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The SERS Report

External Wall Insulation Current Practice Review and Guidance for Improvement

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Executive Summary

This review and report undertaken on behalf of SERS Energy Solutions Ltd to understand the current standard of workmanship and quality control on site looks to analyse current practice and methods of work when undertaking external wall insulation, it applies equally to when it is located either externally or internally. It delivers a critical assessment of current practice in the industry and provides a suggested route for improvement.

This report is a combination of BRE's extensive experience of working across the industry, working with Local Authorities, Social Landlords, and installers. It also feeds into the analysis being undertaken by the BRE on behalf of the Department of Energy and Climate Change (DECC).

The study indicates that although many companies do deliver insulation works that meet the requirement of both Ofgem and PAS2030, it indicates an inconsistent approach across the company structures, in the cases where workmanship and assessment has been observed. The weaknesses in current practice are more reflective of the current state of the external insulation industry than a direct criticism of anyone organisation or system directly and at no stage has workmanship been evidenced that is not at the current industry standard.

However for any company to be at the forefront of Best Practice, changes to procedure, process and knowledge do need to be made, and these in the view of the BRE are set out in the recommendation section of this report. SERS Energy Solutions Ltd are committed to promoting best practice processes and guidance, and commissioned the report so that it can be shared with peers and key stakeholders in the industry to further improve working methods and deliver more robust solutions.

This report acknowledges the support and co-operation of all staff interviewed within numerous companies and the input from Tim Foreman PhD researcher for Cardiff University.

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Section One

Introduction

Background

Climate Change and CO_2 Reduction Commitments

The UK has a legal commitment to a reduction of 34% in greenhouse gas emissions by 2020, 50% by 2025 and a reduction of at least 80% by 2050 all against 1990 levels. It is acknowledged that buildings are a major contributor to emissions of carbon dioxide in the UK; buildings are responsible for approximately 44% of man-made CO_2 emissions, with approximately 27% of the emissions coming from homes.

Building Regulations are already pushing builders and developers to meet ever more demanding targets for carbon dioxide emissions for new houses. But the realisation that about 80% of the building stock in use in 2050 is already built has turned attention towards our existing houses, in particular the older housing stock which is in general, less energy inefficient than the more modern housing stock, predominantly constructed before the requirement of Building Regulations that set minimum standards.

Home owners and landlords are being encouraged and legislated upon to 'improve' their properties and subsequently reducing the CO_2 emissions from their housing stock, and ensuring that they play an important part in the fight against climate change and help to move their tenants out of fuel poverty. But some of the most difficult buildings to tackle are those considered as historic homes, in reality this means the properties were probably constructed prior to 1930. These have the difficult challenge of balancing cost and environmental impact but there are additional considerations centred on the aesthetic and cultural significance of the building and place, its context as part of the built heritage and the many stakeholders who potentially have competing demands and concerns. There are of course other construction types created later that these that are equally poor performing, known commonly as the "system built types" constructed in many cases off site in panellised concrete, steel or other variants, but these properties typically do not suffer from the same issues, being of a non-breathable construction form.

Non-traditional buildings are without doubt the most challenging to improve from a thermal performance perspective, due to their use of natural materials and porous constructions they are the most susceptible to the effects of moisture ingress, subsequently resulting in the need for greater quality control and accurate assessment when choosing an improvement option. The decision to insulate must be taken with the greatest of care, with particular attention to the existing condition of the property, with a focus on fabric integrity, good watertightness, and a thorough investigation of the likelihood of introducing cold bridges into the building, and how these will be designed out in the installation process.

It is accepted that there is a limit to the extent of changes that can be made to improve a building's thermal performance without a significant impact on its appearance and on its historic fabric, and so improving the sustainability of such buildings results in a tension between the competing demands for heritage

preservation and the pressures to reduce the environmental impact of buildings in use. But the option to do nothing is not viable in global terms, we all need to be prepared to take on this challenge and this report offers guidance and a system to this challenge and provides a methodology for assessing the issues that can arise from poor decision making in the insulation process, so called unintended consequences.

The problems caused by moisture in building structures are well known and there is a large body of literature addressing issues including rising and penetrating dampness and 'interstitial condensation'. For regulatory purposes the key document currently is the BS Code of Practice for condensation in buildings BS5250:2011. Besides a discussion of the principals of condensation risk, the main content of BS5250 is prescriptive guidance on how walls, roofs etc. should be designed and constructed to avoid problems. Many if not most designers will refer to this guidance and not carry out any more complex assessments.

If a more detailed analysis is necessary, BS5250 refers to a calculation procedure specified in ISO 13788, which uses a 'Glaser' procedure, taking account only of steady state vapour diffusion. While this may be adequate for some structures, such as flat roofs (and even here there are situations where it is inadequate), it does not represent the whole picture for constructions such as masonry walls where very large amounts of water are stored in the fabric. No account is taken of rain impacts and solar gain on the outside surface, liquid water movement and the effect of moisture on the thermal and moisture transport properties of materials. A further standard, EN 15026 was developed to address these issues and this is now becoming used in the UK through the German software WUFI (which is based on EN15026). Some advocates of WUFI suggest that it will solve all problems and should replace the old ISO 13788 methodology completely. However there are a number of difficulties with this approach at present:

- WUFI is a very complex programme that needs a good understanding of building physics to use successfully. It can be very easy to enter the wrong parameters to produce rubbish results.

- Detailed data on the heat and moisture transport properties of the materials making up the structure is needed. There is a database, which contains mainly German materials, in WUFI. It is difficult to know whether these are relevant to UK constructions. Many of these properties are complicated and expensive to measure.

- Detailed external weather data from the location of the building is needed to run WUFI. This would be very expensive (~£15000) to acquire from the Met Office. It is possible to generate simulated climate data in WUFI format using software such as Meteonorm; however it is not clear how realistic this is of actual conditions.

- EN 15026 describes and models only 1D movement of heat and moisture. The WUFI programme can be 2D but this is currently outside the range of EN15026. As many of the problems of moisture require 2D approach there is currently also a disconnection between the standard and the current practice.

Incorrect moisture predictions can lead to two types of failure:

- Predictions that problems may occur, when in fact the risk is negligible, may limit the installation of insulation unnecessarily.

- Failure to predict real problems and take appropriate precautions will lead to problems such as rot of timbers, frost attack to masonry, damp staining to interior finishes and bad indoor air quality (due to mould and damp).

A number of detailed reports on these issues and the use of WUFI particularly in historic buildings have been produced by bodies such as BRE, EST, English Heritage Historic Scotland and SPAB. However a concise document, which gives a balanced overview and guidance for common understanding and practice, is urgently needed. This should be aimed at specifiers, architects, certification bodies, building control officers and the groups that manage historic buildings. It will provide a temporary framework for understanding moisture more fully and safely, but does not in any way replace the need for further research into moisture physics, modelling and material data, or, when this research is further advanced, for a more comprehensive standard for assessing moisture risk in buildings. For the purposes of this report the focus of attention to risk will be directed to non-traditional buildings as in most cases historic buildings are protected by some form of legislation or listing.

To understand the issues affecting older buildings it is necessary to understand the breathable nature of the building and why these older buildings and construction types start to show signs of dampness. To understand this issue it is important to look at changes in the construction methods used to maintain properties, and why these changes have exacerbated the problems, resulting in an increase of occurrences of these types of issues.

The overriding factor which is apparent is that the difference in building physics and construction between older and more modern buildings has been lost or ignored over recent years, and it vitally important to choosing the correct intervention that these principle differences are taken into consideration, and ensuring that the right materials and assessment process is utilised in the right context, for too long industry has tried to deliver a one fits all solution. With the desire to improve buildings from a thermal performance perspective, the basic principles of ensuring that the building is in a good state of maintenance and understanding the limitations in construction form is rarely considered.

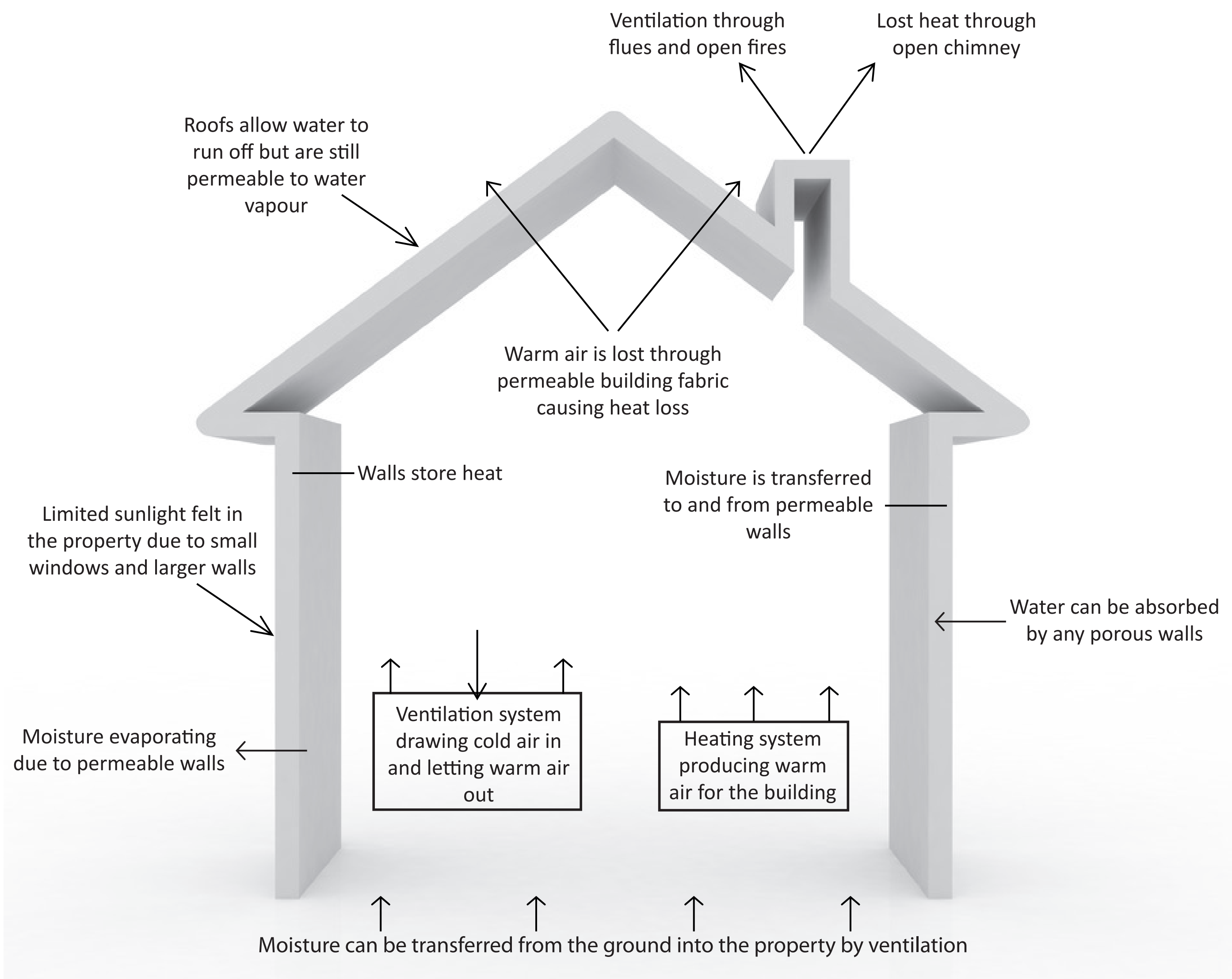
More modern construction methods relies on the creation of a cavity to provide protection from moisture ingress, whereas the older buildings accept the principle in general terms that moisture will penetrate the structure, normally through the mortar beds, and then through a mixture of natural ventilation (chimneys and leakage) etc allowing any moisture which has penetrated the structure to evaporate and vacate the building.

To allow this process to continue it is important that no improvement or intervention restricts the passage of the moisture either to the internal or external surface, without very careful consideration and design,and the possibility of unintended consequences is considered fully.

Should a maintenance or improvement programme introduce a more modern material into the structure, it brings with it a series of risks and potential failure which are rarely considered, these measures can vary, but can include sand cement renders, non-breathing paints, silicone waterproofing layers or other similar measures. The main cause of these problems is the introduction and use of modern construction practices in inappropriate locations and situations.

What needs to be appreciated is that the movement in a structure is dependent on many factors and recent research undertaken that moisture movement is multi-dimensional, and any alterations or change in this free movement can result in a build-up of moisture, either on the inner surface of the wall (mould) or within the structure of the building (interstitial condensation). The underlying cause of this occurrence is the isolation of the wall structure from a source of heat and ventilation by a non-breathing element. The long term effect of this change in wall state can in extreme cases result in wall failure, or in lesser cases, result in early failure of internal coverings (plaster etc) or in winter months frost damage to the external surface of the wall.

Before any fabric improvements to the thermal performance of a building are considered, it is essential that the original construction form and materials are carefully considered when choosing options, the first point of call for any refurbishment is to ensure that the building is in a good state of repair, that no modern materials have been introduced into the structure without careful consideration, and any signs of disrepair, water ingress, damp or deterioration are rectified before considering other measures.



This diagram of a traditional building illustrates moisture, air movement and thermal properties.

Section Two

Unintended Consequences

On-going research at the BRE and other organisations has identified a number of consequences of undertaking insulation to properties using limited knowledge of full understanding of the building physics that are affected. Although not an exhaustive list the most commonly identified and accepted risks are indicated below in Table 1.

Unintended Consequence	Cause
Overheating	Observed through both modelling and in the field. It is recognised that overheating can be a problem in all dwellings which have received solid wall insulation. This is particularly a problem for (but not restricted to) those that have been treated with internal wall insulation as a result of decoupling of thermal mass from the dwelling.
Increased relative humidity, and associated damp and mould growth	As a result of increasing air-tightness (not correctly alleviated e.g. through extract fans), increases in internal humidity can occur. This can lead to damp problems, and mould growth, with associated health problems for the occupants. The problem can be particularly associated with un-treated thermal bridges within dwellings.
Negative effect on neighbouring dwellings	There is the potential for the installation of solid wall insulation on one property to affect neighbouring dwellings. This is because the relative temperatures of the walls of the dwellings will be adjusted. As a result, moisture can condense on a neighbouring property in a place where it did not previously causing damp, mould and other problems.
Shifting of thermal bridging to new points	The application of solid wall insulation can affect the internal condensation points. This can create new points which are incapable of withstanding exposure to condensation.
Increased risk of dry or wet rot to timbers	The risk of dry rot developing increases with increased levels of humidity which can occur following the installation of solid wall insulation. An increase in wet rot can be caused by high levels of moisture or humidity in timbers due to poor detailing.
Increased risk of insect attack on timbers	Insect attack to timber structures is increased if the timbers are not kept dry. In older solid wall dwellings (where timbers are more prevalent) any increase in the relative humidity can lead to an increased risk of insect attack on timbers.
Increased risk of dust mites, bed bugs, clothes moths and other insects within the home	A number of household pests including dust mites, bed bugs and clothes moths are more active and prevalent in increased humidity which can follow the installation of solid wall insulation.

Unintended Consequence	Cause
Increased Radon risk	In areas of the country prone to Radon (e.g. areas of South West England) increasing airtightness following the installation of solid wall insulation could potentially result in an increase in the risk of exposure to occupants.
Rot of internal floor and roof timbers	With internal insulation floor and roof joists can become significant thermal bridges unless particular care is taken. Due to increases in humidity, these thermal bridges can then rot as moisture condenses on them, causing significant structural problems.
Damage to the external wall structure, or failure of internal finishes, due to water fill and frost damage following internal insulation	The application of internal wall insulation can mean that an external wall is no longer dried by heating the interior of the dwelling. As a result, moisture is not driven out of the walls, which can cause structural damage and the failure and decoupling of the internal finishes (including the internal insulation itself). One mechanism for damage is ‘frost damage’ to the brick as the water in the wall freezes. It is important to understand the physics of how solid walls perform and deal with moisture transference based on their levels of humidity.
Increased interstitial condensation	An increase in humidity can result from the application of solid wall insulation, leading to condensation in interstitial spaces (such as in roof eaves etc.), or within the structure of the walls.
Short-term reduction in air quality following installation of solid wall insulation (Formaldehyde and other VOCs)	There is a risk of increased levels of toxic volatile organic compounds (VOCs) including formaldehyde from the adhesives and other substances used in insulation products. These substances can have significant short and long-term effects on the health of occupants, with many being carcinogenic.
Long-term reduction in air quality following solid wall insulation (CO, CO_2 levels)	A reduction in air quality over the longer term as a result of reduced levels of ventilation following solid wall insulation may occur. This may lead to increases of Carbon Monoxide and Carbon Dioxide, both of which can have short and long term effects on physical and mental health of occupants.
Aesthetics	From a cultural or aesthetic point of view, the use of external wall insulation may have a significant impact on the character and vernacular of many towns and cities throughout the UK.
Property value	The effect of solid wall insulation on property value is uncertain. While some value can be assigned to the lower levels of energy consumption, lower values may result from any reduction in aesthetic appeal, or reduction in internal space resulting from the works.
Daylighting	Research undertaken by BRE indicates that the use of wall insulation can have a detrimental effect of internal day light factors. This has a counter factual outcome of providing insulation to reduced energy demand, with the potential for increased energy demand on lighting, and less benefit from solar gain.
Durability and maintenance and repair consequences	Solid walls with no insulation applied either internally or externally are very robust and sturdy structures. The introduction of materials that are effectively air traps and less resilient to impact could potentially have an unintended consequence of an increased demand for maintenance and repair, as a result of damage or even normal usage.

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Unintended Consequence	Cause
Disturbance	The installation of solid wall insulation has the potential for disturbing not only the occupiers but also the surrounding vicinity, with the erection of scaffolding, deliveries and other incidental activities. As a consequence, when residents understand the extent of disturbance, it may become a disincentive to having the improvement works undertaken.
Fire safety	Applying solid wall insulation internally or externally may introduce a potential for increased fire risk to buildings, unless this consequence is fully considered. There are potentially significant risks of creating a fire bridge between dwellings with external wall insulation systems over several dwellings (e.g. a block of flats).

Table 1 – Current topics of Unintended Consequences

Advantages and Disadvantages of Insulation Placement

Both internal and external wall insulation have their advantages and disadvantages, but it is important to take account of the challenges that are faced when making the decision as to which to choose when insulating a building. Table 2 takes into account key considerations and provides insight into the advantages and disadvantages for both types of insulation placement.

Considerations	External wall insulation	Internal wall insulation
External appearance	Can improve the rainscreen protection and appearance of property and can therefore enhance the property value.	No change in external appearance, which may be a benefit when wishing to retain attractive external features.
Influence on floor areas	Some loss of space externally due to insulation (may affect pathways etc.) Surface may be less robust than solid wall, which may require reinforcement in vulnerable areas.	Some loss of internal floor area/ room size. Surface may be less robust than solid surface.
Removal/refitting of items	Guttering/ drainage, aerial/ satellite dishes etc. may need to be moved or refitted to accommodate insulation.	Services, skirting, switches and plug points, etc. will need to be removed and refitted onto newly insulated surface. Subsequent redecorating will also be required.
Continuity of insulation	Generally good continuity across plane wall elements, though may be some disruptions from adjoining garden walls, garages, lean to, etc.	Will inevitably be breaks in the insulation continuity at internal partition walls, intermediate floors, etc.
Thermal mass and responsiveness	Effect of building as a thermal store is improved by reducing swings in temperature, for instance from solar gain.	Increases the responsiveness of the heating system. Likely to reduce the effective thermal capacity of the wall.
Disruption to household	Scaffolding will be required to access upper storeys, but otherwise minimal disruption to occupants.	Would need to move furniture and fittings etc, may need to cut off services temporarily to some locations. Easiest if dwelling empty at time of works.
Planning requirements	Planning permission may be required if the new insulation will front directly onto a public right of way or the building is in a Conservation Area or similar.	Since the external appearance will not be changed, no permissions should be required.
Protecting the wall	Can extend the lifespan of the building by protecting the brickwork/ stonework if carefully detailed, but weak spots of poor assessment can lead to moisture being trapped behind the insulation and against the wall, resulting in penetrating damp and condensation issues as the moisture is now isolated from solar irradiation.	Offers no weather protection to the wall, resulting in moisture build up and risk of freeze thaw frost damage. Can also lead to build up of moisture behind the external wall insulation leading to condensation mould growth and early deterioration of the system.
Potential for partial works	Needs to be done over an entire façade at least, if not the entire dwelling.	Can be done on a room-by-room basis if necessary.

Table 2 – Overview of Systems Placements

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Section Three

Description of the Project

This project looks at the current practices and methods used by external wall insulating companies across the UK on a range of sites and locations, to identify any weaknesses or potential for improvement to ensure the best possible processes are used to undertake surveys, design, and improvements. It looks to deliver a review of current process and methodology to ensure the best possible understanding is utilised by any workforce employed by companies engaged in these activities, and as a consequence a quality installation for the client.

It takes the research undertaken by the BRE and others and sets out a series of findings, and recommendations on surveying processes and the consideration of a future training programme to be undertaken, to ensure that external wall insulation companies perform with the latest knowledge and understanding of the issues surrounding external wall insulation.

The recommendations section of this report covers the additional process and methodologies that should be included by any company should they wish to improve the delivery of their external wall insulation offering.

This section of the report is broken into the following;

3.1 Early Considerations

When undertaking an assessment for applying external wall insulation to older properties or indeed any property it is vital that a clear understanding of possible un-intended outcomes are fully considered, the issues are applicable to either internal or externally applied insulation in varying degrees.

It is important to fully understand the challenges that are faced by choosing either internal or externally applied insulation, both have their merits, but both can be problematic. Table 2 indicated a summary of the advantages and disadvantages of both placements of insulation.

3.2 Findings of Current Practices

Many companies have adopted the PAS2030 process as the means of delivering their external wall insulation business and put in place the requirements of checks, and assessments to follow this principle and standard, producing a number of checklists and guidance documents to help staff follow the adopted principles. However a review of a number of the company practices does highlight inconsistency in the application of those standards, and weakness in the skill sets of the staff involved in undertaking these checks and reviews. Below are set out the identified areas of weakness that have been observed.

3.2.1 External Wall Insulation

3.2.1.1 Initial Preparatory Works

- Inconsistent identification/removal of areas of delaminated render (pre-installation)
- Limited assessment of characteristics of building and siting prior to specification
- Signs of movement in building ignored
- Parge coating essentially never undertaken, regardless of wall surface
- Local climatic conditions not fully considered, wind driven rain, exposure etc

3.2.1.2 Design Weakness

- Gaps left between boards and void at bells
- Reveals not insulated
- Meter boxes left in place, services boxed around rather than moved to outside of system
- Significant thermal bridging left at eaves – both with soffit and without. Heads of top-floor windows often left uninsulated if at roof level
- Thermal bridge at area over porch roofs, etc. (often >100mm left uninsulated) (so as to reduce rain splash-back dirtying render and saturation from snow)
- Flashing over conservatories, shed roofs, etc. not boarded over with insulation, instead insulation is left above level of flashing
- No insulation below DPC (often starts 50mm above)

3.2.1.3 Inconsistent Workmanship

- Weep holes/channels of windows covered by oversills
- Gaps between boards, at times up to 10-15mm
- Mesh not fully embedded
- Stress patches of inadequate size
- Bond pattern of boards not in line with spec (e.g. <200mm vertical edge to vertical edge between courses)
- Fixings: specified pattern not followed, over drilled, over sunk, etc.
- Adhesive (where specified) not applied consistently to board
- Inconsistency of pattress placement for hanging baskets, etc.
- Sills, verge trim, etc. not adequately sealed, or mistakenly left unsealed
- Capillary grooves on sills compromised
- System stops, base rail, trim etc. not firmly fitted
- Poor/no ground clearance, particularly around doorsteps, ramps, etc.
- Spill of verge cap and window sills often inconsistent (e.g. verge cap tilted in toward house)
- Top coat missing in small areas of wall
- No clearance left at gas shut-off valves
- Service penetrations not adequately sealed
- Inadvertent blocking of direct air vents for gas fires and back boilers
- Blocking of drains, poor routing of rainwater goods and wastes to drains (causing splashing or flooding)
- Penetrations of system (e.g. satellite dishes, hanging baskets, rainwater goods) insufficiently robust, may allow rain penetration over time
- Silicone sealant applied to dusty or unclean surfaces

3.2.1.4 Inadequate Specification

- Brick slips or high durability finishes not specified in high traffic areas
- Silicone render not specified over acrylic when climate conditions dictate

3.2.2 Internal Wall Insulation

3.2.2.1 Initial Preparatory Works

- Assessment of suitability of IWI for building is inadequate, no consideration of ‘breathable’ wall construction and specification of ‘vapour permeable’ IWI systems
- Wallpaper, wainscoting, organic material not removed prior to installation
- No inspection of exterior of wall to determine weather-tightness, rising damp, etc
- No consideration of ventilated cavity behind insulation or vents through wall, even in areas of high exposure of likely interior damp

3.2.2.2 Design Weakness

- No vapour control installed
- No insulation installed in floor/ceiling voids
- No insulation continuity between wall element and loft insulation
- Cheeks/reveals not insulated
- Window sills not insulated (including bow windows, etc.)
- Where floor-ceiling voids are not insulated, ceiling and floor penetrations are not sealed to reduce vapour transport

3.2.2.3 Inconsistent Workmanship

- Poor butting of insulation boards
- Large gaps (10-150mm) left between boards and walls/ceilings/floors/sills – often coving is not removed and boards stop short of this height
- Window trickle vents covered by insulation
- Cupboards, meter boxes, in-built furniture etc. left in situ and no insulation placed behind
- Joists not protected from condensation risk (particularly relevant where joist space is not insulated)
- Insulation not returned along partition walls (thermal bridge)
- Service penetrations not adequately sealed
- Inadequate fixings
- Pattresses not provided

3.2.3 Process

- Renders and adhesives applied and/or stored in unsuitable weather conditions (cold, rain, heat)
- Insulation left outside in rain on installation day (wet insulation installed)
- QA processes where evidenced relegated to ‘tickbox exercise’. Individual properties not adequately tracked and photographed at key stages of installation
- No commissioning or handover process

Although the issues highlighted in this section have been evidenced and observed, it is more a record of the state of play regarding current practice in the external wall insulation industry, rather than a criticism of the standard of work undertaken by any one or number of companies, and reinforces the need for more Quality Control and specific expertise in the industry.

The overriding issue that has been identified with current working practices across the industry is an inconsistent approach to assessment, checking, and quality control. The main reasoning behind this weakness appears to be a lack of knowledge and understanding in a number of key areas, specifically the initial surveying and assessment process for system identification, the design of the insulation system and its ability to deal with non-standard junctions and detailing, the understanding by the installation workforce on the importance of following key principles of best practice, and a deep understanding of the principles of Building Physics and the classification of unintended consequences of poor design and quality control by staff involved in signing off key stages of the work.

The main areas of understanding that need to be addressed can be categorised as;

- The key areas that need to be surveyed before insulation works are undertaken
- The impacts of cold or thermal bridging, and the importance of minimising the risk
- The importance of attention to detail and specification on site
- Impact of saturation on conductivity, condensation risk, temperature gradients, cold spots, convective looping
- Communication between site installation and Quality Control in a positive feedback loop to ensure that good practice is reinforced and bad practice not ignored
- Targeted informative tool box talks on the principles of good practice before each project, with any key elements of the insulation system clearly set out to installers
- More robust and evidenced quality control with well trained staff
- Creation of more robust details, reducing the over reliance on sealants and workmanship.

3.3 Installation Guidance

3.3.1 Summer Condensation in Dry Lined Walls

During cold weather interstitial condensation occurring within internally insulated solid walls is normally prevented by a vapour control layer on the warm (internal) side of the insulation. However, in summer, strong sun on unprotected walls can drive moisture towards the inside of the building and through permeable insulation or through gaps between less permeable insulation, to condense on the outside face of the vapour control layer. Moisture contents of the external wall need not be high for this failure to occur. Once condensation has occurred it stays for many days, as transfer out is much slower than transfer in. The condensation can be prevented by internal heating, but this is not an option for the summer. Since the condensation occurs behind a waterproof vapour control layer it is often not noticed. Strong sun on damp solid external walls can cause condensation to occur, which can trickle down the vapour control layer, and wet timber.

3.3.1.1 Prevention

Principle - The moisture must be reduced to a level at which condensation will not occur, by external protection to the wall or by ventilation.

3.3.1.2 Practice

- Assess risk before deciding to insulate thermally solid external walls on the inside;
- External insulation avoids this type of failure, if undertaken correctly.

Decide which walls are at risk, Figure 2; i.e., walls facing East South East to West South West.

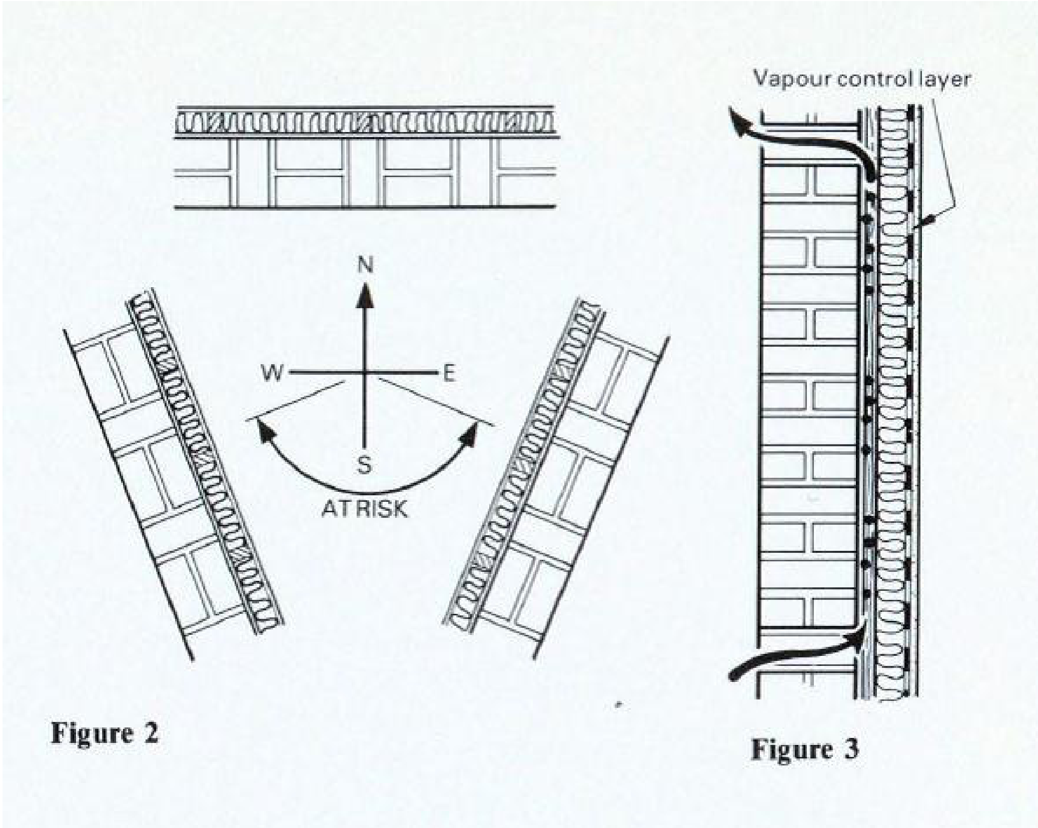

Figure 2

Figure 3

EITHER

• Specify shading for walls exposed to direct sun or specify covering with tile hanging or other claddings;

OR

Specify a cavity ventilated to the outside, Figure 3

- Specify for solid masonry walls, vertical joints to be raked out through the full thickness of the wall at top and bottom of each storey height, or specify slot ventilators angled to shed water outwards;
- Horizontal spacing not to exceed 1.5 metre.
- Specify for existing walls of other materials, ventilation holes to give an equivalent open area of 500 mm^2 per metre run.

Note: Specifying the omission of a vapour control layer is not an acceptable solution. Summer condensation could be deposited behind low permeability internal finishes. But this approach needs to be carefully considered before being attempted, as incorrect detailing can exacerbate problems.

3.3.2 Bridging

3.3.2.1 Problems/ Risks Associated with Thermal Bridging

If the effect of thermal bridging is not taken into consideration when calculating potential heat loss from a building, it is likely that the overall heat loss will be underestimated. It follows that if buildings are improved through insulation but thermal bridges remain, heat loss will be concentrated at the point of the bridge relative to the newly improved walls. While it is obviously desirable to minimise this effect to help reduce heating costs, it can also be the cause of physical problems in certain circumstances. Since heat will transfer out of the building more readily at the point of a thermal bridge, the internal surface temperature at that point will generally be reduced relative to the surrounding surface area. When the temperature difference reaches a critical ratio, measured as the Temperature Factor (f_{Rsi}) at the junction, condensation can form, which can lead to problems such as mould growth.

To limit this risk of surface condensation or mould growth at junctions, the temperature factor should be greater than or equal to the critical value (f_{CRsi}) of 0.75, as quoted in BRE’s Information Paper 1/06, ‘Assessing the effects of thermal bridging at junctions and around openings’[i]. It is therefore important when assessing the effects of thermal bridging at a junction to also understand the impact on the temperature factor to determine whether physical manifestations of this concentrated heat loss phenomenon are likely to be a problem. Latest research indicates that when reveals and penetrations are not insulated the temperature factor and subsequent cold bridge is actually worse than before the walls were insulated, resulting in a concentration of risk in a two dimensional junction that is least capable of dealing with a drop in temperature.

Considerations for Externally Applied Insulation

3.3.2.2 Obstructions and Detailing

When undertaking externally fixed, external wall insulation (over cladding) attention to detail is vital, this importance is not just down to ensuring the finished work is aesthetically pleasing, but to ensure that cold bridges are not built into the structure, by poor workmanship or inadequate attention to detail. Circumstances where this can be seen is at the eaves and roof line details where the roof line has not been extended, or the thickness of the chosen insulation results in a newly created step, where none existed before. Other examples of this phenomena can be experienced on other external features such as incoming service mains, utility boxes. Satellite dishes, telephone junction boxes and other services that abut the wall, or are in such a location as to hinder the installation process.

In many properties where external wall insulation has been applied, there has been little consideration for dealing with one of the largest cold bridges in the building, the floor slab, thermal bridging modelling indicates that this area contributes significantly to the heat loss from a building post improvements , currently the losses through cold bridging have been identified to be the cause of 19% of heat loss through a building envelope., this lack of attention to detail at this area is understandable with the desire to not bridge the damp proof membrane or course, but there are examples of where careful treatment of this area can result in reduced cold bridging and subsequent risks.

3.3.2.3 Workmanship

Without robust and consistent checks and inspections cold bridges or poor performing details can be also be introduced into a building , by poor performance and workmanship on site, including but not exclusive by the following occurrences.

- Poor butting of insulation, resulting in the introduction of another material (sealant)
- Inconsistent fixing
- The base surface not being smooth enough, introducing interlinked cavities behind the insulating layer, which in extreme cases may introduce a cavity bypass, where none previously existed.
- Insufficient care around openings, including the insulation of reveals, jambs, heads and verges etc
- Incorrect storage of materials on site, resulting in deflection or moisture in the boards
- Working in bad weather

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3.3.2.4 Prevention

However, the effect can generally be mitigated by giving special attention to the methods of detailing employed:

- Attention should be given to insulating within the reveals at window junctions, in particular to isolate thermally conducting features such as concrete or stone lintels or sills.

- Where external walls meet with the ground floor it is possible to reduce the extent of thermal bridging by continuing the external insulation to ground level or below, with appropriate consideration given to preserving an appropriate damp proof mechanism.

- Eaves junctions may be improved by extending the eaves so as to allow the loft insulation at ceiling level to be brought out above the line of the external wall insulation. However, this is more complex and costly solution compared to some of the others discussed in this study and will need to be considered on a case by case basis depending on the practical circumstances of any particular installation (e.g. the effect on neighbouring properties).

- At the junction of party walls with external walls, it is interesting to note that the modelling suggests that only insulating one dwelling in an adjoined pair will not necessarily detrimentally affect the uninsulated dwelling assuming the properties are both heated to a similar extent. However, the only real way to improve the potential thermal bridging at such a junction is to insulate both dwellings.

- When undertaking internal wall insulation, it is imperative that the floor / ceiling voids are insulated, this helps prevent cold bridging, and subsequently reduces the risk of condensation, mould, rot and decay of timber elements, such as joists and lintels.

Although thermal bridging may be exacerbated as a result of poorly detailed externally applied insulation, it is reassuring to note that the temperature factors researched are not made any worse in the junctions investigated. Hence there should be no increased risk of condensation compared to the base case (though that is not to say that some junctions may not still be at risk). The risks associated with internal wall insulation are significantly higher than externally applied insulation and the use of numerical modelling and design should be undertaken to reduce the risk from condensation and mould growth.

3.3.3 Overheating

Instances of summer overheating, where none originally had been experienced have been observed through both modelling and in the field. It is recognised that overheating can be a problem in all dwellings which have received solid wall insulation. This is particularly a problem for (but not restricted to) those that have been treated with internal wall insulation as a result of decoupling of thermal mass from the dwelling.

As part of the surveying process, should the solution identified be internal insulation, where the problem is at its greatest, close inspection of the construction materials that make up the internal floors and walls is recommended. Identifying the existence of solid ground floors and internal walls with reasonable mass can help prevent overheating, by the presence of thermal capacity to store any excess latent heat generated by either metabolic or solar gains.

3.3.4 High Exposure

Moisture penetration under specific conditions of driving rain, especially wind-driven rain, can lead to the situation where water will penetrate the exterior face of the walls. This can result in moisture infiltrating the inside, causing reduced thermal performance and damage to the wall and interior, the thermal properties of a dry wall is well known to be better than that of a wet or damp wall. EWI systems can help solve this problem by giving extra protection from the precipitation; however they can still be susceptible to water ingress, through a number of routes. Moisture ingress into the insulation materials will affect its thermal performance dramatically, and the thermal conductivity of porous materials will decrease, as the water replaces the air within the pores. It is common knowledge that it is the main contributor to the insulation value as it has a much lower conductivity (k=0.025W/mK), when compared to water (k=0.6W/mK).

If the insulation is either

- not detailed correctly,
- or poor performing sealant is used,
- or poor workmanship is used

when external wall insulation systems are applied, it can lead to premature failure and in severe cases the moisture is able to run down behind the cladding, thus penetrating the insulation material behind it. There is growing support for the assumption that water will penetrate the building / cladding however careful or well designed the insulation systems may be.

This presumption known as the ASHRAE 160P method demonstrates that if water leakage cannot be completely prevented i.e. 1% of driving rain load penetration; the drying potential of the insulation systems becomes crucial. The study argues that due to the vapour retarding nature of closed cell slabs like EPS, they cannot provide the necessary drying towards the exterior causing a threat of moisture damage to the underlying substrate. Therefore instead of using the expanded polystyrene, a high density mineral wool insulation slab is recommended due to its high vapour permeability, but it is important to ensure that the finishing layer is capable of resisting the ingress of moisture over the life time of the system.

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It is important at this stage that the system selected for the improvement works are thoroughly assessed for suitability in the location of the buildings, and that exposure, wind driven rain and other climatic conditions such as shelter and solar irradiation are factored into that decision process, with a clear and robust case put forward for the system selected.

3.3.4.1 Prevention

The issues raised here can be adequately addressed by the creation of a batch of standard details of a proven performance that are both robust and resilient. Standards and processes exist for the assessment of suitability of materials, and these should be adopted as a key principle for high exposure areas, where no previous assessment on similar buildings has been undertaken.

3.3.5 Ventilation

Extensive research undertaken by many organisations points towards the issues of increased condensation to older properties with high moisture content in the structure suffering from increased surface condensation post insulation improvements, detailed studies indicate that the application of EWI can significantly reduce air infiltration through the normal routes, or poor joints, junction and windows, therefore it is crucial that as a result of increasing air-tightness (not correctly alleviated e.g. through extract fans), increases in internal humidity can occur. This can lead to damp problems, and mould growth, with associated health problems for the occupants. The problem can be particularly associated with un-treated thermal bridges within dwellings if not improved at the time of insulation.

The studies indicate that even when extract fans are evidenced they may either not be correctly installed, commissioned, maintained or even working, and that passive or background ventilation through air bricks and old back boilers, may be blocked up in the insulation process.

It is therefore essential that an assessment of ventilation both active and passive is undertaken before works are undertaken and post insulation to reduce the risk of increased humidity and condensation.

3.3.5.1 Prevention

An assessment of compliance with the principles of Part F of the Building Regulations should be undertaken during the initial survey and assessment stage. Recent research indicates that the air infiltration (draughts) in existing buildings are significantly reduced with the installation of external wall insulation, this factor increases the risk of high humidity and condensation risk if a building is not adequately ventilated. Should the building not meet these requirements than improvements must be installed to ensure compliance, the result of not doing so will be an increased risk of condensation and mould growth, and the associated risks to occupant health.

Section Four

Conclusion and Recommendations

In conclusion there is no doubt that many organisations are striving to deliver a quality process and product, however this study indicates that despite the introduction of the PAS2030 Standard and the required checks and processes set out in that standard there is clear evidence of as inconsistent delivery of the principles and methodologies. There is an addition an identified need for up-skilling of both the work force and the site supervisory staff to drive good practice on towards best practice as a norm.

To make this step change a series of recommendations are set out below that any external wall insulation organisation need to consider if it is to deliver a quality product for their clients, it may require a period of time and investment to ensure that this is delivered consistently company wide.

The following recommendations for training are set out and targeted towards surveying staff, site installation staff and site supervisory staff separately.

Surveying Staff

- The principles of assessing for exposure and wind driven rain, and suitable material selection
- Identifying structural conditions that affect the decision on suitability of properties for insulation, i.e. spalled render, movement cracks, depth of sills, roof line, and openings for minimising cold bridging, and other restrictions that will hinder the installation process
- Moisture content in buildings, and the principles of a breathing structure
- Building Physics differences between traditional and non-traditional buildings
- Ventilation compliance with Part F of the Building Regulations

Site Staff

- The key principles of cold bridging, and the importance of good detailing and attention to detail
- Specific targeted knowledge of the differences in systems performance, the ways in which different insulation works, and how poor workmanship can compromise this performance
- Ventilation assessment principles to ensure that this is not compromised during installation

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Supervisory Staff

Technical

- Identifying structural conditions that affect the decision on suitability of properties for insulation, i.e. spalled render, movement cracks, depth of sills, roof line, and openings for minimising cold bridging, and other restrictions that will hinder the installation process. A final sense check before installation progresses, and is undertaking before work starts.
- Moisture content in buildings and the principles of a breathing structure, to enable informed decisions when signing off workmanship and quality control stages.
- Building Physics differences between traditional and non-traditional buildings
- Ventilation compliance with Part F of the Building Regulations
- Continuity of fixing, and not accepting poor workmanship

Communication

- Briefing of workforce before commencement on particular issues with the properties, i.e. unusual details, restrictions and particular requirements
- The importance of Installation consistency
- The need for a 360 review of each project to disseminate lessons learnt, and opportunities for improvement

Quality Control Improvements

- Evidenced audit trail
- Regular checking by competent staff
- Regular re training on key principles

Maintenance issues

- Maintenance schedules produced for residents and housing managers
- Regular inspection regime
- Designing for robustness

Tool box talks or enhanced training delivery to installation staff

- Regular tool box talks on hot topics, or areas where a drop in standards has been evidenced
- Interactive sessions that are mandatory, checked and relevant

Handover documents

- Documents that are asset out in an appropriate and clear manner, which indicate periods of maintenance and inspection for either the homeowner of management body.
- Setting out of clear instructions of what actions to take in the event of damage either accidental or otherwise to any of the key components of the system installed.
- Information on simple energy efficiency steps that can be taken to reduce the fuel consumption and ensure that maximum cost savings are delivered by the insulation system, such as turning down thermostats, not leaving windows open unnecessarily, and not drilling holes or disturbing the insulation systems.

Section Five

References

[i] Ward. TI, IP1/06: 'Assessing the effects of thermal bridging at junctions and around openings', IHS BRE Press, February 2006

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