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Enhancement of reinforced concrete durability and performance by bamboo and basalt fibres

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ABSTRACT

This paper presents the mechanical characteristics and durability of concrete reinforced with basalt and bamboo fibres. The study involved testing specimens that were cured for varying durations ranging from 7 to 90 days, and subjecting the specimens to compressive, splitting, and tensile strength analyses. Four types of specimens were used, including control, bamboo fibre-reinforced concrete, basalt fibre-reinforced concrete, and a combination of both basalt and bamboo fibre-reinforced concrete. The durability of the concrete was evaluated through tests such as water absorption, acid attack, and water permeability. The results show that the optimum curing age is 60 days, and the hybrid fibre-reinforced concrete (HFRC) exhibited a higher compressive and flexural strength by 6.5% and 21.5% respectively, as compared to the control specimen. Moreover, HFRC had a 28.6% lower water permeability than the control specimen, implying higher durability. HFRC is also more resistant to acid attack, with a 3.9% reduction in weight loss compared to the control specimen. The post-acid attack test revealed that the HFRC has a compressive strength that is 21.8% higher than the control specimen. This study demonstrates that a hybrid of bamboo and basalt fibre can be used to produce a low-cost and eco-friendly concrete building material.

1. Introduction

Throughout their lifespan, concrete structures are exposed to a variety of environmental variables (Paul et al., 2020). Durability of concrete refers to the ability to endure chemical deterioration, weathering, abrasion, and other degrading processes over a long period of time (Khan et al., 2022). Concrete structures are renowned for their longevity, lasting for centuries with minimal or no maintenance. Physical and chemical attacks can destroy aggregate, paste, and reinforcing material in concrete when exposed to harsh environments (ACI Committee, 2016). Numerous concrete structures require reinforcement, either steel rebars or fibre reinforcement, due to the material's low tensile strength and (quasi)-brittleness in tension. As steel reinforcing bars are still frequently employed, the usage of fibre as secondary reinforcement in concrete has increased considerably in recent years (Paul et al., 2020).

Fiber-reinforced concrete (FRC) is highly regarded for its superior performance in tension, energy dissipation, and resistance to cracking by crack-bridging mechanisms that stop cracks from spreading (Paul et al., 2020). Through this technique, the material's integrity is preserved, and the load-bearing capability is increased beyond the point of cracking (Singh and Rai, 2021). In recent years, an increasing variety of fibre types have been used to reinforce cement-based composites. Commonly employed fibres include steel, organic synthetic, carbon, and glass (Liu and Lv, 2021). Extensive research on fibre-reinforced concrete demonstrated that the addition of synthetic fibres, such as steel, polyvinyl alcohol (PVA), polyethylene (PE), or polypropylene (PP), can enhance the toughness, ductility, tensile strength, and impact resistance of concrete (Maier et al., 2020). Nonetheless, the manufacture of steel fibres and synthetic fibres, which are mostly derived from petroleum, is energy- and cost-intensive (Maier et al., 2020). It is difficult to distribute steel fibres evenly in concrete, and they interact poorly with the cement

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