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Development of Interlocking Composite Bricks Made From Recycled Plastic and Construction Waste

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Motivation and Objectives

Plastic pollution represents one of the major threats to the environment and its inhabitants. At the same time, negative attention has come to construction materials, as many of them are energy intensive to produce and require non-renewable materials. To partially solve both these issues, the present project aims to create a new construction brick made from recycled plastic and construction waste. The objectives of these bricks are:

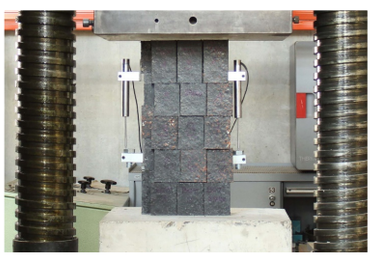
- The materials used for the fabrication of the brick should originate from plastic and construction waste.
- The bricks should show comparable strength, stiffness, and water absorption rates to commonly used construction bricks.
- They should include a mortar-free connection system.
- The manufacturing process should be simple and reproducible.
- The bricks should show comparable or lower environmental impacts compared to traditional bricks.

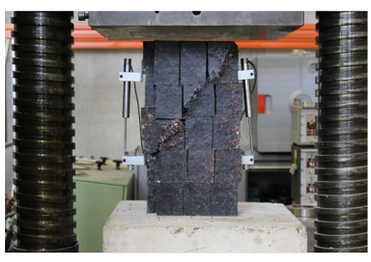
Project Stages

Material characterisation	Polymer matrix testing	Composite mix testing	Brick wall testing	Life cycle analysis

The polymers used as ingredients are PVC, HDPE, and PP. They originate from waste plastic tubes, which are cut and shredded in the lab. The aggregates employed are stone, recycled concrete and fired clay brick aggregates. The final brick is developed and designed in four main steps. First, material characterisation is used to determine the thermal stability and the melting temperature of the polymers. Second, preliminary samples in the shape of plates are used to test how the different materials adhere to each other and how they behave under different fabrication temperatures and pressures. The experiences made from this are used to test a range of larger composite mix samples. These are tested for compressive strength (SN EN 772-1+A1), Young's modulus (SN EN 12390-13), and water absorbance through capillarity (SN EN 772-11). Through these tests, a final brick recipe is defined. Lastly, a complex brick shape is designed that allowed interlocking of the bricks. These bricks are assembled using a rubber mallet and the wall is tested in compression (SN EN 1052-1). Furthermore, a life cycle analysis is executed to determine the sustainability of the bricks.

Brick Wall Testing





Brick wall before (left) and after (right) compression test.

The brick shape is designed to allow vertical and horizontal interlocking. The bricks are assembled using a rubber mallet. The brick wall fails in shearing and the failure plane passes diagonally through the entire wall, indicating that the proposed connection system is effective.

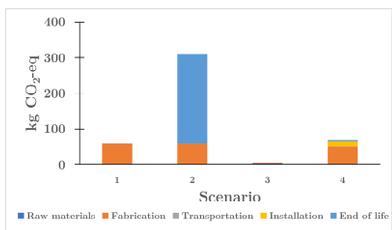
Brick	Brick resistance [MPa]	Brick wall resistance [MPa]	Young's modulus [GPa]
Recycled	30.7	20.327	1.373
Fired clay	28	7	7

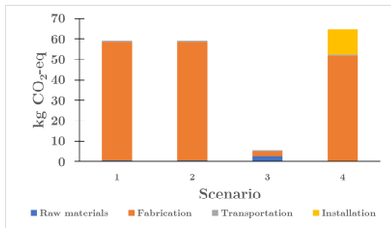
Test results and comparison to fired clay bricks.

Life Cycle Analysis

Four scenarios are studied:

1. Recycled wall, produced at LPAC, recycled at the end of life
2. Recycled wall, produced at LPAC, incinerated at the end of life
3. Recycled wall, produced in an industrial process in Switzerland, recycled at the end of life
4. Fired clay bricks according to KBOB [2]





The LCA shows that the highest impact of the bricks was related to the incineration of the recycled bricks. Without this impact, the recycled bricks allow a reduction of the environmental impact compared to the fired clay bricks. This reduction is significant for the scenario 3.

Conclusions and Future Research

All ingredients used are recycled. The compressive strength of the bricks is very promising, but the Young's modulus is significantly lower than for the reference materials. As a result, the bricks would need to be applied in low stress applications or in combination with a frame of a stiffer material. The proposed mortar-free connection appears to be effective, and it is shown that the environmental impact could be reduced by using the recycled bricks instead of fired clay bricks. However, more research is needed regarding fire resistance evaluations, local plastic waste and whether the proposed industrial process would be applicable.

[1] https://pre-sustainability.com/articles/life-cycle-assessment-lca-basics/
[2] https://www.kbob.admin.ch/kbob/fr/home/themen-leistungen/nachhaltiges-bauen/oekobilanzdaten_baubereich.html