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Short-Term Durability of Hemp Fibers

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Abstract

Short-term durability tests on hemp-fiber confined concrete cylinders made up of one layer of hemp-fiber bundles were conducted to study their behavior. Compression test was performed after wetting and drying cycles in both water and seawater. Moreover, uniaxial tension test on hemp-fiber bundles was conducted to study the effect of extended W/D cycles and prolonged exposure to moisture (1,800 hours). Hemp-fiber confined concrete cylinders showed promising results where there was no significant change in both compressive strength and ductility in comparison to control wrapped cylinders. Regarding tensile testing, after prolonged exposure to water, hemp-fiber bundles were completely destroyed. On the other hand, epoxy coating provided a suitable protected configuration to hemp-fiber bundles. Resistance to seawater was highly apparent in the conservation of tensile stresses. Therefore, natural fibers could be recommended as an alternative to synthetic fibers while taking their drawbacks into account.

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Keywords: Hemp-fiber bundles; Durability; Uniaxial tension test; Compression test.

1. Introduction

Green composites are recently gaining more attention along with raised world's attention toward the concept of sustainability. Jute, coir, flax, bamboo, and hemp are examples of sustainable materials that are being widely explored by many researchers to substitute synthetic materials. Natural fibers have several promising advantages such as low specific weight, low cost, and the fact that they are biodegradable, non-abrasive and renewable eco-

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friendly resources. In addition, their specific mechanical properties are comparable to those of synthetic fibers [1]. Civil engineering is one of the most significant areas for future use of natural fibers as a construction and building material [2]. The first use of natural fibers as a strengthening material was in ancient Egypt about 3,000 years ago where clay was reinforced by straw to form bricks [3]. Various research papers and experiments have proved the effectiveness of using natural fibers in concrete mix design or as a strengthening material against earthquake through concrete confinement. However, the main drawback of these materials is their high variability which leads in return to variability in their physical and mechanical properties. Moisture absorption is another significant disadvantage affecting the mechanical properties of natural fibers. Moisture absorption can lead to dimensional variation in the composites, fiber swelling and eventually rotting due to fungi attack [4]. Moreover, the presence of hydroxyl and other polar groups in natural fibers results in incompatibility between fibers and polymer matrices which leads to a lower interface strength when compared to glass and carbon composites [5]. Among the most used natural fibers as a reinforcement is hemp fiber. Hemp fibers are hydrophilic and absorb moisture where the moisture content of hemp fibers varies between 5 and 10% and may exceed this value [4]. Moisture studies on natural fibers including abaca, jute, hemp, sisal, flax, kenaf, and coir were conducted by Symington et al. [6]. Moisture plays an important role in affecting the mechanical properties of natural fibers. While some natural fibers retained their tensile strength when fully soaked at room temperature/humidity conditions, others showed a notable decrease in tensile strength. Thus, durability and expected lifetime are main short-comings of natural fibers when used in structural applications. The foremost objective of this research is to conduct a preliminary study of the durability of natural fibers when used in real-life construction applications, and to investigate their durability performance as well as their behaviour in different environmental exposures.

2. Materials and Experimental Procedure

2.1. Materials

2.1.1. Hemp Fiber Bundles

Each hemp-fiber bundle was made up of 3 treated hemp fibers twisted manually. The hemp fibers were treated in sodium hydroxide solution at 6% by weight for 48 hours at room temperature. Sodium hydroxide solution has the tendency to enhance the fiber–matrix bond. Alkali treatment eliminates all organic impurities leading to a rough clean surface, and consequently it increases the surface area of contact between hemp fibers and the resin as reported by Yan et al. [7]. Hemp-fiber bundles and epoxy resin were the two main components used to strengthen and reinforce concrete cylinders.

2.1.2. Concrete

Concrete cylinders (95 x 200 mm, H/D > 2) were tested for compression. The reported results mainly represent the average of 3 specimens. The concrete surface was cleaned of any dust before the hemp-fiber bundles were bonded. The hemp-fiber bundles were saturated with epoxy and were applied around the concrete surface in a continuous way until fully wrapped (Fig. 1). An overlap of 150 mm was maintained. An outer layer of epoxy was applied on the surface of wrapped cylinders. The concrete cylinders were left to cure 7 days before proceeding with any test.

Fig. 1. Hemp-fiber confined concrete.