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ORIGINAL ARTICLE

Study on properties of bacteria concrete with two different fibres and carbon-negative supplementary cementitious materials

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Abstract

The research on the use of carbon negative materials in the concrete industry has been quite intensive in the past decade. Though bacterial fibre reinforced concrete showed significant improvement in strength and durability properties, the study on the same with a combination of sustainable carbon negative materials is quite limited. This work aimed to study the performance of the microbial activity of *Bacillus tropicus* bacteria in concrete prepared with carbon-negative supplementary cementitious materials (CNSCM). Iron powder (IP), glass powder (GP), metakaolin (MK), and limestone powder (LP) were added as a replacement for ordinary portland cement in three different proportions, namely 10%, 20%, and 30% by weight of cement. In the concrete mixes, two different natural fibres, namely sisal and coir, were used to determine the mechanical, durable and crack healing properties of bacterial fibre-reinforced sustainable concrete. For this work, 0.5% sisal fibres (SF) and 0.5% coir fibres (CF), and for a hybrid combination, 0.5% sisal and 0.5% coir fibres are incorporated at weight fractions in bacterial concrete for direct addition technique to enhance the performance of crack healing and potential use of natural fibres in fibre reinforced self-healing concrete. In this study, eleven mixes were prepared: two mixes with CNSCM, six mixes with only sisal fibre and coir fibre, and three mixes incorporating a hybrid combination of sisal and coir fibres. For each mix, specimens such as cubes and cylinders were made to evaluate compressive strength, split tensile strength, strength regain, degree of crack healing, sorptivity, water absorption, and porosity. A significant improvement in strength, durability, and healing properties was observed when mixed with *Bacillus tropics* and fibres compared to bacteria without fibres and control mix. Compared to reference concrete (RC), bacteria concrete rendered improved strength, durability, and crack healing properties. The results suggest that CM20S0.5C0.5, the compressive strength, split tensile strength, and compressive strength regain increased by 35.02%, 56.7%, and 85%, respectively. The specimens under durability tests showed an 85.91% reduction in sorptivity. The maximum percentage of crack width healing for pre-cracked samples after 28 days was 98.11%. Microstructure studies, such as scanning electron microscopy (SEM) and X-ray diffractometer (XRD) analysis, identified the presence of calcium carbonate compounds formed through the biological activity of *Bacillus tropicus* in natural fibre reinforced carbon reducing supplementary cementitious system.

Keywords Self-healing concrete · Bacteria · Natural fibre · Sustainable cementitious material · CO_2 reduction

Abbreviations

CNSCM	Carbon-negative supplementary cementitious materials
SCM	Supplementary cementitious materials
MICP	Microbial induced carbonate precipitation
IP	Iron powder
GP	Glass powder
MK	Metakaolin
LP	Limestone powder
LPW	Limestone powder waste
BS	Bacterial solution
NS	Nutrient solution
SF	Sisal fibre
CF	Coir fibre
DA	Direct addition
IM	Immobilization
FA	Fine aggregate
CA	Coarse aggregate
$CaCO_3$	Calcium carbonate
CO_2	Carbon dioxide
C-S-H	Calcium silicate hydrate

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