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Development of unsaturated polyester resin mortar utilizing industrial wastes

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Abstract

In recent years, polymer mortar (PM) has played a crucial role in the modern construction industry. It is gaining recognition as an effective and quick repair material in construction applications because it has several benefits over traditional Portland cement concrete. Various types of polymer binders, such as unsaturated polyester resin (UPR), have been used in these materials owing to their low cost, excellent strength, high workability, and rapid curing. This study investigates the feasibility of reutilizing locally available waste in the production of UPR-based polymer mortar, which facilitates the development of mortars with less environmental impact. In this study, the effects of various materials on the performance of an unsaturated polyester resin mortar (UPRM) made with dune sand (DS) as a fine aggregate were investigated. This study was initiated by investigating the impact of the DS content on the performance of the UPR-based polymer mortar. The DS content varied from 0% to 70wt.%. To address the brittleness of UPR-based polymer mortars, crumb rubber (CR), which is derived from recycled tires, was introduced as a partial replacement for DS. The aim was to enhance the ductility of the developed mortar by incorporating crumb rubber. (CR) as a replacement for the DS (3, 5, 7, and 10 wt. % in 60/40 DS/UPR mortar formulation). Simultaneously, this study assessed the potential of date pits (DP), an agricultural waste product, as an alternative to DS (3, 5, 7, and 10 wt. % in 60/40 DS/UPR). DP exhibits promising potential as a viable substitute for mortar components, providing the advantage of improving their characteristics by exploiting their unique apparent and mechanical characteristics. Physical, mechanical, thermal, and durability tests were conducted to evaluate the suitability of the materials for desired applications. In addition, TGA, FTIR, XRD, DSC, and SEM analyses were conducted to confirm and explain the obtained results. The density of the developed UPRM decreased due to the incorporation of CR and DP replacements, resulting in a lightweight mortar (1475–1800 kg/m^3). CR substitution resulted in a more substantial reduction in mechanical strength, while DP replacement exhibited a more positive effect, demonstrating a moderate improvement in compressive strength, splitting tensile strength and flexural strength. The incorporation of CR significantly improved the ductility index of the developed mortar by 41.7%, whereas the replacement with DP increased the ductility index by 33.22%. The use of CR and DP resulted in a decrease in thermal conductivity, thereby improving their insulation abilities. CR replacement resulted in higher resistance to abrasion and improved durability by resisting wear and tears. The findings of this study provide evidence supporting the utilization of crumb rubber (CR) and date pits (DP) in polymer mortars and highlight their potential value as aggregate alternatives for certain applications.

Keywords: Unsaturated polyester resin (UPR), Mortar; Dune sand, crumb rubber, Date Pit, Mechanical properties, thermal properties, Durability, Ductility.