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INVESTIGATIONS ON CONCRETE AND MORTAR WITH PARTIAL REPLACEMENT OF CEMENT USING BIOCHAR

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Abstract

The carbon dioxide (CO_2) emission in the construction industry sector is a serious concern because of the energy-intensive process involved in manufacturing cement and the CO_2 released during the process itself. The sequestration of carbon in the building materials can address as one of the potential solutions to this issue. Carbon sequestration describes the long-term storage of carbon dioxide or the other forms of carbon to either mitigate or defer global warming and avoid climate changes. Here arises a need to utilize some other material as a partial replacement of cement in the concrete. Therefore, coconut husk biochar is partially used as a replacement for cement in concrete. Biochar is a carbonaceous material produced by pyrolysis. The main aim of the investigation is to study the hardened state properties of mortar and concrete after replacing cement with biochar in mortar and mortar by 10%, 15%, 20%. The main objective of the present investigation is to study the carbon sequestration ability of biochar amended cementitious materials and determine the appropriate percentage of replacement of cement using biochar and compare the strength of biochar amended concrete and mortar with the control specimen.

OPC 43 grade cement is used here, and laboratory tests were conducted on cement to determine specific gravity, fineness, standard consistency, initial setting time. M-sand is used as the fine aggregate and coarse aggregate particles that retain on a 4.75mm sieve. IS 10262:2019 codewas used to find out the mix proportion for M20 concrete. The materials are weighed, then first dry mixed, then mixed with water. The Slump test was conducted with concrete to ascertain the workability of the mix. Mortar and concrete were poured into the moulds in three layers, and each layer is compacted by 25 blows using a tamping rod; the surface was finished using a trowel. After 24 hours, mortar and concrete cubes were demoulded, and the specimens shown in Fig. 1 were kept for curing in water.

(a) (b) (c)

Fig. 1 Biochar amended specimens (a) Beam (b) Cylinder (c) Cubes

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The tests to determine the properties of concrete include compressive strength, split tensile strength, flexural strength, water absorption, workability. In the case of biochar amended mortar, compressive strength tests & water absorption was carried out. The workability of biochar amended concrete was also carried out by slump cone test and compaction factor test. Replacement of cement with biochar during the experiment showed an increase in the normal consistency of the cement. However, it was shown till 15% of biochar replacement for a normal consistency value of 34%. Beyond the 15%, the value was seen to be constant. Whereas, the initial setting time test shows that on increasing the percentage of biochar replacement for cement, the initial setting time of the cement is also increasing. An initial setting time of 50 minutes obtained for the conventional concrete increased to 205, 240 and 265 minutes for 10%, 15%, and 20% biochar replacement. The slump cone and compaction factor tests were carried out to determine the workability of biochar amended concrete. In this study, the slump value reduced with the addition of biochar into the concrete mix as a replacement for the cement. According to IS-456 clause 7.1/ page no. 17, the slump values ranging between 25-75mm can be used for various purposes such as lightly reinforced sections in slabs, beams, walls, columns, etc. Moreover, it can also be used for hand-placed pavements. So, for the following purposes, these concrete mixes are of adequate workability for placing conditions of concrete mix and can be compacted with the means available. The test results of the compaction factor test show that there is a very slight decrease in the values of the compaction factor of biochar amended concrete mixes. According to the provisions in IS-456 Clause 7.1.1, a value of compaction factor 0.75-.0.80 is suggested for low workability concrete. Here we obtained values in the range of 0.8-0.85, which is also having low workability according to IS-456 1978, and it also can be used in the field of the concrete reinforced section with the help of vibration.

After conducting hardened properties tests, we found out that the compressive strength of the biochar amended mortar cubes showed a decreasing trend on increasing percentage of biochar, and these cubes showed an increase in water absorption on increasing the biochar content. The compressive strength test was conducted on the conventional concrete cubes on 3 cubes cast after curing of 28 days and also on the 10%, 15% & 20% biochar amended concrete mix on 3 cubes each. Similarly, flexural strength tests and split tensile tests were conducted on conventional concrete and biochar amended concrete mix beams and cylinders. From the test, the compressive strength biochar amended concrete specimen showed decreasing trend on an increasing percentage of biochar as shown in Fig. 2, and minimum required strength is achieved at 10% replacement.

Similarly decreasing trend was seen in the flexural strength and split tensile strength tests, as shown in Fig. 3. So, there is no improvement in the strength of the biochar amended concrete when the percentage of biochar increases. It was also observed that water absorption showed an increasing trend with increasing percentage biochar content. Biochar amended concrete cubes showed an increase in water absorption on increasing the biochar content. This is because nano-pores and micro-pores absorb water, thus increasing the water absorption in the biochar amended concrete.

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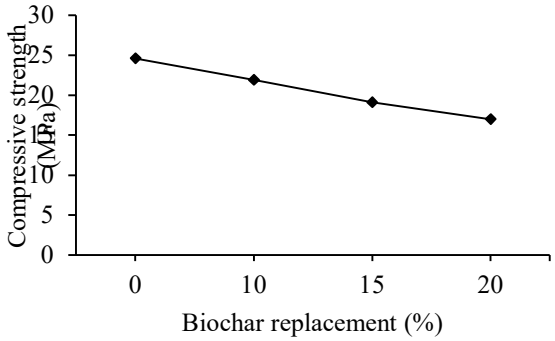

Fig. 2 Compressive strength (MPa) values of biochar replaced concrete

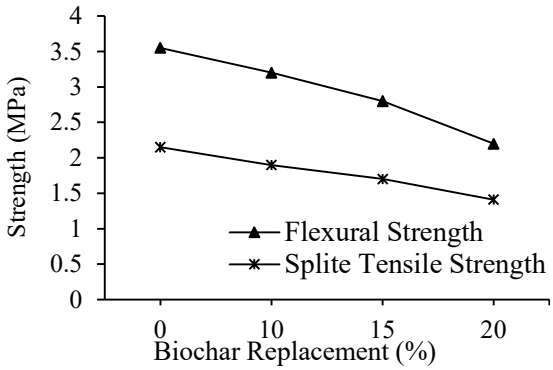

Fig. 3 Flexural strength and Split Tensile strength (MPa) values of biochar replaced concrete

Keywords: Biochar, Cement, CO_2.

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