

BUILDING WITH WASTE: SUSTAINABLE THERMAL INSULATING MORTARS FROM RECYCLED RIGID FOAMS

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ABSTRACT

The increasing accumulation of plastic waste has intensified the need for sustainable recycling strategies that support the transition towards a circular economy. This work presents the development of eco-friendly thermal insulating mortars incorporating high volumes (>90 vol.%) of recycled rigid polyurethane (PU) and polystyrene (PS) foams as lightweight aggregates. The mortars are produced by combining recycled foam particles with Portland cement, water and 1 wt.% performance-enhancing additives, eliminating the need for conventional mineral aggregates.

The density, compressive strength and thermal conductivity of the mortars are strongly influenced by the type of recycled foam and the overall mix design. The optimized formulations exhibit an attractive combination of low density, good mechanical strength, low thermal conductivity, improved sound insulation and favourable fire performance. PU-based mortars achieve a density of 420 kg/m³, a compressive strength of 1.0 MPa and a weighted sound reduction index (R_w) of 40 dB, compared with 340 kg/m³, 0.85 MPa and 32 dB, respectively, for PS-based mortars. In addition, PU-based mortars exhibit lower thermal conductivity (0.07 W/m·K) than PS-based mortars (0.09 W/m·K), resulting in superior thermal insulation. Both mortar systems display comparable reaction-to-fire performance, characterised by very low combustibility and very low smoke production, making them well suited for energy-efficient building applications. The feasibility of industrial-scale production is demonstrated through the design and implementation of a prototype manufacturing system with a production capacity of 1500 L/h of insulating mortar (equivalent to twenty 75-L bags) [1].

By transforming rigid plastic foam waste into value-added construction materials, the proposed mortars offer an environmentally responsible alternative to conventional insulating materials while reducing landfill disposal. Their lightweight nature, favourable thermal and mechanical performance, together with their low environmental impact, make them attractive for floor, roof and other non-structural insulation applications. Overall, the results demonstrate the potential of recycled rigid foams as sustainable lightweight aggregates and highlight their contribution to the development of high-performance thermal insulating mortars for greener and more resource-efficient buildings.

References

1. Kountouris, A.; Efstathiou, K.; Kostoglou, N.; Manolakos, D.; Rebholz, C. *Polymers*, 2025, 17, 2233.