

## Biochar Affects Compressive Strength of Portland Cement Composites: A Meta-Analysis

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**Abstract :** One strategy to reduce CO<sub>2</sub> emissions from cement production is to reduce the amount of Portland cement produced by replacing it with supplementary cementitious materials (SCMs). Biochar is a potential SCM that is an eco-friendly and stable porous pyrolytic material. However, the effects of biochar addition on the performances of Portland cement composites are not fully understood. This meta-analysis investigated the impact of biochar addition on the 7- and 28-day compressive strength of Portland cement composites based on 606 paired observations. Biochar feedstock type, pyrolysis conditions, pre-treatments and modifications, biochar dosage, and curing type all influenced the compressive strength of Portland cement composites. Biochars obtained from plant-based feedstocks (except rice and hardwood) improved the 28-day compressive strength of Portland cement composites by 3-13%. Biochars produced at pyrolysis temperatures higher than 450 °C, with a heating rate of around 10 °C/min, increased the 28-day compressive strength more effectively. Furthermore, the addition of biochars with small particle sizes increased the compressive strength of Portland cement composites by 2-7% compared to those without biochar addition. Biochar dosage of < 2.5% of the binder weight enhanced both compressive strengths and common curing methods maintained the effect of biochar addition. However, when mixing the cement, adding fine and coarse aggregates such as sand and gravel affects the concrete and mortar's compressive strength, diminishing the effect of biochar addition and making the biochar effect nonsignificant. We conclude that appropriate biochar addition could maintain or enhance the mechanical performance of Portland cement composites, and future research should explore the mechanisms of biochar effects on the performance of cement composites.

**Keywords :** biochar, Portland cement, constructure, compressive strength, meta-analysis

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