A Short Paper on Internal Wall Insulation

Summary:

U value claims and targets for Internal Wall Insulation do not take sufficient account of

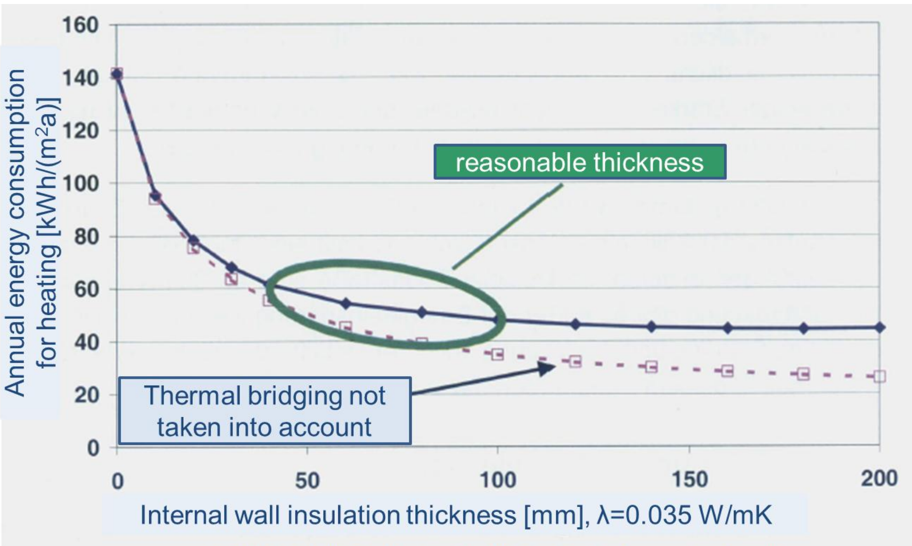
- The technical limitations to heat loss from IWI applications due to unavoidable thermal bridging
- The increased risk to fabric and human health of reducing heat flow into walls beyond a certain limit and particularly in certain locations and orientations. This risk is particularly high in solid wall buildings

There is a need to adjust or amend Building Regulations Approved Document part L1B and L2B and also the Scottish Technical Handbooks and Northern Irish Technical Booklets so that they reflect these facts.
There is a need to ensure that certification and guidance reflect this fact.
There is a need for further research to identify more clearly the limits and risks in different contexts.

Detail:

i) The technical limitations to heat loss from IWI applications due to unavoidable thermal bridging

In regard to the effects of thermal bridging on overall heat loss of a traditional building, the work of Andersson (1980) and Schnieder (2005) identify limits to the effectiveness of internal insulation in reducing heat loss due to thermal bridging around windows, doors, floors, party and partition walls, roof-wall junctions and lintels. In Schnieder's assessment of the passivhaus retrofit of a German solid wall masonry building, there are decreasing marginal returns on the thickness of insulation to walls due to unavoidable thermal bridges, even when these are expertly detailed (including new passivhaus standard windows and insulation installed along the full length of partion and party walls). In Schnieder's calculation insulating solid walls internally with more than 100mm of insulation with a k value of 0.035W/K will provide no meaningful additional thermal benefit even in a passivhaus refurbishment. The optimum amount of such insulation in Schnieder is considered to be between 60 and 100mm as in the chart below (by Schnieder in Ed. Feist), which is equivalent to unbridged U-values of approximately 0.45 to 0.30W/m2K in a solid 9" brick wall in the UK.



Quelle W. Feist: Faktor 4 auch bei sensiblen Altbauten, Passivhauskomponenten + Innendämmung

Where little or no insulation is possible on certain thermal bridges such as window reveals, the possible insulation values of the whole wall are further reduced considerably. Andersson on a single room analysis calculates that it is not possible to achieve an overall U-Value of less than 0.6W/m2K because of the thermal bridging. However, while the German studies identify that there are definite limits to the effectiveness of IWI in energy terms due to unavoidable thermal bridging, there is no sensitivity analysis or practical testing of the findings and it is not possible from this work to quantify the actual limits of IWI in UK traditional buildings[1].

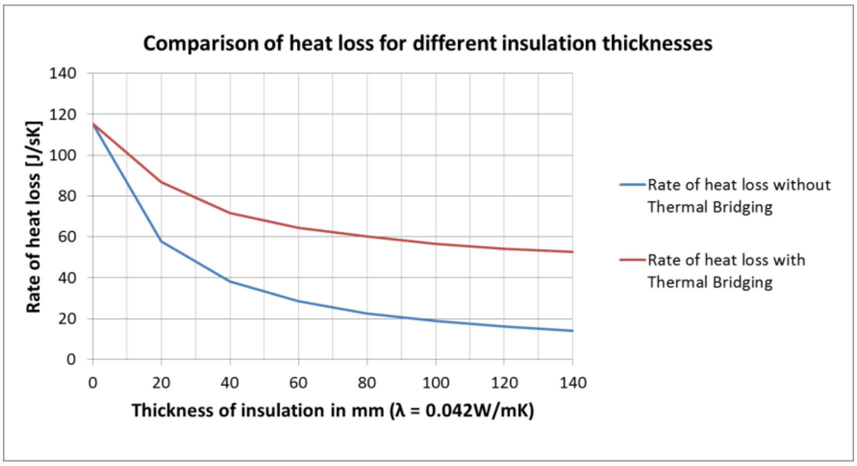
It should be noted that there are also distinct practical and cost limitations to insulation on thermal bridges. In many situations, without expensive and sometimes unacceptable (for planning reasons) measures such as changing windows and doors entirely, it is impossible to apply insulation of more than a few millimetres in thermal bridging locations.

ii) The increased risk to fabric and human health of reducing heat flow into walls beyond a certain limit and particularly in certain locations and orientations. This risk is particularly high in solid wall buildings

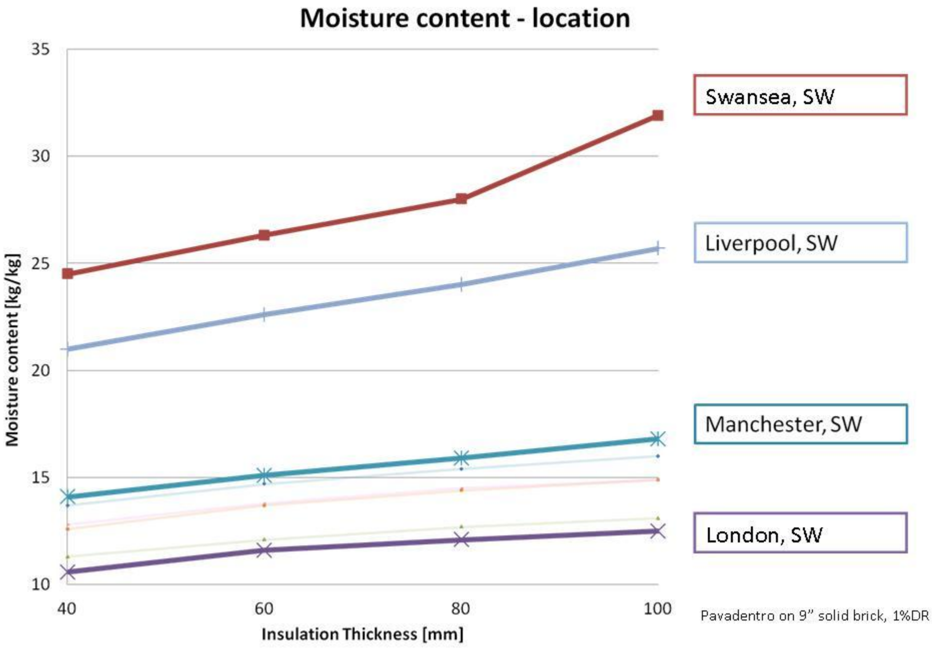
The reduction of heat flow to walls by the application of internal insulation leads to changes in the moisture performance of that wall. As shown in research (Künzel & Holm, 2009) this can lead to significant risks for solid wall buildings where there is liquid moisture due to driven rain onto capillary open surfaces and rising damp due to lack of damp courses. Heat from within the house aids the drying of these walls and maintains a healthy balance for fabric and humans. The problem is particularly acute where there are organic materials in the wall, such as timber. In the case of joist ends, the reduction in heat flow will lead to a significantly increased risk of timber decay and possibly structural failure. There is also a risk to human health of moulds forming behind insulation in walls which are wet and cannot dry out.

The calculations as to the safe levels of internal insulation are complex and require dynamic numerical modelling based upon accurate material data, wall build ups and location and orientation specific weather data. None of this is taken into account by current standards or most guidance (see accompanying paper on heat loss and moisture). Where modelling has been undertaken, it is apparent that the situation in different parts of the UK and on different orientations is radically different, making certain applications safe in some parts or orientations but quite unsafe in others.

[1] Such an analysis has been attempted recently by NBT with the help of UCL (V. Marincioni) on a standard UK terrace solid wall 9" brick house where no insulation is applied to thermal bridges and the same trend has been recorded, as in the chart below. However further work is necessary on the modelling assumptions and on different building types for this to be taken as evidence.



Below are some examples of IWI applied in different locations in the UK and its effect on wall moisture content:



Moisture Content at insulation fabric interface for different locations- source NBT[2]

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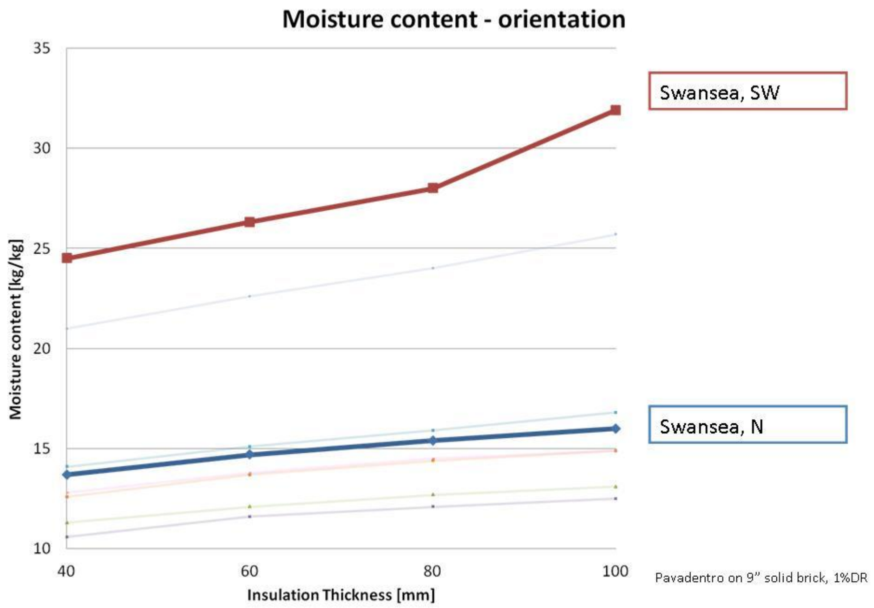
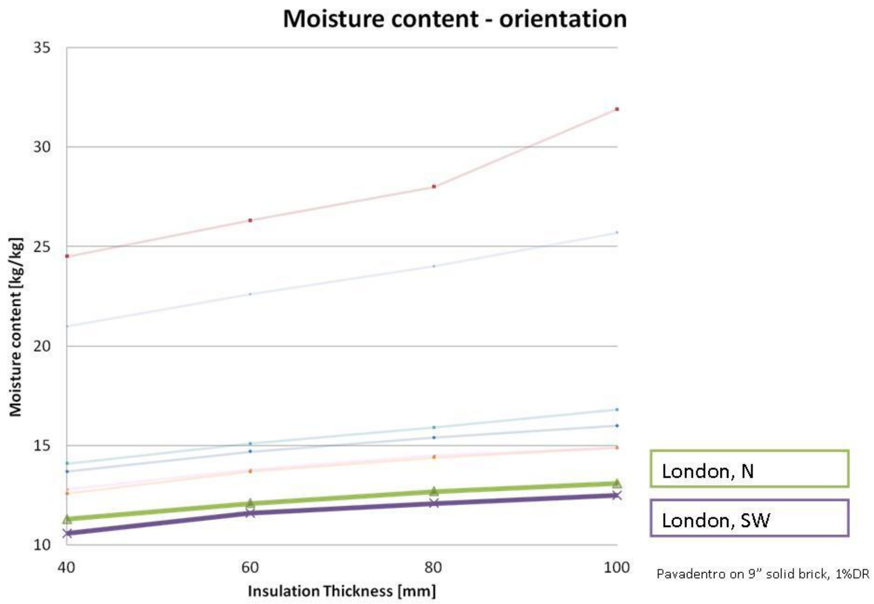
[2] The modelling for all 3 graphs were done by NBT for their Pavadentro product. The moisture content analysis is carried out by means of a 1D transient hygrothermal simulation (with WUFI® pro 5.1 software) for a wall section composed by 215mm solid brick,20mm levelling coat, 5mm bonding plaster, 40 to 100mm Pavadentro woodfibre board for internal insulation, 8mm lime plaster. A moisture source of 1% of the driving rain load is inserted in the wall section, according to ASHRAE standard 160-2009; the selected depth for the water penetration is corresponding to the window position (100mm to the external surface), as the Standard Project Committee for ASHRAE 160 realised that "occasional intrusion of a small amount of water, especially around doors and windows, is probably inevitable". (Ten Wolde, 2008, p.168)
The selection of 1% wind-driven rain is explained by Künzel and Zirkelbach (2008, p.2): "The selected leakage rate in this standard is not meant to be a worst case scenario. It is not based on field test results but on hygrothermal simulations that showed that more than 1% of rainwater penetration may be detrimental for a large portion of existing wall structures".





The above figures show that the risk of going above the maximum desired moisture content (roughly about 20% by weight) is apparent in Swansea or Liverpool but not so in London. Orientation of the wall in question is important in Swansea (apparent in the SW wall but not in the N) but not so critical in London (both orientations below critical value). The risk of moisture at the interface increases as the insulation gets thicker.[3]

[3] It should be noted that this insulation is vapour open to the inside and allows drying internally. Insulations which are vapour closed have higher modelled water content relatively for the same k value in locations with driven rain.

What is apparent here is that in some situations Internal Wall Insulation is possible but in others it is not. In all situations the risk increases with the increase in insulation thickness and reduction of heat flow.

It should also be noted that there is a significant difference (not shown here but as per footnote 4) in insulations which are vapour open and those which are vapour closed. Vapour closed systems prevent drying (see Künzel & Holm, 2009) and in situations where there is moisture in walls from driven rain, rising damp, or other causes, are less preferred than vapour open systems. Again this requires the correct data and modelling for the correct analysis to be made.

Consequences:

Because of the lack of accurate data, lack of research and the use of incorrect or inaccurate modelling, inappropriate IWI solutions are being promoted through certification and guidance. This situation is encouraged by Building Regulations Approved Documents Part L1B and L2 B which set U Value targets for retrofit of 0.30w/m2K, and Scottish Technical Handbook Targets of 0.3 W/m2K, 0.22 W/m2K or 0.19 W/m2K depending on circumstance. Although Part L clearly gives special provision for "buildings of traditional construction with permeable fabric that both absorbs and readily allows the evaporation of moisture", stating that where this clause applies, then the aim should be "to improve energy efficiency as far as is reasonably practical" and that works "should not prejudice the character of the host building or increase the risk of long term deterioration of the building fabric or fittings", it should be noted that this still assumes that 0.3W/m2K is the starting point for U Value targets and is possible. In Scotland the situation is more extreme. These assumptions are taken up by industry and certification and due to poor data, research and incorrect moisture modelling solutions it is commonly suggested for solid wall buildings that U-Values as low as 0.17W/m2K can be achieved (as in the Energy Saving Trust's publication Best Practice CE17 'Internal wall insulation in existing housing – a guide for specifiers and contractors') .

These regulations do not distinguish between different types of building (thickness, capillary qualities, construction type), location or orientation, or between different types of insulation. In themselves they are not incorrect, although technically it may be impossible to achieve the U-values set for retrofit if internal insulation is to be used. However they form implicit guidance to the industry and policy makers which may cause considerable risk and actual damage to fabric and human health, as well as leading to waste of materials, living space and finances.

It should be noted that while the technical limitations of internal wall insulation and the risk to building fabric (and consequentially human health) have been identified in solid wall traditional buildings, there are also risks in all buildings, though to a different degree. The extent of this risk has not been considered in this note.

Conclusion:

Compliance documents for building regulations need to acknowledge the technical limitations and the risks of Internal Wall Insulation more clearly and not set standards which if used, without correct understanding, are dangerous or technically unrealistic.

<u>References</u>

Ann Charlotte Andersson, 1980; Folgen zusätzlicher Wärmedämmung – Wärmebrucken, Feuchteprobleme, Wärmespannungen, Haltbarkeit; Bauphysik 2 (4) 119-124]

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