The project has developed a variety of new multifunctional and flexible building components for a healthier indoor environment. The developed systems are suitable for new buildings and renovation. H-House solutions are durable, energy efficient and affordable. They are suitable for different applications and environments and cover aspects of long service life, reduced maintenance and long-term improvement of energy efficiency. This demonstrator is focused on the building envelope and the development of sandwich façade elements consisting of ultra high performance concrete (UHPC) and autoclaved aerated concrete (AAC). The approach on the material level is an 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.

**UHPC Façade Elements**

The resulting UHPC composite elements offer a number of advantages like reduced thickness and weight or improved durability. Fire safety is assured through the use of integrated insulation based on non-combustible autoclaved aerated concrete insulation boards (Multipor® from Xella). Due to the special structure of the mineral insulation, the AAC core of the elements has a remarkable low thermal conductivity ($\lambda$) of 0.042 W/(m·K).

**UHPC Cementitious Binder**

The aim of the binder development was the highest possible replacement of Portland cement clinker by SCM's within an UHPC mix design and a minimum strength requirement of 100 MPa. The resulting binder composition is named [H]house Compound 5941 and available in grey and white. With less than 55% Portland cement clinker, the embodied energy of the developed binder system is greatly reduced. The following table shows the most essential figures of the LCA.

<table>
<thead>
<tr>
<th>Material / building component</th>
<th>Non-renewable energy</th>
<th>Global warming potential GWP</th>
</tr>
</thead>
<tbody>
<tr>
<td>UHPC-AAC half panel</td>
<td>1,038 MJ/m² wall</td>
<td>118 kg CO₂ eq./m² wall</td>
</tr>
<tr>
<td>Conventional solution</td>
<td>1,586 MJ/m² wall</td>
<td>1,223 kg CO₂ eq./m² wall</td>
</tr>
<tr>
<td>Heating and CO₂</td>
<td>278 MJ/m² wall</td>
<td>6 kg CO₂ eq./m² wall</td>
</tr>
</tbody>
</table>

**Surface Functionalization**

- **Surface Functionalization I**
  - The granulometric optimization of [H]house Compound 5941 and an advanced casting technique allows a micro-structuring of the concrete surfaces. The application of water-repellent agents directly on the textured mould leads to super hydrophobic concrete surfaces.
  - Super hydrophobic surface of the elements (photo: BAM)

- **Surface Functionalization II**
  - By addition of titanium dioxide (TiO₂) to the concrete multifunctional surfaces with photocatalytic and self-cleaning properties are possible.
  - Self-cleaning effect of photocatalytic active surfaces (source: Roswag)

**Thermal Performance**

- H-House aims to improve the energy efficiency of the building envelope by reducing the heat transmission coefficient (U-value) of the façade elements. The thermal conductivity of the materials was measured in accordance to EN 12664 using the Guarded Hot Plate method.

**Project Framework**

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.

- Runtime: September 2013 to August 2017
- Consortium: 12 partners from 4 EU countries
- Coordinator: CBI Swedish Cement and Concrete Research Institute
- Homepage: [http://www.h-house-project.eu](http://www.h-house-project.eu)

**Demonstration Object**

The development and implementation of the demonstrator concept was realized by project partner Dyckerhoff, a member of the Büchi Unicem Group:

- Dyckerhoff GmbH
- Wilhelm Dyckerhoff Institute for Building Materials Technology
- Dyckerhoffstr. 7
- D-65203 Wiesbaden, Germany

**U-value calculation based on UHPC-AAC half panel with a total thickness of 30 cm and cladding with mineral wool insulation of 22 cm thickness and 4 connectors in m² (thermal properties measured and calculated by ITB)**

<table>
<thead>
<tr>
<th>Element</th>
<th>U-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>H-House target value (low energy house)</td>
<td>0.15 W/(m²·K)</td>
</tr>
<tr>
<td>Conventional solution (cladding/mineral wood)</td>
<td>0.18 W/(m²·K)</td>
</tr>
<tr>
<td>UHPC-AAC half panel</td>
<td>0.15 W/(m²·K)</td>
</tr>
</tbody>
</table>

**Project Partners**

- Dyckerhoff
- Xella
- CBI Swedish Cement and Concrete Research Institute
- KTH Royal Institute of Technology
- BAM (Building Materials Institute)
- ITB (Institute for Thermal Building Physics)
- BAM (Building Materials Institute)
- CBI Swedish Cement and Concrete Research Institute
- University of Twente
- KTH Royal Institute of Technology
- EPFL (Ecole Polytechnique Fédérale de Lausanne)

**Energy and CO₂ savings**

- Table with heat transmission coefficients of UHPC-AAC half panel vs. conventional, non-combustible cladding.

**Heat transfer profile of UHPC-AAC composite element calculated according to EN ISO 6496 applying 3D Physibel software (source: ITB)**

**Table with non-combustible building materials based on UHPC-AAC in renovated building in Berlin (Germany), considered life span of components = 55 years; the benefit of UHPC-AAC half panels with respect to the conventional solutions increases with aging due to the limited life span of mineral wool (LCA performed by CYCLECO)**

**Table with heat transmission coefficients of UHPC-AAC half panel vs. conventional, non-combustible cladding.**

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