Evaluation of the Party Wall Thermal Bypass in Masonry Dwellings

J. Wingfield, D. Miles-Shenton and M. Bell
School of the Built Environment
Leeds Metropolitan University
Leeds LS2 8AJ
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Introduction

Research carried out by the School of the Built Environment at Leeds Metropolitan University between 2005 and 2007 as part of the Stamford Brook Field Trial[1] identified significant heat losses via a thermal bypass operating in the party wall cavities of terraced and semi-detached masonry houses. The magnitude of the heat loss associated with this thermal bypass was found to be equivalent to the party wall having an effective U-value of the order 0.5 to 0.7 W/m^2K. The effect of the bypass was to double the fabric heat loss coefficient of a mid-terraced house. The findings are important because modelling conventions used in dwelling energy models such as SAP2005 and heat loss calculations assume that there is no heat loss due to a party wall between dwellings. This was because the fundamental heat loss mechanisms due to this form of thermal bypass were not fully understood at the time. An initial investigation was also carried out at Stamford Brook to investigate the use of an insulated cavity sock positioned horizontally at the top of the party wall cavity, the aim of which was to reduce vertical air flows in the party wall and thus mitigate the bypass. The effect of this horizontal cavity sock was to reduce the effective U-value of the party wall to around 0.2 W/m^2K.

A new research project to further investigate the party wall thermal bypass in more detail has been funded by EURISOL and took place between January and April 2009 on a pair of adjacent terraced masonry houses in Bradford. The first aim of this new project was to develop a better understanding of the fundamental mechanisms of the bypass effect. The second aim was to investigate whether filling the party wall cavity with mineral wool insulation would eliminate or significantly reduce the heat loss due to the bypass. This short report summarises the preliminary findings of this work.

Terraced Masonry Test Houses in Bradford

Experimental Procedure

Two unoccupied terraced masonry houses (including the end terrace) were selected that shared a party wall from a row of four terraced 2 ½ storey dwellings. The party wall for these

[1] WINGFIELD, J., BELL, M., MILES-SHENTON, D., SOUTH, T., & LOWE, R.J. (2007) Evaluating the Impact of an Enhanced Energy Performance Standard on Load-Bearing Masonry Construction – Final Report – Lessons from Stamford Brook: Understanding the Gap between Designed and Real Performance, PII Project CI 39/3/663, Leeds Metropolitan University, Leeds

test dwelling was constructed according to the requirements of the EWM2 acoustic detail (Robust Details Catalogue[2]). This detail consists of two leaves of lightweight aggregate block with a 75 mm clear cavity and 13 mm wet plaster wall finish. The test programme involved subjecting the test dwellings to an extended coheating test over a period of six weeks in order to determine the whole house heat loss coefficient. Half way through the test period, the coheating test was temporarily suspended whilst the party wall cavity was filled with mineral wool insulation using conventional insulation blowing techniques. The coheating test was then resumed again until completion. In addition to the coheating test, a range of sensors were located inside the party wall cavity and on the internal surfaces of the party wall and external wall. These instruments recorded heat flux, pressure differentials, cavity air velocity, cavity air temperature and wall surface temperature at 10 minute intervals during the coheating test. Acoustic tests were undertaken at the start and end of the coheating test to assess the effect of the insulation in the party wall on acoustic performance. Pressure tests were carried out before and after each coheating test phase and again after all internal repairs to the walls had been completed. The airtightness data from the pressure tests were used along with the results of carbon dioxide tracer gas measurements to determine background ventilation rates during the coheating test. The coheating data were recorded for both dwellings under test, but the end terrace was designated as the main test house as it shared no other party walls other than with the other test house. Analysis of the coheating data from the mid-terrace would be complicated by the fact that it shared one of its party walls with an occupied dwelling, the internal conditions of which were not controlled during the test.

Dwelling Construction Details

The test houses were of masonry cavity wall construction with a lightweight aggregate concrete block inner leaf and reconstructed stone external leaf. The external wall cavity width was nominally 100 mm containing 45 mm partial fill rigid polyisocyanurate board with foil facing. The internal wall facings were finished using plasterboard on adhesive dabs.
The houses were of 2½ storey room-in-roof construction with 250 mm mineral wool quilt in the horizontal ceiling areas and polyurethane insulation board in the sloping roof sections. The floor was of suspended concrete beam and block construction with expanded polystyrene insulation below a concrete floor screed.

Predicted Thermal Performance

The expected whole house heat loss coefficient for the end terrace was calculated using the nominal fabric U-values for the wall, floor, roof and windows together with an assumed thermal bridging y-factor (assumes compliance with Part L Accredited Details Catalogue) and the air permeability as measured before the coheating test (see Table 1). The predicted fabric heat loss makes the assumption given in SAP2005 that the party wall is not a heat loss element and that therefore the party wall U-value is zero.

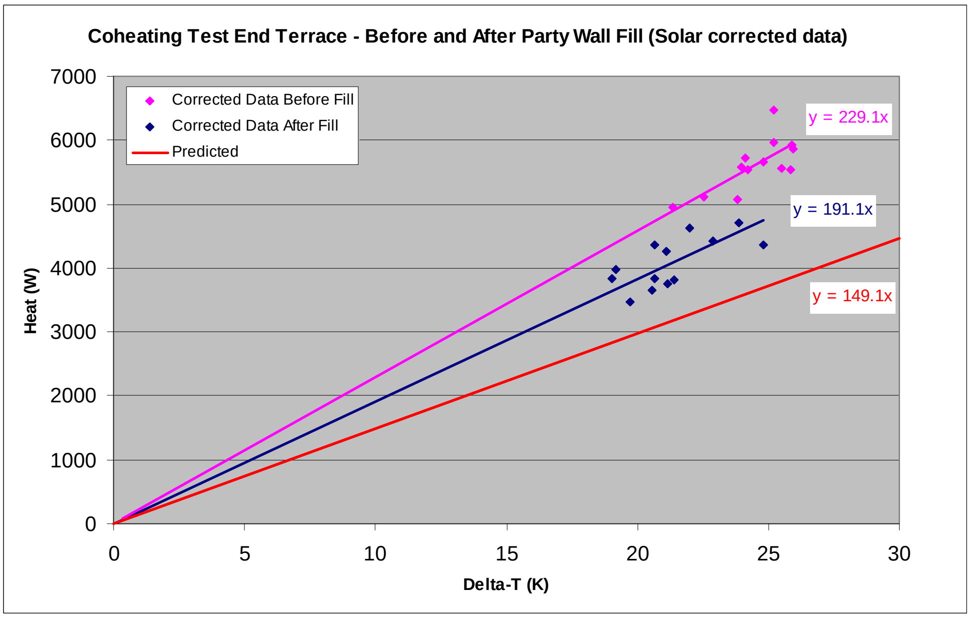
Table 1: Nominal Predicted Thermal Performance

Wall U-value	0.30 W/m^2K
Roof U-value	0.16 W/m^2K
Floor U-value	0.25 W/m^2K
Window U-value	1.80 W/m^2K
Party Wall U-value	0 W/m^2K
Thermal bridging Y-value	0.08 W/m^2K
Calculated fabric heat loss coefficient	92.9 W/K
Measured air permeability before test	8.5 $m^3/h.m^2$
Calculated background ventilation rate	0.43 h^{-1}
Calculated ventilation heat loss coefficient	35.8 W/K
Calculated whole house heat loss coefficient	128.7 W/K

[2] ROBUST DETAILS LTD, Robust Details Catalogue, Separating Wall-Cavity Masonry, E-WM-2. This party wall detail consists of two leafs of lightweight aggregate blocks separated by a minimum 75mm gap. The blockwork walls are faced with a 13mm plaster coat.

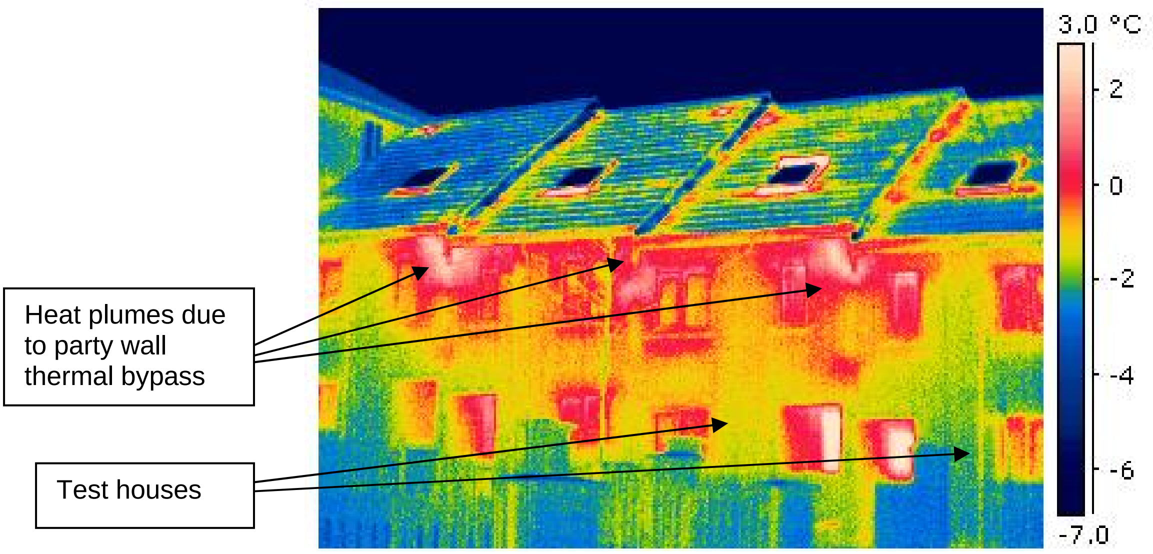
Results and Discussion
The results of the coheating test before and after filling the party wall with mineral wool with insulation are illustrated by the plot in Figure 1 of heat input versus delta-T (inside-outside temperature difference). The data have been corrected for solar gain during the test. The measured whole heat loss coefficient with the unfilled party wall cavity was 229.1 W/K. This is significantly higher than the predicted value of 149.1 W/K. The predicted value in this case uses the mean background ventilation rate measured by tracer gas measurements during the coheating tests (0.67 h^{-1}) and is higher than the predicted value calculated using the pre-coheating test pressurisation test result. This was due to permanent increases in air permeability caused by cracking and movement as a result of heating the test houses. After the party wall cavity was filled with mineral wool insulation, the whole house heat loss coefficient was 191.1 W/K, which is a reduction of 38 W/K over the heat loss before filling.

Figure 1: Coheating Test Results



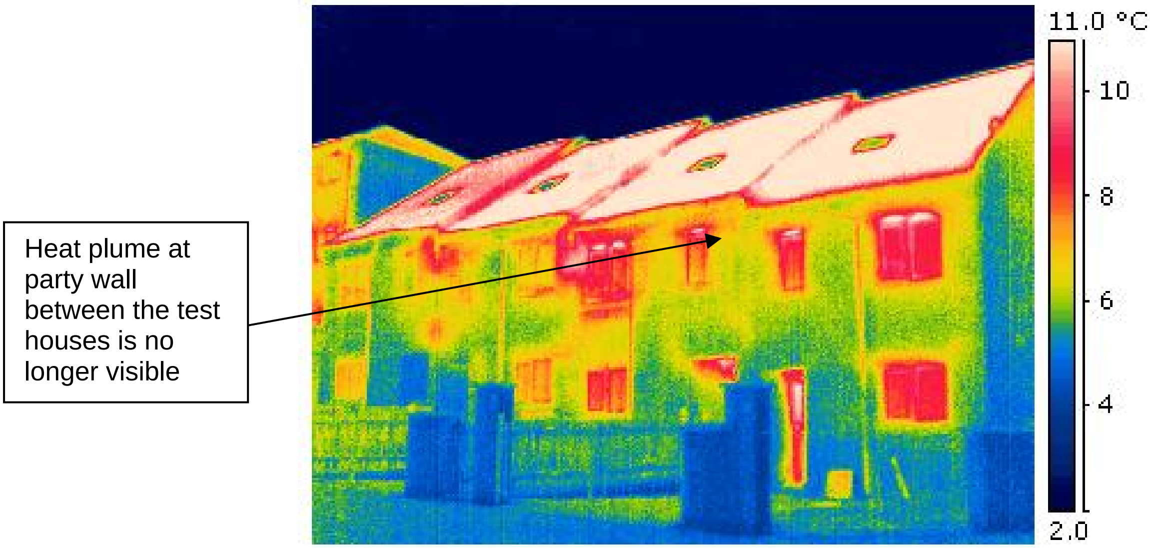
The heat plumes resulting from the party wall thermal bypass can be seen at the top of the party wall junctions in an infra-red thermal image taken of the terrace of four houses that include the two test houses (Figure 2). This image was taken before filling the party wall cavity.

Figure 2: Infra-red Thermal Image of Terrace Containing Test House before Filling



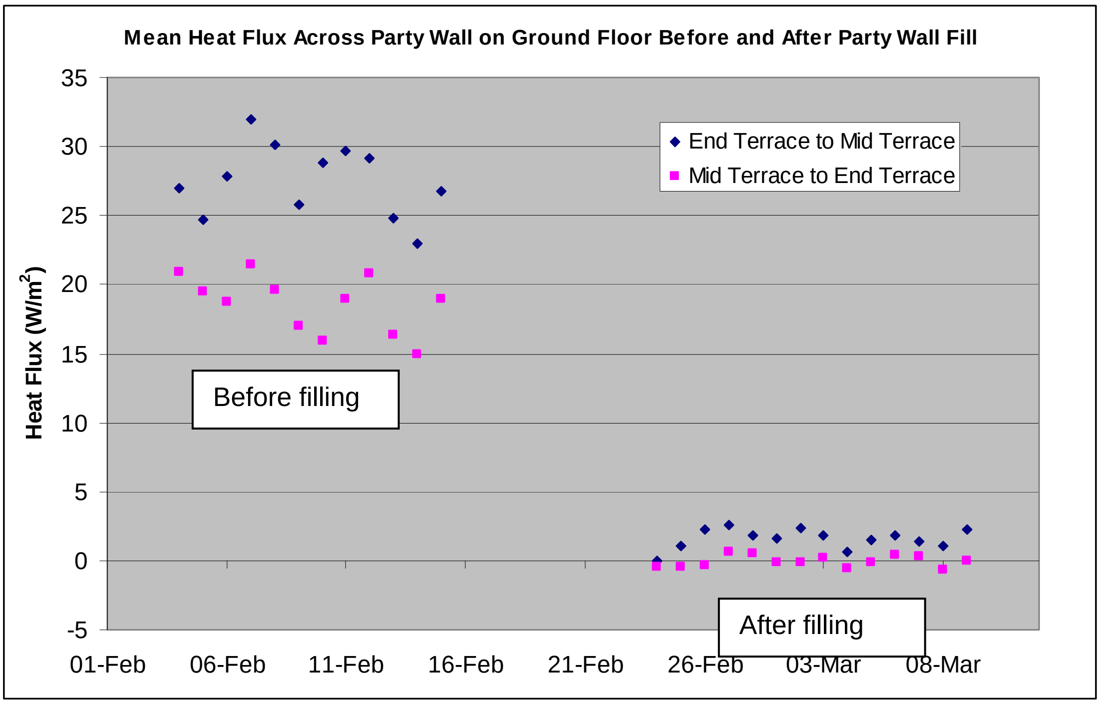
Infra-red thermal images taken after the procedure to fill the party wall cavity between the test houses with insulation, show that the heat plume due to the thermal bypass was no longer visible at the party wall between the test houses, but that the plumes were still present in the other houses in the terrace where the party wall cavities remained empty (Figure 3).

Figure 3: Infra-red Thermal Image of Terrace Containing Test House after Filling



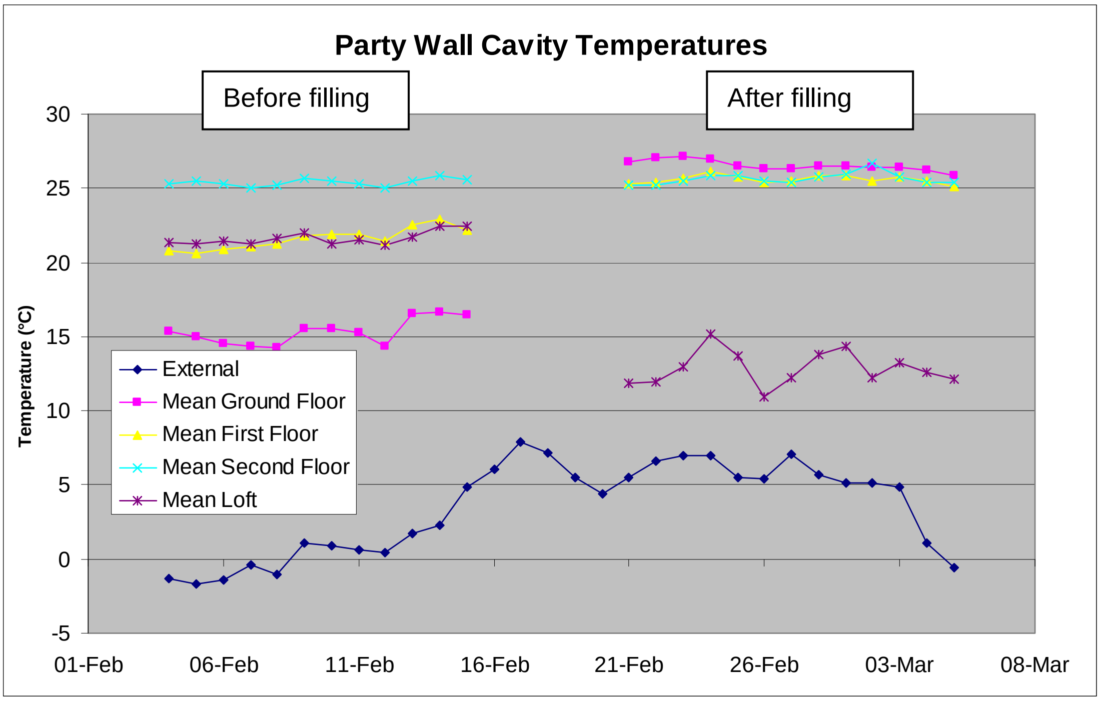
The measured heat flux through the party wall on the ground floor before and after filling the party wall cavity is shown in the graph in Figure 4. The heat flux before filling is of the order 20 to 30 W/m^2. This was equivalent to a U-value at this location in the party wall of the order 0.7 to 1.8 W/m^2K over the test period. After filling the party wall cavity with insulation, it can be seen from Figure 4 that the heat flux, and hence the U-value, from the mid-terrace to the end terrace drops to zero. There is still some small residual heat flux from the end terrace to the mid-terrace which is not due to the thermal bypass but is associated instead with heat loss to the ground as a result of the step in the terrace.

Figure 4: Heat Flux through Party Wall



The test data show that the heat flux varies across the party wall as a result of differences in the temperature in the party wall cavity. The party wall cavity temperatures were lowest at the bottom, gradually becoming warmer higher up the cavity and eventually becoming isothermal with the temperature in the test houses just below the level of the ceiling insulation (Figure 5). Following filling of the cavity with insulation, the temperature in the party wall became uniform and isothermal with the test houses. It is interesting also to note that the cavity temperatures in the loft area (above the level of ceiling insulation) are higher before filling than after filling. This indicates that the fill has reduced the movement of warm air into this wall area and provides further evidence that the bypass has been eliminated.

Figure 5: Party Wall Cavity Temperatures



The measurements of airborne sound insulation provided by the party wall before and after filling with insulation showed that the acoustic performance was unaffected by the filling process. The mean value for $D_{nT,w}$+ C_{tr} measured according to the requirements of Approved Document Part E was 53 dB, both before and after the cavity filling process. This is well within the 45 dB requirement.

Conclusions

The nominal area for the party wall including the area of the warm knee wall voids was 64 m^2. If it is assumed that the reduction in the measured heat loss coefficient of 38 W/K following filling of the party wall cavity is entirely due to the elimination of the party wall thermal bypass, then this would indicate that the test houses have an effective party wall U-value before filling with insulation of the order 0.6 W/m^2K. This is consistent with an average party wall effective U-value calculated from the mean measured heat flux into the party wall before filling of the party wall cavity with insulation. The test results show that by filling the party wall cavity of the test houses with mineral wool insulation, the thermal bypass can be eliminated and the party wall effective U-value will be zero.

Measurements of air flows in the cavities and external wind speeds indicate that the party wall thermal bypass is driven by the movement of cold external air into the empty party wall cavity. The data suggest that the effect of filling the party wall cavity with mineral wool works in eliminating the bypass at two levels. Firstly, the insulation will reduce heat flow across, through and along the party wall cavity. Secondly, the insulation will restrict the movement of air around the cavity.

Further Information

To find out more about this project please contact Dr Jez Wingfield at Leeds Metropolitan University.

Telephone: 0113-8121938
Email: j.wingfield@leedsmet.ac.uk
Web: http://www.leedsmet.ac.uk/as/cebe/build.htm