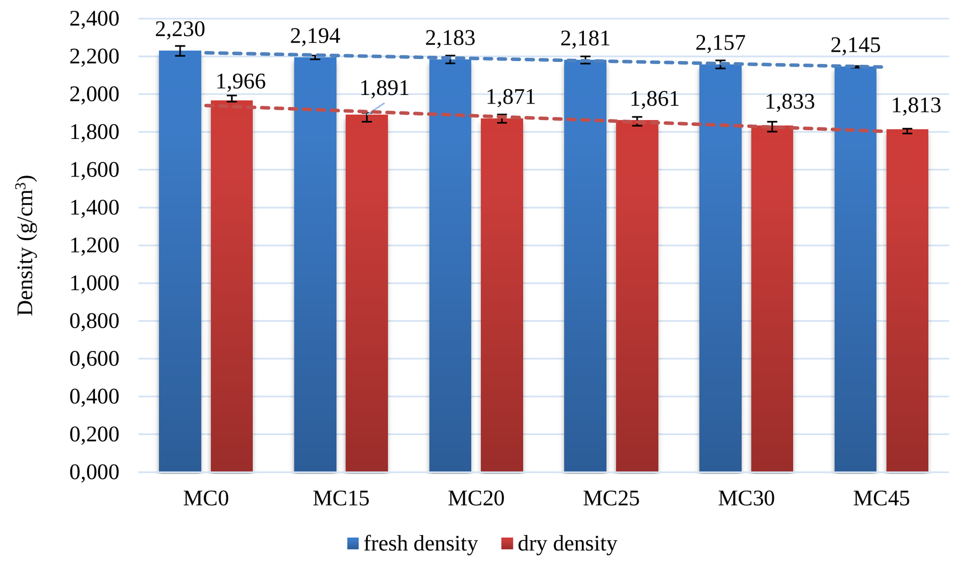

Figure 1. Evolution of the fresh and dry hardened densities of cement mortars

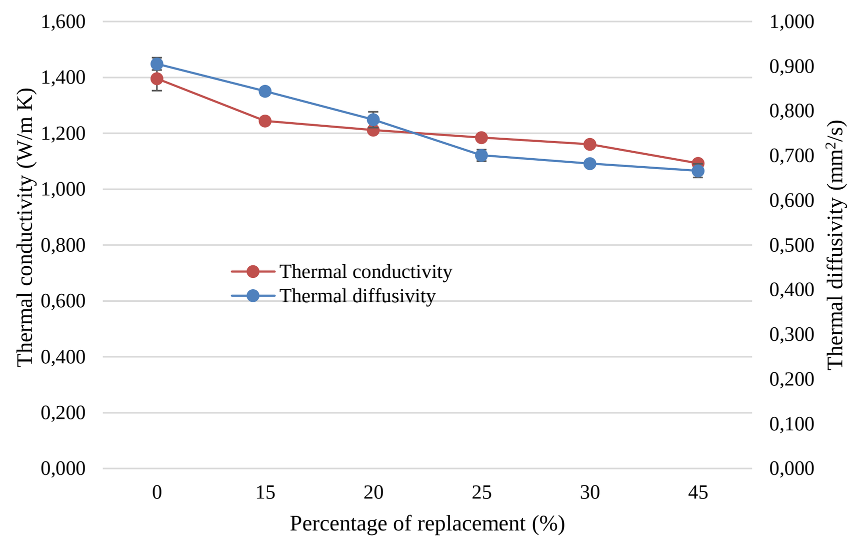

Figure 2. The variation of conductivity and thermal diffusivity as a function of the rate of substitution

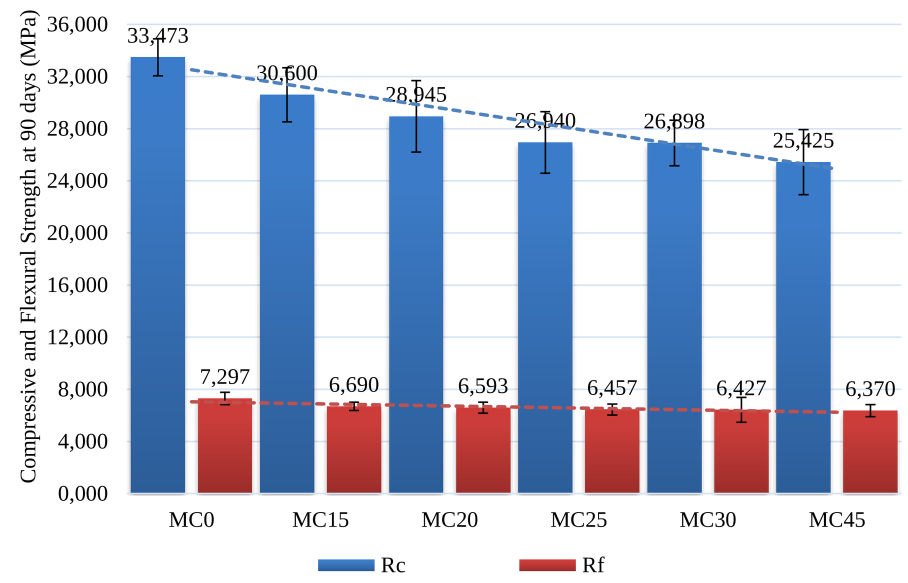

Figure 3. Compressive and flexural strength of different composites at 90 days

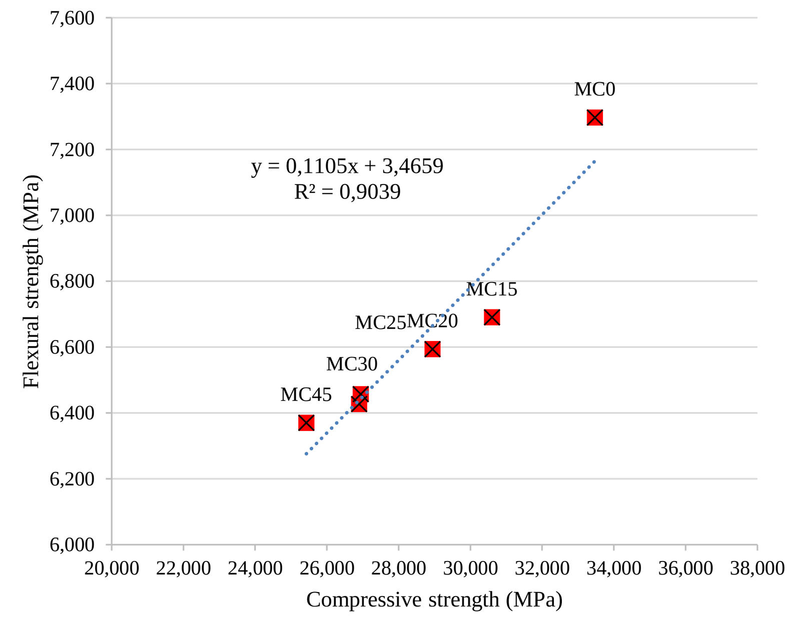

Figure 4. Flexural strength as a function of compressive strength of cement mortars

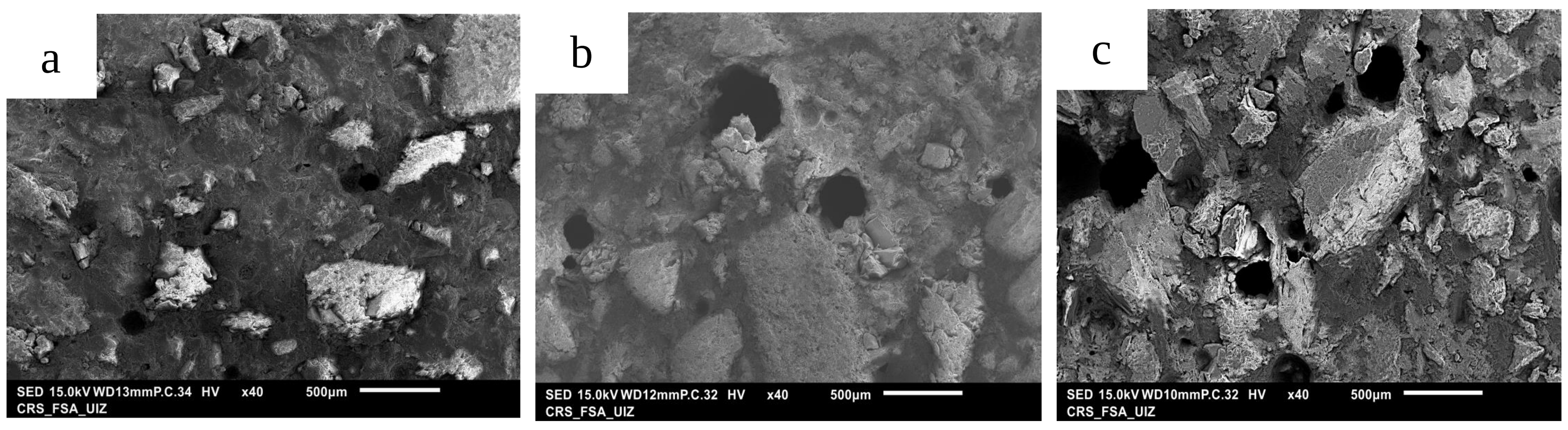

Figure 5. The secondary electron images of the fracture faces of: a) MC0, b) MC25, c) MC45

Figure 3 and **4** indicate flexural and compressive strength of different types of mortar and their errors.There is a slight decrease in both types of strength as the rate of substitution of natural sand by shell sand increases. This decrease reaches a value of 25.425 MPa for MC45 in terms of compressive strength, which corresponds to a reduction rate of 24.04% compared with MC0 and for flexural strength, it reaches 6.370 MPa for MC45, which corresponds to a reduction rate of 12.70% compared to MC0, it was found that flexural strengths were not significantly affected, as was the case for compressive strengths. The main reason for this behaviour is the porosity of the materials, the smooth surface of the shell grains, which causes poor adhesion with the cement paste, and also the poor arrangement of the aggregates due to their flattened, elongated and sometimes laminated shapes. **Figure 5** shows that the porosity increases as the replacement rate increases, which justifies the different results found. These results are in concordance with those of other authors (Ez-zaki et al., 2018) and (Martínez García et al., 2019).

CONCLUSION

This study leads to the conclusion that the choice of the grain size of the shell sand affects the mechanical properties of the mortars: the smaller the grain size, the less the aggregates flatten and laminate. The use of shell sand improves the thermal insulation performance of composites, however, the use of substitution rates of no more than 50% by mass gives acceptable mechanical results compared with the reference.

FUTURE WORK / REFERENCES

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