

Comparative Study of Biochar from Different Concentrations of Bamboo as Concrete Fillers for Carbon Sequestration and Mechanical Strength of The Concrete

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Structured Abstract

Background: The construction sector remains one of the world's highest producers of carbon emissions due to its reliance on cement which has a high CO₂ emission rate. Biochar, a byproduct of biomass pyrolysis, has gained attention in the construction sector for its carbon-capturing ability and its potential to enhance concrete properties. Among the various biochar sources, bamboo stands out as the most effective option due to its high carbon concentration and unique porous structure. In addition, its plentiful growth in areas like Malaysia makes it even more appealing. This study reviews the potential of incorporating bamboo-derived biochar at various concentrations into concrete, evaluating its effects on mechanical strength and carbon sequestration performance.

Methods: This review study adopts a systematic review methodology, assessing peer-reviewed articles and grey literature from 2015 to 2024. The databases Scopus, ScienceDirect, Google Scholar, and Springer Nature were searched with the terms “bamboo biochar”, “carbon sequestration”, and “biochar concrete composite”. Inclusion criteria specialized in experimental studies that utilized bamboo biochar in concrete. Key parameters reviewed include compressive strength, flexural strength, microstructure analyzed through scanning electron microscopy (SEM), and functional group analysis.

Results: Strength improvement has been observed at 2% bamboo biochar concentration for early age concrete performance and 10% for long-term performance in compressive and flexural strength. SEM analysis reveals that biochar fills microvoids and densifies the Interfacial Transition Zone (ITZ), reducing porosity. Regarding CO₂ capture, biochar facilitates high CO₂ adsorption due to its porous structure and functional groups which also promote mineral carbonation. Nevertheless, previous studies also indicate that concentrations surpassing 10% may negatively impact strength, likely due to particle agglomeration and reduced hydration.

Conclusion: This study concludes that bamboo biochar is a viable additive in concrete for enhancing both environmental sustainability and mechanical performance. Its use contributes to reducing the carbon footprint of construction materials and supports the development of green technologies. Further standardization and validation experiments are needed in order to apply this method to practical situations.

Keywords: Bamboo Biochar, Carbon Sequestration, Mechanical Strength, SEM Analysis

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