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Application of bentonite in cement-based composites: A review of current status, challenges and future prospects

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ABSTRACT

The demand for massive cement production requires vast raw materials, consumes high energy, incurs high costs, and contributes to generating 8–10 % of carbon dioxide (CO_2) emissions, which causes enormous ecological and health threats. These issues can be mitigated by adopting sustainable practices, such as using eco-friendly materials in cement production, which is more important than ever. Bentonite (BT), an environmentally friendly alternative, has been widely used as a substitute for cement due to its advantageous properties, including cost reduction, lessened emissions, decreased permeability, and increased chemical resistance. Many researchers have explored the utilization of BT as a substitute for cement in cement-based materials (CBMs) production, however, a comprehensive review substantiating its efficacy in this regard remains to be established. This paper presents a robust literature review and bibliometric analysis conducted on BT, utilizing the VOSviewer tool to scrutinize academic publications. Furthermore, physical and chemical properties, morphological analysis, and the effect of incorporating BT on the fresh, mechanical, and durability properties of CBMs were reviewed. On top of that, BT's life-cycle assessment (LCA) regarding CO_2 emissions and overall costs, challenges, opportunities, and future directions were explored, providing valuable insights for researchers and practitioners in the construction field. The literature review of previous studies concluded that incorporating finely ground BT in optimal amounts (10–15 %) could effectively replace cement in concrete production without compromising strength, performance, or durability. Utilizing BT aligns with sustainability goals, offering a promising solution to global ecological challenges and paving the way for a more sustainable future.

1. Introduction

The global demand for concrete has surged due to rapid urbanization, advancements in material science, and the expansion of infrastructure worldwide. Around 25 billion tons of concrete are used each year globally, making it the second most widely utilized construction material after water [1]. Among all concrete components, the most commonly used building material today is cementing concrete [2]. Cement is a binder in concrete-based technology, essential for setting, hardening, and holding all elements together [3,4]. Based on the exploration of the global cement market analysis, it is anticipated that the global cement market will witness a compound annual growth rate (CAGR) of 3.5 %, surpassing 5 billion tons in 2024, while expected production and consumption figures are estimated to reach 5.31 billion tons and 5.28 billion tons, respectively, by 2029 [5,6]. Nevertheless, the global annual production of

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