Roles and Acknowledgements

Within SERC, the project was led by John Ross MSc (Research Lecturer) who carried out the data analysis and authored this report. Assistance during the preparation and research stages was provided by Stewart Nelson (Lecturer). The Geographical Information Systems (GIS) maps were created by Kathryn McNair (GIS Consultant). Overseeing the project delivery within SERC was Janice Cooke (Project Manager, Business Services).

The excellent surveying work, sometimes in extremely demanding circumstances, was carried out by Jim Stewart and Mark Hunter from approved subcontractor, Energy Store.

The bespoke surveying software package and advice was provided by Gareth McCullough and his team at G3S Software.

Thanks to the staff at NIHE for their support, in particular Joe Frey (Head of Research) and Shauna Mulgrew (Project Manager, Research Department) and her staff.

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<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>BBA</td>
<td>British Board of Agrément</td>
</tr>
<tr>
<td>BRE</td>
<td>Building Research Establishment</td>
</tr>
<tr>
<td>BUFCA</td>
<td>British Urethane Foam Contractors Association</td>
</tr>
<tr>
<td>BREDEM 12</td>
<td>BRE Domestic Energy Model 2012</td>
</tr>
<tr>
<td>CIBSE</td>
<td>Chartered Institute of Building Services Engineers</td>
</tr>
<tr>
<td>CIGA</td>
<td>Cavity Insulation Guarantee Agency</td>
</tr>
<tr>
<td>DPC</td>
<td>Damp Proof Course</td>
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<tr>
<td>EPA</td>
<td>Environmental Protection Agency</td>
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<tr>
<td>ESP</td>
<td>Environmentally Safe Product</td>
</tr>
<tr>
<td>EST</td>
<td>Energy Savings Trust</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographical Information Systems</td>
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<tr>
<td>GRP</td>
<td>Glass Reinforced Plastic</td>
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<tr>
<td>IARC</td>
<td>International Agency for Research on Cancer</td>
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<tr>
<td>MERA</td>
<td>MountEagles Ratepayers Association</td>
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<tr>
<td>NIA</td>
<td>National Insulation Association</td>
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<tr>
<td>NIHE</td>
<td>Northern Ireland Housing Executive</td>
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<tr>
<td>SERC</td>
<td>South Eastern Regional College</td>
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<tr>
<td>SPF</td>
<td>Spray Polyurethane Foam</td>
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<tr>
<td>UFFI</td>
<td>Urea-Formaldehyde Foam Insulation</td>
</tr>
<tr>
<td>QALY</td>
<td>Quality Adjusted Life Years</td>
</tr>
<tr>
<td>UUJ</td>
<td>University of Ulster at Jordanstown</td>
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</tbody>
</table>
1.0 EXECUTIVE SUMMARY

Within the last couple of years, the local insulation industry suggested, based on its own research, that the quality, and therefore the energy efficiency, of cavity wall insulation installed in homes since the 1970s may not be as efficient or meet standards as originally assumed.

It is well documented that poor cavity wall insulation not only impacts significantly on health, social and environmental issues, but has financial and energy costs which in turn, drive fuel poverty.¹

In August 2013, the Housing Executive appointed South Eastern Regional College (SERC) to carry out a research project with a view to establishing whether there are quality and effectiveness issues with all types of cavity wall insulation their properties, and if so, to report on the scale of the problem and highlight potential cost effective remedies.

Within this research project, a total of 206 homes were surveyed across Northern Ireland. Survey methods were physically intrusive into the cavity, allowing visual data recording using electronic equipment and captured on bespoke software.

The research found that many homes suffered poor and inadequate levels of thermal protection. Only 9% (19 homes) were deemed to have sufficient cavity wall insulation and be fit for purpose.

<table>
<thead>
<tr>
<th>Quality</th>
<th>Homes (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Severe with critical needs</td>
<td>81 (39%)</td>
</tr>
<tr>
<td>Unsatisfactory with grave needs</td>
<td>54 (26%)</td>
</tr>
<tr>
<td>Significant needs</td>
<td>22 (11%)</td>
</tr>
<tr>
<td>Specified needs</td>
<td>28 (14%)</td>
</tr>
<tr>
<td>Fit for purpose</td>
<td>19 (9%)</td>
</tr>
<tr>
<td>Solid wall</td>
<td>2 (1%)</td>
</tr>
</tbody>
</table>

Since most NIHE cavity insulation was carried out during the 1980s, quality control, inspection methods and industry training was not as advanced as it is today. Many historical building knowledge and insulation practices may look poor when assessed against modern quality control measures. It should be pointed out that the cavity wall insulation industry was in its infancy in the 1980s, installation techniques were not as advanced or as well researched as they are today and inspectors would not have had borescopes or thermal imaging cameras. Inspections would have been difficult without very costly and intrusive measures.

It is worth noting that whilst this report relates to NIHE stock, similar results have been found in many private sector dwellings from the 1980s and 90s as it was basically the same contractors using similar installation practices.

¹ Davidson, M et al (2012) ‘The Cost of Poor Housing in Northern Ireland’ IHS, NIHE, BRETrust, BREPress foreword by Dr John McPeake C.E. NIHE
POSTNOTE (2011) ‘Housing and Health’ POST Houses of Parliament
This project found that, since installation, the cavity wall insulation material within many of the properties had deteriorated. Whilst the insulation was originally installed using the best available practices at the time, advances in knowledge and technology mean that insulation installed today would be less likely to deteriorate due to better training, higher quality materials and improved systems of control and inspection.
2.0 INTRODUCTION

2.1 Background

The Northern Ireland Housing Executive was designated as Northern Ireland’s Home Energy Conservation Authority by the Home Energy Conservation Act (1995). In this role the Housing Executive is tasked with identifying practicable, cost-effective measures which would significantly improve the energy efficiency of Northern Ireland’s housing stock.

Within the last couple of years, the local insulation industry suggested, based on its own research, that the quality, and therefore the energy efficiency, of cavity wall insulation installed in homes since the 1970s may not be as efficient or meet standards as originally assumed.

In August 2013, following a tender process, South Eastern Regional College (SERC) was appointed by the Northern Ireland Housing Executive (NIHE) to undertake a research project – The Quality of Cavity Wall Insulation in Housing Executive homes, with a view to establishing whether there are quality and effectiveness issues with all three main types of cavity wall insulation, and if so the scale of the problem in Northern Ireland and highlight potential cost effective remedies.

SERC appointed Energy Store who are a British Board of Agrément certified company, to carry out the required survey and inspection work and subsequently provided the findings and data to the Research team for analysis.

To ensure the integrity of the survey and its findings, lead researchers (SERC) carried out their own spot checks on dwelling inspection methods and the secure storage of electronic data. In addition, NIHE carried out a number of quality site inspections.

2.2 Terms of Reference

2.2.1 Aims and Objectives

The overall aim of the research project was to establish if there is a quality issue with the three main types of cavity wall insulation (fibre, beads, insulation board) in Housing Executive houses, and if this is the case to provide evidence of the scale and extent of these issues. In meeting this overall aim, the following objectives should be achieved:

1. Undertake a detailed technical survey of cavity wall insulation in 300 dwellings.

2. Using accepted statistical procedures provide estimates for the scale and extent of the problem at the Northern Ireland level for each of the three main types of cavity wall insulation.

3. Where possible and appropriate provide broad indications of the geography and age/type of dwellings most affected by any quality issues identified.
4. Work in partnership with the Housing Executive’s technical experts to recommend cost effective solutions to any quality issues identified.

5. The research team should also provide an up to date review of relevant academic and trade literature, particularly from Northern Ireland.

2.2.2 Key Outputs
The key outputs from the project would be:

1. A project initiation document which set out agreed and refined timescales and methodologies.

2. A quality assured dataset of the properties surveyed and associated summary tables will be completed.

3. A comprehensive written research report, which will include methodological issues, analysis, findings and any associated recommendations.

2.3 Project Phases
The research project would be carried out in three phases:

Phase 1: A short (c20 page) literature review of recent research on cavity wall insulation, the importance of correct installation and how its effectiveness may change over time.

Phase 2: A survey of 300 Housing Executive dwellings across Northern Ireland out of a total of 495 which were surveyed as part of the 2009 or 2011 House Condition Surveys. The achieved surveys must be broadly representative of all six counties in Northern Ireland. The Housing Executive will provide the addresses of the dwellings to be surveyed and would forward a letter of introduction to each of the sample dwellings.

Phase 3: SERC would provide an analysis of the research findings for each surveyed home and where appropriate, detail issues and recommend remedial action directly with the Housing Executive. A comprehensive report for each surveyed home and a separate overarching report would be written. The Housing Executive would provide technical advice where appropriate and would jointly develop recommendations.

2.4 Project Implementation
A project initiation meeting took place in August 2013, with key representatives from NIHE, SERC and Energy Store. Management processes and responsibilities for the research project were established, along with work programmes and methodologies, milestones, reporting dates and deliverables.

Following this a Project Initiation Document (including project plan) was created by the project team within SERC and approved by the Housing Executive.
The Housing Executive undertook to select and provide details of up to 300 of their properties for survey by SERC. However, the target of 300 homes proved difficult for a number of reasons and the sample size was reduced and accepted by the Housing Executive to 206 properties.

2.5 Report Structure

The report is structured as follows:

Section 1: Executive Summary
Section 2: Introduction
Section 3: Survey Methodology
Section 4: Literature Review
Section 5: Geographical Context
Section 6: Best Practice
Section 7: Findings
Section 8: Conclusion and Recommendations
Section 9: Remedial Action

The report should also be read in conjunction with the following appendices:

Appendix 1: CIGA Guarantee Scheme
Appendix 2: MountEagles Resident’s Letter
Appendix 3: Sample BBA Certificate
Appendix 4: Maps of NIHE Surveyed Homes
Appendix 5: Knauf Letter Stating Unsuitability of Cavity Wall Insulation
Appendix 6: Building Control Letter to MountEagles Residents Group
Appendix 7: Sample Survey Report
3.0 SURVEY METHODOLOGY

3.1 Sample Design

The sample frame for this survey of cavity wall insulation in Housing Executive dwellings was drawn from the 2009 and 2011 Northern Ireland House Condition Surveys. These two surveys were based on a stratified random sample of more than 5,000 dwellings drawn from the sampling database of all domestic properties held by the Northern Ireland Statistics and Research Agency. The Housing Executive provided the research team with approximately 500 addresses comprising all Housing Executive homes in the 2009 and 2011 survey which the House Condition Surveyors had identified as having Cavity Wall Insulation.

It was agreed that the research team would survey a maximum of 300 of these dwellings across a reasonably representative geography for Northern Ireland as a whole. In fact, given the widespread distribution of the sample and access difficulties and issues, the research team were only able to survey 206 properties. While this was somewhat lower than had been hoped, the Project Advisory Group agreed that it still provided a statistically sound sample which would provide a broad indication of the quality of cavity wall insulation in Housing Executive properties. Figure 1 shows the geographical distribution of the achieved sample.

Figure 1: Geographical Distribution of Inspected Houses by Type
3.2 Eco Compliance Platform (ECp)

All survey data was captured using ECO Compliance Platform (ECp) software developed by Belfast company GS3 Software. The modular, electronic data capture and transfer system enabled the survey team to collect and provide the required energy efficient evidence, while ensuring visibility and quality standardisation by incorporating the following:

- Modular data collection methodology and/or requirements can be quickly modified to ensure continued compliance.
- Real time data transfer from point of collection.
- GPS, date and time stamping ALL information including photos.
- Lockdown of data collected to prevent improper use, theft or loss.
- Prevent tampering or modification of collected data.
- Standardised data collection methods with enforced data fields ensure that errors and omissions are minimised/eliminated.
- Helps prevent the inappropriate use of data, e.g. identity fraud.
- Proof of attendance for appointments.
- Opportunity for simple and immediate “eligibility” checks.
- Integration of WiFi borescopes to record and ensure visibility of cavity insulation is identifiable
- Integration of drones to record and check roof condition of a property eliminating H&S issues.

3.3 Survey Equipment

The surveys were visual and intrusive and carried out using Apple Ipad2 tablets and Dart WiFi Borescopes shown in figure 2.

![Figure 2: Dart Wifi Borescope and Iphone (Ipad 2 was used throughout the inspections)](image)

This high resolution Dart Endoscope Camera is a unique instrument that can wirelessly stream high-quality video from a camera at the tip of a long probe to a nearby iPhone or iPad screen. Real-time video can be viewed via WiFi connection with WEP (WiFi) Password Setup Security. It can also broadcast simultaneously to iPad, iPhone and Android.
Typical applications include inspections of hard-to-reach or hard-to-see areas. The standard 1m Flexible & removable/detachable has a 7mm tube diameter with 45mm minimum bending radius. It can retain its configured shape for inspecting hard-to-reach areas. The tube also has a 9.8mm camera head with IP67 waterproof level rating. An iOS viewer and controller that enables remote monitoring of live video and taking pictures from a Borescope Camera.

Borescope inspections were carried out to confirm the quality of insulation in the cavity. In a few surveys the use of a thermal imaging camera assisted in identifying and deciding where exactly to drill for the Borescope inspection.

3.4 Methodology for Borescope Inspections

For each of the properties, cavity wall survey by Borescope involved localised drilling of external walls in agreed positions and a roof void inspection (if relevant). It was agreed that where possible, boreholes would be drilled at an angle on elevations rather than at 90° and laterally along the building corners to achieve maximum views down the length of the cavity to achieve best results.

The number and elevation of Borescope readings was dependent upon the number of storeys within individual dwellings, as follows:

3.4.1 Single storey dwellings

Three Borescope readings per elevation:

- One at least 300mm above the DPC
- One within 300mm of the wall plate below the roof (for gable walls this should be along or just above the dividing line between the ground floor accommodation and the loft)
- One below a window sill (for gable walls where there are no windows, this can be halfway up the wall between the ground and roof space line)

3.4.2 Two storey dwellings

Four Borescope readings per elevation:

- One at least 300mm above the DPC
- One within 300mm of the wall plate below the roof (for gable walls this should be along or just above the dividing line between the first floor accommodation and the loft)
- One at first-floor floor joist level (i.e. between ground and first floor)
- One below a second storey window sill (for gable walls where there are no windows, this can be halfway up the wall between the first floor and the loft).

It should be noted that, due to the individual property inspections being dependent on the tenant’s approval, availability and the issues surrounding access and safe working practices, not all of the surveys met these criteria.
3.5 Data Recorded

The cavity wall inspections aimed to determine and record:

1. Property address
2. Property description
3. Surveyor name
4. Survey date
5. Completion date
6. Data received date
7. Property details
8. Insulation type if any
9. Borescope Test Yes or No
10. Borescope images
11. Conclusion
12. Comments
13. Signatures
14. Captured electronic images

3.6 NIHE Quality Audit Sampling Inspections

In line with the requirements of the tender, SERC staff and members of the survey team accompanied NIHE staff on quality sampling inspections on 16 surveyed homes. This equated to around 8% of the total house survey numbers from the full survey list (206). These homes were chosen at random by the NIHE team and agreed with SERC project staff prior to quality inspections. The quality process involved travelling to the selected homes and involved the survey team opening the inspection cavity Borescope penetrations to view the type and level of materials found within the cavity of each property. New holes were drilled at the request of NIHE staff in several property locations.
4.0 LITERATURE REVIEW

4.1 Introduction

Project leader, John Ross MSc (SERC) completed a review of published literature, trade publications and research-based evidence on insulation practices, current and past, its rationale, materials, thermal abilities, and relative impact on UK CO₂ savings targets.

4.2 Overview

Home energy use is responsible for 28 per cent of UK carbon emissions which contributes to climate change. By following Best Practice standards, new build and refurbished housing will be more energy efficient and will reduce these emissions, saving energy, the resident’s costs and damage to the environment.

In 1921 there were fewer than 10 million households in the UK. Today this has grown to more than 26 million homes as trends move towards smaller families and more single-person households. In 1921 the mean household size was approximately 4.5 people, but by 2011 this had almost halved to 2.3 people per household. The UK population grew from around 44 million in 1921 to about 60 million in 2011 when there were 26.3 million households. This is projected to rise to 32.8 million by 2033.

In Northern Ireland the number of dwellings doubled from 354,000 in 1951 (the earliest data available) to 737,000 in 2008. Northern Ireland's housing stock continued to grow between 2006 and 2011 to reach a total of 760,000.

4.2.1 Dwelling Unfitness and the State of Repair

Between 2009 and 2011 there was an increase in the rate of unfitness of Northern Ireland’s housing stock. The headline unfitness rate increased from 2.4 per cent in 2009 to 4.6 per cent in 2011. This was associated with an increase in the rate of vacancy, particularly in isolated rural areas. In 2011 there were 35,200 dwellings that were statutorily unfit (compared with 17,500 dwellings in 2009). The most common reasons for unfitness were unsatisfactory facilities for the preparation and cooking of food; no, or unsuitably located, bath, shower and wash hand basin; and serious disrepair.

4.2.2 Components of Decent Homes

Overall, 62 per cent of the stock in Northern Ireland which failed the Decent Homes Standard did so on the thermal comfort criterion. This compares with 68 per cent in 2009.

4.2.3 Household Type - Dwelling Type

As in 2009, the highest proportion 28% of households lived in terraced housing.

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3 Frey et al 2011 Northern Ireland House Condition Survey. p.17 Available at www.nihe.gov.uk
4 Frey et al 2011 Northern Ireland House Condition Survey. p.59
5 Frey et al 2011 Northern Ireland House Condition Survey. p.19
Households with children (31%) were most likely to occupy terraced housing. Higher than average proportions 33% of older households lived in single storey houses. Households with children were most likely to live in detached houses (24% compared with 20% overall). Adult households (12%) were most likely to live in flats/apartments (8% overall). Households with children (4%) were the least likely household type to live in flats/apartments.\(^6\)

Currently about 97% of homes are centrally heated, with the majority using oil and natural gas as the heating fuel. Previously, homes would have been mostly heated by individual coal fires and it would have been common to only heat a part of the home (single room). There was no such thing as central heating until the 1970s.

Now about 97% of roofs have insulation, 91% of homes have double glazing and about a third of homes have insulated walls. No homes in 1921 would have had even basic insulation.

Energy use per household has almost halved since 1921, despite the higher standards of comfort, and very much wider range of energy services, that we now demand. This has been possible because of increased insulation and other energy efficiency measures.

Today, there are national targets for reducing CO2 emissions. The key target is to reduce emissions by 80% by 2050. If this target is to be met, all homes built from 2016 must be zero carbon, all current dwellings must be refurbished with cost-effective energy saving measures, and the electricity grid must be decarbonised. The CO2 emission target for 2050 is extremely challenging. To put it into perspective, simply achieving the refurbishment objective, which on its own will not meet the target, requires that more than one dwelling per minute is brought up to near zero carbon standards between now and 2050. In 1921, CO2 emissions were simply not an issue.\(^7\)

### 4.2.4 Estimates of Home Insulation Levels in Great Britain: April 2013

Key points it is estimated, that at the start of April 2013, there were 27.1 million homes in Great Britain; of these 19.1 million had cavity walls with the remaining 8.0 million having solid walls.

A loft was found in 23.7 million properties with 16.2 million homes having loft insulation of at least 125mm (68 per cent of homes with lofts). Of the 7.4 million homes with lofts without at least 125mm of insulation, only a small number are estimated to have no insulation – around 1 per cent of all properties with lofts. 13.4 million homes had cavity wall insulation (70 per cent of homes with cavity walls).

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\(^6\) Frey et al 2011 Northern Ireland House Condition Survey. p.34, Table A4.7. [www.nihe.gov.uk](http://www.nihe.gov.uk)
\(^7\) BRE NI Homes 2003 The Cost of Poor Housing in Northern Ireland
Of the 5.3 million homes without cavity wall insulation, most are hard to treat, with only 0.7 million of them being easy to treat standard cavities. 205,000 homes had solid wall insulation (3 per cent of homes with solid walls). Through Government schemes since April 2008 (the start of CERT), there have been 5.5 million lofts insulated, 2.6 million cavity walls insulated and 140,000 solid walls insulated.

Compared with April 2012, 1.4 million more properties had loft insulation of at least 125mm, 610,000 more had cavity wall insulation and 73,000 more had solid wall insulation.

“Information from housing surveys in Northern Ireland is not sufficient to be able to produce the UK estimate using the same methodology as the rest of Great Britain”. 8

4.3 Factors Influencing the Performance of Thermal Insulation

The effectiveness of a dwelling in conserving energy is dependent upon the effectiveness of its walls, floor, roof, windows and doors in reducing the rate of heat escaping from the internal environment of the dwelling to the outside. The ability of a wall, floor, roof, window or door to impede heat loss from a dwelling is described in terms of its thermal transmittance (U-value), which is expressed as the transfer of heat in watts per square metre (W/m²) of area per degree difference in temperature between outside and inside. A wall, roof or floor that is well insulated will have a low U-value whereas one which is poorly insulated will have a high U-value.

The calculation procedure described in BS EN ISO 6946 is the main standard for calculating U-values of walls. It is largely based on “ideal” constructions, although limited provision is made for imperfections in the structure, such as small air gaps around the insulation. The standard also allows for the thermal conductivities of construction materials, geometrical effects and some types of air voids, but does not deal with moisture-related phenomena, adventitious air movement or factors that may be influenced by workmanship or performance of machinery. Furthermore, certain types of construction are more vulnerable to these processes than others, and there are a number of factors, such as cavity width, robustness of insulation materials, the use of air/vapour barriers, and the use of rendering or moisture control layers which could potentially affect the U-value of a building element over time.

Some research has also been carried out by IEA Annex 32 on the impact of building techniques which has shown that certain construction defects carry a risk not only of causing higher U-values but also of the onset of major problems such as fungal defacement, rain penetration, reduction in comfort and interstitial condensation.

Further studies on the impacts of quality-related problems have shown that U-values can in some cases be raised considerably as a result of these factors.

It is thought that the main benefits of reduced U-values, which ensue as a result of the application of cavity wall insulation, are:

1. More comfortable indoor environments with reduced risk of hypothermia, safer indoor environments.
2. Reduced energy consumption and reduction in associated costs.
3. The possibility of reduced sizing of the heating system when the heating system is subsequently replaced.

The main environmental benefits are often considered to be:

1. Less damage to the environment
2. Lower reliance on fossil fuel stocks
3. Reduced carbon dioxide (CO$_2$) emissions

The precise effectiveness of cavity wall insulation depends not only upon the theoretical properties of the insulating material but depends also on the manner of installation and on the environmental conditions which the insulation is subjected to.

The U-value of an insulated cavity wall can be influenced by several factors, including the following:

1. Thickness of the insulation.
2. Thermal conductivity of the insulation (which depends upon the material used, its density and the environmental conditions to which the material is subject).
3. The presence of any air gaps or voids in the insulation and the distribution of these.
4. The presence of any areas in the insulation where the insulation is of lower than normal compactness or where the material is inhomogeneous.
5. Air movement through and around the insulation (which in turn is likely to be influenced by convection, external wind conditions and the air-tightness of other parts of the wall construction).
6. Thermal bridging of the insulation caused by wall ties, mortar snots or other obstructions within the cavity.
7. The grade or density of the concrete blocks forming the inner leaf of the cavity wall.

Some of the above factors may in turn be influenced by the following factors:

1. The condition of the insulants, including presence of moisture and, in the case of insulating beads, the composition of the binding agent.
2. The spacing of the drill holes made by the installers of the cavity wall insulation. Too wide a spacing could potentially lead to air voids in the insulation layer.
3. The settings in the machinery used to blow or inject the insulation into the cavity and accuracy of machinery calibration. This is sometimes loosely referred to as 'density'
4. The condition and cleanliness of the cavity and presence of obstructions e.g. rubble or Damp Proof Course (DPC) prior to the installation of the cavity wall insulation.
5. The accuracy of the estimation of the amount of insulation material needed.
4.3.1 Previous Research Involving in-situ U-value Measurement
Research carried out by the Building Research Establishment (BRE) between 1998 and 2000 showed that true (measured) U-values were often higher than expected, even when thermal bridging and wall ties were taken into account. The difference depended upon the construction type. The differences between measured U-values and expected U-values were found to be as follows:

1. For internally insulated cavity walls, 0.05 W/m²K (approx.)
2. For fully filled cavity walls, 0.05 W/m²K (approx.)
3. For partially filled cavity walls, 0.10 W/m²K (approx.)
4. For timber frame walls, agreement between measured U-values and calculated U-values appears to be close, but accurate cutting of mineral wool quilt at horizontal timbers is likely to be crucial to the overall energy efficiency.
5. For sloping ceilings with insulation in the slope of the ceiling, actual realised U-values can be very high in some cases

4.3.2 Recent in-situ U-value Measurements on Existing Dwellings
One of the most relevant and appropriate pieces of research into thermal transmittance of house walls before and after the application of cavity wall insulation was completed for BRE Scotland in March 2008\(^9\) which reported the following:

In 2004, AEA Technology carried out, for the Energy Saving Trust, a study of 41 dwellings receiving cavity wall insulation and found that in practice U-values were significantly higher than would be expected on the basis of standard U-value calculations. The AEA study was extensively peer-reviewed, including by the Cavity Insulation Guarantee Agency (CIGA) and BRE.

The review noted some recommended changes to the analysis and initial drafts of their report raised some inconsistencies which were subsequently rectified. In particular it appeared that heat flow readings were initially combined in an incorrect manner (although this in itself did not, of course, invalidate their field measurements). There was also a concern that it was unclear whether insulation might have been missing at some of the measurement points. It was noted in the AEA study that the measured U-values were, on average, 23% higher than would be expected on the basis of conventional methods of calculating U-values. However the peak (modal point) of the distribution occurred where the measured U-value was in reasonable agreement with the calculated U-value, indicating that there was a significant number of instances where the insulation was performing satisfactorily. There were, however, a large number of cases where the measured U-value was significantly higher than expected.

Thermographic imaging of the cavity walls indicated that about 40% of the houses showed defects in the installation leading to higher heat losses, and AEA estimated that the area of coverage was equivalent to 10% or more unfilled cavity.

Theoretically, the U-value of an insulated cavity wall would be expected to be less for wider cavities than for narrow cavities, however, in that study, no clear correlation between the measured U-values and the measured cavity widths was found in practice.

Although that study included a range of house age groups, ranging from 1940 to 1970, there was no significant correlation between the age of the house and the U-value of the walls, although the researchers did consider a number of plausible reasons why this might be the case. In conclusion it was suggested that wind speed might have influenced the U-values to some extent, making correlations more difficult to discern.

The breadth of the distribution of U-value results and the evidence gained from thermographic imaging both suggested a need for greater quality control at the time of installation. However it was concluded that there are other influences apart from workmanship that can influence performance of cavity insulation in practice.\textsuperscript{10}

This is one of the most relevant and appropriate pieces of research completed by Doran, S. & Carr, B. BRE Scotland. This document sets out the ‘real life’ scenario that cavity wall insulation performance affords in terms of thermal protection, if not installed in a professional manner.

This report describes the results of in situ measurements carried out to determine the as built thermal performance of a sample of seventy dwellings during 2005 and 2006. The dwellings in the sample had all been targeted for cavity wall insulation under the Warm Front and related programmes. For most dwellings thermal performance was tested both before and after the application of insulation.

Through this work, a better understanding of the effectiveness of cavity wall insulation, as currently applied in existing dwellings, has been obtained, together with an estimation of the benefit in practice of cavity wall insulation. It can be said with certainty that the application of cavity wall insulation helps to improve the energy efficiency of dwellings. It is clear, however, that for many dwellings the coverage of cavity wall insulation is not complete partly as a result of the nature of wall constructions, including lintels, tile-hung areas, adventitious voids and areas in and around conservatories.

The estimated savings from insulation, as calculated by BREDEM 12, are subject to two corrections. The first is a correction for underperformance and is -35%. The second is a correction for comfort taking, which is applied after the underperformance correction, and is -23%. The overall correction is therefore (100%-35%)*(100%-23%) = 50%. Note that, if there were no underperformance, the correction factor for comfort taking would be 15% of the estimated BREDEM saving from insulation.

\textsuperscript{10} Inbuilt & Davis Langdon (2010) Study on Hard to Fill Cavity Walls in Domestic Dwellings in GB, p14, Department of Energy and Climate Change, CESA EE0211
This inconsistency in cavity wall insulation performance due to the indicated quality factors above, could possibly be directly associated with the issue of ‘hard to heat homes’, mould and damp factors and attributed energy costs over and above what would be seen as reasonable for many households. Whilst at this point in time it’s not measureable to link this as an increased reason for fuel poverty it must have a portion of the blame attached, due to insulation failures. There is a clear need for consistency when installing all cavity wall insulation types to attain regulated U values.

4.4 Fuel Poverty

Fuel poverty is defined as follows:

“...a fuel poor household is one that cannot afford to keep adequately warm at reasonable cost. The most widely accepted definition of a fuel poor household is one which needs to spend more than 10% of its income on all fuel use and to heat its home to an adequate standard of warmth. This is generally defined as 20°C in the living room and 18°C in the other occupied rooms – the temperatures recommended by the World Health Organisation.”

Northern Ireland has the highest prevalence of fuel poverty in the UK (see Figure 3 below), and one of the highest in the EU, with the current estimate indicating that 42% of households in Northern Ireland are experiencing fuel poverty (NIHE, 2013).

<table>
<thead>
<tr>
<th>Country</th>
<th>Number (millions)</th>
<th>Percentage</th>
<th>Year of estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>England</td>
<td>3.20</td>
<td>15%</td>
<td>2011</td>
</tr>
<tr>
<td>Scotland</td>
<td>0.58</td>
<td>25%</td>
<td>2011</td>
</tr>
<tr>
<td>Wales</td>
<td>0.37</td>
<td>29%</td>
<td>2011</td>
</tr>
<tr>
<td>Northern Ireland</td>
<td>0.29</td>
<td>42%</td>
<td>2011</td>
</tr>
</tbody>
</table>

Figure 3: Number and proportion of fuel poor households by country (DECC, 2013)

There are many reasons why Northern Ireland should have such a high predominance of fuel poverty, but the principal driver has been demonstrated to be the region’s reliance on oil for domestic heating.\textsuperscript{12}

It could be argued that one of the main contributions to fuel poverty is the assumption that the majority of our homes are well insulated. But the inefficient nature of the housing stock as has been uncovered in this project (and also past work completed by the College in conjunction with the University of Ulster, Jordanstown) maybe highlights a major energy dilemma. Oil and natural gas prices have remained on par with each other and the energy performance differences are not that far apart as to cause major costs differentials in relation to the rest of the UK. The possible energy performance of old and relatively new homes identified in this research seems to greatly add to this phenomenon.

\textsuperscript{11} Department of Energy & Climate Change The UK Fuel Poverty Strategy, 2001

\textsuperscript{12} Liddell, C & Lagdon, S (2013) Tacking Fuel Poverty in Northern Ireland, p2
4.4.1 A new indicator of fuel poverty

The government, in reaction to the rise in fuel poverty figures, have taken steps to redirect the analysis factors for the cause of the same:

We (the government) have decided to adopt a new indicator to measure fuel poverty, based on the recommendations from Professor Hills's independent review. This new indicator (which is depicted in Figure 4) finds a household to be fuel poor if:

- Their income is below the poverty line (taking into account energy costs); and
- Their energy costs are higher than is typical for their household type.

It also uses a fuel poverty gap. This is the difference between a household’s modelled bill and what their bill would need to be for them to no longer be fuel poor. In Figure 4, example fuel poverty gaps are depicted by arrows. The purpose of the fuel poverty gap is to measure the severity of the problem faced by fuel poor households. Under this new approach we therefore have twin indicators of the ‘extent’ and ‘depth’ of fuel poverty. 13

**Figure 4**: The low income high costs definition (Hill's Review of Fuel Poverty)

Fuel Poverty is a serious issue that arguably affects social housing the most, with low income families as the main stay tenants in these homes. If the reasons behind fuel poverty and the associated additional energy costs are mainly proven to be insulation based causes, then identification and remedial actions are available. The most important element to providing comfort in any building is the ‘fabric first’ approach, simply secure the internal areas from the external climate. If we contemplate any other energy improvements in any guise then these will be best served working in a thermally separated environment.

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The heating demand for domestic homes is conventionally measured in ‘degree days’ which is enshrined in heatloss calculations for design engineers. The base temperature used to calculate degree days in the UK is 15.5ºC, because at this temperature most UK buildings do not need supplementary heating.

Degree days is a measure of the difference between the baseline and the actual outdoor temperature multiplied by the number of days. For example - the temperature measured hourly records a temperature of:

7.5°C for 48 hours the degree days total would be: (15.5 - 7.5) x 2 = 16
Note - it is not possible to have a ‘negative’ degree day value. When the outdoor temperature exceeds 15.5°C it is accepted that no heating is needed. When the outdoor temperature exceeds the 15.5°C baseline, then the degree days are set to zero.

4.5 Cavity Wall Development

Early records show that since the late 1920s, masonry cavity walls have been used in house construction throughout most of the UK. Although utilised for more than 100 years cavity-walled houses should be easy to refurbish as the cavity can be filled with insulation. In cases where such treatments are not appropriate, they can be treated in the same way as solid walls.

4.5.1 The Use of Cavity Walls in Housing

Recorded development of cavity widths (mm):

1920s Cavity in walling start to grow in popularity (variable size of the cavity)
1930s Cavity walls become main form of construction (variable size of the cavity)
1940s Cavity width becomes standardised 50mm
1950s Concrete blocks are used for inner leaf 50mm
1960s Lightweight ‘aircrete’ blocks are introduced 50mm
1970s Cavity width is increased 60mm -70mm
1980s onwards Cavity wall insulation (partial or full-fill) starts to be ‘built-in’ 60mm-70mm extending to 100mm

Best practice refurbishment specification:
Where possible, walls should be insulated to achieve a maximum U-value of 0.30W/m2K.
Assumed insulation standard of existing wall types
Unfilled cavity walls (U-value 1.45W/m2K), timber-frame walls (U-value 1.2W/m2K) or solid nine-inch brick walls (U-value 2.1W/m2K), as appropriate
A typical pre-1976 cavity wall with 65mm unfilled cavity and plaster facing would have a typical U value of 1.4W/m2K. With a filled cavity the U-value would be 0.48W/m2K.
A typical post-1976 cavity wall with 65mm unfilled cavity and plaster facing, would have a typical U-value of 1.0W/m2K. With a filled cavity it would have an U-value of 0.42W/m2K.\(^\text{14}\)

### 4.5.2 Traditional U Values

The Energy Saving Trust (EST) publication suggests the use of the following default U-values:\(^\text{15}\)

- 1.7 W/m2K for traditional sandstone (or granite) dwelling with solid walls: stone thickness typically 600 mm with internal lath and plaster finish (for the pre-1919 period)
- 1.7 W/m2K for cavity walls involving brick and block with external render (for 1919-1975)
- 0.3 W/m2K for brick/block cavity walls with insulation (for 2003-present)

The Chartered Institute of Building Services Engineers (CIBSE) Guide suggests the use of U-values as follows:\(^\text{16}\)

- 1.38 W/m2K for a 600 mm stonewall with a 50 mm airspace and finished with 25 mm dense plaster on laths
- 2.09 W/m2K for a 220 mm solid brick wall with 13 mm dense plaster
- 1.41 W/m2K for a 220 mm solid brick wall with 50 mm airspace/battens and 12.5 mm plasterboard
- 1.44 for a brick/brick cavity wall with 105 mm brick, 50 mm airspace, 105 mm brick, and 13 mm dense plaster.

A detailed survey of all existing properties in accordance with BS 8208: Part 1:1985 prior to cavity insulation being installed should be adhered too. This standard sets out actions that allow for quality to be maintained in the process. Where necessary general cleaning of the cavities and other remedial work that may cause issues with the quality of the installed insulation must be identified and addressed before filling cavities.

Specify all work to be carried out by reference to BS or an approvals certificate. A CIGA guarantee should also be provided (excludes non-traditional structures). Independent body, CIGA, was established in consultation with the government to provide householders with an independent, uniform and dependable 25 year guarantee. The CIGA Guarantee Scheme is outlined at Appendix 1.

All Mineral wool and Polystyrene bead cavity wall insulation should have a current British Board of Agrément (BBA) certificate as shown in Appendix 2.

When insulating cavity walls, the installer will normally drill small holes, 16 mm in size at intervals completed to the recommendations set out to BBA standards. With specially designed equipment, they then blow insulation into the cavity, using bead, fibre or foam products. Whenever the measured product

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\(^{14}\) Energy Saving Trust (2006) *Refurbishing dwellings – a Summary of Best Practice CE189*

\(^{15}\) Energy Saving Trust (2004) *Scotland: Assessing U-values of Existing Housing Table 2*

fill levels have been completed (all the insulation is in), the installer fills the holes in the brickwork to finalise the weather seal on the external wall.

Filling cavity walls should always be completed by a registered and industry certified installer. All installers should be a member of one of these recognised organisations:

- The British Board of Agrément (BBA) [http://www.bbacerts.co.uk/]
- The National Insulation Association (NIA) [http://www.nia-uk.org/]
- The Cavity Insulation Guarantee Agency (CIGA) [http://www.ciga.co.uk/]

4.6 Profile of Unfitness

The 2011 House Condition Survey estimated that there were some 35,200 dwellings that were statutorily unfit in Northern Ireland. This represents a headline rate.

From the findings of this research project, SERC believes the ‘classification’ of unfit may need to be reconsidered with the widespread quality issues throughout all properties types and locations found in this research. Clearly homes deemed to be correctly insulated have a questionable performance level in relation to perceived fit for purpose standards.

4.7 Health Issues Associated with Poor Housing

Research indicates that there is an association between homes with visible damp or mould and the prevalence of asthma or respiratory problems of residents, particularly children.

In addition, poor quality housing can have an adverse effect on psychological well-being. Parents and children both complain of the social stigma of living in bad housing there is currently no widely accepted definition of what constitutes sub-standard, inadequate or non-decent housing, although a recent Government policy document described decent homes as “homes that are warm and weatherproof with reasonably modern facilities”.

Cold weather affects the circulatory and respiratory systems most. On a cold day in Northern Ireland, an average of 5% more people die of a circulatory or respiratory problem than die from these problems on a warm day. The reasons for this are straightforward. To keep a stable temperature throughout the day and night the human body works hard, quickly losing heat if body temperature starts to rise a little, and reacting just as quickly if body temperature starts to fall.

When the temperature outdoors falls below 15.5ºC, the human body begins its work, and the colder it gets the greater the body’s workload. For example, blood thickens, arteries narrow, and blood pressure rises. These place strain on the heart, which explains why cold days are associated with more coronary events such as heart attacks, and more clot-related events such as strokes. 17

Poor quality housing is associated with poor health. Dampness is associated with increased prevalence of allergic and inflammatory lung diseases, such as asthma, independent of smoking and socioeconomic factors.\(^{18}\)

Mould spores in the environment can be carried over great distances and can regularly migrate indoors through favourable air movements. Spores are also a constituent of household dusts. The concentration of mould spores in the air will depend on factors such as the environment, climate, season and time of day.

In rooms with adequate insulation and healthy thermal conditions such as low humidity, natural ventilation and characteristic air conditions these spores will not have a chance to colonise and reproduce (Haas, et al., 2007).

Inhalation of mould spores can lead to respiratory tract disorders. These disorders include asthma, sinusitis and recurring respiratory infections and are very common due to prolonged exposure (Environmental Protection Agency, 2008).

Several studies have shown that excess winter deaths are linked to cold homes. Excess winter death rates are highest among those living in the coldest homes. For many older people, the problem is that they simply cannot afford to heat their home properly, increasing their risk of serious illness or death Marmot Review Team (2011).

Recent ventilation regulations in England and Wales (HMSO, 2006a) introduced new performance criteria for the control of mould. The UK Government's Building Regulations Research Programme subsequently funded University College London (UCL) to investigate the extent to which these are the most appropriate criteria for the control of mould in UK dwellings. The current (2006) moisture criterion as stated in ‘Approved Document F’ (ADF) is that there should be no visible mould growth on external walls. The guidance also states: “For the purpose of this Approved Document, the moisture criterion will be met if the relative humidity (RH) in a room does not exceed 70% for more than 2 hours in any 12 hour period, and does not exceed 90% for more than 1 hour in any 12 hour period during the heating season”\(^{19}\)

Variety of representative moulds (Rowan et al 1996) with an appropriate range of moisture requirements:

- *Aspergillus repens*
- *Aspergillus versicolor*
- *Penicillium chrysogenum*
- *Cladosporium sphaerospermum*
- *Ulocladium consortiale*


A 2009 World Health Organisation report entitled "Children Living in Homes with Problems of Damp" stated that:

"Excess moisture leads – on almost all indoor materials – to growth of microbes such as moulds, fungi and bacteria, which subsequently emit spores, cells, fragments and volatile organic compounds into the indoor air. Moreover, dampness initiates chemical and/or biological degradation of materials, which also causes pollution of the indoor air. Exposure to microbial contaminants is clinically associated with respiratory symptoms, allergies, asthma and immunological reactions. Dampness has therefore been suggested to be a strong and consistent indicator of risk for asthma and respiratory symptoms such as cough and wheeze."

Badly constructed and older houses with inherited issues are difficult and expensive to heat. Insufficient warmth in the home can have health consequences for the tenants, particularly during winter. Domestic energy efficiency is linked with health, because income spent on energy cannot be spent on other necessities; food, clothing or consumables. Colder houses place more physiological and mental stress on older people, sick people who have a less robust metabolism, these people are prone to spend more time indoors.

Usually cold houses are likely to be damp, and in some incidents have issues with mould growth, which cause respiratory symptoms. The link between inadequate heating; damp, cold, and mouldy houses; and poor health has been highlighted in many international reports. It could be said that fitting insulation into houses, rather than intervention for the individual by providing occupants with thermal clothing would be a more cost effective, practical way to improve sedentary health.

### 4.8 Benefits of Cavity Wall Insulation

Most houses built between the late 1920s to the present day have a cavity wall, the cavity was originally planned to prevent rain that falls on the external walls crossing to the internal walls of the dwelling. The cavity, ranging from older 25mm width’s to current standards of 150mm allows the water to drain to the bottom of the wall, reduced as it seeps into the ground and ventilated by the presence of air flow in the cavity. Originally the air gap was seen as an effective form of thermal insulation, though minor in its effective levels. Modern cavity wall insulation products are designed to the maintain moisture drainage in the usual way, while providing enhanced insulation for the property.

In a typical building up to 35% of the buildings heat can be lost through the walls (dependent on source of information), with effective cavity insulation this loss can be reduced with consequent saving on fuel bills. British Board of Agrément (BBA) who approve companies, set out industry standards that should be utilised to provide the most cost effective and ozone friendly methods to insulate walls. By using modern BBA approved insulation products, which have been specifically designed to meet the reduced energy demands of dwellings, the industry can help reduce fuel poverty, energy costs and CO2 reductions.
4.8.1 **Main Benefits**

Homes with well insulated cavity walls will be warmer in winter, cooler in summer, and therefore more energy efficient:

- Savings of up to 25% on heating bills can be enjoyed (location dependent).
- Savings of up to 35% on heat loss through external walls can be had.

Cavity wall insulation correctly installed can be a cost effective choice, which can pay for itself in a short period of time and an effective long-term investment in terms of fuel cost reductions, CO2 emissions and recognised health and wellbeing benefits. This scenario is backed up with the contents and premise of the UUJ report McLarnon, D and Hyde, T (2013) into retrofit insulation where after the identification, extraction and refill of poorly insulated cavities correctly remediated, there were a minimum 30% improvement in heat retention.

Cavity wall insulation is easy to install in most situations, normally completed from outside of the property, but can also be completed internally.

The British Board of Agrément (BBA) is the UK's major authority offering approval and inspection services to manufacturers and installers supplying the construction industry. Originally set up in 1966 by Government, but now an independent non-profit distributing organisation, the BBA's certification and inspection services are recognised by building control, local authorities, industry insurers and key trade associations in the construction industry. A main issue has been the failure of local building control to deem it important to have insulation installation inspections as part of the build recording process. Insulation is now part of the inspection process in the new building regulation changes in terms of sound compliance.

### 4.9 Cavity wall insulation cost savings

The estimations in figure 5 are based on insulating a gas-heated, semi-detached home with three bedrooms. The average installed cost is unsubsidised. Source: Energy Savings Trust (EST).

<table>
<thead>
<tr>
<th>Measure</th>
<th>Annual saving</th>
<th>Installation cost</th>
<th>Payback time</th>
<th>Carbon dioxide saving per year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavity wall insulation</td>
<td>Up to £140</td>
<td>£450 to £500</td>
<td>Under 4 years</td>
<td>Around 560kg</td>
</tr>
</tbody>
</table>

**Figure 5:** Likely savings from the use of cavity wall insulation

Of late, these EST figures have been questioned with regard to the reality of the cost advantages. The Guardian newspaper released details how a study of 21,000 homes tracked by the Department of Energy and Climate Change had
suggested the savings claims made by the EST were seriously flawed and in no way borne out by real-life conditions.20

In 2013 a Government publication asked: “Is it best to deliver whole-house packages of measures (which potentially means supporting fewer households in the short term with more expensive insulation and heating options)?”21

“We (the government) have been working with external experts in health and energy to develop a methodology to estimate and monetise the change in Quality Adjusted Life Years (QALY) that results from improving the efficiency of dwellings and the resulting increase in temperatures.”

Figure 6 shows the findings from the Government report.

<table>
<thead>
<tr>
<th>Intervention</th>
<th>QALY saved per measure installed</th>
<th>Value of health saving per measure installed (£NPV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cavity wall insulation</td>
<td>0.049</td>
<td>£969</td>
</tr>
<tr>
<td>Solid wall insulation</td>
<td>0.036</td>
<td>£742</td>
</tr>
<tr>
<td>Replacement boiler</td>
<td>0.009</td>
<td>£224</td>
</tr>
<tr>
<td>Central heating</td>
<td>0.012</td>
<td>£303</td>
</tr>
</tbody>
</table>

Figure 6: QALY and Value of Health Saving per Measure Installed

4.10 Cavity Wall Insulation Materials

Apart from blown fibre there are other materials commonly used for cavity wall insulation – foam, bonded polystyrene beads and solid board. If properly installed, these materials should theoretically be superior to mineral-wool fibre, as they are inherently waterproof.

With Environmentally Safe Product (ESP) bonded polystyrene beads insufficient or no bonding can allow the beads to "escape", when carrying out building alterations, evident when any activity that penetrates into insulated walls. On a windy day the beads can be drawn out of the cavities by wavering effects (found in several locations during the surveys). There are issues with poorly bonded ESP beads escaping through airbricks, out into loft spaces, or even out through soffit vents into the gutters. As with all modern adhesives/plastics the technology has only been use for a relatively short time, therefore its material aging process is unknown.

5.3 Insulation practices

Firstly all insulation materials at all times must be approved and tested products, fit for purpose and suitable for the task in hand. These guidelines should prevent professional insulation installer companies from using second rate, unapproved materials or products in unapproved areas or in an inappropriate installation manner, contrary to certified best practice.

20 Brignall, M (8th Feb 2014) Can you trust the energy saving claims? The Guardian
Approved insulation companies are responsible for communicating and agreeing the best practice guidelines and processes within their insulation supply chain. Companies should maintain evidence of quality driven practice with ongoing staff training having been completed at regular intervals.

It is assumed that all materials discussed in this report meet current Building and Fire regulations requirements for installation.

4.10.1 **Mineral Wool Fibreglass**

Mineral wool fibreglass (also called glass-reinforced plastic, GRP) is a fibre reinforced polymer made of a plastic matrix reinforced by fine fibres of glass. Fiberglass is a lightweight, extremely strong, and robust material. Strength properties are supple and the material is typically not brittle, and the raw materials are at present less expensive than other insulation materials. Its bulk strength and weight properties are also deemed by many as favourable being lightweight, and it can be easily formed and moulding during the installation process.

The Energy value of GRP insulation is rated in terms of its density and installation should be considered on the volumetrics of the spaces that are to be filled by this method. Bail sizes must be measured for each task.

4.10.2 **Rockwool**

Rockwool/Stone wool is furnace produced molten rock manufactured at a temperature around 1600 °C, through which a stream of high pressure air is blown. Other cutting-edge production techniques are based on high speed spinning of molten rock. Rockwool/Stone wool is a mass of fine fibres with a typical diameter of 6 to 10 micrometres. Mineral wool often contains a binding agent and an oil to reduce the dust levels for health purposes during installation.

Rockwool is a dry cavity wall insulation system using granulated constituents blown into the cavities to predetermined density and volumes. No glues or catalysts are normally involved during the installation.

4.10.3 **Beads or granules**

There are several bead products available from many differing sources but White Bead is generally used less now due to its lower performance for insulation values, however it is preferred and deemed better as an install material than an average fibre insulation material.

White bead has a thermal insulation entry level of $0.040\lambda$ - value, applied with a specialised fine mist bonding agent, this is blended together just prior to the point of installation.

Thermal Resistance, $R (m^2K/W) = \frac{\text{Thickness (mm)}}{1000 \times \lambda (W/mK)}$

When cured it forms a very stable bonded insulation mass in the form, shape and contours of any walling which has been the subject of installation. Seen by the industry as a more advanced and developed product, with better thermal performance. The bead is an thermal heat retaining insulating product which is applied with an adhesive mist injected bonding agent, which is blended together
just before the point of installation. When the binding agent cures it forms a very stable, bonded insulation mass in the form, shape and contours of any walling which has been the subject of the injected installation. The thermal value for “Grey bead is normally equated to around a 0.033λ - 0.034λ value. This is seen as an advanced method of installing the insulation, usually by way of drilling a quantity of access holes. This is usually up to 40% fewer holes than with fibre/non bead products into the property outer walling.

NB Polystyrene insulation should not be placed in contact with PVC-coated electrical wiring, otherwise the PVC may degrade. Also, steps should be taken to ensure that any electrical wiring covered by the insulation does not overheat.

4.10.4 Foamed Insulants: Urea-Formaldehyde Foam Insulation (UFFI)
The use of Urea-formaldehyde foam insulation (UFFI) Urea-formaldehyde, also known as urea-methanal, dates back as far as the 1930s. It is basically a foam, not unlike shaving cream that is easily injected into walls under pressure. It is made by using a pump set and hose with a mixing gun to mix the foaming agent, resin and compressed air. The fully expanded foam is pumped into cavities in need of insulation. It becomes firm within minutes but cures within a week. UFFI is generally spotted in homes built during the 1970s and on. Visually it looks like oozing liquid that has been hardened.

Over time, it tends to vary in shades of butterscotch but new UFFI is a light yellow colour. Early forms of UFFI tended to shrink significantly. Modern UF insulation with updated catalysts and foaming technology have reduced shrinkage to minimal levels (between 2-4%). The foam dries with a dull matte colour with no shine. When cured, it often has a dry and crumbly texture.

Foam Insulation systems should be certified by the British Board of Agrément and installed according to strict guidance laid out in the associated BBA Certificates.

4.10.5 Health Considerations
Urea formaldehyde foam, although rarely used in Northern Ireland now should conform to BS 5617:1985 and be installed in accordance with BBA guidelines. Due to health issues with the gas release and seepage through gaps in the building structure on installation this product is not readily used much too any great degree anymore.

The great majority of masonry cavity walls, especially those built in the 1930s or later, are suitable for filling with cavity wall insulation. While perceived technical risk is the main barrier to the uptake of cavity wall insulation, the failure rate of filled cavities is considered low. In most cases, failures were attributed to existing building defects due to poor installation and not identified in an individual survey. Urea formaldehyde cavity wall insulation should not normally be used in particularly exposed areas. BR262 ‘Thermal insulation: avoiding
Regular users of cavity wall insulation are convinced of its benefits, and take a few simple precautions to ensure high quality.\textsuperscript{22}

There are concerns about the health effects of formaldehyde foam cavity wall insulation. Allergic skin reaction to formaldehyde is unlikely at the concentrations used for cavity fill. However, some individuals may suffer irritation to the eyes or upper respiratory tract. Formaldehyde is a colourless, flammable, strong-smelling chemical that is used in building materials and to produce many household products.

When exposed to formaldehyde, some individuals may experience various short-term effects.

Formaldehyde has been classified as a known human carcinogen (cancer-causing substance) by the International Agency for Research on Cancer and as a probable human carcinogen by the U.S. Environmental Protection Agency.

Research studies of workers exposed to formaldehyde have suggested an association between formaldehyde exposure and several cancers, including nasopharyngeal cancer and leukaemia.

When formaldehyde is present in the air at levels exceeding 0.1 ppm, some individuals may experience adverse effects such as watery eyes; burning sensations in the eyes, nose, and throat; coughing; wheezing; nausea; and skin irritation. Some people are very sensitive to formaldehyde, whereas others have no reaction to the same level of exposure.

Although the short-term health effects of formaldehyde exposure are well known, less is known about its potential long-term health effects. In 1980, laboratory studies showed that exposure to formaldehyde could cause nasal cancer in rats. This finding raised the question of whether formaldehyde exposure could also cause cancer in humans. In 1987, the U.S. Environmental Protection Agency (EPA) classified formaldehyde as a probable human carcinogen under conditions of unusually high or prolonged exposure. Since that time, some studies of humans have suggested that formaldehyde exposure is associated with certain types of cancer. The International Agency for Research on Cancer (IARC) classifies formaldehyde as a human carcinogen. In 2011, the National Toxicology Program, an interagency program of the Department of Health and Human Services, named formaldehyde as a known human carcinogen in its 12\textsuperscript{th} Report on Carcinogens\textsuperscript{23}

Airborne formaldehyde acts as an irritant to the conjunctiva and upper and lower respiratory tract. Symptoms are temporary and, depends upon the level and length of exposure, may range from burning or tingling sensations in eyes, nose, and throat to chest tightness and wheezing.\textsuperscript{24}

\begin{itemize}
\item \textsuperscript{22} Best Practice Programme (2013) \textit{Good Practice Guide 155 Energy efficient refurbishment of existing Housing}
\item \textsuperscript{23} National Cancer Institute (2011) \textit{Factsheet: Formaldehyde and Cancer Risk}
\item \textsuperscript{24} US Environmental Protection Agency (1994) \textit{Indoor Air Pollution: An Introduction for Health Professionals}
\end{itemize}
4.10.6 **Spray Polyurethane Foam (SPF)**
SPF is considered the best solution for floors over crawlspace (that must be vented), it is a petroleum based product with a significant environmental impact. It is blown in, used in some exterior walls situations where other products combined with sealing the exterior sheathing would work just as well.

4.10.7 **Future Products: Nanotechnology**
Recent developments in materials science and nanotechnology have enabled the development of novel methods for thermal insulation (see figure 7). Aerogel is a nanostructured material which is becoming more and more popular as a material choice for insulation in many applications, from houses and commercial buildings to oil pipelines and space probes. Aerogel insulation is said to provide about 40 times the insulation protection provided by fibre glass, which allows its use in space-restricted scenarios, and even in insulating glass panels. Whilst many of the commercial applications so far are in construction, aerogel insulation finds applications in deep sea gas and oil pipes, medical devices and space vessels. Technological improvements to traditional aerogels have enabled many of these applications, and continue to make this novel material progressively more commercially viable.

<table>
<thead>
<tr>
<th>Natural/ cellulose insulation</th>
<th>Mineral insulation</th>
<th>Petrochemical insulation</th>
<th>Layered foil</th>
<th>Vacuum insulated panels</th>
<th>Aerogel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conductivity (mW/mK)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40-50 (cork)</td>
<td>30-40</td>
<td>30-40</td>
<td>33-35</td>
<td>4-10</td>
<td>13-14 commercial</td>
</tr>
<tr>
<td>40-50 (cellulose)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>39 sheeps wool</td>
<td></td>
<td>expanded polystyrene,</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20-30 polyurethane</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Breathable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>Variable (may have facing)</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Absorbs moisture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes and moisture will reduce insulation</td>
<td>Yes but not so much as with cellulose</td>
<td>Variable</td>
<td>No</td>
<td>No</td>
<td>Usually hydrophobic to reduce condensation</td>
</tr>
<tr>
<td>Can be cut to fit installation considerations</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Must be ventilated</td>
<td>Yes</td>
<td>Some fibres can cause lung damage</td>
<td>Yes</td>
<td>No</td>
<td>Very delicate best suited to prefabricated components</td>
</tr>
<tr>
<td>In-use considerations</td>
<td></td>
<td>Joints between panels must be sealed</td>
<td>None</td>
<td>No</td>
<td>Cutting raises dust not expected be a health risk.</td>
</tr>
<tr>
<td>Must be ventilated to prevent mould and fungus.</td>
<td>None</td>
<td>Toxic fumes can be released in case of fire.</td>
<td>None</td>
<td>Expected age variances</td>
<td>None</td>
</tr>
<tr>
<td>Scalable</td>
<td></td>
<td></td>
<td></td>
<td>Manufacturing complex with manual steps</td>
<td>Yes</td>
</tr>
<tr>
<td>Mature Product</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Early products available</td>
</tr>
</tbody>
</table>

**Figure 7**: Characteristics of different kinds of insulation including some recent materials
Advanced insulation products have a very low conductivity (between 5 and 10 times lower than traditional thermal insulation materials, depending on ageing time). Ageing is a process in which various stresses cause irreversible changes of material properties with time, thus reducing progressively the attitude of insulation in enduring the stress itself. This process ends when the insulation is no longer able to withstand the applied stress. There are numerous benefits of advanced materials when compared with traditional solutions, including their thinness. This feature offers opportunities in various types of refurbishments (including hard-to-treat buildings), heritage buildings, or construction projects where space is limited or of a high real estate value. Although they deliver attractive operational energy savings, they are still a great deal more expensive than traditionally used materials. Future steps for bringing advanced thermal insulation materials and solutions to the market should focus on reducing the initial cost, delivering evidence of ageing and environmental credentials, providing case studies and demonstrating the benefits in situ.

Tests conducted by the University of Salford in their Thermal Measurement Laboratory during 2009 found an increase in thermal resistance of 40% on 9.5mm plasterboard.

Testing of the insulation effectiveness of nanomaterials is ongoing and awaiting approval.

4.11 Insulation Properties

Because the thermal properties of individual products vary, conductivity values should be checked with manufacturers. These values can then be used to calculate the minimum insulation thickness:

\[ t[\text{mm}] = R \times \lambda \times 1000 \quad \text{where:} \quad R = \text{the required thermal resistance of the insulation in m2K/W} \]
\[ \lambda = \text{the thermal conductivity of the insulation in W/mK}. \]

The benefits in U-value performance for basic insulation can be seen from the case where an un-insulated external wall with an air gap has a co-efficient of heat transfer (U-value) of about 1.5 W/m2K. If a 6 cm air gap is insulated, this figure is reduced to 0.5 W/m2K. This represents a reduction of about 66%. The reduction in heat transfer results in a temperature rise of the interior wall surface which, in turn, leads to improved home comfort and wellbeing and reduces the risk of mildew growth.

4.12 Effect of Insulation Density

The thermal conductivity of mineral wool is known to vary with density. For densities lower than the typical installation density of around 25 kg/m3, the thermal conductivity is higher, leading to higher U-values and therefore poorer insulation performance. On the basis of published figures mineral wool of low

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Density will conduct significantly more heat than mineral wool with a density that is close to optimum. Density of insulation, therefore, is an important determinant of thermal performance in practice. Also notable is the fact that the deterioration in conductivity is only slight for densities a little higher than the optimum suggesting that the use of higher densities of cavity fill would only have a slight detrimental effect upon thermal performance. The following figures illustrate the relationship between conductivity and density for one particular type of mineral wool.

<table>
<thead>
<tr>
<th>Density, kg/m$^3$</th>
<th>Conductivity, W/mK</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>0.042</td>
</tr>
<tr>
<td>20</td>
<td>0.035</td>
</tr>
<tr>
<td>30</td>
<td>0.033</td>
</tr>
<tr>
<td>40</td>
<td>0.032</td>
</tr>
<tr>
<td>50</td>
<td>0.031</td>
</tr>
<tr>
<td>100</td>
<td>0.032</td>
</tr>
<tr>
<td>150</td>
<td>0.033</td>
</tr>
</tbody>
</table>

It is notable that the relationship between density and conductivity will not always follow the table above, depending upon the exact nature of the material, however it is true that for mineral wools in general, including glasswools, there is an optimum density and that the conductivity is higher for densities lower than the optimum.

4.13 Identified Issues with Cavity Wall Insulation

Cavity walls were generally first built, in exposed coastal areas, in order to keep out wind-driven rain. Filling any cavity with insulation will always hold the risk that moisture will be able to cross to the inside wall, whatever the insulation material due to a range of factors. There is the quality issue, with the possibility that the installation will be less than perfect, leaving voids and air pockets, these will lead to 'cold spots' on the internal walls attracting condensation and mould. There are other concerns one being wall-tie corrosion, the state, finish and tidiness of the brickwork within the cavity with snots (mortar excess) rubble or rubbish left in the cavity will affect the performance of the insulation.

The British Board of Agrément approval of insulation products clearly states that there are certain materials unsuitable for areas of high exposure to wind-driven rain. These requirements are often ignored by the industry and in themselves are prior reasons for the failure of the system to protect the home.

Since the 1980s, the Building Regulations have required new houses to be built with insulation material in the cavity. As long as existing buildings standards are met then insulation should not compromise the resistance to rain penetration.

Recent cavity insulation material is usually rigid foam boards, which are intrinsically waterproof, or mineral-wool or glassfibre "batts" (panels), where vertical aligned fibres run penetrating rainwater downwards in the cavity, reducing the chance of moisture penetration across to the inner leaf. This type of installation can be partial fill or full fill of the cavity width. In partial fill the
insulation is fixed to the inner leaf, leaving a narrow cavity to intercept any rainwater that penetrates the outer wall. Building Research Establishment (BRE) research has found that single-leaf brick walls always leak when exposed to wind-driven rain. The leakage occurs at the vertical joints between adjacent bricks, because of drying shrinkage, settlement cracks in the mortar, common natural occurrences in buildings.

Another factor is with increased thicknesses of insulation in cavities, the outer leaf is at risk of becoming wetter and colder for longer, thereby increasing the risk of frost damage and sulphate attack.

4.13.1 Exposure Zones and Rain Penetration
Exposure to wind driven rain zones across the UK is shown in figure 8.

![Figure 8: UK National exposure to wind-driven rain zones](image)

Despite the constant insistence by manufacturers that cavity wall insulation doesn’t allow rainwater to cross the cavity, BRE has found that it can. Their findings have been published in a number of BRE publications, notably BRE Good Building Guide 44: part 2: "Insulating masonry cavity walls - principal risks

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27 BRE Good Building Guide 44: part 2
and guidance" This states, "There can be an increased risk of rain penetration if a cavity is fully filled with insulation, i.e. moisture is able to transfer from the outer to the inner leaves resulting in areas of dampness on internal finishes. Rainwater, under certain driving rain conditions, can penetrate the outer leaf of masonry leading to wetting of the cavity insulation, a reduced thermal performance and damage to internal finishes."

The guidance document contains a table indicating the maximum exposure zones recommended for cavity wall insulation, for different cavity widths and different types of insulation material. There are many variables contained in this table but local climatic conditions should be used to determine the best product for any given location for “best practice”.

It should be added that even where it does not transmit rainwater across the cavity, CWI can still create dampness problems through increased condensation. It has been published that 40 percent of houses whose cavity walls have been filled with blown mineral fibre suffer from gaps in the insulation28, and it is these voids which cause condensation and black mould on the walls inside. Because, in a house which has been only partially insulated, the temperature still rises, and with it, the humidity - the amount of water vapour held in the air. Any remaining cold spots will therefore experience more condensation than before. Common areas for condensation and black mould growth are near ground level, between windows, and at ceiling level in upstairs bedrooms.

4.13.2 Damp

The three most common kinds of damp are rising damp, penetrating damp and condensation.

Rising damp is caused by ground water moving up through the wall materials. Most contain some moisture but the damp is usually stopped by a damp-proof course (DPC).

Penetrating damp is caused by water permeating through external walls, mostly horizontally. Penetrating damp is usually caused by structural problems in a building, such as faulty guttering or roofing and is increased by wind and rain loadings.

Condensation is caused by moist air condensing on poorly insulated cold walls, mainly during winter months. Condensation can be exacerbated by inadequate ventilation and an increased heating need due to poor thermal protection. Weather and local climate conditions can and do greatly add to the inability to protect the building’s thermal fabrics, allowing it to be measured and perform as designed. With the geographical island nature of Northern Ireland being mostly rural and hilly, vast temperature and rainfall differences can be experienced by many locations.

28 http://www.telegraph.co.uk/property/3346244/On-the-level-should-I-insulate-my-cavity-walls.html
4.13.3 Damp-Related Behaviour of Walls

One part of the project was to run simulation-based calculations on the thermal and moisture-related (temperature and water) behaviour of external cavity walls. This was done with the help of the Delphin simulation program and used various given parameters. These calculations showed that the masonry of an external cavity wall still has the ability to dry out, even after the cavity has been insulated.

If, for the purposes of the simulation, it is assumed that the internal wall is damp, then the drying time for an insulated wall is three times as long as a wall with a ventilating (non-insulated) air gap. The drying process takes place towards the interior. Given normal conditions in the room itself (20 °C, 50 % relative humidity) then all of the requirements for effective damp-protection are fulfilled as long as drying out of the wall towards the interior is not inhibited.

If, however, the air in the room is not able to absorb sufficient moisture (low temperature, high relative humidity) or if there is a barrier on the interior surface which prevents moisture transfer, then drying out can be inhibited to such an extent that damp-related problems arise.29

Location, aspect, and the differing exposure of individual elevations to direct sunlight and wind driven rain have important influences on a building’s condition and performance.30

4.13.4 Wall Tie Corrosion

Wall ties are vital for the structural integrity of a cavity wall, as they hold the inner and outer leaves of masonry together. Being made of iron or steel, they will inevitably rust eventually, but in dry conditions they should last for many years. Where metal wall ties are used and the cavity insulation is itself wet, then clearly it will be holding moisture in close contact with the wall ties, and hence accelerate their corrosion.

When persistently damp however, they can corrode much quicker, and replacing them is a costly and time-consuming process, involving cutting out dozens of individual bricks from the outer leaf. Replacing corroded wall ties becomes much more difficult in a building with cavity wall insulation, as the insulation itself has to be removed around each tie, and then replaced afterwards.

Anyone thinking of having cavity wall insulation installed should first have the condition of their home’s wall ties assessed using the method described in BRE Digest 401, which specifies that two bricks should be removed on each elevation (at high and low levels) and tested for corrosion. Inspecting ties by drilling a hole in the outer leaf and looking through a Borescope is not a satisfactory way of assessing their condition, as the most serious corrosion is likely to be where the ties are embedded in the mortar. Wall tie corrosion is a growing problem, and mortgage evaluation surveyors are increasingly

recommending that wall ties should be inspected as a condition of a mortgage advance. It is likely that the widespread presence of retro-fill cavity wall insulation will increase surveyors’ alertness to the possibility of wall tie corrosion, and might therefore create delays when homes with cavity wall insulation are put on the market.

Homes most at risk of wall tie corrosion are those built with wrought-iron "fish-tail" ties prior to 1920, and those built with galvanised steel "butterfly" ties between 1964 and 1981. Any house about to have its cavity walls insulated is supposed to be inspected and assessed for suitability by "a trained surveyor".
5.0 GEOGRAPHICAL CONTEXT

5.1 Northern Ireland Topography and Climate Considerations

The climate of Northern Ireland is characterised by equability, a consequence of the moderating effects of the Atlantic Ocean - bringing relatively mild winters and cool summers. However, the indented shape of the coastline and the presence of high ground introduce localised differences in temperature, cloud and precipitation. This over the past number of years has seen the growth of unusual weather events not only here but globally with the questionable (in some quarters) effects of climate change and the increase in CO₂ into the atmosphere.

From the information supplied by the Met Office, site designers and installers need to be aware of the local climate in all areas. There is not a situation that allows a ‘one solution’ approach to providing thermal comfort at any level. Having the relevant information at hand to properly design a solution for each property is a main consideration, utilising weather data, suitable and appropriate materials and a quality driven demeanour is key to protecting the inhabitants of any home. The heating requirements therefore needs to be matched to the local climate information as stated by Walker, McKenzie, Liddell, Morris (2011) the Heating burden has never been included in small area analysis of fuel poverty before. Consequently, figure 9 provides the first visual analysis of this element of risk. It clearly illustrates wide variation. Central areas of Northern Ireland are exposed to a greater heating burden. There is generally reduced risk in coastal areas, with lowest exposure in the Southwest.

Figure 9: Heating Burden
5.1.1 **Temperature**
The mean annual temperature at low altitudes in Northern Ireland varies from about 8.5 °C to 9.5 °C, with the higher values occurring around or near to the coasts. The mean annual temperature decreases by approximately 0.5 °C for each 100 metres increase in height so that, for example, Parkmore Forest in County Antrim (at 235 metres) has an annual mean temperature of 7.4 °C. On this basis, Slieve Donard (at 852 metres) would have an annual mean temperature of about 4.5 °C.

The variation of mean daily maximum and minimum temperatures month by month, together with the highest and lowest temperatures recorded, is shown for Aldergrove and Lough Navar Forest.

5.1.2 **Local climate issues**
Many reports define the issues of climate as a main consideration in the success rate of cavity wall insulation.

Figures 10-12 below show the average rainfall and ground frost in January and the annual hours of sunshine between 1971–2000.

![Figure 10: Average Days of Rainfall in January, 1971-2000](http://www.metoffice.gov.uk/climate/uk/ni/print.html)
Figure 11: Average Days of Ground Frost in January, 1971-2000

Figure 12: Annual Average of Sunshine Duration 1971-2000

http://www.metoffice.gov.uk/climate/uk/ni/print.html
Rainfall penetration levels through the outer fabric of a home can and will create issues with the transfer of moisture across the cavity. As highlighted in the weather data contained in figures 8-10 above, Northern Ireland has in comparison to the UK a very high level of rainfall with major local variances. The rainfall levels within the country can be seen to be extremely local to many areas, with as much as 1500 hours of rainfall difference a year in parts of the country. The hours of sunlight and therefore the drying factors for housing is also a measure that need addressed when considering the reaction and performance of cavity wall insulation. The days of air and ground frost due to the terrain will also determine the overall success of cavity wall insulation performance in meeting comfort levels. This will under certain circumstances lead to damaging effects for building fabric’s, due to fabric water retention and frost damage.

5.1.3 Frost
The average number of days with frost in Northern Ireland varies widely depending on the location. The main controls are: distance from the sea and altitude, but the ability for cold air to drain into inland valleys is another important factor. An ‘air frost’ occurs when the temperature at 1.25 metres above the ground falls below 0 °C, whereas incidence of a ‘ground frost’ refers to a temperature below 0 °C measured on a grass surface. Sites along the coast typically have fewer than 25 days of air frost each year and inland the number increases with altitude to over 55 days in the highest upland areas. Ground frost occurs on average on less than 80 days each year on the coast and over 115 days in the highest upland areas and the most frost-prone lowland locations, with a similar distribution to air frost.

5.1.4 Sunshine
On the whole, Northern Ireland is cloudier than England, even so, the coastal strip of County Down manages an annual average total of over 1400 – 1600 hours of sunshine. The dullest parts of Northern Ireland are the upland areas of the north and west, with annual average totals of less than 1150 hours. This can equate to a maximum of over 450 hours difference (drying time) in a large area of the country.

5.1.5 Rainfall
Rainfall in Northern Ireland varies widely, with the wettest places being in the Sperrin, Antrim and Mourne Mountains. The highest areas have average annual totals of about 1600 mm, which is about half that of the English Lake District or the western Highlands of Scotland. In addition to topographic effects, greater exposure to rain-bearing winds off the Atlantic results in higher averages in the more western counties of Fermanagh, Londonderry and Tyrone. The wettest places are in the upland area around Kilteer Forest in the extreme west of County Tyrone, where the annual average reaches about 1950 mm. The driest places are further east - around Strangford Lough and close to the east coast, and near to the southern and eastern shores of Lough Neagh - where the annual totals are just under 800 mm.

5.1.6 Snowfall
The numbers of days with snow falling and lying show an increase with increasing latitude and altitude, so values reflect topography. Snow is comparatively rare near sea level in Northern Ireland, but much more frequent
over the hills. The average number of days each year when sleet or snow falls varies from around 10 near the east coast to over 35 in the mountains of Sperrin, Antrim and Mourne. The average annual number of days with snow lying in Northern Ireland varies from less than 5 around the coasts to over 30 in the mountains.

5.1.7 Wind
Northern Ireland is one of the windier parts of the UK, with the windiest areas being over the highest ground and along the coasts of Counties Antrim and Down. Wind speed is sensitive to local topographic effects and land use - places sheltered by hills or in urban areas will have lower wind speeds and fewer days of gale.

The annual wind rose for Aldergrove is typical of low lying, inland locations in Northern Ireland, with a prevailing south-westerly wind direction through the year. However, there is a high frequency of north, north-east and easterly winds during the Spring.

Wind chill effects in local geographical locations will determine the thermal comfort of homes, due to enforced heatloss due to weathering.
6.0 BEST PRACTICE

6.1 Pre and Post Treatment Survey
The October 2010 INBUILT Ltd report Study on hard to fill cavity walls in domestic dwellings in GB possibly sets out the clearest way to conduct the survey in terms of pre and post treatment for cavity walls:

The level of detail that a full survey would need to establish beyond reasonable doubt the issues with cavity failures, would have time and cost implications. This would be additional compared with current practice, requiring a significantly greater precision than currently seen, being undertaken as part of a general “energy efficiency” inspection as compared with the “technical assessment” being undertaken in more detail.

6.2 Academic research
There is a vast amount of academic research on the subject of cavity wall insulation techniques, practices and performance, with numerous research papers, guidance documents and reports available. The key factors are always materials based and involve quality in the sense of thermal performance and workmanship in its application.

6.3 Thermal Performance Report by University of Ulster
The University of Ulster (UUJ) Report states that high performance thermal envelope and fabric based solutions that promote energy efficiency and prevent heat loss have been shown to significantly reduce the capital cost of energy running costs in the home.

The report states:

“There is limited knowledge about the performance of wall insulation which has been in use for a number of years, there is both anecdotal and scientific evidence that properties with older insulation could be performing less well than properties which have just had insulation installed. There are two possible reasons for older properties performing less well:

- Installation techniques and quality controls at that time were different, and
- The insulation has physically deteriorated since it was installed due to ageing processes, stability, slumping, voids and air gaps, settling, weathering processes, disturbance by operatives (eg plumbers or electricians) or biological processes.”

The UUJ report sets out the methods used for thermographic surveys to be carried out in order to identify areas where cavity insulation may be missing (voids and air gaps), sagging or of low compactness. These surveys are in line

with existing practice, agreed and carried out with SERC staff in other joint inspections. The thermographic surveys are followed up with cavity inspections utilising the naked eye and Borescope technology.

“The in-situ U-value measurements are conducted on a sample home before and after a retrofit cavity wall insulation exercise has been completed on the property. The in-situ U-value measurements are conducted on a sample home before and after a retrofit cavity wall insulation exercise has been completed on the property.”

“The initial in-situ U-value evaluation on a sample property is followed by the removal of the existing cavity wall insulation (fibre) followed by a retrofit installation of cavity wall (bonded bead) insulation by the clients. Finally, a post retrofit in-situ U-value study (thermographic survey) is carried out on the property to establish if a retrofit cavity bonded bead wall installation can act to reduce the heat loss in the wall and thereby increase the energy efficiency of the property.”

“Lecompte et al34 carried out a study of partially filled cavity walls and showed that the U-value can be altered substantially when air is able to circulate on both the warm side and cold side of the insulation. Lecompte reported that where there is a gap of 10 mm at the top, bottom and sides of the insulation board the U-value can rise by over 90% leading to near-doubling of the wall U-value. Lecompte also points out that air permeability of insulation materials can be a major factor in influencing heat loss and he recommends that mineral wool insulations in cavity walls should be of high density in order to reduce this effect. Lecompte concludes that the presence of small air leaks can cause a substantial increase in heat transfer in practice. It seems that some of these problems can be alleviated when the cavity is fully filled (rather than partially filled) and where the insulation is compressible enough to accommodate the rough faces of the walls.”

“A recent Kingspan online communication entitled ‘Avoid Gas Guzzling Buildings’ provides for some solid criticism of fibrous based cavity wall insulation and states in the strongest possible terms that: “Fibrous insulants are typically glass fibre or stone wool both of which are man-made mineral fibre MMMF. These insulants rely on air between the fibres to provide their thermal integrity However these insulants are prone to degradation due to moisture ingress air infiltration ageing thinning and settlement all of which can reduce thermal performance This can result in building fabric failure and in turn cause increased heat loss energy running costs and carbon emissions”.

“The communication briefing from Kingspan goes on to state:

- Reduced thermal performance of fibrous insulants in building envelope and fabric systems can increase energy running costs and carbon emissions.
- 1% moisture content in fibrous insulants can reduce thermal performance by up to 85% or more which can cause massive energy and heat loss.

34 Lecompte, J (1990) The influence of Natural Convection on the Thermal Quality of Insulated Cavity Construction, Building Research and Practice, CIB.
Degradation of fibrous insulation due to ageing thinning and settlement can reduce U-value performance by up to 20%

Air movement through fibrous insulation can result in increased energy and heat loss of up to 500%”

“All cavity insulation can be removed. Mineral fibres and polystyrene granules can be blown or vacuumed out, whilst solid foam insulation must be manually broken up and scraped out.”

“In expressing the value of the removal (extraction) and refill of the cavities it is best set out in layman’s terms as found in the table below from the recent UUJ on a home in MountEagles estate Belfast. This shows improvements in individual walls thermo-graphically measured in a before and after scenario. The bay window right and gable wall left upper show figures that have probably been affected by the embossed paper on which the sensors where located on.

<table>
<thead>
<tr>
<th></th>
<th>% improvement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bay Window Left</td>
<td>39</td>
</tr>
<tr>
<td>Bay Window Right</td>
<td>23</td>
</tr>
<tr>
<td>Gable Wall left upper</td>
<td>21</td>
</tr>
<tr>
<td>Gable Wall left lower</td>
<td>33</td>
</tr>
</tbody>
</table>

Figure 13: Improvement in U-value of bonded bead over fibre insulated wall

Figure 13 above shows that the improvement in thermal performance was in the range from 21% to 39% depending on sensor location. It must be remembered that this test is for one room of the house and that this improvement may be greater especially on the upper floors where settlement of the insulation may have occurred.” Source: Pg 27 McLamon. D, Hyde. T, UUJ

The finding of this research report is more or less in direct agreement with the research findings in the EST report 222077 for BRE Doran. S, Carr. B. where the effectiveness of sampled cavity wall insulation is reflective of the UUJ report findings.

Through this work, a better understanding of the effectiveness of cavity wall insulation, as currently applied in existing dwellings, has been obtained, together with an estimation of the benefit in practice of cavity wall insulation. It can be said with certainty that the application of cavity wall insulation helps to

improve the energy efficiency of dwellings. It is clear, however, that for many dwellings the coverage of cavity wall insulation is not complete partly as a result of the nature of wall constructions, including lintels, tile-hung areas, adventitious voids and areas in and around conservatories.

Recommendations are given on how methods of applying insulation might be improved with a view to making installations more effective. It is also clear that the actual realised improvements to U-values are in many cases less than would be expected on the basis of conventional methods of calculating U-values, even when the actual measured cavity widths are taken into account.

Moreover it was found, contrary to expectations, that there was no discernible correlation between the benefits obtained from cavity insulation and the widths of the cavities being filled. Indications are that the improvement in thermal resistance is, on average, around 38% less than that which would be expected on the basis of measured cavity width, and low insulation compactness might account for some of this difference. It was also noted that in the majority of cases the measured improvement in thermal resistance was less than the improvement that would be expected on the basis of the measured cavity width, and this is true not only for the sample of houses as a whole but also of the modal class.”

6.4 The MountEagles Situation (UUJ report)

Referred to in Section 6.5, the MountEagles housing estate in Poleglass, Belfast, has around 600 privately owned homes ranging between two years old to ten years old and has been plagued with high energy costs, hard to heat homes, heavy mould and condensation problems and multiple health issues. These homes are a direct correlation to the issues found in a major percentage of the NIHE homes surveyed hence the importance of the relationship.

The MountEagles Ratepayers Association (MERA) have been at the forefront to find a solution to the problem of their poor energy efficient homes, with high energy bills and health related problems. The group have assumed a link between inefficient homes and health issues (excess mould and condensation issues) and this is worthy of further investigation. One MountEagles resident (UUJ thermal evaluation test house) has indicated that as a result of the recent cavity wall bonded bead retrofit by local insulation manufacturer and installation company (Winter 2013) that “the house’s change in temperature is ‘amazing’. A year on we (the family) have less chest infections and colds due to the comfort levels within the house”. It would be important to investigate fully whether the health issues will continue to be alleviated as a result of the recent cavity retrofit in the demonstration test house. The MountEagles resident’s letter at Appendix 3 reinforces the University’s findings and clearly sets out the beneficial lifestyle changes as a result of remedial treatment.

The project has certainly gained the support of MERA and the resident’s personal account backs up the improved analytical U-value findings from the UUJ research project.
It was a belief in MountEagles that the insulation and building remedial work guarantees would be honoured, but due to other mitigating factors this was not possible.

6.5 Cavity Insulation Guarantee Agency (CIGA)

CIGA provides independent 25 year guarantees for Cavity Wall Insulation fitted by registered installers in the UK and Channel islands. The standard Guarantee covers traditionally constructed residential property. The Government regards cavity wall insulation as the most effective energy savings measure that most people can carry out on their homes and a major contributor to reducing emissions of carbon dioxide, the main greenhouse gas.

CIGA also operates and administers the Cavity Wall Insulation Self Certification scheme (CWISC)

CIGA was established in consultation with the Government's Energy, Environment and Waste Directorate (a division of the Department of Transport) to provide householders with an independent, uniform and dependable guarantee covering defects in materials and workmanship.

6.6 British Urethane Foam Contractors Association (BUFCA)

Some BRE research in the 1990s showed that cavity wall insulation when assessed & installed properly does not lead to an increased risk of damp. The study found that the structural condition of the walls was the most important factor in damp problems - for example, badly filled mortar joints or 'dirty cavities' (where, during construction, mortar has dropped down inside the cavity - i.e. if too much is used). Over time, this can cause problems with damp-proofing. Using Energy Saving Trust Recommended insulation means it complies with British standards and it has a 25-year guarantee.

6.7 Cavity wall insulation Methods

6.7.1 Standard Equipment
The following standard equipment used in cavity wall insulation is illustrated in figures 14 – 16 below:

- Machine unit - base and hopper
- 50’ 14ga cord with twist/lock end
- (2) 50’ sections of 2.5” blowing hose, with quick-connect coupler set attached
- Wireless remote (attached to end of hose)
6.7.2 Properties

**Thermal Conductivity:** For the purpose of U-Value calculations to determine if the requirements of the building (or other statutory) regulations are met, the thermal conductivity of the insulation may be taken as 0.040 W/MºC.

**Density:** Typical installed densities range from 18kg/m3 for glass wools to 40kg/m3 for rock wools (depending on individual BBA certificates).

**Fire:** Blown Mineral Wools are non – combustible, tested to BS 476 : Part 4 : 1970.

**Water:** Mineral Wool is resistant to water penetration and will not transmit water across the cavity or from below DPC level by capillary action. It does not however act as a water vapour barrier.
6.7.3 Application

Survey: A pre-installation survey is carried out to assess the suitability of the property for the installation of cavity wall insulation, a survey requirement set out fully in guidance documentation.

Site Preparation: Essential ventilation openings such as those providing combustion air or underfloor ventilation, and all flues in the cavity wall must be checked. If adequate sleeving or other cavity closures are not present, installation must not proceed until these openings have been sleeved or otherwise modified to prevent blockage by the insulant. This was seen to be an issue in several locations where loose bead product was found around the property due to wavering effects on vents, not isolated from the cavity.

6.7.4 Installation Procedures:

Where a semi-detached or terraced property is to be treated, the insulation is contained by inserting a cavity barrier at the line dividing the properties. This consists of a nylon brush which is retained in the cavity. Injection holes of 22mm or 25mm diameter are drilled at a predetermined pattern/distance (depending on individual BBA certificate). Wool is blown into the cavity via a flexible hose fitted with an injection nozzle, using an approved blowing machine. Filling proceeds from the bottom to the top of the wall and from one end of the elevation to the other. After injection of any insulant, the holes are made good to match the existing finish as closely as possible.

6.7.5 Post Installation Checks

All necessary air vents are checked e.g. those providing underfloor ventilation and combustion air. In all cases flues are carefully checked on completion of the installation by means of an appropriate test to ensure they are not obstructed by the insulant.

In relation to the evidence uncovered in the surveys, this paper has given an account of and the reasons for the widespread use of cavity wall insulation and the present study was designed to determine the effect and quality of the materials found in the NIHE properties taken from the 2009 and 2011 home condition survey reports.
7.0 FINDINGS

7.1 Introduction

The research inspections carried out under the tender agreement provided SERC with the opportunity to examine a sample of Housing Executive properties with a view to establishing whether there are quality and effectiveness issues with all the main types of cavity wall insulation, and if so to identify the scale of the problem in Northern Ireland and highlight potential (cost) effective remedies.

In total 206 homes were surveyed across Northern Ireland during a period of 11 weeks by two survey teams using the information provided by the Housing Executive. The completed research reports for each home inspected will be provided to the Housing Executive, a sample of which is Attached at Appendix 4. The information was taken directly from the Eco Compliance software (bespoke programme wrote for the NIHE inspection process) supplied by G3S Software. Maps showing the locations of Housing Executive properties inspected are at Appendix 5.

The research found that many homes suffered poor and inadequate levels of thermal protection, resulting in unnecessary energy losses and assumed high heating costs. There are a percentage of properties with materials that have physically deteriorated since installation due to ageing processes, stability, slumping, voids and air gaps, settling, weathering processes, disturbance by operatives (e.g. plumbers or electricians) or biological processes. Whilst the insulation was originally installed using the best available practices at the time, advances in knowledge and technology mean that insulation installed today would be less likely to deteriorate due to better training, higher quality materials and improved systems of control and inspection.

During the periods that most if not all of these surveyed homes were built, Building Control didn't add importance to the practice of inspecting wall cavities. No appropriate or regulated inspections were ever deemed to be part of the inspection process. A letter from local Building Control contained in the Appendix 6 corroborates this.

7.2 Significance of the findings

The need for a high performance thermal envelope with suitable fabric based solutions that provides energy efficiency, prevents heat loss and reduce energy running costs are paramount to clients of the NIHE. Information in the NIHE house condition survey (see figure 17) reflects that the proportion of the stock with full cavity wall insulation remained broadly similar to 2009 findings. In 2011, 503,120 dwellings had full cavity wall insulation which accounted for two thirds (66%) of the total housing stock (65% on 2009).
There was also little change in the proportion of dwellings with no wall insulation; almost one-quarter (173,600 dwellings, 23%; 21% in 2009) of the total housing stock had no wall insulation. The analysis of the housing stock in terms of wall insulation is complex, primarily due to the fact that many older dwellings (often with solid walls) now have modern extensions with insulated cavity walls. For the purpose of this analysis the following classification has been adopted.

SERC carried out a total of 206 Inspections on homes under the control and governance of the NIHE. The outcomes of the surveys and research analysis found many areas of concern in the quality of the thermal protection found in all house types and the materials used. The narrative must be stated that in the majority of cases the results will have a major negative effect on energy retention and comfort levels of the homes for all the occupants/tenants involved.

The use of thermographic imaging under control conditions (time of day, wind speed and if the home was heated in advance) helped to identify areas where insulation was missing or of low compactness. (It also helped to identify the locations where it was not possible to insulate, such as at lintels.) Where uninsulated (unfilled) areas were identified in the thermal imaging surveys, inspection holes were at times drilled in the wall and the cavity was examined using a Borescope in order to determine whether insulation was missing or of unusually low compactness. Using thermography, voids were found in a number of the properties, however the voids in most cases tended to be relatively small in area but in some cases large.

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36 Frey et al, 2011 Northern Ireland House Condition Survey, p. 79
7.3 Classification of inspected homes

The project team within SERC established a categorised system to classify the surveyed properties, which would identify homes most in need in relation to addressing thermal comfort levels, energy costs and treatment priority:

Category 1: Severe with Critical Needs
Category 2: Unsatisfactory with Grave Needs
Category 3: Significant Needs
Category 4: Specific Needs
Category 5: Deemed Fit for Purpose
Category 6: No Cavity Wall

This categorisation merely indicates what was found during the inspection process and is a pointer to target what would be deemed to be the worst affected properties in a graded way. The inspection process which sampled prescribed areas on the external fabric of the homes may not in its methods fully expose or constitute the complete state of the insulation within the cavities. The overall recommendation must be a ‘whole house’ analysis methodology which would establish a baseline situation from which to proceed from, in terms of understanding, remedial action and cost related interventions.

7.3.1 Category 1: Severe with Critical Needs

“Homes that as a result of the inspections that have been found to have little or no insulation present in the cavity walls of the property”.

This situation may also include issues surrounding mould or damp within the homes. Due to the nature of the inspections and in all 5 main categories on some occasions access to all areas could not be guaranteed and surveys were partially completed. Therefore by categorising these homes it must go with the recommendation that further detailed inspection is envisaged to achieve the best results. Further ‘whole house’ analysis would set out the remedial actions, based on the findings uncovered, targeting available funds to achieve the best outcomes per capital spent.

7.3.2 Category 2: Unsatisfactory with Grave Needs

“Homes that as a result of the inspections that have been found to have little insulation present in the cavity walls of the property”.

This situation may also include issues surrounding mould or damp within the homes. Due to the nature of the inspections, in some occasions access to all areas could not be guaranteed.

7.3.3 Category 3: Significant Needs

“Homes as a result of the inspections that have been found to have appropriate insulation present in some of the cavity walls of the property”.

This situation may also include issues surrounding mould or damp within the homes. Due to the nature of the inspections, access to all areas at times could not be guaranteed.
7.3.4 **Category 4: Specified Needs**

“Homes as a result of the inspections that have been found to have little insulation present, in the areas below the windows and soffits (cavity walls) of the property”. There may also be other areas where small gaps had been discovered.

This situation may also include issues surrounding mould or damp within the homes. Due to the nature of the inspections, access to all areas at times could not be guaranteed.

7.3.5 **Category 5: Deemed Fit for Purpose**

“Homes as a result of the inspections that have been found to have sufficient insulation present, in the cavity walls of the property”.

It reflects homes that displays insulation material volume within the cavities and shows no noticeable gaps in the thermal protection of the fabric with any insulated materials used. This reflects resistance in the volume of insulation under pressure from the Borescope or grabbing tool, free from visible gaps or voids during cavity inspection. This would be deemed as fit for purpose, to have sufficient amounts present during Borescope inspections.

7.3.6 **Category 6: No Cavity Wall**

Properties with solid walls.

### 7.4 Data Presentation

A total of 206 homes across Northern Ireland were surveyed. As previously stated, not all properties were fully surveyed due to access and safety issues. The findings of the surveyed homes are presented below.

#### 7.4.1 By Category of Need

Figures 18-19 show the results of the survey by category of need.

<table>
<thead>
<tr>
<th>Category</th>
<th>Classification of Surveyed Houses</th>
<th>Number of Houses Surveyed</th>
<th>Percentage of Houses Surveyed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Severe with Critical Needs</td>
<td>81</td>
<td>39.3%</td>
</tr>
<tr>
<td>2</td>
<td>Unsatisfactory with Grave Needs</td>
<td>54</td>
<td>26.2%</td>
</tr>
<tr>
<td>3</td>
<td>Significant Needs</td>
<td>22</td>
<td>10.7%</td>
</tr>
<tr>
<td>4</td>
<td>Specified Needs</td>
<td>28</td>
<td>13.6%</td>
</tr>
<tr>
<td>5</td>
<td>Deemed Fit for Purpose</td>
<td>19</td>
<td>9.2%</td>
</tr>
<tr>
<td>6</td>
<td>No Cavity Wall</td>
<td>2</td>
<td>1.0%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>206</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 18:** Number and Percentage of Surveyed Homes by Category of Need
7.4.2 **By House Type**

Figures 20-21 show the numbers and proportions of house types surveyed.

<table>
<thead>
<tr>
<th>House Type</th>
<th>Number of Houses</th>
<th>Percentage of Houses</th>
</tr>
</thead>
<tbody>
<tr>
<td>Detached</td>
<td>1</td>
<td>0.5 %</td>
</tr>
<tr>
<td>End Terrace Bungalow</td>
<td>16</td>
<td>7.8 %</td>
</tr>
<tr>
<td>End Terrace House</td>
<td>37</td>
<td>18.0 %</td>
</tr>
<tr>
<td>First Floor Flat</td>
<td>1</td>
<td>0.5 %</td>
</tr>
<tr>
<td>Ground Floor Flat</td>
<td>10</td>
<td>4.9 %</td>
</tr>
<tr>
<td>Mid Terrace Bungalow</td>
<td>17</td>
<td>8.3 %</td>
</tr>
<tr>
<td>Mid Terrace House</td>
<td>79</td>
<td>38.3 %</td>
</tr>
<tr>
<td>Semi Detached House</td>
<td>23</td>
<td>11.2 %</td>
</tr>
<tr>
<td>Semi Detached Bungalow</td>
<td>22</td>
<td>10.7 %</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>206</td>
<td>100 %</td>
</tr>
</tbody>
</table>

**Figure 20:** Numbers and Percentages of Surveyed Home Types

**Figure 21:** Bar Chart showing Surveyed Home Types
The information on the percentage house type Pg 22, NIHE 2011 House Condition Survey (Figure 22) reflects the following stock type in percentage form with the surveyed house totals identified on a percentage ratio base:

<table>
<thead>
<tr>
<th>House type</th>
<th>NIHE HCS 2011 Percentage</th>
<th>Surveyed homes (pooled)</th>
<th>Percentage Surveyed</th>
<th>Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bungalows</td>
<td>21.1 %</td>
<td>26</td>
<td>26.8 %</td>
<td>+ 5.7 %</td>
</tr>
<tr>
<td>Terraced House</td>
<td>27.6 %</td>
<td>106</td>
<td>56.3 %</td>
<td>+ 28.7 %</td>
</tr>
<tr>
<td>Semi Detached</td>
<td>21.7 %</td>
<td>23</td>
<td>11.2 %</td>
<td>- 10.5 %</td>
</tr>
<tr>
<td>Detached</td>
<td>20.9 %</td>
<td>1</td>
<td>0.5 %</td>
<td>- 20.4 %</td>
</tr>
<tr>
<td>Flats</td>
<td>8.7 %</td>
<td>11</td>
<td>5.4 %</td>
<td>-3.3 %</td>
</tr>
</tbody>
</table>

**Figure 23**: NIHE home types and percentage surveyed by type

The surveyed homes type percentages, in relation to the percentage of housing stock types from the 2011 House condition survey (figure 23), shows that there was an over examination of Terraced houses and Bungalows and an under examination of Semi-detached, Detached and Flats. This is somewhat distorted by the categories that the SERC surveys identified, 9 house types to the basic 5 types in the 2011 House condition survey. But in general the findings for all house types are poor in terms of quality.

Despite its exploratory nature, the findings give some insight into what are major issues with the current state of existing cavity wall insulation in a great number of NIHE properties. Although the research project was based on a small sample of the overall properties that the NIHE has responsibility and due diligence for, if it was expanded in exponential terms across the total NIHE housing stock (89,000) the ramifications on energy losses and the possible energy improvements are huge.

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37 Frey et al, 2011 Northern Ireland House Condition Survey, p. 22
The findings suggest that notwithstanding these limitations the inspection process clearly has displayed that a number of issues across a range of materials, house types and geographical locations exist.

The outcomes are identical to the large numbers of other homes that the College, University of Ulster staff working along with the industry has researched, they display exactly the same inherent issues. Limitations of the current study (research) are that not all surveys (a small percentage) were fully completed due to the nature of the inspections being dependent on the tenant’s approval, availability and the issues surrounding access and safe working practices. Not all of the surveys therefore met the pre-set criteria, but in each circumstance whilst reduced in nature, issues in most cases were uncovered warranting action. The surveys included two solid walled properties which couldn’t be evaluated due to the limitations of the research, but these in many ways are the most difficult and costly homes to provide remedial treatments for.

7.4.3 Breakdown of insulation types for the surveyed homes

<table>
<thead>
<tr>
<th>Insulation Type</th>
<th>Total</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blown Fibre</td>
<td>92</td>
<td>44.7 %</td>
</tr>
<tr>
<td>Loose Bead</td>
<td>55</td>
<td>26.7 %</td>
</tr>
<tr>
<td>Bonded Bead</td>
<td>4</td>
<td>1.95 %</td>
</tr>
<tr>
<td>None Found</td>
<td>5</td>
<td>2.43 %</td>
</tr>
<tr>
<td>Fibre &amp; Insulated Board mix</td>
<td>10</td>
<td>4.85 %</td>
</tr>
<tr>
<td>Bead &amp; Insulated Board mix</td>
<td>6</td>
<td>2.91 %</td>
</tr>
<tr>
<td>Fibre &amp; Insulated Bead mix</td>
<td>4</td>
<td>1.95 %</td>
</tr>
<tr>
<td>Urea Formaldehyde Foam</td>
<td>1</td>
<td>0.49 %</td>
</tr>
<tr>
<td>Solid wall</td>
<td>2</td>
<td>0.97 %</td>
</tr>
<tr>
<td>Insulated Board only</td>
<td>27</td>
<td>13.1 %</td>
</tr>
<tr>
<td><strong>Total homes surveyed</strong></td>
<td><strong>206</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

*Figure 24: Breakdown of insulation types for the surveyed homes*

As seen in figure 24, most of the homes surveyed were as expected, mainly split between both blown fibre and bead products within the cavities, with the makeup being 44.7 % fibre, 28.7 % bead (loose bead 26.7 %, bonded 1.95 %). Only 19 (9.22%) of the homes surveyed would be deemed to have a quality system installed. This is a major concern under any circumstance.

There were 5 properties found (2.43 %) with no insulation in the cavities, with one situation in a mid-terraced home where the tenants were happy with the comfort levels within the home, even though the cavity was empty of any materials. None of these homes would be deemed to have a thermal protective system installed and each would be deemed as a property most in need.

There were 10 situations (4.85 %) where a mix of fibre & insulated board materials were found in the cavities this mainly due to extensions or alterations having taken place, with the new element being fitted with insulated board products. None of these homes surveyed would be deemed to have a quality system installed overall. The fibre product in all these homes were defective with sparse to no materials found in some locations within the cavity. The board materials in the new built sections where in place. One property had an
unacceptable situation (Rockview Park, Moneymore) where board was directly mixed with sparse fibre product below a window with gaps visible between both.

There were six situations (2.91%) where an ESP bead and insulated board mix was uncovered, the main reason being homes where extensions or alterations had taken place. One of the homes has a partial fill in line with accepted BBA CIGA guidance, the only one of those surveyed that would be deemed to have a quality system installed. One of the homes surveyed was an unoccupied property with loose bead materials scattered around the outside of the home, escaping from the cavity by wavering.

Another of these homes had severe mould and some insulated board material missing in the extension, overall the insulated bead was reasonable.

Two of these homes had voids below the top windows and one the mortar was in poor condition with patchy bead at the soffit levels areas.

There were 4 situations (1.95%) where an ESP bead and a fibre insulation mix was uncovered, this showed areas of large voids and also empty walls in some cases. This seems to have been an attempt to improve existing defective fibre by installing bead into the cavities. In one location the bead seems to be an overspill from the property attached.

There were 27 situations (13.1%) where insulation board was uncovered, this seen areas of poor joints and missing sections. leaving voids and also empty walls in some cases. There were 6 of the surveyed board systems deemed to be satisfactory, fit for purpose.

There was one situation (0.49 %) in Sullenboy Park, Cookstown where Urea Formaldehyde foam insulation was found. The foam has broken down, powder and loose material was found, with mortar and bare block visible at all elevations. A sample from both walls broke to dust when touched. This has left large voids throughout the cavities in this semi-detached bungalow.

There were 4 situations (1.95%) were bonded bead insulation was uncovered in the cavity, there were 2 of those systems surveyed that were deemed to be satisfactory, fit for purpose. One had small voids in the system and the other poor quantities of material and the home was a victim to internal mould.

There were 92 situations (44.7%) were fibre insulation was uncovered in the cavity, only 4 of those surveyed were deemed to be satisfactory, fit for purpose. The rest had varying levels of quality issues ranging from sparse levels to empty walls in some situations.

There were 55 situations (26.7%) were loose bead insulation was uncovered in the cavity, only 6 of those surveyed were deemed to be satisfactory, fit for purpose. The rest had varying levels of quality issues ranging from sparse levels, small voids to empty walls in some situations.

Making decisions regarding uprating insulation is made easier having a basic understanding of U-values. U-value is the amount of energy in watts transmitted/lost through one square metre of the wall, floor or roof elements for every degree Kelvin based on the internal and external air temperature. So if a
1 square metre (m²) section of wall has a U-value of 2.0 and the temperature difference is 20 degrees the heat loss per m² is 40 watts.

For example, a typical 1930’s 100m² cavity wall home with a U-value around 1.6 W/m²K, the heat loss with a 20°C difference between the inside and outside temperature would be 3.2 Kilowatts. Insulate the property to a U-value of 0.30 W/m²K, the heat loss will be around a meagre 600 watts i.e. a 533% improvement.

### 7.4.4 Sample treatment for solid wall

Solid wall properties were found in two locations during the surveying and these homes represent the most difficult and costly in most cases to treat.

There are two recognised types of treatment, external and internal insulation applications. A simple annual heating cost versus heat loss example is given below to set out in very basic terms what is possible using the extra thickness of insulation and its possible worth in capital cost. This excludes other factors that can be an influence in the overall performance and reasons for underperformance, i.e. windows, airtightness, boiler type and efficiency etc.

An example brick built solid wall home with 13mm plaster internally would have a U-value around 2.17 W/m²K for the 220mm solid brick wall. In a modest 100 m² house this could account for, say, £750 of the overall annual heating cost. Basically this is an annual cost of £345.62 per 1.0 U-value (£34.56 per 0.1) if we assume a basic heating cost to heat loss calculations.

In an attempt to improve the performance if we insulate internally with modern dense, foam backed plasterboard (50mm insulation) and other measures and reduce the overall U-value to around 0.40W/m²K. The possible outcome could see us attain an annual heating cost around £138.36. Increase the thickness of the thermal board to 80mm and along with other measures we could reduce the U-value further to around 0.27 W/m²K. Therefore again using a basic assumption would/could see the heating costs per annum drop to about £93.33.

This under any circumstances is not scientific, but the appraisal by using the fundamental heat loss improvements, shows in the simplest of terms a major improvement in heating costs for any tenant. The material costs on thicker insulation to overall cost reduction benefits needs to be assessed, the insulation thickness shows that payback in improved performance tails off noticeably the further you increase the material thickness. This basic assumption could be attributed to any insulation improvements based on costs per W/m²K.
8.0 CONCLUSION & RECOMMENDATIONS

8.1 Conclusion

The property inspections and survey analysis has uncovered various levels of quality issues relating to the thermal protection in all types of homes within this survey across Northern Ireland.

The research findings appear to have uncovered problems and/or reinforced complaints by many tenants who struggle to heat their homes and keep warm.

The simple questions, “Is your home hard to heat, Does it cool down quickly when the heating system switches off and have you damp or mould issues?” can be easily answered ‘yes’ by the vast majority of householders, due to the levels of poor quality insulation encountered. This problem is not only found in social housing: as other research has highlighted, no one is immune from poor quality insulation.

The level of poorly insulated homes is extremely concerning and has major social implications in terms of energy costs, health, social and environmental issues. It serves no purpose within this report to try to apportion blame for this phenomenon but to realise the issue is real and present and needs attention for those suffering in certain homes.

Since most NIHE cavity insulation was carried out during the 1980s, quality control, inspection methods and industry training was not as advanced as it is today. Many historical building knowledge and insulation practices may look poor when assessed against modern quality control measures. It should be pointed out that the cavity wall insulation industry was in its infancy in the 1980s, installation techniques were not as advanced or as well researched as they are today and inspectors would not have had borescopes or thermal imaging cameras. Inspections would have been difficult without very costly and intrusive measures.

There are significant financial cost barriers in dealing with badly filled wall cavities due to the process of survey, identification, treatment types and overall quality. The knowledge and remedial methods for correcting this phenomenon is available and has been proved successful in combating the issues of poor quality insulation systems. The recent University of Ulster report on MountEagles shows not only the energy and financial savings, but also significant health, social and environmental benefits as a result of remedial treatment.

This SERC research has identified homes, categorised in relation to need, that could be treated on a priority basis and the outcomes fully measured and monitored.
8.2 **Recommendations**

Considering the findings of this research project, the author makes the following recommendations.

1. Quality Control
2. Whole House Solutions
3. Climate & Weather Consideration for Materials
4. Industry Training
5. Upskilling Housing Executive staff
6. Remedial Action

8.3 **Recommendation 1: Quality Control**

In the past the assumption was that the work carried out met existing regulations and provided adequate, reasonable comfort levels, were deemed appropriate. Clearly there was a major issue with industry standards in the past and with the recent changes from BBA, NIA and CIGA’s new regulations safeguards are addressing this situation.

The processes of surveying, design, remediation, installation needed to be formalised and quality assured to ensure best practice. This element seems to be a main omission in a great number of sampled homes in terms of quality outcomes. Insulation originally installed in the 1980s used the standards and best practices available at the time. However, advances in knowledge and technology mean that insulation installed today would be less likely to deteriorate due to better training, higher quality materials and improved systems of control and inspection.

A strict policy for cavity voids fill volumes to be estimated and agreed in writing, before any insulation fill is carried out is recommended. The measured insulation material volumes should equal the fill volume with a small allowable tolerance. This should be a required part of the process agreed with the *authoritative* bodies BBA, NIA and CIGA as guarantees need to be met and agreed to. The regulatory bodies will/should ensure a level of compliance.

A quality control system within NIHE that controls and fully monitors the insulation processes from start to completion for any project is recommended. Control needs to be put in place that only allows certified companies and staff to undertake any insulation work on behalf of NIHE that is reflected in Best Practice methods, set out by the professional bodies BBA, NIA and CIGA.

The importance of extracting poor quality cavity fill materials and replacing with equally sub-standard materials must not be allowed to happen. Appropriate control means that a checking procedure is in place for cleaned cavities after extraction. That they are free from mortar, debris or other materials which may cause issues. Checks should be made on the state of cavity ties, thermal bridging and any areas of dampness, all must be addressed before starting any cavity insulation or remedial work.

There is a need for the industry and NIHE to investigate fully the safe handling, removal and disposal of Urea Formaldehyde Foam insulation in the form found within some local cavity walls. The foam was originally injected as a liquid mix.
of chemicals to form a solid core within the cavity. Recent inspection surveys has discovered the aged product as a powder, dust or partial solid material within the cavity. Various research documents and contacts with recognised academic authorities feel that it is a possible hazardous substance and appropriate action is needed to identify the risk and establish safe methods to handle or deal with the materials.

8.4 Recommendation 2: Whole House Solution

It is important to understand how to obtain the best return on investment. To achieve value for money in thermal improvements to a dwelling, the building envelope should be the first priority, starting with insulating and draught-proofing. Payback periods on sensible energy efficiency measures that will save money are sometimes questioned, yet research has shown that over time such measures will save much more money than aesthetic improvements such as new kitchens or conservatories.

The way forward must be a ‘whole house solution’ where a qualified energy surveyor (not EPC) considers all energy elements for the home and sets out possible energy related improvements, a menu of interventions related to existing energy costs. This must be a ‘fabric first’ approach where any other energy intervention is maximised for the home and can be costed, based on existing energy prices and related to the likely cost benefits for the intervention.

This will create an established baseline analysis from which to manage each home, allowing for real costs to be measured and associated with appropriate interventions. The outcome should be a ‘menu of choice’: a list of opportunities to improve each home where the responsible landlord can react to funding opportunities and choose to select interventions for the individual home rather than have a ‘scattergun approach’ to improvements.

If the whole house solution recommendations were implemented, the true benefits of interventions like the boiler scrappage scheme or NIHE heating replacements, where claims of reduced energy benefits and CO$_2$ emissions could be realised. At present the bulk of the energy improvements are merely dissipating out through the badly insulated walls of most homes.

8.5 Recommendation 3: Climate & Weather Consideration

If climate change is to be accepted then the local Metrological office information and the micro-climate must be referred to in considering any intervention or treatment for a home. There must not be a “one solution fits all scenario”, each home should be judged on its location, relevant weather data and the appropriate remedial action chosen.

Recent extreme weather conditions and the recorded increase in rainfall since December 2013 requires preparation, reaction to counter the likely increase in water entering the cavity.

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The choice of cavity wall insulation material must be tailored to the weather conditions for each property. The letter at Appendix 7 from a major insulation manufacturing company states that a home in a County Down location was unsuitable for fibre insulation (due to weather conditions). The outcome of the generic analysis on 75 mm fibre filled cavity using the BuildDesk software programme where it fails the interstitial condensation analysis must be used as a pointer to drive change using weather data.

In addition to monitoring and preparing for increased rainfall, consideration should be given to the use of a weather-screen product(s) that protects the outer wall of homes in high risk situations i.e. areas of high rainfall. The application of the coating should be breathable in nature, allowing for vapour to dissipate from the cavity. The permeability of existing brick types and the mixes of mortar may need to be revised if the levels of exceptional rainfall experienced of late are a common event for the future. SERC has video footage of exceptional water ingress into a local cavity during the recent extreme weather conditions.

8.6 Recommendation 4: Training

8.6.1 Training Requirements
There are insufficient certified and qualified staff to conduct surveys and assess the scope of the possible problems with existing cavity walls.

Training on survey methods both pre and post installation will be foremost in addressing the quality agenda with the need for qualified and certified staff. The area of costs for any surveying work, extraction, materials and refill to attain a quality solution will be crucial. The lack of recognised skill sets, training agendas and technical guidance in filling cavities needs to include guidance on the mitigation of cold-bridges, damp and mould issues and thermal comfort provision.

8.6.2 Local Industry Training
The local insulation industry has come to recognise the need for change and has embarked on up-skilling and training to address the quality issues that clearly marred previous work. There is an amalgamation of around 95% of the industry who have pooled together to improve standards and react to change. SERC is working closely with this group to establish up-skilling and training needs, with certified outcomes helped with the Department for Employment and Learning’s funded programmes, including:

- The Employer Support Programme
  This provides Customised Training designed to enhance the skills base within Small and Medium-sized Enterprises (SMEs). Where no existing DEL training product will meet the skills need of an SME, SERC can create a tailored project.

  Support is available for accredited training at Level 2 or above. Funding rates are typically 75% contribution from the Department with the company paying the remaining 25%. Professional or industry standard training will also be considered.
Training can be delivered at a time and location to suit the employer. Employers will be required to release staff to undertake any training and will be required to make a financial contribution of 25%.

**Bridge to Employment Programme**

The offers a bespoke recruitment and pre-employment training programme designed for employers to get new recruits job ready from day one of their employment. This programme is designed to provide assistance to inward investment companies and local companies who are taking on new staff. This supports the recruitment and selection of applicants and customises a training programme built around the needs of the precise job to be filled. Bridge to Employment programmes can be arranged for one company or a group of companies with similar needs.

### 8.7 Recommendation 5: Upskilling Housing Executive Staff

It is recommended that NIHE inspection and associated staff are up-skilled in all the areas of the survey and inspection processes, as the broad nature of materials, modern methods and construction defects encountered will need communicated to all staff involved.

Adherence to BBA or CIGA standards on surveys, pre and post, insulation types, thermal bridging, thermal imaging and the use of modern electronic capture methods for inspection purposes will be essential.

There will be a need to inspect, recommend and monitor the extraction process in line with professional body standards. SERC has provided training to NIHE staff in the use of a thermal imaging camera to assist in this and other line of work.

### 8.8 Recommendation 6: Remedial Action

Three options to address the issues of poor quality cavity wall insulation in identified properties are:

1. Do Nothing
2. Top Up
3. Extract and Refill

These are set out in Section 9.
9.0 REMEDIAL ACTION

9.1 Introduction

To address the issues of poor quality cavity wall insulation in identified properties, there are three options:

1. **Do Nothing**
   Due to the minimal losses below windows and at soffit levels, the most cost effective solution may be to accept the current levels of heat loss and do nothing.

2. **Top Up**
   Where insufficient or slumped bead/board insulation is present below windows or soffit level, top up existing insulation materials to meet regulations. However, this would need approval by the industry certification bodies and CIGA Guarantee Scheme.

3. **Extract and Refill**
   Where there poor quality (or no) cavity wall insulation, extract and refill with suitable replacement materials.

   It is essential that the appropriate approved materials are used in an applicable manner, to best serve the needs and lifestyle of the property and the local climate conditions.

9.2 Top up

To the author’s knowledge, topping up existing insulation has not been carried out or recommended before, but feel that with due diligence this could be an effective solution for treating minor voids in cavity wall insulation (bead or board only). Clearly, this practice would need approval by the industry certification bodies and CIGA Guarantee Scheme.

The top up method might include the removal of a brick (several) to look into the cavity (Borescope/camera) and ascertain the amount/volume measure of insulation fill in areas below windows and at soffit levels. **The ‘top up’ of fibre insulation is questionable and should only be completed after professional approval in any situation.**

There would be possible gains (time and cost) to be had where voids in loose bead is found in cavities. With careful application there may be an opportunity to settle, compact the loose bead by mechanical means i.e. vibration methods that would move the material into a settled *monolithic* state. This may be approached as a research project where brickwork is removed in carefully selected spots to settle the bead and the remaining voids measured for “material top up” solutions. Loose white bead cannot be topped up with bonded products and white and grey bead should not be mixed.

Poorly fitted insulation board can be addressed by approved partial fill techniques using bonded bead.
9.3 Extraction and Refill

The condition of many of the wall cavities surveyed can only be resolved by extracting the existing levels of materials from the voids. There would need to be an agreed process for NIHE that follows the guidance from BBA or NIA (industry leaders) that secures ‘best practice’ methods. Safe methods must be adopted that safeguard the tenant and the staff when extracting and refilling cavity materials.

9.3.1 Extraction

• **UFFI Foam Product**
  In the survey only one home was found to have a foam product (Urea Formaldehyde Foam Insulation or UFFI) found merely as a powder, semi-solid form in the cavity. It is widely recognised that there are health issues associated to the use of UFFI projects with potential for particles in the respirable size to be released along with the potential release of formaldehyde. The toxicity of formaldehyde has been studied and reviewed many times including by the WHO leading to their recommended indoor air quality guideline (for the vapour).

  It is considered that the current process of product removal which uses a weighted airline, suction and capture appliances, is vulnerable and unsafe as it can push microbes of the UFFI into the internal rooms of the home, due to failures in cavity pipework, cables seals etc. This would require a structured review to produce recommendations for an appropriate approach in dealing with this product in a safe and secure manner for all involved in its extraction, removal and safe disposal.

• **Fibre and Bead Products**
  There is no major difficulties associated with removing fibre and loose bead cavity materials. Occasionally pieces can remain stuck to wall ties or adhere to snots on the wall after the initial extraction. In the houses surveyed, fibre products were the main insulation method (106 properties surveyed had fibre/mix) and the current removal process is established and working well in ongoing situations.

• **Polyurethane Foam Products**
  Polyurethane foam has been found in other similar situations as a robust, hard material almost impossible to breakdown. There are methods that use chemicals to remove this product from the cavity but again safe methods would need to be agreed and put in place for this.

• **Board Products**
  Board products will be almost impossible to remove from the cavity without major intrusive structural renovation work.

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9.3.2 **Extraction and Refill of Defective Materials**

There are a number of potential technical options to extract and refill defective cavities, dependent on the material types used. It is important (dependent on the materials within the cavity) that safe working practices are in place to identify risks to both the onsite operative and tenants.

Assessment of other materials that may have an inherent danger with airborne dust and fibrous materials will need specifically risk assessment, pre removal.

Particular combinations which have been found during the inspections of mixed insulation materials will need addressed, pre extraction and refill. This will include the dwelling type, the work site, access and the potential technical solutions. Whilst cost is not a major part of the remit in this project, this methodology will allow additional or other costs to be estimated for such interventions.

There are now approved and certified methods to address the removal and refilling of defective materials contained within cavities. BBA control a licenced scheme for approved and trained installers to remove the contents and dispose of safely. Figures 25 to 28 below shows extraction plant on site removing defective materials by vacuum and the collection methods.

*Figure 25: Extraction plant in use to remove defective materials in a home in Bangor*

- The extraction process involves carrying out risk assessments before any work is started.
- The extraction method sets out a drill pattern that covers the complete external walled area of the building.
- Predetermined bricks are removed to allow a brick sized extraction nozzle into the cavity.
• Extraction starts thereafter and as the process continues a careful watch is kept on the transparent suction to monitor the level of materials being removed.

• After an initial first extraction a weighted air hose is put into the cavity to exacerbate the breakdown of the remains, allowing them to be broken up to a size that can be extraction by the system.

• With the removal of predetermined bricks other tools can be utilised to break up solid materials for extraction.

Figure 26: Extraction of materials at a property in MountEagles Estate Belfast

Figure 27: The extraction (suction) collection unit

Figure 28: Collected materials for safe disposal
9.3.3 **Hard to treat properties**
In situations where cavities are hard to access and treat, including those found to be narrow, bowed, polluted with debris and mortar, careful consideration must be given to the survey, analysis and treatment methods.

9.3.4 **Local Cavity Extraction & Refill Costs**
BBA figures for cavity extraction and refill ranged between £2,000 and £3,000 for a 3 bedroom home.

Local companies (approved only) in Northern Ireland have developed the process and now complete extractions and refills at present for around £20-£25 per square metre.

These costs are dependent on the nature of the site, the location, ease of access, the type of insulation involved and the operational difficulties of removing it from the cavity.

9.4 **Critical Issues for Consideration in Remedial Work**

9.4.1 **Thermal Bridges**
A thermal bridge is defined as a separate and localised area of a building which transmits more heat than the surrounding area. The effect of a thermal bridge is to create spots of reduced temperature which then are prone to condensation and its associated damage as well as mould or mildew. Moreover, these localised thermal bridges lead to increased heat loss and, thus, greater energy consumption. Filling a cavity wall with insulating material can increase the effect of any thermal bridges such as window reveals.

9.4.2 **External Inspection of the External Wall**
The external, outer leaf of the wall must be in good condition. If not, any necessary repairs must be undertaken before any remedial work is undertaken.

Inspections\(^\text{40}\) should be carried out and checks made for poor mortar, failed pointing, cracks or gaps, existing dampness or mould issues. All should be carefully inspected by an approved person and the origins ascertained. Cracks can be caused by shrinkage or due to sulphate attack, ground subsidence or wall tie corrosion. In these cases specialist advice should be sought from a professional source to arrange remedial solutions.

Any penetrations of the external wall e.g. flues, pipes, cables and air ventilators must be checked, and the status of cavities of any directly adjoining terrace or semi-detached house established.

Areas of spalled masonry (chips, fragments, or flaking caused by frost action or by Efflorescence, crystallisation of salts) should be identified and cured.

\(^\text{40}\) Guidance on inspection, causes and remedies is given in BRE Digests 217, 251, 329, 352 and 359, setting out best principles for survey and management of the cavity wall before any solutions are applied.
Properties with widespread spalling are unsuitable for cavity filling and may be best remedied using external insulation. Similar criteria must be applied to renderings which suffer spalled or hollow defects in their structure.

Mortar joints should be inspected for gaps or cracking of mortar and defective pointing. It would also be advisable to test the strength of the mortar joints as “soft” poor mortar will allow greater rain penetration as was found with a number of homes during the drilling process for Borescope inspection. External walls should be checked for deflection or leaning.

The cause of any moisture ingress must be identified and repaired, e.g. leaking gutters, downpipes, etc.

Walls painted externally with paints that are impermeable to water vapour may mean that they are unsuitable for cavity fill. In these cases walls should be carefully assessed by the installer prior to any works carried out.

Gaps in the outer leaf at wall heads may need sealing to prevent loss of cavity fill material. This is unlikely to be the case when using mineral wool cavity insulation.

### 9.4.3 External Mortar Joints

When subjected to persistent wind-driven rain, the outer leaf of most masonry cavity walls will permit water to enter into the cavity, generally through poor joints or cracks between the masonry and mortar. Partially filled or poor mortar joints can allow wind-driven rain to enter the cavity and create issues. Lesser proportioned mixes will result in reduced bonding between the masonry and the mortar.

To provide adequate resistance against rain penetration, it would be essential to certify that all joints are adequately packed. Designated mortar mixes should be specified for durability requirements based on local climatic conditions and the type of masonry being used. Attention should be drawn to the fact that strong mortar mixes have less ability to accommodate movement due to temperature and moisture changes.

Where mortar joints are cracked, or in poor condition, repointing should be carried out to restore the integrity of the external wall. If the wall is constructed to standards, water will transfer down the inside face of the outer brickwork leaf and be released through recommended, positioned weep-holes.

### 9.4.4 Internal Inspection

Damage to internal decoration caused by damp should be investigated and rectified.

If there is any condensation, the cause should be identified and remedial measures taken.

Dry-lining should be properly sealed and be in good condition. Holes in the inner leaf and open cavities at wall heads may need sealing to prevent ingress of fill into the property. Services, ventilation ducts and flues should be sleeved.
through both leaves of the wall, and precautions taken to isolate polystyrene and polyurethane insulation from hot flues.

9.4.5 **Cavity Inspection**
The cavity should be continuous. Where bricks have been used as wall ties and to bridge the cavity, as in some older properties, the wall is likely to be unsuitable for filling.

CIGA requires cavities to be at least 50mm wide for them to be eligible for a guarantee. Some systems may have separate approvals for use on cavities less than 50mm. This should be checked with the system supplier before the work is undertaken.

Other defects, e.g. missing wall ties, debris or mortar blocking the cavity, should be identified. If they cannot be remedied, the cavity may be unsuitable for filling.

9.4.6 **Internal Cavity Obstructions**
Poorly installed wall ties can act as a moisture route across the cavity. Ties should always be horizontal and never angled down towards the inner leaf. Deposits of mortar on wall ties (snots during construction), obstructions and mortar extrusions on the inside surface of the outer leaf, predominantly at bed joints, can transmit moisture to the inner leaf. This is illustrated in figure 29.

![Figure 29: Photograph showing mortar in the cavity Main Street, Carrowdore, County Down](image)

9.4.7 **Cavity Insulation**
Existing partially filled cavities where boards have are used should have been appropriately installed, if problems with rain penetration are to be avoided. Although in most cases the materials themselves are waterproof, water can be conveyed across the cavity through voids or gaps or via mortar extrusions or droppings at joints.

9.4.8 **Cavity Trays and DPCs**
Inaccurately installed cavity trays and DPCs may result in rain penetration problems.
Any horizontal DPC should protect the full width of each leaf and not project into the cavity where it can gather falling materials. Vertical DPCs should be secure in at all jambs to prevent wilting and should protrude at least 25mm beyond the closure into the cavity. Effective stop ends should be permanent to prevent water running off the end of the tray into the cavity and drainage weepholes formed in the outer leaf, shown in figure 30 (minimum of two per tray) at centres not exceeding one metre.

![Figure 30: Weep hole in situ during construction](image)

Cavity trays should be used in continuous lengths but if or where a joint is unavoidable these should overlap by a minimum of 150mm. They should be sealed with an appropriate, recommended jointing compound.

9.4.9 **Water Repellent Coatings**

Due to the high rainfall figures for Northern Ireland, the application of water repellent coatings, should be seriously considered to remove/reduce weather driven rain penetrating into the fabric of the building.

The importance of weather proofing may be an inevitable outcome, if we consider the recent extreme weather conditions over the 2013 – 2014 winter period. With the very high levels of rainfall and the increased wind loading on the already saturated external walls, problems of water ingress into and across the cavities may occur. Consideration may need to be given to the fact that the brick/mortar permeability may be questioned in changing weather patterns.

Most water repellent coatings “coat” rather than block the pores of masonry, therefore permitting water vapour to diffuse to the surface, allowing in principle for the wall to ‘breathe’. This is particularly important for walls constructed with complete cavity fill or solid masonry (samples found in the inspection process).

Most surface treatments, water repellents have a limited working life probably a period of ten years is usually assumed before another application is required (manufacturer’s guidelines should be adhered to). The application of a water repellent coating should be carried out in line with the manufacturer’s guidance and should never be applied if any damp or moisture issues exist within the building. The quality of the product will not compensate for defective workmanship or poor application.

9.4.10 **BuildDesk Software material analysis**

Using the analysis from the BuildDesk software figures 31 – 33, blown fibre could be questioned as a suitable material in most Northern Ireland’s homes. Utilising generic materials and high occupancy as set parameters and (the only
available climate location) Larne in the software for Northern Ireland. We see that 75 mm blown fibre cavities fail to provide adequate protection from the environment under these conditions. The Larne location used in the software would be considered a location of average rainfall as per Met Office information, receiving between 100 and 120 mm of rainfall at worst annually and not fully reflective of major areas of the country. Therefore other definitive areas particularly in the West, North West and Down will create greater risk of material failures as they can receive between 180 mm and 260 mm of rainfall annually. The concern will be the retention of moisture with high humidity levels retained internally, which under certain conditions will generate damp and/or mould within the properties.

![Figure 31: BuildDesk software cross section on 75 mm blown fibre cavity wall, generic materials](http://www.builddesk.co.uk)

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41 BuildDesk software by BuildDesk Ltd., Pencoed, Bridgend; [http://www.builddesk.co.uk](http://www.builddesk.co.uk)
Rainfall in Northern Ireland varies widely, with the wettest places being in the Sperrin, Antrim and Mourne Mountain ranges. The highest areas have average annual totals of about 1600 mm, which is about half that of the English Lake District or the western Highlands of Scotland. Therefore careful decisions must be made to alleviate the additionally of this phenomenon in protecting the fabric of homes from this major negative.

The mean annual temperature at low altitudes in Northern Ireland varies around 8.5 °C to 9.5 °C, with the higher values occurring around or near to the coasts. The mean annual temperature decreases by approximately 0.5 °C for each 100 metres increase in height, example: Parkmore Forest in County Antrim (at 235 metres) has an annual mean temperature of 7.4 °C. Slieve Donard (at 852 metres) would have an annual mean temperature of about 4.5 °C, an average 2.9°C difference.

In winter, temperatures are influenced largely extent by those of the surface of the surrounding sea, which reach their lowest values in late February or early March. Around the coasts February is therefore normally the coldest month, but inland there is little to choose between January and February. The January mean daily minimum temperatures vary from about 0.5 °C in the upland areas to about 2°C on the coast, with the highest values on the coast of County Down.
Figure 33: Accumulated moisture and humidity levels

Note
Other generic cavity widths 25mm, 50mm, with blown fibre were sampled on the BuildDesk software platform and the outcomes were the same that the insulation within the cavity did not have the opportunity to dry sufficiently over the 12 month annual period, thus rendering it unsuitable for the Northern Ireland climate.
Appendices

Appendix 1:  CIGA Guarantee Scheme
Appendix 2:  Sample BBA Certificate
Appendix 3:  MountEagles Resident’s Letter
Appendix 4:  Sample Survey Report
Appendix 5:  Maps of NIHE Surveyed Homes
Appendix 6:  Building Control Letter to MountEagles Residents Group
Appendix 7:  Knauf Letter Stating Unsuitability of Cavity Wall Insulation
APPENDIX 1

The Cavity Insulation Guarantee Agency Scheme

Underpinning the work of reputable cavity wall insulation contractors is the CIGA guarantee scheme. This is administered by the Cavity Insulation Guarantee Agency (CIGA), which was established in consultation with the government to provide householders with an independent, uniform and dependable 25 year guarantee. CIGA is an independent agency, managed by a committee of system designers (the insulation material suppliers) and approved installers, with support from trade associations and the government.

Under the scheme, an approved installer is required to:

- Carry out a pre-installation assessment of the property to determine its suitability.
- Carry out the installation in accordance with approved technical requirements.
- Provide the customer with a guarantee, issued by CIGA, on completion of the contract.
- If there is a post-installation problem, the homeowner can contact the approved installer who will inspect and remedy the problem where possible. If the problem is unresolved, the customer can contact CIGA, who will arrange for the relevant system designer to investigate the complaint and, where necessary, carry out remedial work free of charge.

Most Agrément Certificates for cavity fill materials impose a number of conditions. These vary slightly from product to product; the ones below are common:

- walls must be in a good state of repair
- walls must show no signs of frost damage
- the inside of the wall must not show any signs of dampness, other than those caused by condensation
- mortar joints must not be raked or recessed and must not show evidence of cracking other than hairline cracking
- installation should be carried out to the full height of each wall unless the top edge is protected by a cavity tray (this usually means at gable ends)
- cavity walls should be designed and constructed so as to incorporate the normal precautions to prevent moisture penetration (see below)

Most Agrément Certificates also specify that the walls should comply with good practice as described in the BBA/BRE (and others) joint publication: Cavity Insulation of Masonry Walls - Dampness Risks and How to Avoid Them. Some of the risks, and general defects in cavity walls, are shown on a later page. In addition, certificates often state that existing buildings should be suitable for cavity fill if they are assessed in accordance with BS 8208 Part 1, 1985. A summary is set out below.
BS 8208 Part 1, 1985: Assessment of suitability of external cavity walls for filling with thermal insulants - Existing traditional construction.

Key points:

General condition of wall should be assessed.
If there are cracks in the construction which exceed 1mm in width, the cause should be ascertained.
The exposure to wind-driven rain should be assessed.
Evidence of damp should be noted - appropriate remedies should be recommended.
Ducting, flues, or vents crossing the cavity, or cables within the cavity, should be assessed. All essential vents should be sleeved
Where they cross the cavity. Cables may need moving or uprating before a cavity is filled (they can overheat if surrounded by insulation).

A wall is unsuitable for filling if:

The cavity is less than 40mm wide.
Bricks are used as wall ties or if bricks bridge the cavity (early walls mostly).
The wall is coated with impermeable paints.
Identifiable problems which require remedial treatment before filling cavity:
The wall has parapets which do not contain cavity trays.
Open cavity at top of cavity wall (cavity needs to be closed).
Damaged render or extensive brick spalling.
Features which might encourage wetting of the outer leaf; eg projecting string courses, faulty rainwater goods, lack of overhang at verges, sills and copings with inadequate drips.
APPENDIX 2

Sample BBA Certificate

This certificate has been issued to:

EXAMPLE ONLY

and confirms that the above company has been accepted as an Approved Installer for the BBA Schemes indicated below and is a BBA Registered Cavity Cleaning Company

<table>
<thead>
<tr>
<th>Loft Insulation</th>
<th>Floor Insulation</th>
<th>Draught Proofing</th>
<th>Flat Roof Insulation</th>
<th>Cavity Wall Insulation</th>
<th>Internal Wall Insulation</th>
<th>External Wall Insulation</th>
<th>Pitched Roof Insulation</th>
<th>Hybrid Wall Insulation</th>
<th>Energy Efficient Glazing &amp; Doors</th>
</tr>
</thead>
</table>

Signed: [Signature]

Date: 17th September 2013

Expiry Date: 31st August 2014

To confirm validity please check the BBA website: www.bbacerts.co.uk
Email: construction@bba.star.co.uk
Tel: +44(0)1923 665 300
MountEagles Resident's Letter

Jim Stewart
Energy Store
42 Barnfield Road
Lisburn
BT28 3TQ

22nd March 2013

Dear Jim,

I just wanted to thank everyone at Energy store who worked so hard in planning and carrying out the work at my house and Mary's. The change in temperature in both our houses is amazing. Finally the house is warm. I first noticed my hall as being unusually warm the next day after the work was completed. The kids rooms and my room are now toasty warm. It's great not to be awakened during the night because of the cold and having to run downstairs and turn on the heating! There has been no sign of condensation on my bedroom windows or front door first thing in the morning so far. Getting out of the shower to a warm bathroom is great! You really have no idea the difference this will make to my family life.

Hopefully now we'll have less chest infections and colds due to the heat in the house. Myself and and my daughter are asthmatic and the less colds and chest infections we get the better. I'm sure my heating bills will reduce too. I had the heating off today when I went out and when I walked in the door to a warm house I was delighted. I had a friend call who knew we were getting the work done and they are in my house very regularly and they noticed how warm the house was and the heating was off as we were only coming home. It's amazing the impact on your everyday life that this can have. My heating bill will probably be less than usual. It was getting to the point before this work was completed that coats and layers would have to be used because it was so cold and the heating was getting too expensive.

Mary has a daughter with severe epilepsy who has been taking fits every day. She is having problems recognising her family and may have some form of brain damage. Due to the cold she never really stayed in Mary's but resided with her dad. Now Mary say's she will be able to stay and give her dad a bit of respite. Mary can't use a computer and has asked me to thank you for improving her situation. Neither of us would have been able to afford to privately get this work done. I can't thank you enough.

We're the envy of everyone in our group who knows about this project. Jokes are already circulating about the party in our houses no coats and hats allowed! When I go to my mum and dad's who were one of the test houses that failed and see my dad sitting with a fleece and hat on with layers underneath it because the house is so cold it makes me angry that this has been allowed to happen in the first place and secondly that there currently is no help to resolve it.
My dad has an immune disorder and is very prone to infections this would dramatically improve his health, he catches the cold all the time, heat helps his condition. He can't afford to have this work completed privately. He has to suffer the cold.

At the minute he can't heat his home sufficiently. This is the reality of living in Mount Eagles people sitting with outdoor clothes on inside their homes to stay warm. These houses should have been energy efficient being 10 years or less old, instead the heat is going out the walls.

It's ridiculous there were only 7 bags of insulation in total taken from my home when there should have been about 20. The previous insulation was damp in areas and really in a bad state. I seen the bags and was shocked. Decision makers really need to sort this problem. People in our estate are seriously in fuel poverty and living in extremely cold houses. I can see the difference immediately without having to get the readings from the university. I know there will definitely be an improvement for anyone lucky enough to be getting this work done to their homes. I'm totally focused now on helping my community to resolve this!

Thanks again for all the hard work. I'm so glad we came across Energystore and this innovative solution. I'm sitting at home today, blizzards outside and no heating on all morning. Amazing the change! Previously I would have had to put heating on and still the house would have been cold.

Regards,

Orla McCabe
Mount Eagles Ratepayers Association (MERA)
Sample Survey Report

Property Report

Property Address
1 Calvin Street, Belfast, BT54NS

Property Description
Flat House

Surveyor Name
Jimmy Stewart

Completed
12 December 2013 13:11:57

Received
12 December 2013 14:21:22

Property Details
Is there existing insulation in the property?
Details: Yes
board 25 mm

Did you perform a borescope inspection?
Details: Yes

Borescope Image: To include commentary per drillhole

What is the type of insulation in the cavity?
Is external drill pattern visible?
Unknown
Not Answered
Conclusion

Is the property suitable for cavity extraction? No
Is the property suitable for installation of cavity wall insulation? Yes

Overall Comments

The tenant complains that the house is cold and suffers badly from mould in the left hand bedroom. She claims that her daughters bed became badly affected and needed to be replaced. There was no mould at my visit but the house was cold there. There is 25 mm board in the walls of this flat and it is poorly fitted zinc all areas.

Sign Off

Surveyor Signature  Tenant Signature

G Teward

G Carson

Signed 12 December 2013
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<th>All Photos for ES8_2013121201164</th>
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<tr>
<td>N I H E Borescope Right: first floor sc board &amp; void</td>
<td>N I H E Borescope Right: u. kitchen window void</td>
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NIHE Surveyed Houses
Prepared by Kathryn McNair
January 2014
Response letter from Local Building Control to MERA Group

Subject: 39 Mount Eagles Drive
To: orlamccabe@hotmail.co.uk
From: Michael.McGuire@lisburn.gov.uk
Date: Wed, 19 Dec 2012 09:53:37 +0000

Good morning Orla,

Sorry for the delay in coming back to you, it took me some time locating the correct file for the development.

The following checks were carried out on your dwelling:

- Foundation inspection on 09/10/02
- Hardcore Inspection on 14/10/02
- Joist inspection on 08/01/02
- Drainage inspection on 25/02/03
- Completion inspection on 14/04/03

These inspections are in line with the statutory inspections which we endeavour to carry out on all dwellings not just a sample.

The installation of insulation is not a statutory inspection. I have spoken to the developer and he advised me that back when your house was constructed, blown fibre was used to insulate the walls. A U Value of only 0.45 Wm²K was required back then so this should comply. The insulation standards were upgraded in 2006 and then 2012 however insulation is still not a statutory inspection. An installation certificate should have been provided to the developer, Building Control would not have required a copy of this nor do we have any note of the installer.

The U Value of the floor back in 2001 (when the application was made) was required to be only 0.35 to 0.45 Wm²K (depending on the SAP energy ratings) and would have been achieved by installing 50mm of Polystyrene insulation. Having spoken to the surveyor for the site back in 2001 and from my own experience of working on the current Mount Eagles development, we have no reason to suspect that the insulation would not be installed or installed incorrectly.

To sum up my findings: all required inspections were carried out on your property and construction works carried out to the approved plans. The dwelling was completed on the 14th of April 2003 and a completion certificate issued, therefore this office felt that the property complied with all relevant Building Regulations of the time.

I hope this answers your queries, please do not hesitate to contact me if I can be of any further assistance.

Best regards

Michael

Michael McGuire
Building Control Service
Lisburn City Council
Building Control (2nd Floor)
Island Civic Centre
The Island
Lisburn
BT27 4RL
Letter Stating Unsuitability of Cavity Wall Insulation for Local Home

Date 13 March 2013

Re: Pilkington Guarantee 166938

We are responding to our recent telephone conversations and email’s concerning your property that was filled with our Supafil cavity wall insulation in September 1992. We again do not understand why it has taken another year for your response to our last letter dated 16th March 2012, where we agreed to pay the sum of £1810.67 inclusive of VAT for the extraction of material and remedial works related.

From what we can gather from your correspondence, you have now involved an insulation contractor who has carried out inspection works and thermographic surveys to your property. As this is an on-going situation we are of the opinion we should have been notified of any intention to bring in any other party and gain their involvement. We stand by our previous comments, Ref. letter 20th June 2011 that the property is not suitable for the installation of cavity wall insulation so therefore we cannot agree to fund this measure of refilling the walls with any product.

We therefore stand by our original offer from March 2012 as stated above.

Yours Sincerely

Graeme Waugh
Regional Technical Manager
On behalf of Knauf Insulation Northern Europe

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