[H]house

H-House is a collaborative research project and has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 608893.

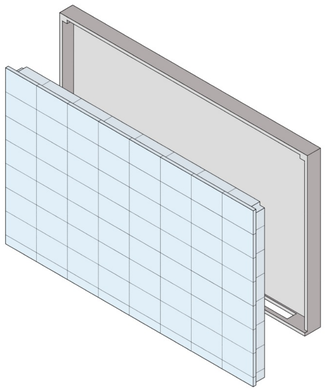
HEALTHIER LIFE WITH ECO-INNOVATIVE COMPONENTS FOR HOUSING CONSTRUCTIONS

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 ultra high-performance concrete (UHPC) and very low-density autoclaved aerated concrete (AAC) 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) and an additional functionalization of the UHPC element surfaces towards self-cleaning properties.
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.

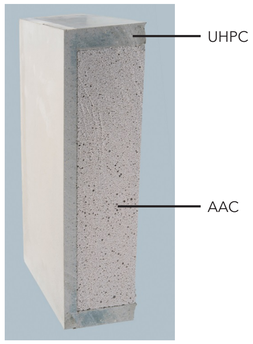
UHPC-AAC Facade Elements



The UHPC-AAC composite elements offer a number of advantages such as strongly reduced thickness, light weight and improved durability. Fire safety is assured through the use of an integrated insulation layer based on inflammable AAC.
Due to the special structure of the very light-weight AAC (MULTIPOR®) the insulation core of the elements has a remarkably low thermal conductivity (λ_D) of 0.042 W/(m·K).

◂ UHPC-AAC composite façade element, © BAM

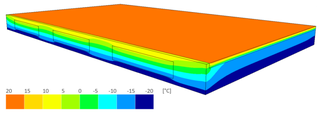
UHPC Cementitious Binder



The aim of the UHPC development was the highest possible replacement of Portland cement clinker by SCMs considering a minimum compressive strength of 100 MPa. The research of the binder composition resulted in the **[H]house Compound 5941** that is available for purchase in grey and white. With less than 55% Portland cement clinker, the embodied energy of the developed binder system is greatly reduced.

◂ Section of UHPC-AAC composite element, © BAM

Thermal Performance

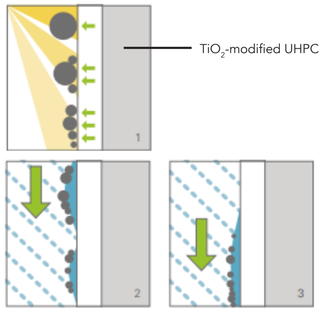


▴ Heat transfer profile of UHPC-AAC composite element, © ITB

[H]house aims at improving the energy efficiency of the building envelope by reducing the heat transmission of the façade elements. For this purpose the shape of the elements was optimised in an iterative process where numerical thermal modelling supported the structural design.

Self-Cleaning Surfaces

▴ Super hydrophobic surface of UHPC elements, © BAM



▴ Self-cleaning effect of photocatalytic surface

The granulometric optimization of the UHPC and an advanced casting technique allow a micro-structuring of the concrete surfaces. The combination with water-repellent agents directly applied on the textured formwork leads to a super hydrophobic UHPC that makes raindrops easily run-off and remove dirt deposits from the surface.

The addition of photoactive titanium dioxide (TiO2) to the UHPC provides it with photocatalytic self-cleaning:

1 The UV radiation of the sunlight is activating the breakdown of dirt deposited on the photocatalytic surface;

2-3 Decomposed dirt particles are detached from the surface and removed by rainwater that flows down the façade.

Life Cycle Assessment

The environmental impacts of the new UHPC-AAC elements were compared to those of a conventional rear-ventilated reinforced concrete cladding with mineral wool insulation having the same U-value of 0.15 W/(m²·K).

Building component	Non-renewable energy	Global warming potential
UHPC-AAC composite element	1308 MJ/m²	118 kg (CO_2 eq)/m²
Conventional solution (cladding/mineral wool)	1586 MJ/m²	123 kg (CO_2 eq)/m²
Saving of energy & CO_2	278 MJ/m²	5 kg (CO_2 eq)/m²

▴ Comparison of the environmental impacts of UHPC-AAC composite element with conventional rear ventilated reinforced concrete cladding with mineral wool insulation (LCA performed by CYCLECO)

Acknowledgements

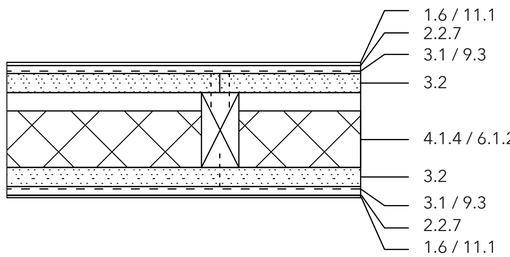
[H] house acknowledges the friendly support of:

JORDAHL anchored in quality · BASF The Chemical Company · schoeller Switzerland · HALFEN · RECKLI DESIGN YOUR CONCRETE · WACKER · CLAYTEC Baustoffe aus Lehm · pavatex

Internal Partition Wall

The internal partition wall is designed as timber stud construction, which is covered with a wood fibre wall lining board. The board is plastered with a fine earth plaster, which is painted with a marble flour paint. A wood fibre mat is used as insulation layer.
All materials demonstrate an outstanding water vapour sorption behaviour, very low to no emissions, a good noise protection and are fully recyclable. In addition, the earth plaster is able to remove airborne pollutants such as VOC's.

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

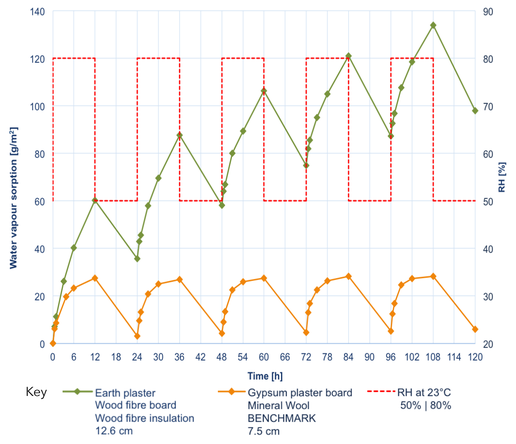


1.6 / 11.1	Marble flour paint / Casein primer (0.05 mm)
2.2.7	Earth fine plaster final coat (3 mm)
3.1 / 9.3	Earth adhesive / Flax fibre reinforcement (3 mm)
3.2	Woodfibre board (22 mm)
4.1.4 / 6.1.2	Woodfibre insulation mat (60 mm) / Timber stud (80 mm x 40 mm, 37.5 cm distance)
3.2	Woodfibre board (22 mm)
3.1 / 9.3	Earth adhesive / Flax fibre reinforcement (3 mm)
2.2.7	Earth fine plaster final coat (3 mm)
1.6 / 11.1	Marble flour paint / Casein primer (0.05 mm)

Result noise protection test: $R_W(C;C_{tr})$ = 45 (-1; -6) dB

Total thickness of the wall build-up: 13.6 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 (gypsum plasterboard) with an innovative one, based on earthen plaster and wooden materials, demonstrated that natural building materials adsorb 5 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)

RI SE · BAM · ITB quality in construction Building Research Institute · AERCRETE www.aercrete.se · CYCLeco Life Cycle Assessment · Roswag Architekten · AEROGEL · FASADA · Dyckerhoff · CONSOLIS STRÄNGBETONG · Xella · Mostostal WARSZAWA