Low Energy Retrofit of Historic Timber Framed Buildings in the UK

Christopher J. Whitman  B.Arch(Hons), Dip.Arch, Architect
Deputy Course Leader MSc Sustainable Building Conservation and PhD staff candidate
Welsh School of Architecture
Cardiff University
Christopher J. Whitman

1993-1999  B.Arch(Hons), Dip.Arch - Edinburgh College of Art
2000-2007  Architect, Director, Edward Cullinan Architects
2006-2007  Studio Tutor, 3rd Year, Nottingham University
2007-2014  Academic/Researcher Universidad Central de Chile, Universidad Andrés Bello & U. Católica de Temuco
2014-today  Deputy Course Leader MSc Sustainable Building Conservation, Welsh School of Architecture, PhD Staff Candidate

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Previous Research

- Sustainable and energy efficient construction system for special interest tourism in the region of Araucanía Andina, Chile. (FONDEF)
- Environmental Comfort in the living heritage of the Araucanía, Chile. (FONDART)
- Hygrothermal properties of Traditional Chilean Adobe Construction. (UCEN)
- Environmentally Efficient Housing in Central-Southern Chile. (UCEN)
- Straw Bale Construction for Rural Central Chile. (UNAB)
Current Research

• Low Energy Retrofit of Historic Timber-Frame Buildings in the UK.

• Correlating maintenance, energy efficiency and fuel poverty for traditional buildings in the UK.
Low Energy Retrofit of Historic Timber-Frame Buildings in the UK

- Quantify and locate surviving UK timber-framed buildings
- Identify possible retrofitting solutions
- Simulate interstitial hygrothermal conditions within walls
- Construct and monitor physical test panels
- In-situ measurement and monitoring
- Energy simulation of retrofit solutions
Sweet Track 3806 BC - Somerset Levels.  
Source: Coles 2006

St Andrew’s Church, Greensted, Essex. 9th Century AD  
Source: Turner

Close studding and Square framing  
Sources: DBRG 2008, CAS 2010

Infill materials
Survival and Distribution

UK Timber-Frame Distribution
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UK Domestic Building Stock
Source: Based on (Nicol et al. 2014)

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Possible Retrofit solutions based on (Reid 1989; McCaig & Ridout 2012; Ogley 2010)
### Potential risks

<table>
<thead>
<tr>
<th>Insect/Condition</th>
<th>Temperature Range</th>
<th>Relative Humidity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Powderpost</td>
<td>8-25°C</td>
<td>26%</td>
</tr>
<tr>
<td>Lycus linearis</td>
<td>15°C-25°C</td>
<td>20-30%</td>
</tr>
<tr>
<td>Goeze</td>
<td></td>
<td></td>
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<tr>
<td>Hylotrupesw</td>
<td></td>
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<tr>
<td>bajulus</td>
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<tr>
<td>&amp; Lyctus brunneus</td>
<td></td>
<td></td>
</tr>
<tr>
<td>House Longhorn</td>
<td>&gt;12°C</td>
<td>22%</td>
</tr>
<tr>
<td>Anobium punctatum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Woodworm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Deathwatch</td>
<td>&gt;15°C</td>
<td>&gt;10%</td>
</tr>
<tr>
<td>Xestobium</td>
<td></td>
<td></td>
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<tr>
<td>rufovillosum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry Rot</td>
<td>&gt;25°C</td>
<td>17-23%</td>
</tr>
<tr>
<td>Serpula lacrymans</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oak Rot</td>
<td>&gt;28°C</td>
<td>5-40%</td>
</tr>
<tr>
<td>Coniophora</td>
<td></td>
<td></td>
</tr>
<tr>
<td>puteana</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cellar Rot</td>
<td>&gt;25°C</td>
<td>20-32%</td>
</tr>
<tr>
<td>Coniophora</td>
<td></td>
<td></td>
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<tr>
<td>puteana</td>
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</tr>
</tbody>
</table>

Hygrothermal parameters for insect attack and fungal decay. Source: (McCaig & Ridout 2012)
Simulation of hygrothermal performance: WUFI (Wärme und Feuchte Instationär) software Results of simulation for Hereford, UK. Source: (Author’s own, 2016)
Proposed physical test cell for measurement of interstitial hygrothermal conditions of replacement infill panels. Source: (Author's own, 2015)

Dual climate chamber testing
In situ monitoring of case studies

Replacement Wattle and Daub
3.25 W/m²K
Repaired Lath and Plaster
2.51 W/m²K
Triso-mur 25mm + Lime plaster
0.71 W/m²K

Pre-retrofit
16.5 ac/hr @ 50 Pa
Secondary Glazing installed

Post-retrofit
10.8 ac/hr @ 50 Pa

Pressure testing (Author’s own, 2016)
Thermography (Author’s own, 2016)

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Energy Simulation of case studies

Conclusion

• Where historic infill is beyond repair there exists the opportunity to retrofit an alternative panel with a higher thermal resistance.

• Care must be taken not to increase interstitial moisture that can lead to fungal decay and insect attack.

• Simulations to date show no significant risks but are WUFI simulations reliable for heterogeneous, traditional construction techniques? Monitoring of physical test panels is therefore required.

• Air tightness remains a major issue for timber-framed buildings, especially when frame is exposed internally and externally.

• Retrofit strategies need to consider a holistic approach to achieve true energy savings.
Key questions for debate in this session

- What are the key lesson in the UK and Egypt for retrofit of heritage buildings?
- Do we know the potential risks of retrofit to historic fabric?
- Could improved maintenance of historic and traditional buildings improve their energy performance? - One step before retrofit