Compressed earth blocks stabilisation: Recycled cement for a greener solution

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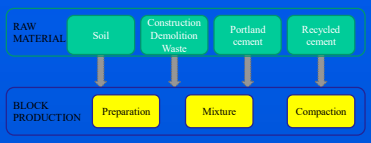
Introduction

The building sector is responsible for over 35% of the total waste generation and about 50% of all extracted material in the European Union (EU). To save up to 80% of the 5-12% total GHG emissions a change in construction and renovation sector is needed. Of course, the use of more eco-efficient building materials could be part of the solution. Traditional earth-based materials respond to the need of more environmentally friendly materials, but present also shortcomings that need to be addressed. Their durability and water resistance, for instance, can be improved through stabilisation.

Figure: AI generated picture of pollution caused by the construction sector



Nevertheless, many of the common solutions for stabilisation such as ordinary Portland cement (OPC) are severe for the environment. The use of recycled cement (RC) can mitigate this effect, with consistent CO_2 savings, here evaluated (cradle-to-gate analysis). Compressed earth blocks (CEB) were produced with: soil transported for 67 km; the addition of clay and construction and demolition waste retrieved from factories at 177 and 132 km, respectively; OPC produced at 75 km and RC at 100 km.

Figure 2: Diriyah's At-Turaif, Saudi Arabia google credit (up); methodological approach.

Results & Discussion

The hybrid cradle-to-gate model built on external information, analogy approximations and direct simulation, estimated carbon emissions of **0.073, 0.485,** and **0.202** $kgCO_2$, respectively, to produce unstabilised CEB, CEB stabilised with OPC and CEB stabilised with RC.

As expected, the production of UCEB has the lowest environmental impact, but their application is mainly recommended for indoor or protected solutions. Stabilisation with OPC intended to improve their water resistance, would increase almost 7 times their carbon emissions. The RC stabilisation, however, was found to produce about ½ of the carbon emissions of OPC, without jeopardizing the final material properties.

The production of RC from concrete waste was implemented in the model with the following assumptions:

► the concrete waste would be available already partially crushed, thus only additional crushing and sieving would be required (energy consumption of 1/3 of that for clinker production);

► the total energy for the thermal treatment is estimated based on the temperature ratio 650/1450 °C.

Accordingly, the carbon emissions for RC production was estimated 185.9 $kgCO_2/t$.

The production of OPC was evaluated based on the latest available official reports on clinker production from the five cement plants operating in Portugal. The OPC clinker content was estimated 97%, with addition of 3% gypsum and 4% filler. The carbon emissions for OPC production were estimated 778.5 $kgCO_2/t$.

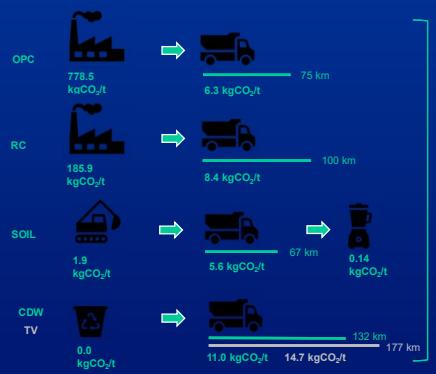


Figure: Carbon emissions flowchart

The CEB included in the analysis were: i) unstabilised (UCEB); ii) stabilised with 8 wt% ordinary Portland cement (OPC CEB); iii) stabilised with 12 wt% recycled cement from concrete waste (RC CEB). Construction and demolition waste (CDW) was added at 25 wt% to all the composition and water at 9 wt%, except for RC CEB that required 12 wt% of water. Additional clay (TV) was added at 11% to the stabilised CEB and 18% to UCEB.

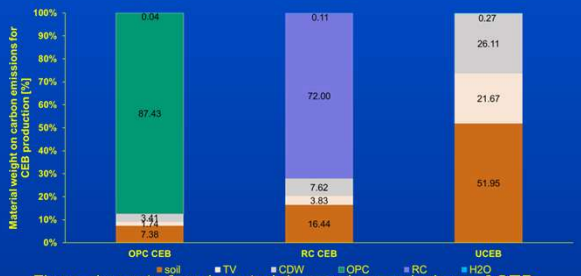


Figure: impact of each material on carbon emissions of CEB

From the previous Figure:

►The impact on carbon emission of the stabiliser addition decreased from about 87% to 72% using RC instead of OPC on the total materials weight.

► The soil has the biggest impact on carbon emissions of UCEB, although transport play an important role in the use of recycled materials, as confirmed by the following Figure.

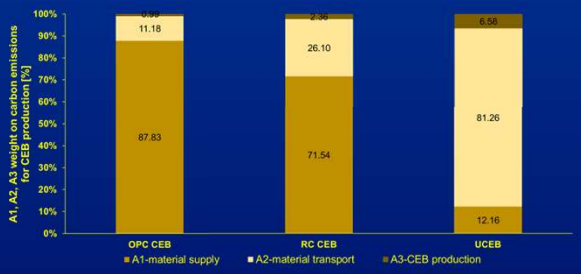


Figure: Impact of the product stages (raw materials supply - A1, transportation - A2, manufacturing - A3) on carbon emissions of CEB

Conclusions

The production of UCEB showed the lowest carbon emission, although their technical performance is not the same as stabilised CEB. OPC stabilisation increased up to almost 7 times the carbon emissions of UCEB, whereas RC stabilisation about 3 times. The model built can have a big impact on the quantification of environmental impact for unstabilised earth-based materials, as the transport stage has a major weight. In the case of stabilised CEB, the stabiliser production has the greatest weight.

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