POLITECNICO
DI TORINO

Honors thesis

COURSE OF ARCHITECTURE FOR THE SUSTAINABILITY DESIGN

Abstract

Biochar as eco-friendly filler to enhance the sustainable performance of cement.

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27 September 2018

The growth of the world population has generated an increase in the demand for buildings to meet the needs of housing, work and leisure, leading to a greater consumption of building materials. However, nowadays, it is necessary that the process of producing traditional materials is the most efficient and sustainable from an environmental and economic point of view.

In the construction world, concrete is the most produced and used material in the world. One of its main components is cement, whose production has reached over 4 billion tons in recent years. This production process requires large quantities of non-renewable raw material and consumes a high amount of energy; moreover, it is highly polluting, being responsible for over 5% of CO_2 emitted into the atmosphere each year, generating serious environmental consequences.

Another major problem unresolved to date is that related to the management of organic waste (biomass) which, due to their low recycling rate, are now a major problem for the world states: their disposal causes serious problems of contamination of the soil and water, during the degradation process, emissions of methane and other greenhouse gases are generated, the costs of disposal and management are high.

Recent studies have demonstrated the energy potential of biomass treated with thermochemical processes, for example those with limited oxygen such as pyrolysis or gasification, from which we obtain bio-oil, syngas and Biochar; the former are used as biofuels, while the third, which is the solid by-product of the process, has been used as soil improvers. However, several construction researchers have verified the potential application of Biochar as inert green in cement pastes, mortars and concretes, improving their mechanical properties such as compressive strength, flexural strength and ductility.

Therefore, the present work is based on the use of the "Borgotaro grigio" Biochar, coming from wood chips, as inert to improve the mechanical resistance in traditional cement-based materials. In addition, the purpose of this work is also to know the influence of the cost of Biochar dded to cement paste.

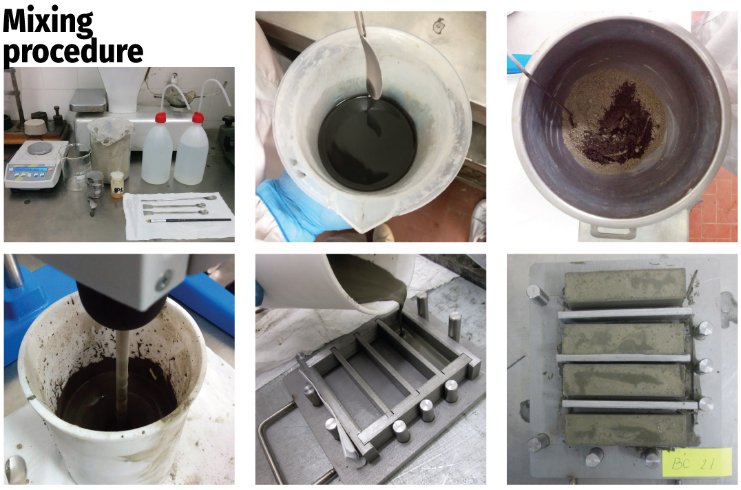
In the laboratory activity was added the Biochar, obtained by gasification, in different percentages with respect to the weight of the cement. The final results showed that the micro-particles of Biochar are very useful for improving the mechanical properties of cement compounds. In particular, the addition of 2% of Biochar has shown an improvement in flexural strength, toughness and ductility since the particles have the property to divert the fracture, generating a much more tortuous and less linear trajectory of typical brittle cement, which results in an increase in fracture energy. As for the compressive strength, compared to pure cement paste, there was an improvement of more than 5% at 7 days, however at 28 days there was no improvement of this property.

Regarding the economic field, it has been shown that using 2% of Biochar in the cement mixture does not significantly increase the final cost, this could open interesting scenarios regarding its application. Moreover, by replacing part of the cement with the same amount of Biochar (2%), it is possible to obtain a mixture of almost 1% cheaper than the traditional mixture due to the lower amount of cement also leading to a reduction of CO_2 emissions.

In conclusion, with this study it was possible to appreciate how the Biochar has a great potential as a filler in cement, with a reduction in costs as it replaces the cement with a waste material. In particular, this last feature implies a double advantage: on the one hand, in fact, there is a reuse of otherwise unusable material; on the other hand, we have a reduction in the emission of greenhouse gases into the atmosphere due to the reduced use of cement and the production of Biochar which avoids the generation of almost 900 kg of CO_2 equivalent for each ton of biomass treated.

Experimental activity - **specimens**

Mixing procedure



CEM mix	# provini 7 giorni	# provini 28 giorni
Pure cement	4	4
CEM+BC 0.8%	4	4
CEM+BC 1%	8	8
CEM+BC 1.5%	4	4
CEM+BC 2%	12	4
CEM+BC 2%_S	8	-
CEM+BC 2%*	4	-
CEM+BC 2.5%	4	4
CEM+BC 2%_Sost	4	-
CEM+BC 2%_S_Sost	4	-
CEM+BC 2%_Sost*	4	-

Biochar percentage added based on the weight of the cement
Dynamon SP1 = 1% based on cement weight
w/c: 0.35

*w/c:0.40

Figure 1. Mixing process and made specimens.

Experimental activity - **results**

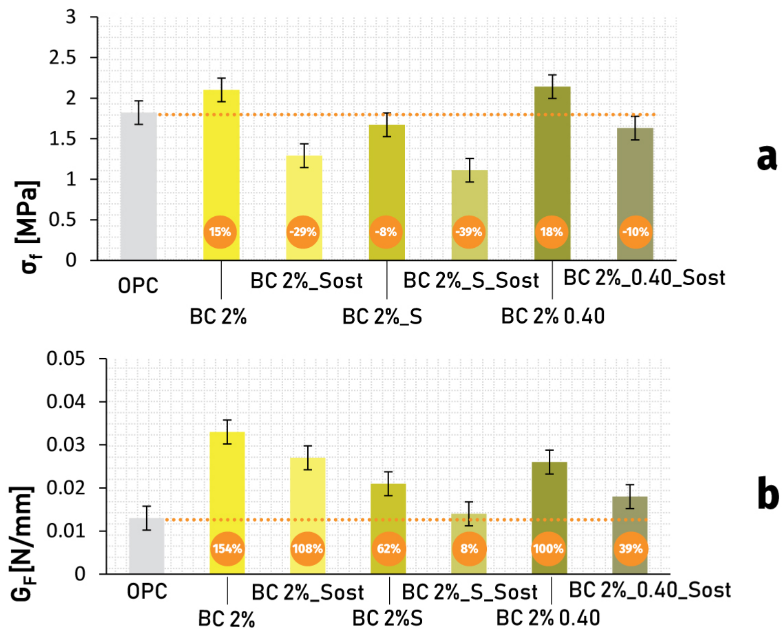


Figure 2.(a) Flexural strength average for each sample set at 2% at 7 days..
(b) Fracture energy average for each sample set at 2% at 7 days.

Economic-environmental benefits

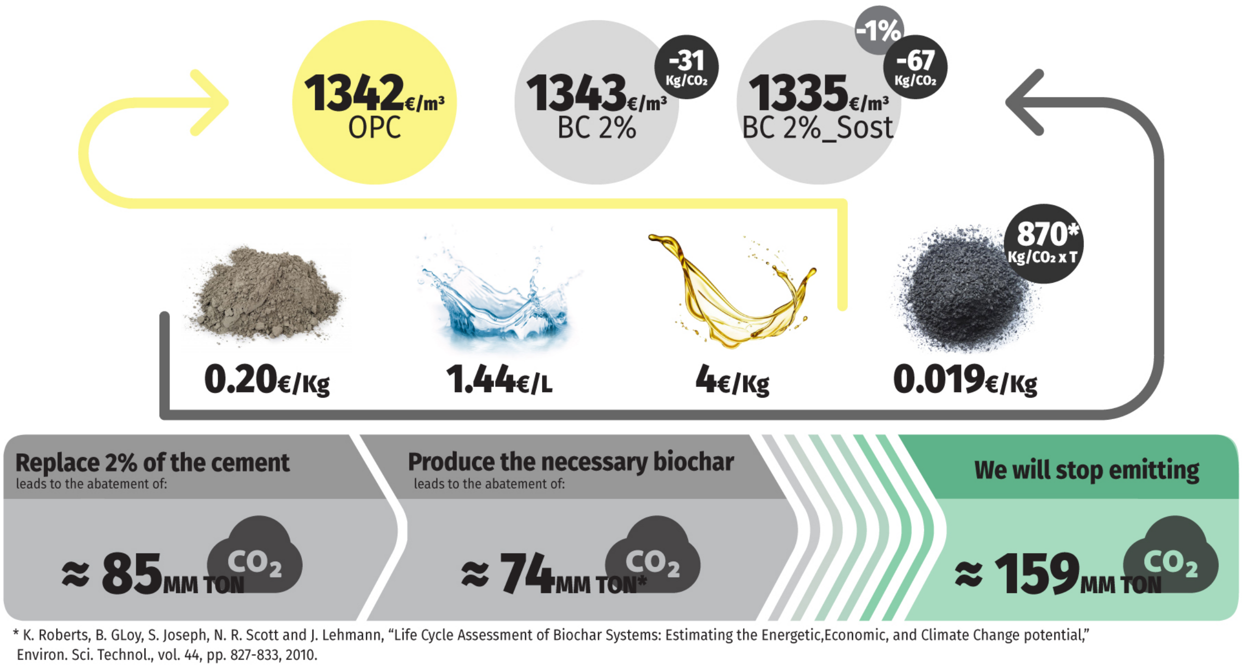


Figure 3. Economic-environmental benefits

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