Long-Term Performance of Super-Insulating Materials in Building Components & Systems

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Reading 2015 /April

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Challenges in the Building Sector

Renovation/Retrofitting
- Building stock: more than 80% of energy consumption.
- 75% to 90% of current buildings will still be standing in 2050.

New Buildings
- NZEB (Net or Nearly Zero Energy Building)
- only 10% to 20% of additional energy consumption (2050)

Energy Efficiency
- Through Building Envelope & Thermal Insulation
  (IEA Roadmap)
Scope

Two main types of SIM:
- Vacuum Insulation Panel
- Advanced-Porous Materials, such as Aerogel

State of the Art
Learning from the past (ST1)

Three scientific & technical issues:
Performance & Durability - (ST2)

Design & Installation (ST3)

Sustainability (LCA, LCC, EE) – (ST4)
Table 1: Summary of the insulation materials

<table>
<thead>
<tr>
<th>Insulation Material</th>
<th>Thermal conductivity (mW/K)</th>
<th>Density (kg/m³)</th>
<th>Prices (US $)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mineral wool</td>
<td>30-40 at 10 °C</td>
<td>30-200</td>
<td>0.5-4.2/Square meter</td>
</tr>
<tr>
<td>Expanded Polystyrene (EPS)</td>
<td>30-40 at 10 °C</td>
<td>100-150</td>
<td>3.5-5.2/Square meter</td>
</tr>
<tr>
<td>Extruded Polystyrene (XPS)</td>
<td>30-40 at 10 °C</td>
<td>120-200</td>
<td>1/Square meter</td>
</tr>
<tr>
<td>Cork</td>
<td>45 at 25 °C</td>
<td></td>
<td>0.2-2/Piece</td>
</tr>
<tr>
<td>Polyurethane (PUR)</td>
<td>35 at 10 °C</td>
<td>40-60</td>
<td>(H-26mm, D-13mm)</td>
</tr>
<tr>
<td>Cellulose</td>
<td>35 at 10 °C</td>
<td>24-27.2</td>
<td>2.2–2.5/Kilogram</td>
</tr>
<tr>
<td>Vacuum Insulated Panel (VIP)</td>
<td>3-4 at 10 °C</td>
<td>—</td>
<td>7.18–7.45/Kilogram</td>
</tr>
<tr>
<td>Gas-filled Panels (GFP)</td>
<td>36.1 for Air</td>
<td>—</td>
<td>5-28/Square Meter</td>
</tr>
<tr>
<td></td>
<td>49.2 for Argon</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td></td>
<td>86.7 for Krypton</td>
<td>—</td>
<td></td>
</tr>
<tr>
<td>Aerogel</td>
<td>13-16 at atmospheric pressure</td>
<td>3</td>
<td>75.24/Square Meter</td>
</tr>
</tbody>
</table>

Source: (Alibaba, 2012); (Thermablok, 2010); (Foamsales, 2012)
Annex65 & SIM value chain

ST1 : learning from the past

ST2 : Testing/Ageing

1. Raw Materials

2. Films

3. Porous Materials
   Aerogel

4. VIP

5. Porous Materials

6. Components

7. Systems

8. ST3 : Installation
   Testing/Ageing

9. ST2 : Testing/Ageing

10. ST2 : Testing/Ageing

11. ST2 : Testing/Ageing

12. VIP

13. ST4 : Sustainability
Annex65: a bridge between science & market

ST1: learning from the past

ST2

Knowledge Science

ST3

Market/Standard Production/Industry

ST4: Sustainability

Buildings

Testing

http://aasarchitecture.com/2013/03/phyllis-j-tilley-memorial-bridge-by-rosales-partners-architects.html
SubTask Description - SubTask Leaders

SUBTASK 1: State of the Art - Materials & Components - Case Studies
SubTask Leader: ZAE Bayern – Ulrich Heinemann
Action 1A : Materials, Components & Systems
Action 1B : Characterization Methods
Action 1C : Case Studies at the Building Scale

SUBTASK 2: Characterization of materials & components - Lab Scale
SubTask Leader: FIW Munich – Andreas Holm
Action 2A : Materials Assessment & Ageing Procedures
  (Experiments & Simulation)
Action 2B : Components & Systems Assessment
  (Experiments & Simulation)
SUBTASK 3: Practical Applications – Retrofitting

Subtask Leader: Chalmers Univ.  Bijan Adl Zarrabi

Action 3A : Mapping of the Use Conditions (Components & Systems)
Action 3B : Performance at the Building Scale (Experiments & Simulation)
  (possible links with Annex 58)
Action 3C : Practical Applications focused on Retrofitting
  (possible links with Annex 61)

SUBBASK 4: Sustainability (LCC, LCA, EE)

Subtask Leader : Chalmers Univ.  Holger Wallbaum

Action 4A: Life Cycle Assessment (LCA), including Embodied Energy (EE)
  (links with Annex 57)
Action 4B: Life Cycle Cost Analysis (LCC)
36 Participants from Countries: 16

Belgium: Recticel, Dow Corning,
Canada: Ryerson University - Toronto
China: Nanjing University of Aeronautics and Astronautics (NAUU), Siltherm, Creek
France: EDF, Mines-Paristech, INSA Lyon, Univ. Lorraine, CNEES, Saint-Gobain, Toray, ArcelorMittal, REXOR, PCAS, CSTB,
Germany: ZAE Bayern, Fraunhofer IVV, va-Q-tec, FIW Munich, Evonik, DLR, Metra-Group, Porextherm, Cabot, Aspen-Aerogel
Greece: National Technical University of Athens (NTUA)
Italy: Politecnico di Milano, Politecnica di Torino
Israel: Hanita Coatings (observer)
Japan: Annex65 Japanese Support Committee
Norway: SINTEF
Sweden: Chalmers University
Switzerland: EMPA
South Korea: Kongju National University, OCI
Spain: Tecnalia,
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Long-Term Performance of Super-Insulating Materials

**Task 3: Practical Applications – Retrofitting at the Building Scale – Field scale**

**Subtask Leader: Chalmers Univ. Bijan Adl Zarrabi**

Action 3A: Mapping of the Use Conditions (Components & Systems)

Action 3B: Performance at the Building Scale (Experiments & Simulation)

(possible links with Annex 58)

Action 3C: Practical Applications focused on Retrofitting

(possible links with Annex 61)
Course of action:

Pre study → Gap identification → Filling the gaps

- Complementary guidelines, recommendations & tools
- Future research

Existing Annex & etc
Existing recommendations
Case Studies

• General guidelines/tools/..
• Specific guidelines/tools/..
• Special cases/tools/..
Parameters:

- **Type of building**
  - Single family house
  - Multi family house
  - Office
  - Special building e.g. hospital, fitness centre, ...

- **Components**
  - Walls
  - Roof
  - Floor
  - Windows
  - Ground
  - ......

- **Climate**
  - Cold/warm
  - Dry/wet
  - Windy
  - ......

- **Age of building**
  - New
  - Old
  - Medium
SIM in buildings

• Retrofitting
  – Wall
  – Roof
• New buildings
  – Wall
  – Roof
  – Terraces

Field study
Välten 1930

Photo: Sören Nilssons vykortssamling, 1930
Field study building

- Landshövdingehus from 1930, retrofitted in the late 1970s
Wall insulated on the exterior

Energy use (kWh/m²)
Before: 158.7
After: 127.5 -20%

Thermal bridges 3-7% increase
External and internal Insulation

Applications
Case Studies
Installation Tips
Retrofitting Munich

External Wall Insulation - Heritage

- Project: Renovation
- Location: Switzerland
- Bldg. Type: Private Dwelling
- Application: External Wall 20mm, 10mm
- Benefit: Heritage protected, breathable thermal bridge treatments
External Wall Insulation

- Project: Renovation
- Location: USA
- Bldg. Type: Industrial Unit
- Application: External Wall – 20mm under rolled metal profile
- Benefit: Space saving, energy saving fast install, existing trades compatible
Internal Wall Insulation

- Project: Renovation
- Location: Italy
- Bldg. Type: House
- Application: Internal Wall
- Benefit: Energy Saving, Space Saving
Interior insulation
Copenhagen

http://dx.doi.org/10.1016/j.enbuild.2012.07.046
Facade and roof, Thun
New office block Munich

- First commercial VIP project
- Concrete with VIPs, PUR between VIPs
- "Ultra low energy standard" (20 kWh/m²,a)
Internal Wall Insulation - Heritage

- Project: Renovation
- Location: Podebrady, Czech Rep.
- Bldg. Type: Commercial, Dwelling
- Application: Internal Wall – 20mm, 10mm
- Benefit: Heritage protected, breathable, thermal bridge treatments, challenging environment
Heritage Detail

Existing Cornice
Existing Solid Wall
3mm Magnesium board
20mm existing lime plaster
Angle bead
3mm Lime plaster
20mm Aerogel Insulation
9mm Magnesium board
Existing Skirting
Roof and floor Insulation
Flat roofs and terraces

Source: Dr. Samuel Brunner, EMPA

other thermal bridges on the dominating VIP application (over 90% of the Swiss market)

(25 000 m²)
Dormer Roof Insulation

- Project: New Build
- Location: Switzerland
- Bldg. Type: Single Family
- Application: Onsite fabricated dormer roof elements
- Benefit: Energy saving, improved aesthetic appearance, reduced heat bridges, increased light gain
Facade and roof, Thun, Switzerland
Pitched Roof Insulation - Heritage

- **Project**: Renovation
- **Location**: Dublin, Ireland
- **Bldg. Type**: Government, historic stone
- **Application**: 20mm Pitched roof insulation
- **Benefit**: Energy saving, space saving, vapour open to allow roof elements to breathe

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**Figure 1 – inside view of existing roof**

**Request for analysis**
Client wishes to assess performance of Aspen Aerogel as roof insulation in warm-roof buildup between a timber ceiling deck and battens of a vaulted Victorian courthouse building in the south suburbs of Dublin. Roof buildup to be absolutely minimised. Building to be intensely used by small number of people with a lot of electronics.
Flat roofs och terraces

(25 000 m²)

Mineralull 120 mm
VIP 20 mm

Indoor (heated)
Outdoor
Drain gutter
VIP

Same level

Apartment below terrace (heated)

Terrace Insulation

- Project: Renovation
- Location: Switzerland
- Bldg. Type: Multi Family – concrete terrace
- Application: Terrace Insulation
- Benefit: Energy saving, height gain, no disruption to fixtures, no water ingress risk
Thermal Bridge Treatments
Heat Bridge Insulation - Reveals

- Thin reveals do not interfere with window function
- Maintain temperature factors above condensation limits
Apartment Thermal Bridges

- Project: Renovation
- Location: Ireland
- Bldg. Type: Apartment Block
- Application: 10mm thermal bridge treatment
- Benefit: lower $\psi$ values, space saving solution
Thank you for your attention