Comparative Analysis of an Existing Public Building Made from Natural Building Materials and Reference Buildings Designed from Common Building Materials

By Péter Medgyasszay

Budapest University of Technology and Economics, Department of Construction Materials and Technologies
Content

1: Research questions (role of natural building materials)
2: Method (building variations, LCA, LCC)
3: Results (LCA, LCC)
4: Conclusions
Research questions

**Building and constructions** [1]

36% of global final energy use

39% of energy-related CO₂ emission

**Proposed new constructions**[1]

By 2060 230 billion m² new building (every year 1 Japan)

**Proposed change of construction and operation** [2]

<table>
<thead>
<tr>
<th>Year</th>
<th>Construction</th>
<th>Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>15%</td>
<td>82%</td>
</tr>
<tr>
<td>2050</td>
<td>43%</td>
<td>50%</td>
</tr>
</tbody>
</table>

**What are the environmental benefits of using natural building materials?**
The realised case study building

1: R. Questions – 2: Method – 3: Results – 4: Conclusions

P. Medgyasszay: Comparative analysis…
Graz, 12. 09. 2019.
Examined variations of case study building (both public and dwelling function)

<table>
<thead>
<tr>
<th>Main constructions and HVAC system</th>
<th>Realized building</th>
<th>Imagined building 2010 fulfils the energetic requirements from the year 2010</th>
<th>Imagined building 2019 fulfils the energetic requirements from the year 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>- Pile foundation,</td>
<td>- Pile foundation,</td>
<td>- Pile foundation,</td>
<td></td>
</tr>
<tr>
<td>- Wall: wood frame, adobe brick</td>
<td>- Wall: brick wall U=0,45</td>
<td>- Wall: brick wall with 10 cm EPS U=0.22</td>
<td></td>
</tr>
<tr>
<td>and straw bale insulation U=0,15</td>
<td>- Roof: 15 cm rock wool insulation U=0,24</td>
<td>- Roof: 25 cm rock wool insulation U=0,15</td>
<td></td>
</tr>
<tr>
<td>- Roof: 25 cm rock wool</td>
<td>- Floor: 6 cm EPS, insulation U=0,49</td>
<td>- Floor: 12 cm EPS, insulation U=0,3</td>
<td></td>
</tr>
<tr>
<td>insulation U=0,15</td>
<td>- Openings: double glazing U=1,4</td>
<td>- Openings: wood frame, triple glazing U=0,8</td>
<td></td>
</tr>
<tr>
<td>- Floor: 5 cm EPS, 15 cm XPS</td>
<td>- H, HWS: gas boiler</td>
<td>- H, HWS: condensing gas boiler</td>
<td></td>
</tr>
<tr>
<td>insulation U=0,33</td>
<td>- No air-conditioning</td>
<td>- No air-conditioning</td>
<td></td>
</tr>
<tr>
<td>- Openings: wood frame, triple</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>glazing U=0,8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- H, HWS: wood chip boiler</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>- No air-conditioning</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1: R. Questions – 2: Method – 3: Results – 4: Conclusions

P. Medgyasszay: Comparative analysis…
Graz, 12. 09. 2019.
Operating parameters

Public building
- average air-change rate: 1.16 l/h
- internal heat gain: 7 W/m²
- correction factor because of intermittent use: 0.4
- net specific energy demand of lighting: 6 kWh/m²·yr
- reducing factor of lighting: 0.6
- Net specific energy demand of hot water supply: 7 kWh/m²·yr.

Residential building
- average air-change rate: 0.5 l/h
- internal heat gain: 5 W/m²
- correction factor because of intermittent use: 0.9
- net specific energy demand of lighting: 0 kWh/m²·yr,
- reducing factor of lighting: -
- Net specific energy demand of hot water supply: 30 kWh/m²·yr.
LCA calculations for all 6 variations

**Data sources:** Ecoinvent 2.0

**Examined indicators:**
- non-renewable cumulative energy demand (CED, n.r.) [MJ]
- global warming potential (GWP100a, CML 2001) [kg CO2-eq]
- acidification potential (AP, CML 2001) [kg SO2-eq]

1: R. Questions – 2: **Method** – 3: Results – 4: Conclusions

P. Medgyasszay: Comparative analysis…
Graz, 12. 09. 2019.
LCC calculations for 4 variations

Method: EN 15459
Main basic parameters:

- calculation period: 30 years,
- discount rate, excluding inflation 4%,
- long-term energy price escalation: 2% for electricity and wood and 2.8% for natural gas,
- 50 HUF/kWh for electricity,
- 8.3 HUF/ kWh for wood chips,
- 16 HUF/kWh for natural gas.

1: R. Questions – 2: Method – 3: Results – 4: Conclusions
Cumulative energy demand [MJ/yr]

1: R. Questions – 2: Method – 3: Results – 4: Conclusions

Global warming potential [kg CO$_2$-eq/yr]

Public building

Residential building

1: R. Questions – 2: Method – 3: Results – 4: Conclusions

P. Medgyasszay: Comparative analysis…
Graz, 12. 09. 2019.
Acidification potential [kg SO₂-eq/yr]

1: R. Questions – 2: Method – 3: Results – 4: Conclusions

P. Medgyasszay: Comparative analysis…
Graz, 12. 09. 2019.
Global cost (LCC) [1000 HUF]

Public building

Residential building

1: R. Questions – 2: Method – 3: Results – 4: Conclusions

P. Medgyasszay: Comparative analysis…
Graz, 12. 09. 2019.
1) Impact of the use of natural building materials on the wall structure is positive and significant.

2) Due to the higher energy requirements the environmental impact of constructions is increasing.

<table>
<thead>
<tr>
<th></th>
<th>Realized building</th>
<th>Imagined building 2010 fulfils the energetic requirements from the year 2010</th>
<th>Imagined building 2019 fulfils the energetic requirements from the year 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>CED [MJ/yr]</td>
<td>1394,53</td>
<td>4089,75</td>
<td>5766,36</td>
</tr>
<tr>
<td>GWP [kg CO₂-eq/yr]</td>
<td>82,72</td>
<td>314,41</td>
<td>413,65</td>
</tr>
<tr>
<td>AP [kg SO₂-eq/yr]</td>
<td>0,51</td>
<td>1,21</td>
<td>1,53</td>
</tr>
</tbody>
</table>
3) The environmental impact of wall structures is not significant compared to the environmental impact of the other structures and mechanical systems.

<table>
<thead>
<tr>
<th></th>
<th>Realized building</th>
<th>Imagined building 2010 fulfils the energetic requirements from the year 2010</th>
<th>Imagined building 2019 fulfils the energetic requirements from the year 2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>CED [MJ/yr]</td>
<td>31251,71</td>
<td>30146,88</td>
<td>36240,33</td>
</tr>
<tr>
<td>GWP [kg CO$_2$-eq/yr]</td>
<td>2219,16</td>
<td>2055,34</td>
<td>2440,71</td>
</tr>
<tr>
<td>AP [kg SO$_2$-eq/yr]</td>
<td>17,72</td>
<td>15,84</td>
<td>17,43</td>
</tr>
</tbody>
</table>

4) In the case study, the greatest environmental benefit is not connected to the construction phase but to the operation phase.
5) From the point of view of LCC analyses the phase of construction phase, while from the point of view of LCA analysis the operation phase is dominant at the common residential building.
6) At present, the savings in environmental load by using natural materials is not significant in Hungary, but it is expected to become an increasingly important area in the future.

References

Thank you for your attention!

Péter Medgyasszay

www. em.bme.hu