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Development of Fly Ash-based Geopolymer Mortars Focused on Mechanical Properties

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Introduction

The construction industry faces significant environmental challenges, primarily due to the substantial carbon emissions associated with traditional Portland cement production, which accounts for approximately 8% of global CO_2 emissions. In response to the urgent need for sustainable building materials, researchers and practitioners have been exploring alternatives that can mitigate the environmental impact of construction activities [1]. One promising solution is the use of fly ash, a by-product of coal combustion in power plants, in the development of geopolymer mortars. Geopolymers are inorganic polymers formed through the reaction of aluminosilicate materials with alkaline activators, offering advantages such as reduced carbon emissions, enhanced mechanical properties and improved resistance to chemical attacks. This paper aims to provide a comprehensive analysis of fly ash-based geopolymer mortars, focusing specifically on their mechanical properties. It will examine the factors influencing these properties, including the composition of fly ash, the choice and concentration of alkaline activators, curing conditions and the incorporation of additives, ultimately highlighting advancements in the field and areas for future exploration [2].

Description

The composition and properties of fly ash significantly impact its effectiveness as a binder in geopolymer mortars. Fly ash primarily consists of silica, alumina, iron oxide and calcium oxide, with variations based on the coal source. It is generally classified into Class F and Class C, with Class F being predominantly pozzolanic and Class C exhibiting both pozzolanic and cementitious properties [3]. The pozzolanic activity of fly ash enables it to react with alkaline activators, producing compounds with cementitious properties that enhance the strength and durability of geopolymer mortars. The activation process, which involves adding alkaline solutions such as sodium hydroxide or sodium silicate, plays a pivotal role in the geopolymerization process. Factors like the concentration of alkaline activators and curing conditions are critical for optimizing the mechanical properties, including compressive strength and flexural strength [4]. Research indicates that fly ash-based geopolymer mortars can achieve compressive strengths comparable to or exceeding traditional cement-based materials, making them suitable for various structural applications. Additionally, the incorporation of additives such as fibers and silica fume can further enhance these properties, leading to improved performance in load-bearing elements and durable pavements. Curing conditions, including temperature and duration, also significantly influence the mechanical properties, with elevated temperatures generally leading to higher strength [5].

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Conclusion

The development of fly ash-based geopolymer mortars focused on mechanical properties represents a vital advancement in sustainable construction materials. By harnessing the unique characteristics of fly ash and optimizing the alkaline activation process, these geopolymers provide high-performance alternatives to conventional cementitious materials. The ongoing study of mechanical properties, including compressive strength, flexural strength and durability, is essential for evaluating the applicability of these materials in various construction applications. As the construction industry prioritizes sustainability, the potential of fly ash-based geopolymer mortars to reduce waste and lower greenhouse gas emissions becomes increasingly important. Future research should explore innovative formulations and long-term performance, along with the development of standardized testing protocols to facilitate their widespread adoption. Ultimately, the responsible use of fly ash-based geopolymer mortars can revolutionize construction practices, promoting a more resilient and eco-friendly built environment.

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Conflict of Interest

None.

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