[H]house

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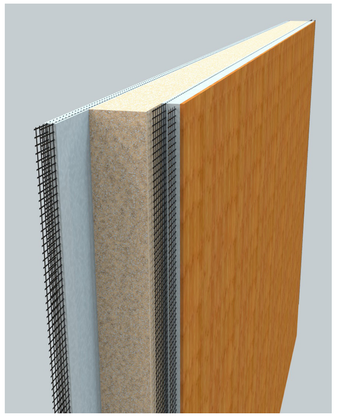
HEALTHIER LIFE WITH ECO-INNOVATIVE COMPONENTS FOR HOUSING CONSTRUCTIONS

Project Concept

The project has developed a variety of new multifunctional and flexible building components for a healthier indoor environment. [H] house solutions are durable, energy efficient, safe and affordable. They are suitable for use in new buildings and for renovation. [H] house solutions cover aspects of long service life, reduced maintenance and long-term improvement of energy efficiency.

This demonstrator presents composite concrete façade elements and internal partition walls made of natural building materials.
The façade elements consist of textile reinforced concrete (TRC) and very low-density foam concrete (FC) applied as insulation. The approach on the material level is the optimization of the cementitious binder by means of an increased amount of supplementary cementitious materials (SCM) , the use of non-corrosive reinforcement based on carbon fiber and glass fiber reinforced polymer (GFRP) connectors.
The innovative internal partition wall consists of sustainble, natural building materials that are new to the market. Their potential to contribute to a healthy and comfortable indoor environment, while reducing the need for mechanical ventilation, has been investigated and established.

TRC-FC Facade Elements



The TRC-FC composite elements offer a number of advantages like strongly reduced thickness, light weight and improved durability. Fire safety is assured through the use of an integrated insulation layer based on inflammable FC.
For new buildings, the elements are composed by a 30 mm external TRC layer, a 150 mm FC insulation layer and a TRC internal load-bearing layer of 50 mm. The inner surface of the element is rendered with an earth plaster.
Half-sandwich elements for renovation of existing buildings were also developed.

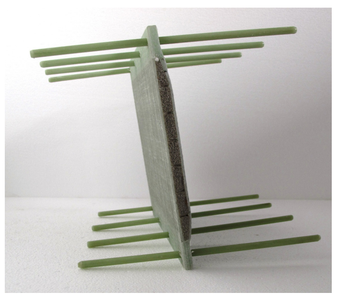
◀ TRC-FC composite façade element, © CBI

Textile Reinforced Concrete

TRC is a high-performance, fine graded and self-compacting concrete mix with a high level of clinker replacement (45% fly ash) for reduced embodied energy.
Steel reinforcement is replaced by carbon fiber grid, significantly reducing thickness and weight whilst improving durability by avoiding corrosion.

▲ TRC with double layer of carbon fiber grid, © CBI

Connectors



GFRP plate shear connectors transfer the loads from the front to the back panel. These were produced by an infusion process of E-glass and epoxy resin and a PVC core for increased stiffness. Reinforcement bars were pultruded from E-glass and impregnated with epoxy resin.

◀ GFRP plate shear connector, © Mostostal

Foam Concrete

▲ Foam concrete, © Aercrete

Foam concrete is a highly porous cementitious material with good thermal and acoustic insulation properties.
In [H]house, the use of Arcrete Aercell A-7® foaming agent and Buzzi Unicem NEXT® cement allowed the development of rapid setting foam concrete with a dry density of 130 kg/m3 and a thermal conductivity as low as 40 mW/(m·K).

▲ Quartzene aerogel, © Svenska Aerogel

Svenska Aerogel AB has a patented ambient pressure drying technology that allows the production of Quartzene® aerogel at a much lower cost.
In [H]house, the incorporation of Quartzene® aerogel into foam concrete allowed to further reduce the thermal conductivity of the insulation layer down to 0.03 W/(m·K).

Life Cycle Assessment

The environmental impacts of the new TRC-FC elements were compared to those of a conventional reinforced concrete wall with EPS insulation having the same U-value of 0.15 W/(m²·K).

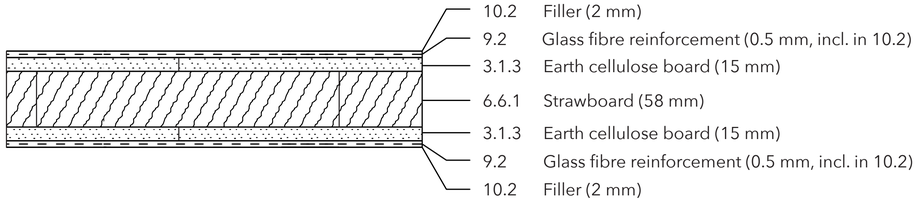
Building component	Non-renewable energy	Global warming potential
TRC-FC composite element	1350 MJ/m²	88 kg (CO_2 eq)/m²
Conventional solution (reinforced concrete / EPS)	2215 MJ/m²	328 kg (CO_2 eq)/m²
Saving of energy & CO_2	865 MJ/m²	240 kg (CO_2 eq)/m²

▲ Comparison of the environmental impacts of TRC-FC composite element with conventional reinforced concrete wall with EPS insulation (LCA performed by CYCLECO)

Internal Partition Wall

The internal partition wall is designed as solid board construction, which makes the traditonal timber stud system as support structure redundant. The selfsupporting core consists of a strawboard, which is covered with an earth cellulose board either side to improve the hygrtothermal performance but also the noise protection. An earth cellulose filler is applied as final finish.
All materials demonstrate very low to no emissions, and are fully recyclable. In addition, the earth cellulose board is able to remove airborne pollutants such as VOC's.

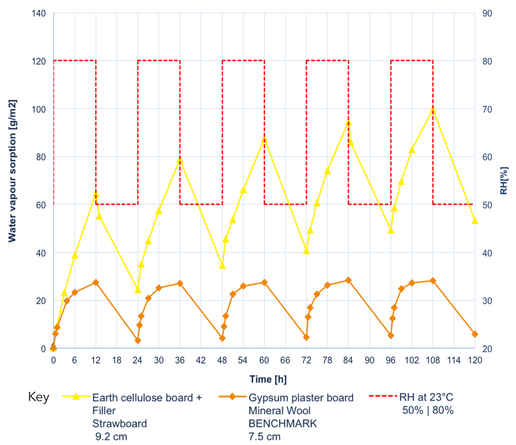
◀ 1:1 Sample wall build-up showing single layers and connection means



Result noise protection test: $R_W(C;C_{tr})$ = 44 (0; -3) dB

Total thickness of the wall build-up: 9.2 cm

Water Vapour Sorption Capacity



A new test method to determine the moisture sorption performance of internal partition walls has been developed. The specimen are undergoing five ad- and desorption cycles (12 h each) to indetify the capacity and potential hysteresis effects, while taking into account the potentially slower desorption process.
A comparison of a conventional wall build-up with an innovative one, based on a straw - and earth cellulose boards demonstrated that natural building materials adsorb 3 times more moisture and contribute to a healthier and more comfortbale indoor environment as they are able to regulate and stabilise RH levels.
In addition, these constructions minimise the risk for mould growth and condensation and protect the building fabric against defects.

◀ Water vapour sorption test (following DIN 18947)

Acknowledgements

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