SUMMARY

Using Sustainable Biochar to Lower the Detrimental Effects of Fire in Concrete

The hypothesis suggested that biochar's unique properties, such as its intricate microporous structure, could help moisture escape and prevent crack formation in concrete under high temperatures. Biochar's non-combustible and thermally stable nature was anticipated to offer extra protection against heat-induced damage. However, despite achieving sustainability goals by reducing the carbon footprint through cement replacement, experimental results indicated that biochar's impact on concrete's fire behavior was limited, not aligning with the initial hypothesis.

Purpose and Goal

The project aimed to investigate the changes in mechanical properties of biochar-added sustainable concrete when exposed to the standard fire curve.

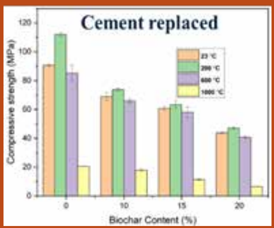
Methods

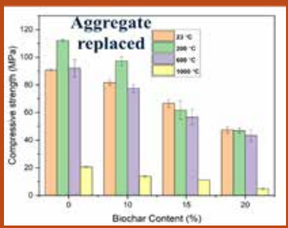
Two different biochars, one fine powder, made from the pyrolysis of wood waste, and the other coarse, made from fruit pits, were used to replace 10, 15, and 20 wt% of cement and fine aggregates, respectively in a particular concrete recipe.The biochars were characterised for their density, water absorption capacity, and particle size. Additionally, their particle hardness/ stiffness and their reaction-to-fire properties were elucidated. The concrete samples with biochar (and a control sample) were cast using a conventional method that included a slump test according to EN 12350–2 followed by curing underwater for 28 days. The samples were tested for their compression and tensile strengths according to EN 12390–3 and SS-EN 12390:2009, respectively. The concrete samples were subjected to the standard fire curve of ISO-834 in a furnace. However, the experiments were intentionally halted at three specific temperature points: 200, 600, and 1000 °C, corresponding to critical stages of fire development within an enclosure, representing fire growth, flashover, and fully developed fire conditions. Post fire exposure, the samples were tested for their mechanical properties using the same aforementioned methods as well as their microscopic properties were investigated by scanning electron microscope.

Results

The densities of the fine and coarse biochar were 1.9 and 1.5 g/cm3, respectively whereas the fine one had particle size ranging from 100-400 µm and the same for the coarse one was ca. 3 mm. The fine biochar absorbed more water in comparison to the course one but had ca. 50% higher Young's modulus. However, both the biochar had similar particle hardness i.e., ca. 0.2 GPa. Both the biochars did not ignite at 35 kW/m2 heat flux and had peak heat release rates below 40 kW/m2.

For the concrete samples, in general (with and without fire exposure), it was found that with the increase in the amount of biochar, for both cement and fine aggregate replacement, the compressive and tensile strength declined, albeit not drastically, because reducing the cement quantity minimised the binding ability. Exposure to 1000 oC was detrimental to all the samples due to thermal cracking and decomposition of calcium oxide, significantly reducing their mechanical properties. However, it was observed that concrete can incorporate up to 20 wt.% biochar as a substitute for fine aggregates, maintaining compressive strength as the standard concrete, after fire exposure up to 600 °C. Furthermore, concrete can accommodate up to 20 wt.% of biochar by replacing cement and maintain comparable compressive strength





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