Double glazing in traditional windows

BY CARSTEN HERMANN

Slim-profile double glazing fitted to windows of a tenement flat.

How a building is glazed has a significant effect on energy efficiency and thermal comfort, so upgrading of windows is becoming a priority for many homeowners and building managers.

Historic Scotland Technical Paper 1, published in 2008, has shown that there is a range of options now available to significantly improve the thermal performance of traditional windows, generally sash and case windows constructed from timber. Such measures include draught proofing, the use of window blinds, shutters, curtains and secondary glazing.

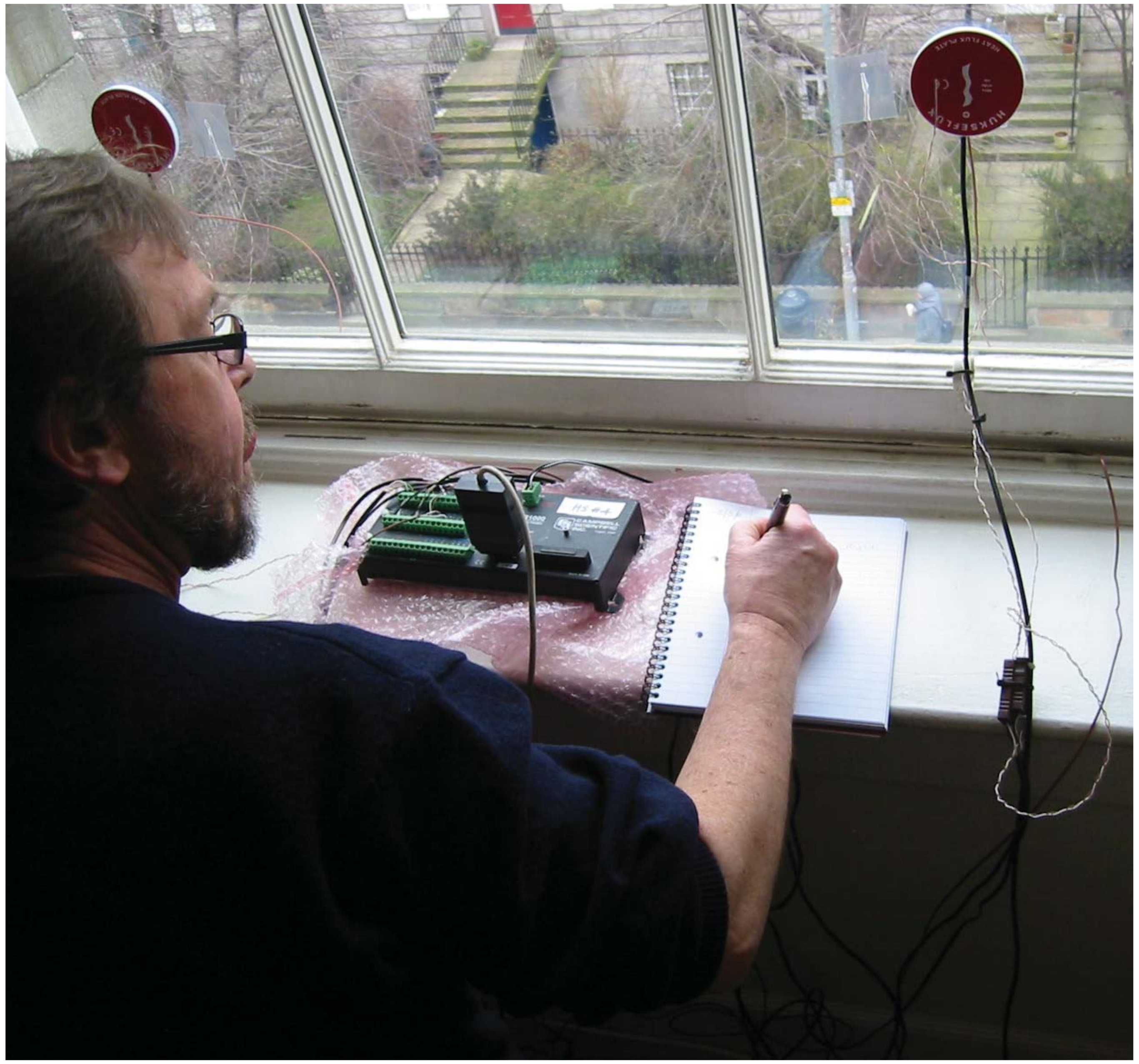
This article focuses on another improvement option; slim-profile double glazing, which is of particular interest in situations where window joinery is to be retained or reproduced but the loss of existing glazing is acceptable. Research on such double glazing systems has recently been published as Historic Scotland Technical Paper 9, presenting the findings of thermal performance and embodied energy studies.

Slim-profile double glazing is of smaller thickness than conventional double glazing. Both consist of two panes of glass containing a hermetically sealed cavity generally filled with inert gas. Whereas conventional double glazing has an overall thickness of 20 to 25 mm, the slim-profile units are only 8 to 16 mm thick. Slim-profile double glazing is still thicker than single-glass panes, generally 4 to 6 mm, but it is slim enough to be fitted, in many situations, into windows designed for single glazing. It is therefore possible to retain the existing windows, or replace them like-for-like with exactly matching timber profiles while still upgrading the glazing.

In order to determine how different systems compare, and whether these are necessarily the best option for traditional windows, Historic Scotland joined a research project studying the performance of various slim-profile double glazing systems during the winter period 2009/2010. The project involved retrofitting existing windows, and exactly matching replacement windows in nine tenements in Edinburgh. A different double glazing system was installed in each flat. A tenth system was trialled in an office. All buildings were of Georgian origin, listed, in conservation areas and within Edinburgh's World Heritage Site. The windows were not original, dating roughly to the 1970s onwards, but had retained the original appearance of a Georgian window. They were timber sash and case windows with 6 over 6 glass panes.

Measuring U-values of traditional timber sash-and-case windows as part of ongoing monitoring and improvements to properties in the care of Historic Scotland

The project was initiated and funded by the City of Edinburgh Council together with the Edinburgh World Heritage Trust and Lister Housing Co-operative. It was developed and led by Changeworks, an Edinburgh-based sustainable development organisation. Historic Scotland provided funding for on-site measurements and the associated technical studies carried out by researchers at two Scottish universities: Dr. Paul Baker of Glasgow Caledonian University measured the thermal performance of the glazing systems on-site and extensively evaluated the data; and Dr. Gillian Menzies of Heriot-Watt University, Edinburgh, studied the embodied energy associated with the manufacture and installation of the glazing. Parts of Dr. Baker's study were carried out, exclusively for Historic Scotland, after



Dr. Baker setting up the in situ measuring equipment in a tenement flat

completion of the Changeworks projects in spring 2010.

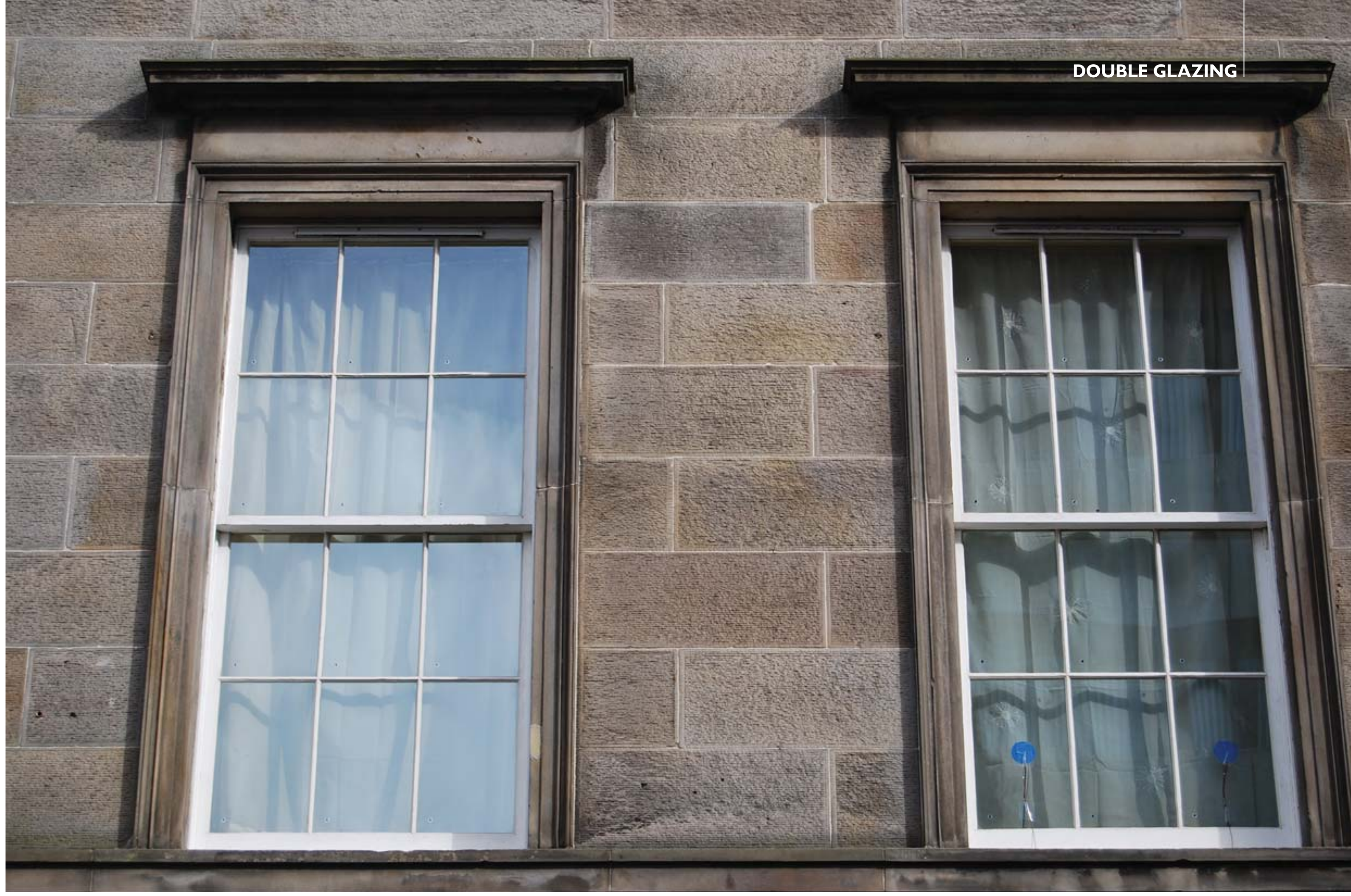
As part of the project, Dr. Baker measured the thermal conductivity of the different glazing systems. These measurements were carried out in situ, which in practice involved working on-site in flats occupied by tenants during the two-week measurement period. The measurements therefore present indicative, rather than precise, results. The latter would have required testing in a laboratory.

The differences of the trialled double glazing systems lay in the thicknesses of their cavities and glass, and in the type of cavity fill. One system had an air-filled cavity; most systems had their cavities filled with the inert gases argon or krypton, or with krypton-xenon mix. One glazing system achieved its insulating properties by creating a vacuum in the cavity.

The thermal performance was measured in the centre of the glass panes, and is expressed as U-value (or thermal transmittance co efficient) in W/m^2K. A well insulating glazing system has a low thermal transmittance, and therefore a low U-value; whereas a poorly insulating system has a high thermal transmittance, and a high U-value.

The lowest U value (1.0 W/m^2K), i.e. the best thermal performance, was achieved by the vacuum-glazing system. The highest U-value (2.8 W/m^2K) was achieved by the air-filled system. The U-values of the gas-filled cavities ranged between 1.7 and 2.7 W/m^2K depending on cavity width and type of gases used, as presented in the table overleaf.

It is important to remember that these values are only indicative, and can vary from the manufacturers' data. Furthermore, the values stated are centre-of-pane measurements. However, a window does not only consists of glass but also of timber in the form of sash frames and astragals. Also, the edge of a double glazed unit performs less well thermally than the rest of the unit.



Top: **Typical Georgian style window retrofitted with vacuum slim-profile double glazing. Two heat flux sensors (blue discs) can be seen in the right window.**

Bottom: **Differences in thickness between a slim – profile double glazing unit (left) and a conventional double glazing unit (right).**

To assess the overall performance of a complete window, Dr. Baker calculated 'whole-window U-values' using a computer simulation program. This resulted, for 6 over 6 windows, in whole-window U-values ranging from 1.9 W/m^2K (for the vacuum system) to 3.4 W/m^2K (for the air-filled system). The calculations were also carried out for 2 over 2 and 1 over 1 windows. For the latter the results ranged between 1.4 and 3.0 W/m^2K, clearly showing that slim-profile double glazing performs better thermally in windows with fewer, or no, astragals, and with fewer but larger glass panes.

So how does the double glazing then compare to the alternative of installing secondary glazing? To provide a comparison, Dr. Baker also calculated single-glazed windows retrofitted with secondary glazing. These achieved U-values of 2.0 and 2.1 W/m^2K for 6 over 6 and 1 over 1 windows respectively. Compared to the trialled double glazing, the secondary glazing generally performs better thermally than the double glazing systems, except for the vacuum system which outperforms any other option. In the case of 6 over 6 windows, secondary glazing appears to be especially beneficial as it not only improves the thermal performance of the single glazing but also insulates the timber astragals.

The embodied energy study by Dr. Gillian Menzies found that the inert gases used in most double glazing systems account for a significant proportion of the embodied energy due to the energy-intense processes needed to extract them from air. Xenon in particular carries a very high embodied energy. The vacuum double glazing system appears to have the lowest embodied energy compared to the other systems (when transported to Britain by sea from its manufacturing country, Japan). However, further research into the embodied energy for this product is required to make this estimation more reliable.

WEB LINKS

The results of the double glazing research are available online as Historic Scotland Technical Paper 9. The paper can be downloaded at the following web link where also all previous Technical Papers are available: www.historic-scotland.gov.uk/technicalpapers

The Changeworks project is presented in more detail in a Project Report available from the Changeworks publications website: www.changeworks.org.uk/publications.php

Since completion of the research project, the City of Edinburgh Council has revised, in December 2010, their planning guidance regarding the replacement of windows and doors, and is now considering the use of slim-profile double glazing (with a cavity width of up to 6mm) normally acceptable in listed buildings. However, listed building consent is still required, and double glazing may not be acceptable in cases where historic glass exists. The planning guidance is available online at: www.edinburgh.gov.uk/directory_record/21247/replacement_windows_and_doors

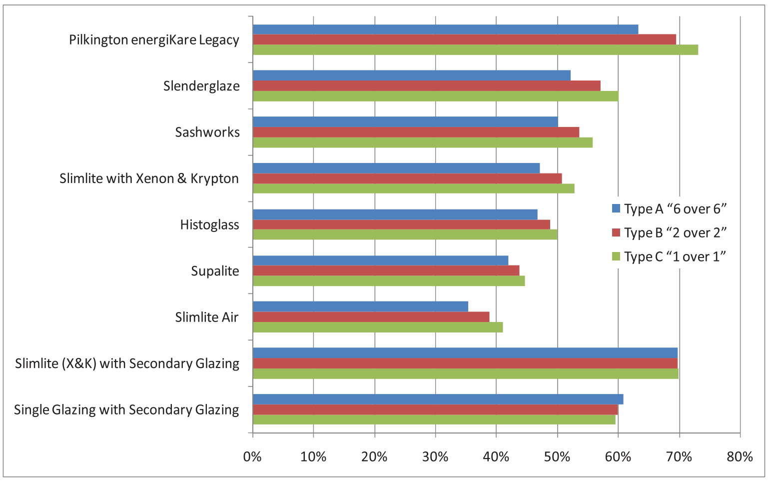
Above: **Slim-profile double glazing with two fitted heat flux sensors.**

Chart, right: **Estimate reduction of heat loss through whole window (glazing and timber profiles) comparing the impact of single glazing, slim-profile double glazing and secondary glazing for three different window sash styles (6 over 6 glass panes, 2 over 2 and 1 over 1).**

Both slim-profile double glazing and secondary glazing provide good options to improve the thermal performance of traditional sash and case windows. Each option provides the opportunity to retain and re-glaze existing sashes. In situations where existing glass is of special historic or architectural interest and replacement is considered not acceptable, secondary glazing will allow for its retention whilst still providing thermal improvements to a high standard.

However, the thermal performance is only one factor, and other factors, such as appearance, cost or practicalities, were not considered in this research. Which energy efficiency measure is best suited to a particular location will still need careful consideration on a case-by-case basis.

For listed buildings, or buildings in conservation areas, please discuss the installation of slim-profile double glazing and secondary double glazing with the planning officer at your local council.



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