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BIOCHAR TIME: The zero CO_2 Concrete Clock

Introduction

The massive use of concrete throughout the world, make construction sector responsible for a significant proportion of CO_2 emissions [1]. The production of cement is responsible for about 5 - 8% of global CO_2 emissions [2]. Despite the progress made by new cement binders - the GWP (Global Warming Potential) of CEM III (blast furnace cement) is ~ 280 [kg CO_2-eq / t], compared to CEM I (Portland cement) with ~ 530 [kg CO_2-eq/ t] [3] it is crucial to further reduce the GWP of binders.
The use of biochar with a GWP value of -2 kg to -3 kg CO_2-eq per kg of biochar [4], offers a viable solution to reduce CO_2 emissions associated with concrete production and is gaining increasing attention. Biochar is a fine-grained, carbon-rich solid obtained from the thermal decomposition of biomass feedstocks without oxygen (pyrolysis). Biochar is known for its ability to sequester large amounts of carbon and its potential use in concrete is increasingly being investigated.

Materials, Biochar Preparation, and Mixing Process

To investigate the fresh and hardened properties of the concrete mix design the materials shown below were used. Before mixing, the biochar was dried and milled for 3 hours in a steel milling container.
The required quantity of cement, milled Biochar, limestone powder and aggregates were added to the mixer. The optimized amount of water and superplasticizer was added and all ingredients were mixed together. Finally, the molds for the clock and the prisms for testing the mechanical properties were filled and stored for the curing process.

Limestone powder H100

Cem III/B "Der Violette"

Biochar (milled)

River aggregate 1-4 mm

Tap water

Superplasticizer ACE 430

Concept

The aim of this project is to optimize a concrete mix with zero CO_2 emissions by replacing part of the cement with biochar. At the same time, the mechanical properties of the concrete should not be significantly reduced, making it suitable for a wide range of construction applications.

Results

Results obtained so far show that the replacement of cement with 10-15% biochar and 20-25% limestone powder added to the cement paste gives promising results and ensures sufficient mechanical properties of the concrete to allow its use in different areas of construction.
In particular, the mix design for the clock, in which 15% of the CEM III is replaced by charcoal and 30% by limestone, has a compressive strength of 5.2 MPa after two days and a compressive strength of more than 25.0 MPa after seven days, while the GWP value remains below zero.

Literature

[1] https://doi.org/10.1016/j.conbuildmat.2018.02.104
[2] https://doi.org/10.1016/j.conbuildmat.2020.121942
[3] Veröffentlichte EPDs | Institut Bauen und Umwelt e.V. (ibu-epd.com)
[4] https://doi.org/10.1007/s42773-022-00182-x

Conclusions

By partially replacing cement with biochar, the total CO_2 emissions of the concretes produced could be significantly reduced without significantly affecting the mechanical properties.
It was even possible to develop concrete mixes with a negative global warming potential (GWP), as the mix design for the clock shows.
This outcome not only offers an environmentally friendly solution, but also indicates that concrete could serve as a long-term storage for CO_2.