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Effect of elevated temperature of hybrid fibres on the mechanical performance of cement mortar

Nur Nabila Syazwani Marsidi [a], Siew Choo Chin [b,*]

[a] Faculty of Civil Engineering Technology, Universiti Malaysia Pahang Al-Sultan Abdullah, 26300 Gambang, Malaysia
[b] Centre for Research in Advanced Fluid and Processes (Fluid Centre), Universiti Malaysia Pahang Al-Sultan Abdullah, 26300, Gambang, Malaysia

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ABSTRACT

Exposure to fire can cause significant damage to concrete structures that use cement as a binding material, which in turn can affect their stability. However, there has been less research into the fire-induced damage of concrete mixed with natural materials such as basalt and bamboo fibres. Therefore, the purpose of this study is to investigate how elevated temperatures affect cement mortar containing basalt fibre, bamboo fibre, and a combination of the two, and to determine the mechanical properties of different percentages of hybrid fibre concrete in terms of compressive strength and flexural tensile strength. Cement mortar blocks and prisms were prepared with and without fibres, and basalt fibres ranging from 0.1% to 0.5% were added to cement mix containing 0.5% of bamboo fibres. The strength of the mortar was then determined after being exposed to temperatures ranging from 400 to 1000 °C for 2 h, following a curing period of 28 days. Both the compressive and flexural strengths reduced significantly after the specimen was subjected to heating, especially at temperatures $\geq$ 800 °C. The results indicate that the mortar containing 0.1% basalt fibre and 0.5% bamboo fibre exhibits the highest fire resistance, with the highest compressive strength even after being heated to 1000 °C. Overall, the combination of basalt and bamboo fibres demonstrates greater strength compared to specimens containing only a single fibre after exposure to elevated temperatures.

1. Introduction

Reinforced concrete is a widely used construction material that is made of steel and concrete, which allows the two components to work together to bear stresses. Particularly, it is used for civil infrastructure such as bridges, dams, and tall buildings because of its proven track record in terms of structural safety and durability [1]. But when the two materials are separated based on their strength, steel is known for its high ductility and strength compared to concrete, but it has less fire resistance [2]. In critical temperatures of fire, the steel can lose its stability and soon appear to undergo plastic deformation, resulting in local damage [3]. Meanwhile, when compared to other building materials such as wood or steel, concrete is generally thought to have acceptable fire resistance due to its constituent materials, cement and aggregates. When the materials are chemically combined, they can form an inert material that has low thermal conductivity and high heat capacity, and its strength decays slower with increasing temperature [4,5]. It is also assumed that concrete cross-sections retain their integrity in the presence of fire [2]. As a result, the performance of concrete exposed to fire attacks significantly impacts the fire resistance of reinforced concrete buildings.

Despite the outstanding fireproof performance of concrete, there is evidence that conventional concrete has insufficient resistance to fire attacks to protect steel reinforcements [6]. Concrete that is said to have a high heat capacity, however, under prolonged high temperatures can suffer severe damage, and even collapse due to a reduction in strength [7]. As evidence, in 2003, an 8-story reinforced concrete frame-supported masonry structure, the Hengzhou Building, that is located in the Hengyang City of China, suffered a severe fire for 3 h and collapsed during the rescue operation, costing the lives of 20 firefighters and causing 16 injuries [8]. Even recently, in June 2022, a Philadelphia firefighter died in a rescue mission when a building that had been on fire for about an hour and a half collapsed, trapping six people under the rubble [9]. These incidents simply demonstrated that buildings are supposed to withstand high temperatures, and fire incidents are one of the most severe hazards that can occur in reinforced buildings.

* Corresponding author.
E-mail address: scchin@umpsa.edu.my (S.C. Chin).

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