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ReBuilt

Activity 2.2 – Upscaling and testing of green and bio-concrete products

D.2.2.3 Summary Report on Testing of New Circular Products

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Table of Content

1. Introduction

As part of Activity 2.2 – Upscaling and testing of green and bio-concrete products, various innovative material strategies were developed and tested to promote the use of sustainable and circular building materials in the construction industry. The main objective of this activity was to design, produce, and evaluate technical products based on biogenic and recycled materials and to assess their performance, durability, and environmental potential.

The work focused on the following material systems:

- Recycled concrete with 100 % recycled aggregates (PP14)
- Recycled concrete with alternative binders (PP10)
- Bio-concrete products: Hempcrete panels for sound insulation (PP3 and PP6, Hempstatic)
- Concrete with natural fibres (PP6 and PP14)

The implementation of Activity 2.2 included:

- Development and optimisation of bio-based and recycled concrete compositions
- Laboratory testing of mechanical, acoustic, and environmental properties
- Preparation and testing of technical product prototypes for use in pilot applications in Slovenia (PP3) and Germany (PP14)
- Life cycle assessment (LCA) to evaluate ecological performance compared to conventional materials
- Peer-to-peer exchange between project partners to ensure methodological consistency

This summary report **D.2.2.3 'Summary report on testing of new circular** products', the most important results of the investigations carried out in D.2.2.1 (Bio-Concrete) and D.2.2.2 (Green Concrete) are summarised.

- results from laboratory and pilot tests
- Evaluating performance, sustainability and practicality
- Identifying insights for future applications

construction industry. The aim was to develop and test materials based on biological and recycled materials and to evaluate their potential for use in practice.

2. Bio-Concrete (D.2.2.1)

Under D.2.2.1 'Report on tested bio-concrete solutions, two material approaches were investigated:

- Hempcrete panels as reusable lightweight elements for sound insulation (PP3, Hempstatic),
- Concrete with natural fibres (hemp) to improve crack resistance and sustainability (PP6).

2.1. Hempcrete Panels (PP3, Hempstatic)

The hempcrete panels developed by the start-up Hempstatic are reusable lightweight elements made from hemp shives and a lime-based binder, using regionally available raw materials. The design follows a circular approach, enabling reuse and recycling.

Laboratory tests confirmed high acoustic performance, low emissions, and good fire resistance. A life cycle assessment (LCA) showed a 94 % lower global warming potential compared to conventional polyurethane insulation materials.

The panels were installed in the pilot building in Maribor (Slovenia) for in-situ testing. Acoustic measurements before and after installation showed a significant reduction in reverberation and confirmed the effectiveness of the panels in improving room acoustics. The efficiency of sound absorption depends heavily on the installation conditions.

2.2. Concrete with Natural Fibres (PP6)

As part of the Bio-Concrete, the influence of hemp fibres on the properties of mortars with 100% recycled aggregates was investigated.

The results showed that the addition of hemp fibres had only a minor effect on the strength properties, while the crack behaviour and ductility were improved. Only the workability offers further potential for optimisation.

From an ecological point of view, hemp fibres offer a negative global warming potential of approx. -0.2 to -2.5 kg CO_2 equivalent/kg, based on literature values.

Compared to conventional fibre-reinforced concrete (e.g. with steel, glass or plastic fibres), bio-based fibres represent a sustainable and potentially recyclable alternative. This opens up an approach to the development of fully recyclable fibre-reinforced concrete.

3. Green Concrete (D.2.2.2)

Under D.2.2.2 'Report on tested green concrete solutions with 100 % recycled aggregate and alternative binders', three material approaches were investigated as green concrete:

- Recycled concrete with 100 % recycled aggregates (PP14)
- Concrete with alternative binders (PP10)
- Recycled concrete with 100 % recycled aggregates including natural fibres and alternative binders (PP14)

3.1. Recycled Concrete with 100 % Recycled Aggregate (PP14)

A concrete consisting of 100 % recycled aggregates was developed in the laboratory. The results show that there is no significant loss of strength or durability compared to conventional concrete. The recycled concrete conforms to EC2 requirements and has been successfully used in selected components of the pilot project in Germany. Long-term studies are currently ongoing to further validate its performance.

This demonstrated that concrete with 100 % recycled aggregates is an ecologically attractive alternative system, especially when regional recycling cycles exist and the binder content is optimized.

Recycled concrete contributes to the reduction of construction waste, the conservation of primary raw materials, and as a result, CO_2 reduction and resource conservation. It makes an important contribution to the circular economy in the construction industry. Recycled Concrete with a slightly higher cement content (approx. +12 kg/m^3 compared to NAC) achieved a comparable climate impact and provided, that longer transport distances or higher landfill costs are incurred in the linear system.

3.2. Concrete with Alternative Binders (PP10)

The effect of replacing up to 50% of Portland cement with alternative binders on the properties of concrete was investigated. The study used limestone powder, metakaolin and granulated blast furnace slag.

The results showed that initial strengths were lower due to the lower hydration heat. However, a continuous and significant increase in strength was observed as the concrete aged. Notably, the relative strength gains exceeded the respective replacement proportions (30–50%).

Overall, the results highlight the potential of low-carbon binders to reduce Portland cement usage while maintaining sufficient mechanical performance. Therefore, this approach offers a promising opportunity to reduce the carbon footprint of concrete.

3.3. Recycled Concrete with 100 % Recycled Aggregate Including Natural Fibres and Alternative Binders (PP14)

A concrete has been developed that consists entirely of recycled aggregates, hemp fibres and brick dust.

Test results show that this combination is ideal for producing concrete with enhanced mechanical properties and greater durability.

In particular, adding hemp fibres improves strength, reduces shrinkage and lowers carbonation depth.

Integrating natural fibres and alternative binders improves the mixture's overall sustainability and demonstrates the potential for fully recyclable concrete systems that combine mechanical performance with significant CO_2 savings.

4. Technical Products

The developed concretes and tested hempcrete panels are innovative technical products that help reduce CO_2, save natural resources, and promote circular construction.

Providing recyclable, low-emission alternatives to conventional materials, they demonstrate how sustainable product design can support the transition to a climate-neutral construction sector.

The concrete products investigated under Activity A2.2 for D2.2.1 and D2.2.2, and their main sustainability potentials, are shown in Table 1.

Table 1:Products and Potential

Product	Potential
Hempcrete Panel	- Improvement of room acoustics (sound absorption) - Fully demountable - Low-emission and recyclable material
100 % Recycled Concrete	- Saving resources - Contribution to circular economy - Reduction of primary raw material
Alternative Binder	- Improved durability - CO_2 reduction - Reduced clinker content
Natural Fibre Concrete	- Improved ductility and durability of recycled concrete - CO_2-negative fibre content - Recyclable fibre-reinforced concrete

Hempcrete panels and 100% recycled concrete have already been used in pilot projects in Slovenia and Germany. In Maribor, the hempcrete panels were installed indoors, where they demonstrated their acoustic effectiveness and positive impact on the indoor climate. In the 'Campus Ost' pilot project in Munich, 100% recycled concrete was successfully used for components such as bored piles, walls and ceilings.

These pilot applications confirm the technical feasibility and ecological advantages of these new materials under real construction conditions.

Further research and development work is underway to optimise the properties of the materials and the production processes. The aim is to establish these products on the market in the near future and implement new sustainable technical products.

Their broader application is highly desirable to advance the transition toward sustainable, circular, and low-carbon construction across Europe.