Mechanical and hydric behavior of plaster reinforced with date palm fibers

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Abstract

a new composite material has been developed from date palm fibers and gypsum to improve the mechanical and water properties of plaster. These gypsum boards based on date palm fibers can be used as thermal and acoustic insulation in constructions. In order to evaluate the physical and mechanical properties of different mixtures of gypsum and fibers, tests were carried out by varying the mass fraction of date palm fibers (from 0 to 5%). These tests determined properties such as water absorption, flexural strength and compressive strength. In addition, all of the above properties were tested on the samples after 28 days of curing under normal conditions. The results showed a significant improvement in the mechanical performance of the bio-composites, with an increase in flexural and compressive strength. However, the increase in fiber mass percentage leads to an increase in water absorption and a decrease in density. Gypsum compounds reinforced with date palm fibers can be considered as green building materials.(1,2,3)

Introduction

Current environmental and eco-design issues demand the use of environmentally friendly materials, which constitute a significant portion of the construction materials market. Natural fibers are already utilized in various types of materials such as plastics, concrete, and lime-based products. They possess different attributes, including a good combination of mechanical, thermal, and acoustic properties, allowing for their use in different applications. The main drawback associated with plaster is its brittleness, particularly under mechanical stress. Therefore, it becomes interesting to explore different methods that could improve the mechanical properties of plaster. Adding fibers to plaster to obtain a composite material is already recognized as a means of improving the behavior of the product, particularly after matrix failure. The objective of this work was to investigate the effects of adding natural fibers derived from date palm on the physical properties and mechanical behavior of the composite matrix.

Mix Proportion

We conducted a study on construction materials composed of a mixture of gypsum and date palm fibers (see Figure 1). To obtain a homogeneous slurry, we added five different quantities of date palm fibers (1%, 2%, 3%, 4%, and 5%) to a gypsum suspension. For comparison, we also prepared a sample of pure gypsum to evaluate mechanical and physical properties. The samples were molded into 100x100x100mm cubes for compressive strength testing, 160x40x40mm prisms for flexural strength testing, and 100x100mm cylinders to determine water absorption percentage. All samples were air-dried for 28 days and then dried in an oven at 45°C to eliminate any moisture.

Fig. 1

Results and discussions

✓ Compressive strength

According to Figure 2, it can be observed that there is a slight increase in compressive strength between 0% and 3%, followed by a sharp increase at 3%, and then a decrease in compressive strength beyond that percentage. The increase in compressive strength of the plaster reinforced with palm date fibers, compared to the non-fibered plaster, can be explained by the fibers playing a role as large aggregates in normal concrete. The subsequent decrease in compressive strength beyond the 3% threshold suggests that the addition of fibers disrupts the mineral skeleton of the plaster by creating voids inside the paste and increasing its porosity, resulting in decreased strength.

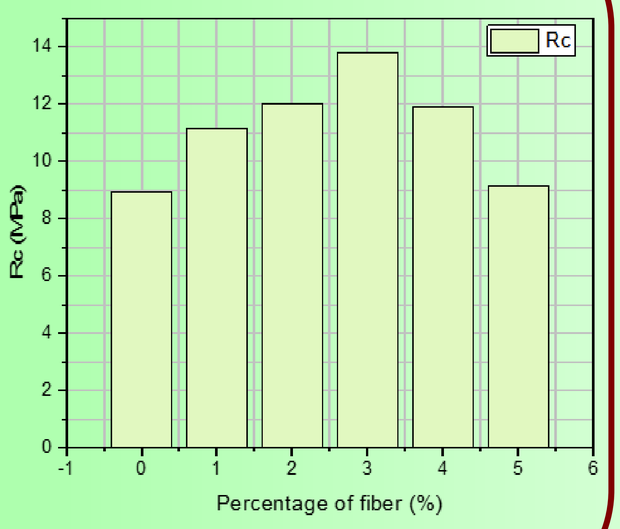

Fig. 2

✓ Flexural strength

According to Figure 3, it can be observed that the flexural strength increases with the increase in fiber dosage, reaching a maximum value at a fiber percentage of 3%. Beyond this percentage, it decreases due to poor fiber distribution in the paste caused by an excess of fibers.It can also be said that the phenomenon of fiber slippage between fibers may be visible during this test.

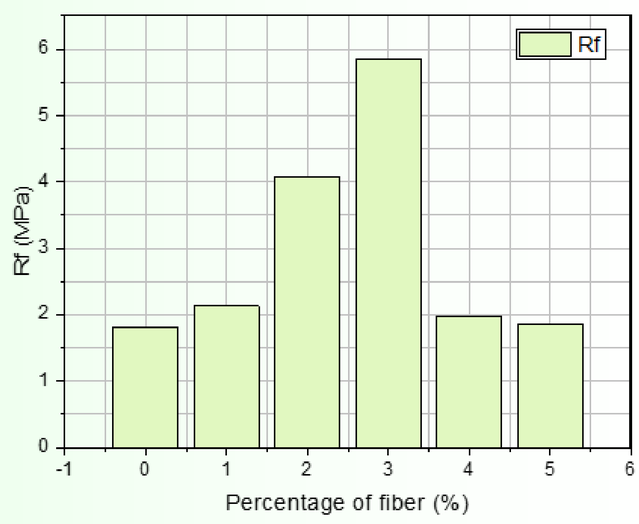

Fig. 3

✓ Water absorption

- Figure 4 shows the water absorption evolution for a plaster mortar reinforced with date palm fibers. It is evident and visible that water absorption increases as the percentage of vegetable fibers increases. This is due to the high void volume created by the addition of fibers and the nature of the fibers themselves.

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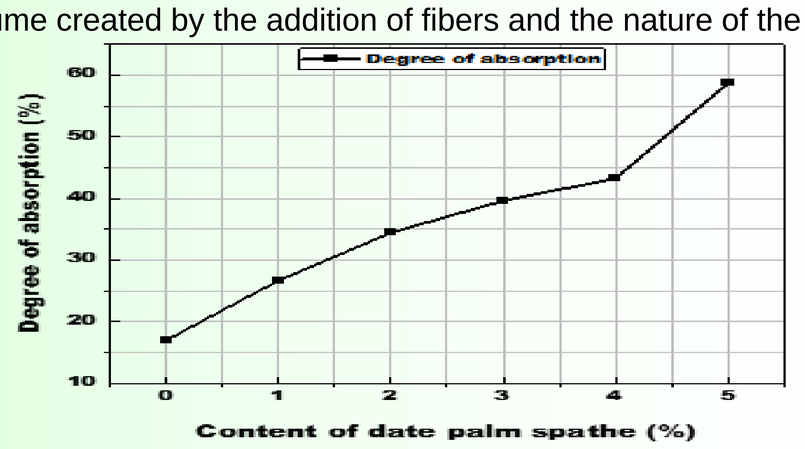

Fig. 4

Conclusion

After all the tests we have conducted, we can say that we have achieved an optimal composition for a plaster mortar reinforced with date palm fibers, meeting the different mechanical and physical characteristics and requirements necessary for a construction material, such as workability, compressive and flexural strength, and water absorption. The plaster mortar reinforced with date palm fibers seems to have a great future in some fields. The technical and economic advantages of this material suggest significant development in the future.

Reference

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