Building Performance Evaluation

A design approach for refurbishment of a small traditional building in Scotland

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Land Sea and Islands Centre - Arisaig
Drivers

• EU Energy Performance of Buildings Directive
• Climate change and CO$_2$ emission targets
• National Planning Framework recognition of conservation of historic environment
• LSIC appointed architect with experience of refurbishment of existing buildings
• Climate Challenge Fund to improve energy efficiency
• Goal 75% reduction CO$_2$ emissions
• Model for similar buildings – domestic and non-domestic in rural setting
• Architect required understanding of pre-refurbishment performance
• Innovation Voucher from Scottish Funding Council Pre-refurbishment (BPE)
• Funding from Zero Waste Scotland Post-refurbishment (BPE)
BPE - Work Undertaken

• Questionnaires with volunteers

• Airtightness test with thermography

• In-situ U-value testing

• Indoor environment monitoring

• Electrical energy monitoring
BPE – Monitored Rooms

Figure: © Sam Foster Architects
Results – Building Users

• Internal temperature too cold

• Bulk up with layers in winter

• Building too draughty in winter

• Heating on all of the time

• Condensation forming on some windows

• Not certain how to operate all controls in the building
Results - Airtightness

- Joist ends
- Wall junctions
- Window heads and sills
- Pipe penetrations
- Electrical penetrations
- Air permeability - 18.04 m$^3$/h.m$^2$ @ 50Pa
- Air changes per hour ~ 0.9ACH
## Results – In-situ U-Value

<table>
<thead>
<tr>
<th>Room</th>
<th>Building Element</th>
<th>Approx Orientation</th>
<th>Theoretical U-Value (W/m²K)</th>
<th>In-situ U-Value (W/m²K)</th>
<th>1999 Elemental U-Values (W/m²K)</th>
<th>2013 Elemental U-Values (W/m²K)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Room with a View</td>
<td>Ceiling</td>
<td>East</td>
<td>0.43</td>
<td>0.72</td>
<td>0.20</td>
<td>0.20</td>
</tr>
<tr>
<td>Room with a View</td>
<td>Wall</td>
<td>East</td>
<td>0.49</td>
<td>0.40</td>
<td>0.30</td>
<td>0.27</td>
</tr>
<tr>
<td>Exhibition</td>
<td>Lined Wall</td>
<td>East</td>
<td>0.49</td>
<td>0.25</td>
<td>0.30</td>
<td>0.27</td>
</tr>
<tr>
<td>Exhibition</td>
<td>Stone Wall</td>
<td>North</td>
<td>1.64</td>
<td>0.93</td>
<td>n/a</td>
<td>0.27</td>
</tr>
</tbody>
</table>

Table: © MEARU
Results – Indoor Environment

Land Sea and Islands Centre
Internal Room Temperature
03 Dec 2014 - 08 Jan 2015

Figure: © MEARU
Results – Electrical Energy

**Land Sea and Islands Centre**

**Electrical Energy Consumption**

05 Dec 2014 - 02 Jan 2015

Figure: © MEARU
Refurbishment
Refurbishment
BPE - Work Undertaken

- Questionnaires with volunteers
- Airtightness test with thermography
- In-situ U-value testing
- Indoor environment monitoring
- Electrical energy monitoring
Results – Building Users

• Comfortable internal temperature

• Only two radiators used for thermal comfort

• Windows now opened to ventilate

• All trained in how to operate systems

• Visitors remain in the building for longer

• Hosting more community events

• Building now used through the winter!
Results – Airtightness

<table>
<thead>
<tr>
<th>Test</th>
<th>Air Permeability Measurements (m³/h.m² @ 50Pa)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Negative</td>
</tr>
<tr>
<td>Pre-Refurbishment</td>
<td>16.76</td>
</tr>
<tr>
<td>Post-Refurbishment</td>
<td>2.61</td>
</tr>
</tbody>
</table>

Air permeability – 85% Reduction infiltration to the building
## Results – In-situ U-Value

<table>
<thead>
<tr>
<th>Room with a View</th>
<th>Building Element</th>
<th>Approx Orientation</th>
<th>Theoretical U-Value (W/m²K)</th>
<th>In-situ U-Value 2014 (W/m²K)</th>
<th>In-situ U-Value 2015 (W/m²K)</th>
<th>Reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ceiling</td>
<td>East</td>
<td>0.43</td>
<td>0.72</td>
<td>0.26</td>
<td>63</td>
<td></td>
</tr>
<tr>
<td>Wall</td>
<td>East</td>
<td>0.49</td>
<td>0.40</td>
<td>0.22</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Lined Wall</td>
<td>East</td>
<td>0.49</td>
<td>0.25</td>
<td>0.21</td>
<td>16</td>
<td></td>
</tr>
<tr>
<td>Stone Wall</td>
<td>North</td>
<td>1.64</td>
<td>0.93</td>
<td>0.40</td>
<td>57</td>
<td></td>
</tr>
</tbody>
</table>

Table: © MEARU
Results – Temperature

Figure: © MEARU

Photo: © A O'Rourke
Results – Electrical Energy

Electrical consumption pre and post refurbishment

- Before
- After

Figure: © MEARU
• Draughts reduced by 85%
• Less heat loss through walls, floor and roofs reduced
• More energy efficient heating and lighting installed
• Energy use reduced by 57%
• Clients can open throughout the year and heat the building to more than 16°C!
Thank You

http://www.gsa.ac.uk/research/research-centres/mearu/

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