Institution: Glasgow Caledonian University

Unit of Assessment: 16

Title of case study: Setting the agenda for traditional building refurbishment

1. Summary of the impact (indicative maximum 100 words)

Approximately 70% of the existing building stock will still be in use in 2050. A series of projects funded by EPSRC, FP7, Historic Scotland and English Heritage has changed the level of awareness on the impact of climate change on the thermal and moisture performance of traditional and historic buildings when considering improvements to their energy efficiency. This has helped set the agenda for the refurbishment of traditional buildings, for example advice on for the Green Deal has resulted in DECC commissioning further work, including a Responsible Retrofit Guidance Tool developed by the Sustainable Traditional Buildings Alliance.

2. Underpinning research (indicative maximum 500 words)

The research has focussed on the impact of climate change on buildings, improving their energy efficiency and assessing the risks these measures may have on the building fabric, particularly from moisture damage. The research is underpinned by the experience of the staff with backgrounds and expertise in Building Physics gained at other academic institutions and the Building Research Establishment. Dr Baker's expertise in thermal performance testing and analysis of buildings has been developed through participation in various European projects since 1987 starting with PASSYS, a European concerted action in the field of passive solar component and system testing. These projects have resulted in improved testing and analysis procedures, which have been applied to, for example, the integration of photovoltaics in buildings[1]. Sanders developed expertise at BRE in condensation and moisture problems in buildings with an understanding of climate impacts on buildings. Since joining GCU in 2003 they have participated in Engineering Historic Futures[2] (GR/S18359/01, total £410k), part of the EPSRC climate-change research initiative "Building Knowledge for a Changing Climate", which examined the issues arising from water damage to historic buildings, and focused on developing appropriate methodologies for drying, producing guidance for the key stakeholders (English Heritage, Historic Scotland, the National Trust, and the Ecclesiastical Insurance Group plc, the leading insurer of historic buildings in the UK) on the drying out of historic buildings to avoid hygrothermal stresses in the building fabric. Currently, the Centre is involved in a FP7 project, Climate for Culture (Grant Agreement no. 226973, £280k, 2009-2014) which builds on this previous experience. The project concerned future-proofing our heritage in the face of climate change. Our role in the project is developing building simulation models to assess the impact of climate change scenarios including driving rain on the building fabric and the internal environment within historic/traditional buildings.

Following the Engineering Historic Futures project, the Centre has attracted over £250k funding from Historic Scotland and English Heritage. Both organisations consider the fifth of UK's dwellings, which are traditionally constructed, have significant value to UK's built heritage. The key issue with these buildings is how to make them energy efficient, in a way that does not detract from their character or damage the building fabric. Initially research on evaluating energy efficiency measures for traditional windows was carried out[3]. The research has provided practical information on simple energy efficiency measures for traditional timber windows. Subsequently we have carried out research on evaluating the thermal performance of traditional buildings in Scotland[4] and England, which contributes towards guidance for energy performance assessments. This work is underpinned by previous work on thermal performance carried out by Baker in European projects (PASSYS I & II, IQ-Test, DAME-BC)[5]. We have developed research programmes with both Historic Scotland and English Heritage which focus on the evaluation of risk of moisture problems post-refurbishment. Risk evaluation is based on a clear understanding of the principles of moisture transfer and its measurement in buildings developed during research projects including International Energy Agency Annexes 14, 24 &41[6].

3. References to the research (indicative maximum of six references)

1. Bloem J.J., **Baker P.H.**, Stirling C. PV Systems and specific requirements for Building Integration. In Proceedings of the 16th European PV Solar Energy Conference & Exhibition,

WIP, 1-5 May 2000, Glasgow
2. Contribution of **GCU** in Scientific Research Reports Chapters 1-4 in Cassar. M & Hawkings C. (eds). Engineering Historic Futures, Stakeholders Dissemination and Scientific Research Report, UCL 2007 ISBN 978-0-9539021-8-7 http://eprints.ucl.ac.uk/2612/1/2612.pdf
3. **Baker P.** Research into the thermal performance of traditional windows: Timber sash windows. English Heritage 2009. http://www.english-heritage.org.uk/publications/thermal-performance-traditional-windows/thermal-performance-traditional-windows.pdf
4. **Baker P.** Historic Technical Paper 10, U-values and traditional buildings - In situ measurements and their comparison with calculated values. Historic Scotland Conservation Group 2011. http://www.historic-scotland.gov.uk/hstp102011-u-values-and-traditional-buildings.pdf
5. **Baker P.H.** and van Dijk H.A.L. PASLINK and dynamic outdoor testing of building components. Building and Environment Vol.43 pp143–151, 2008

Kumaran K., **Sanders C.**, Boundary conditions and whole building HAM-analysis, Final Report IEA, EXCO ECBCS Annex 41, subtask 3, ACCO, Leuven, 235 p. 2008

4. Details of the impact (indicative maximum 750 words)

The work has helped shape and extend the research agenda for Historic Scotland and English Heritage in terms of the following:

- How do traditional buildings perform? There is now consistent research and measurements concerning the heat loss of traditionally-built (solid) walls [1], which is addressing the lack of reliable data available to policy makers planning for climate change impacts on the performance of historic and traditional buildings.
- What measures can be applied to improve energy efficiency without detriment to the building fabric? Research is in progress looking at the performance and risk of different measures for insulating traditional buildings [2,3]. For example, the Historic Scotland and Glasgow City Council Energy Efficiency for Pre-1919 Historic Buildings Pilot Project is intended to assess the robustness of a range of insulation solutions and the risks of refurbishment due to moisture in traditional tenement buildings. In Glasgow this will have a significant impact on advice given by the City Council to homeowners and social landlords.
- How should assessments and measurements be carried out? The work has developed test methodologies adopted by other contactors for Historic Scotland (see Case Studies 3,6 & 7 http://www.historic-scotland.gov.uk/index/heritage/technicalconservation/conservationpublications/refurbcasestudies.htm).

The Historic Scotland & English Heritage publications and presentations of our research outcomes have acted as a catalyst for others. For example, the Society for the Protection of Ancient Buildings, following advice from Dr Baker, has pursued a complementary programme of investigations on thermal performance of different vernacular constructions[4].

GCU's research along with others has increased interest in the refurbishment of traditional buildings and has resulted in the formation of the Sustainable Traditional Buildings Alliance (STBA) of which GCU is a member. One of the main issues to come out of the research is the discrepancy between the heat loss of solid walls as measured in situ and the standard calculated values, which tend to underestimate the thermal performance of traditional walls and consequently the energy rating of the building. The consequence of this gap needs to be more widely understood within retrofit processes. The STBA has brought this to the attention of the UK Government Department for Energy & Climate Change (DECC), since the energy rating of the building before upgrading affects the financing of the energy efficiency measures which may be implemented in the Green Deal (the UK Government's scheme for energy saving in homes and businesses).

These concerns have resulted in DECC re-evaluating its understanding of how the Green Deal should be implemented in traditional buildings. In 2012 it commissioned the STBA to identify existing research and guidance that could (a) aid the responsible design and decision-making process for the Green Deal in older and traditional buildings and (b) identify gaps in knowledge where further information and guidance could help optimise the delivery of the Green Deal in these properties. We contributed as experts to the STBA's submission regarding heat loss estimates,

moisture risk analysis and internal wall insulation and STBA's research report 'Responsible Retrofit for Traditional Buildings'[1]. This has been developed into a software tool which will be launched in 2013.
Following the STBA submission, DECC is commissioning a major, long term research programme on understanding the performance of solid wall insulation (SWI) in the UK housing stock, in order to address the issue of predicted energy savings based on physics-based models in the domestic sector being greater than those seen in practice (https://online.contractsfinder.businesslink.gov.uk/Common/View%20Notice.aspx?site=1000&lang=en&noticeid=758256&fs=true). The successful contract is worth £1.5-2 million.

The mismatch between measured and calculated heat loss in some traditional walls has now been addresses in software for U-value calculations (BuildDesk http://builddesk.co.uk/software/), which now enables mortar joints to be added to walls constructed from stone. The results of the calculations now give better convergence with measured values – however the problem is often that the precise details of a wall construction are unknown.
The test methodology for carrying out in situ thermal performance measurements (U-values) [5] is cited as guidance for carrying out such measurements by the Technology Strategy Board (TSB) for building performance evaluation studies in innovative buildings: Richard Miller, TSB head of sustainability, said: "The government has set the challenging target of an 80% reduction in carbon dioxide emissions in the UK by 2050. With 45% of the UK's CO2 emissions coming from buildings, we need to stimulate innovation towards achieving these goals. A key challenge is to ensure that building designs lead to physical buildings that perform as intended." (http://webarchive.nationalarchives.gov.uk/20130221185318/www.innovateuk.org/content/competition-announcements/how-green-is-your-building.ashx)
The methodology has also been applied to research & consultancy carried out by GCU for the insulation industry investigating the performance of widely used cavity wall insulation materials and novel insulation materials to ensure they perform as specified (http://hybrid.insulation-actis.com/boostr-hyrbid/).

5. Sources to corroborate the impact (indicative maximum of 10 references)

1. STBA, Responsible Retrofit of Traditional Buildings, http://www.sdfoundation.org.uk/downloads/RESPONSIBLE RETROFIT_FINAL_20_SEPT_2012.pdf
2. Jenkins M., Historic Scotland Refurbishment Case Study 4, Sword Street, Glasgow - Internal wall insulation to six tenement flats, Historic Scotland, ISBN 978 1 84917 100 7, 2012 (http://www.historic-scotland.gov.uk/refurbcasestudies)
3. Jenkins M., Historic Scotland Refurbishment Case Study 8, Garden Bothy, Cumnock - Upgrades to walls, floors, windows & door, Historic Scotland, ISBN 978-1-84917-112-0, 2012 (http://www.historic-scotland.gov.uk/refurbcasestudies)
4. Rye C. The SPAB Research Report 1. U-Value Report. SPAB London 2010 www.spab.org.uk/downloads/SPABU-valueReport.Nov2012-v2.pdf

Baker P.H., In situ U-value measurements in traditional buildings – preliminary results, Historic Scotland Technical Paper 2, 2009 (http://www.historic-scotland.gov.uk/u-value_measurements_traditional_buildings.pdf)