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Effect of leaf fiber modification methods on mechanical and heat-insulating properties of leaf fiber cement-based composite materials

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Abstract:

Using plant leaves as eco-friendly heat-insulating building materials, five poplar leaf modification methods were employed to improve the compatibility between leaf fibers and cement-based materials in composites. Mechanical properties, water absorption and heat-insulating properties of leaf fiber cement-based composite materials (LFCCM) containing unmodified and modified leaf fibers were analyzed. The results indicated that pure acrylic emulsion spray was the best fiber processing method in terms of mechanical properties of LFCCM, followed by sodium silicate solution spraying; water dipping was also recommended and the strength of LFCCM with lye fiber dipping performed the worst. The optimal fiber treatment method of improving thermal insulation properties of LFCCM was lye dipping, followed by pure acrylic polymer emulsion spraying and sodium silicate solution spraying had the worst performance. With a thermal conductivity <0.250 W/(m.K), LFCCM is an ideal heat-insulating material. Overall, considering strength and thermal conductivity, pure acrylic polymer emulsion spraying is an optimal treatment method of leaf fibers.

Keywords: Leaf fibers; Modification; Cement-based composite materials; Mechanical properties; Heat-insulating properties

1. Introduction

Developing and utilizing eco-friendly heat-insulating building materials is of vital importance from both environmental and energy-conserving considerations [1-2]. Using fibers from natural plants and crops as heat-insulating building materials has attracted greater global attention [3-7]. Because of its affordability, abundance and eco-friendliness, many countries and regions have shown strong interests in applying plant fiber cement-based composite materials [8-12].

Back in early 1990's, Sarigaphuti et al. [11] adopted plant fibers of pine and poplar tree as a concrete reinforcing material. And Filho et al. [13] used short sisal and coconut fibers for producing plant fiber reinforced cement mortar composites and examined the effect of fibers on free and restricted plastic shrinkage, early drying shrinkage and long-term drying shrinkage of cement mortar. In a review of plant fiber reinforced cement-based building materials, Pacheco-Torgal et al. [14] discussed the methods of improving fiber properties, compatibility between fibers and cement matrix and the effect of fibers on the performance of cement. Claramunt et al. [15] examined the effect of preliminary keratinized plant fibers (i.e. cork kraft pulp & short linters) on mechanical performance and durability of cement mortar composite materials. As summarized by Agopyan et al. [16], there were rapid developments of improving the durability of plant fibers. Evaluation of the durability of a prototype house in use for 11 years proved that coconut shell fibers were a suitable plant material for reinforcing large components while eucalyptus waste paper pulp, sisal and coconut fibers could be used as a substitute for asbestos roofing.

Although application of plant fiber cement-based composites have made tremendous progress [17-20], vexing problems and shortcomings persist in their practical applications.

Firstly, there is a poor compatibility of plant fiber and cement [21-23] due to the following aspects: a) anti-coagulant effect of dissolved substances (aka extracts) of plant was attributed to cement hydration; b) numerous polar hydroxyl groups existing in plant fibers allowed for such a