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'Are the Building Regulations fit for the purpose of upgrading traditional, historic and listed buildings using modern applications in Wales?'

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Declaration

I declare that this work has not previously been accepted in substance for any degree, and is not being concurrently submitted in candidature for any degree.

All the work in this dissertation, including figures and photos are the author's own unless otherwise stated.

Signed:  **Anthony Gwynne (candidate). Date: 1 March 2020**

Statements

Statement 1- This dissertation is being submitted in partial fulfillment of the requirements for the degree of MSc.

Signed:  **Anthony Gwynne (candidate). Date: 1 March 2020**

Statement 2 - This dissertation is the result of my own independent work/investigation, except where otherwise stated. Other sources are acknowledged by footnotes giving explicit references. A Bibliography is appended.

Signed:  **Anthony Gwynne (candidate). Date: 1 March 2020**

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1.0 Executive summary

This dissertation investigates the key aspects of concerns that the Building Regulations and supporting Approved Documents produced by the Welsh Government are fit for purpose when carrying out building works to traditional, historic and listed buildings. This research was carried out by the report author who has 28 years' experience in building control as a team leader and chartered building surveyor working for a Local Authority in England on the Welsh Boarder. With special partnership arrangements, Local Authorities based in England can carry out building control functions in Wales and vis-versa. This requires dealing with two separate systems of building control which are almost identical.

This report begins by describing the background to vapour permeable (breathable) construction and problems associated with upgrading traditional buildings using the Approved Document to the Building Regulations and recognises significant gaps in this legislation. It considers the drivers of change for making improvements to the Welsh building stock. It also considers case studies which draw out the consequences of applying modern methods of construction to traditional buildings. A literature review then follows to gain a better understanding of how scholars view the Building Regulations and Approved Documents. A questionnaire survey then assesses how the construction industry view the Approved Documents to the Building Regulations, followed by suggested solutions to the problems.

The report concludes with key findings and finds that the Building Regulations and supporting Approved Documents produced by the Welsh Government are not fit for purpose when carrying out building works to traditional, historic building and listed buildings. Finally, there are recommendations on how the problems could be resolved without placing these buildings or their occupants at risk.

1.1 Key findings

1. Non-vapour permeable applications are being inappropriately applied to traditional forms of vapour permeable construction with disastrous results.
2. Approved Documents to the Building Regulations do not provide enough practical guidance for traditional buildings.

3. The Welsh Government is unlikely to make any changes to the Approved Documents unless there is good reason.
4. Current U-value calculations underestimate the actual thermal performance of traditional solid walls.
5. The Building Regulations elemental U-value requirement of 0.3 for upgrading traditional buildings are unrealistic and problematic as it traps water and increases the risk of condensation and mould growth. The U-value should be increased to 0.7.
6. Drivers of change for improvements and energy efficiency measures have been brought about by:
    a. Owner's aspirations of improved thermal comfort
    b. Changes in climatic conditions
    c. Changes in legislation and the Building Regulations
    d. UK Government driving ever improving insulation standards
7. Case studies confirm Approved Documents are being inappropriately applied to traditional and historic buildings.
8. Standards reviewed for retrofit are insufficiently detailed in respect of solid wall insulation and are not fit for purpose.
9. Industry produced standards providing guidance are too expensive to buy and the public are reluctant to use them.
10. Criticism that patented vapour preamble solutions provided by the private sector are exclusive and too expensive.
11. Three solutions to the problems were recommended:
    a. Make changes to the Approved Documents to the Buildings Regulations
    b. Produce a National Compliance Guide
    c. Invest in technical solutions and information hub

2.0 Introduction

2.1 Introduction to the dissertation

This dissertation focuses on the complex interrelations of concerns that the Building Regulations and supporting Approved Documents produced by the Welsh Government are not fit for purpose when carrying out building works to traditional, historic and listed buildings. The Approved Documents are held up as a means to question the suitability for their application and consequences if they are not, and what can be done to ensure they are fit for purpose. It is assumed the audience reading this dissertation has some understanding of the Building Regulations, Approved Documents as well as traditional and modern forms of construction.

This research was carried out by the report author who has 28 years' experience in building control as a team leader and chartered building surveyor working for a Local Authority in England on the Welsh Boarder. With special partnership arrangements, Local Authorities based in England can carry out building control functions in Wales and vis-versa (www.labc.co.uk). This requires dealing with two separate systems of building control which are almost identical. The main purpose of this role is dealing with building regulations applications and providing conservation advice to the planning department and general public. To establish the frequency that building regulation applications are submitted for traditional and listed buildings, the Council's building control records have been examined for the last 15 years. All building control bodies are required by law to keep records for at least 15 years under the requirements of the 'Building Control Performance Standards' (www.gov.uk, 2017). The Council's records indicate that this report author has dealt with at least 3,424 Building Regulation applications of which 750 have been works in connection with traditional and historic buildings and of those 750, the report author has had only three submitted by conservation accredited designers and works carried out by two conservation accredited builders **(Appendix A).** Three of these Building Regulations applications have been reviewed as case studies for this report and two as examples of unintended consequences of using inappropriate impermeable applications on vapour permeable buildings.

A review of current literature amounting to 23 documents was carried out to gain a better understanding of how scholars view the Building Regulations and Approved Documents.

To establish the construction industries current thinking of the building control process, 150 questionnaires were sent out to architects, surveyors, builders, conservation officers and manufacturers and suppliers. Of those 149 questionnaires sent out, 15 were returned **(Appendix J).** It's interesting to note the findings confirmed that the Approved Documents do not provide enough guidance and advice for traditional buildings and only refer to standards which don't provide practical guidance. The findings also confirmed that solutions contained within the Approved Documents are not suitable for application to traditional vapour permeable buildings.

This research demonstrates there is a lack of understanding of traditional building performance in industry and policy. It also demonstrates there is a lack of connection between good research, standards, certification process, guidance and practice. This is particularly evident in the SAP software for traditional buildings which produces incorrect results (SPAB, 2019). Traditional buildings require different assessment and practice regarding the control of moisture which is vital for fabric and human health. For example, Approved Document C of the Building Regulations (paragraph 4.2) provides guidance on the damp proofing of walls and floors using waterproof membranes, and Approved Document L provides guidance on insulations which are inappropriate for traditional buildings. There is no practical guidance on vapour permeable solutions in any of these Approved Documents.

There are good opportunities for the development of safe, robust energy-efficient and cost-effective retrofit measures for many areas of traditional buildings. However, these will have to be developed on a different basis and structure from those in the Approved Documents.

The Welsh Government and the Society for the Protection of Ancient Buildings (SPAB) and the Sustainable Traditional Buildings Alliance (STBA) have confirmed support of this dissertation and its research. SPAB have agreed to provide access to ongoing research they have carried out on building performance and the use of vapour – open

insulation and old buildings (SPAB, 2017). Work contributed by others will be identified in this dissertation.

The research provided by this dissertation may provide the basis for future research to make improvements to guidance within the Approved Documents to the Building Regulations.

2.2 Research aim

This is a research aim based on the novel question of whether the Building Regulations and supporting Approved Documents are fit for purpose or not when upgrading traditional and historic buildings using modern applications. This will include:

- Background research (desktop and site-based research)
- Construct a hypothesis (theory based on the relationship of variable outcomes)
- Test the hypothesis (examine various outcomes)
- Analyze the data (comparison of outcomes)
- Draw a conclusion
- Make a recommendation

2.3 Research design and methodology

The research is exploratory in design and will take the approach of researching ‘what is going on’ and ‘why is it going on’. The theory will be tested by the examination of various propositions and deductions made. Measures will be developed to collect data, for example the use of questionnaires aimed at designers (architects etc), building control surveyors, builders and property owners. The site inspection of works (both in progress and post inspection of works already carried out) will be undertaken. The use of data loggers will not be practical given the amount of time available to test and analyze the data. This data will then be analyzed and the implications of relationships between propositions can be derived and inference with the theory examined to draw conclusions. Ethical approval will be required (forms have been submitted and approved – see **Appendix C**) and data protection matters will need to be discussed and agreed (how collected/stored/disposed etc).

2.4 Possible obstacles and limitations

There is a real risk the research for this study could be too broad a scope for this dissertation. To ensure it is achievable and balanced, it will be limited to research of the Welsh Building Regulations in connection with:

(i) Approved Document A (Structure);

(ii) Approved Document C2 (Resistance to moisture);

(iii) Approved Document L1B (Conservation of fuel and power in existing dwellings);

(iv) Regulation 7: Materials and workmanship (2013 edition).

A brief explanation of the Building Regulations and Approved Documents are provided in paragraph 3.3.1.

By limiting the scope of this report, it is considered this study is achievable with the resources that are available in terms of time, access to data, money and people to do it justice. A Gantt chart has been produced to present a timetable to manage the project **(Appendix B),** identifying possible obstacles and design out any potential problems. This will be reviewed regularly, and progress reports provided to the Tutor and discussed in tutorials. Ethical approval has been granted and questionnaires have been sent out **(Appendix C).**

2.5 Principle resources

Principle resources are considered already available for this project, including:

- Access to technical information and standards (IHS technical index) and library
- Access to building control records
- Access to designers, building control surveyors, property owners etc
- Access to building sites and works in progress and completed
- Access to copying and printing facilities

2.6 Outline research programme

As identified in item 2.4, a Gantt chart has been produced to present a timetable to manage the dissertation, identifying possible obstacles and design out any potential problems. This will be reviewed regularly, and progress reports provided to the Tutor and discussed in tutorials.

3.0 Background

3.1.0 Vapour permeable ('breathable') construction

3.1.1 Breathability of traditional buildings

In the context of building materials, and with reference to traditional and historic buildings, the generic term 'breathable' is used to describe the 'vapour permeability' of the building fabric: the extent to which building materials are able to transmit moisture as a liquid and as a gas (water vapour). Breathable materials should be sufficiently permeable to enable absorbed and surface moisture to evaporate during ambient drying conditions. Loss of moisture from the material needs to occur rapidly enough to ensure that there is no accumulation of moisture which can lead, over time, to significant deterioration of building fabric, development of mould growth, infestation, or other form of decay. A breathable material, by definition, cannot be impermeable and should not trap moisture (www.spab.org.uk).

3.1.2 Moisture movement mechanisms

Many traditional building materials have characteristics that enable moisture as a vapour to pass through them (they are vapour permeable) as well as holding water in vapour form (they are hygroscopic or 'moisture buffering'). Due to their pore structure these materials may also encourage the movement of water (absorbtion as a liquid via surface diffusion and capillarity (sometimes called 'wicking') (www.spab.org.uk).

When undertaking work on an older building an appreciation of how all these moisture mechanisms function within the existing materials is required to avoid the application of an inappropriate material. A vapour permeable insulating material may be applied to an existing solid masonry wall without a damp-proof course and this will allow the assembly to continue to 'breathe'. However, in particular circumstances, at the base of the wall or if it is particularly porous or exposed, for example, there may also be a need for the insulating material to provide hygroscopic buffering and/or to promote the capillary movement of water, as these may also be mechanisms by which the wall remains reasonably 'dry' (www.spab.org.uk).

3.1.3 Measurement of breathability

Considerations of breathability is the vapour permeable nature of a material, this quality can be expressed in its opposite form as vapour resistance. Vapour resistance may be measured in meganewton seconds per gram (MNs/g). An example of a material with an acceptable level of permeability is 19mm thick non-hydraulic lime render which has a vapour resistance of approximately 1.0 MNs/g. As a guide 'breathable' material that could be considered suitable for use in older buildings should have a vapour resistance of up to 2.5 MNs/g. However, water as a vapour is only one form of moisture threat to buildings and how materials perform in response to the possible presence of liquid water also needs to be considered (www.spab.org.uk).

3.1.4 SPAB Building Performance Survey- performance of moisture in buildings

Extensive research has been carried out by SPAB between 2011 and 2017 on various aspects of building performance in traditionally constructed buildings built before 1919 (www.spab.org.uk/interimreport/2011).

In 2014, the survey was extended to include the monitoring of performance of moisture in the external walls of three separate buildings before and after refurbishment. The existing walls were fitted with sensor nodes on the internal and external wall surfaces, four sensors were located at varying depths throughout the walls and the interfaces of the applied insulation and wall. The sensors were used to measure and record the humidity and moisture movement within the walls (SPAB, 2014). This study was concluded in 2017 and the summary of findings relevant to this report is provided in **Figure 1** (www.spab.org.uk/interimreport/2017).

Figure 1: The SPAB Building Performance Survey 2011 to 2017- summary of findings (www.spab.org.uk/interimreport/2017).

Building study reference	Existing wall construction	Thermal upgrading of wall	Summary of findings
Shrewsbury	350mm thick porous and permeable brick in lime mortar	Internally applied 40mm thick wood fibre board and lime plaster finish These finishes are vapour permeable	Had the lowest rates of relative and absolute humidity Had the widest saturation margins and lowest moisture content Driving rain penetrated towards centre of wall but dries out rapidly after due to direct and diffuse heat, solar radiation and air exchange through substrate. Has extremes of drying and wetting. Interface between insulation and masonry maintained a stable relative humidity profile below that of the 80% risk profile[1] Long term trend of relative humidity continued to decline Hydroscopic qualities of the wood fibre insulation made a positive to the vapour profile by buffering humidity and flattening out relative humidity responses Overall average relative humidity proceeds downward away from the 80% risk threshold[1]
Drewsteignton	580mm thick granite in lime mortar	Internally applied 100mm thick polyisocyanurate (PIR) insulation board, with plaster board and skim internal finish. Reduces the U-Value from 1.2 to 0.16W/m^{2}K. These finishes are not vapour permeable	Average relative humidity was above 90% and well above the threshold for mould growth[1] and is a risk to organic materials embedded within the wall such as joist ends, timber bearers and wall plates etc. Rising trend of humidity within the centre of the wall and moves this part of the wall closer to saturation conditions and can cause deterioration of the building fabric Trend of rising humidity is not solely a response to atmospheric conditions but also a function of the construction that inhibits drying of the wall The insulation itself has a negative impact on the wall's performance as follows: -less heat passes into the cold side of the wall during winter and saturation margins are lower -air likely to become saturated and remain saturated for longer periods, limiting drying potential

			-the foil facing of the insulation acts as barrier to moisture and restricts any movement and prevents evaporation to internal surfaces
Riddlecombe	545mm thick cob faced externally with 100mm thick masonry and 20mm thick lime plaster internally	Externally applied 60mm thick insulated lime render.	Had the highest rates of relative and absolute humidity and moisture content, although is continues to dry excessive moisture Saturation margins widened and has an improved moisture profile and long-term trend of declining relative humidity Relative humidity is high and well above the threshold for mould growth[1] and is a risk to organic materials embedded within the wall such as joist ends, timber bearers and wall plates etc.
Notes; Note 1: Relative humidity above 80% can cause mould growth which is prejudicial to human health and can cause serious health conditions such as lung disease. High levels of relative humidity is also a risk to organic materials embedded within the wall such as joist ends, timber bearers and wall plates etc.			

3.1.5 Conclusion of SPAB findings

The research carried out by SPAB (2017), summarised in **Figure 1** has suggested there is evidence to support the long-held contention that the use of 'breathable' 'vapour-open') insulation minimises the risk of elevated moisture levels that can harm not only traditionally constructed (pre-1919) buildings but also their occupants health. A note of caution- It should be noted that SPAB research is at an early stage and further research may be required to confirm early findings. However, early research has found the thermal performance (U-value) of old, solid walls are frequently better than assumed under the current system of calculation. Indeed, SPAB findings to date are that standard U-value calculations (used across the construction industry to quantify the rate of heat transmittance through building elements) underestimated the thermal performance of the traditional solid walls sampled in 77% of cases. In some instances, heat loss was up to three times lower than calculated. Ultimately, this could have negative consequences for old buildings because the adoption of overly pessimistic theoretical U-values as the baseline for assessing the thermal performance of their walls may lead to disproportionate energy saving interventions that are not only unnecessary but also invasive and potentially harmful to historic fabric.

SPAB research has found the performance of solid walls after insulation is affected not only by the external and internal climate but also material characteristics (such as vapour permeability), quantity of insulation, location, orientation and condition. It suggests that excessive thicknesses of insulation and non-breathable materials should be avoided. It also found that uninsulated solid walls tend to lose less heat than previously thought and that thinner installations of less high performing, more breathable insulation – where insulating is justified – can achieve successful upgrades.

3.2.0 Traditional construction (before 1919)

3.2.1 Legislation

The Great Fire of London in 1666 **(Figure 2)** shaped legislation and the construction of buildings today. By royal proclamation the rebuilding work could not commence until new regulations were put in place. This resulted in the 1667 Rebuilding Act to eradicate the risks that had made the fire so catastrophic (www.buildingtalk.com). The new Building Regulations required:

- Upper floors of houses were no longer permitted to jut out over the floor below.
- Hanging signs were banned.
- All houses or buildings, whether great or small, were to be built only in brick or stone – if new houses were built of other materials they would be pulled down, meaning no more building with wood and thatch.
- New Fire Prevention Regulations included easy access to water and the beginnings of a fire hydrant system for the city.

Figure 2: The Great Fire of London in 1666 (Source: www.publicdelivery.org).

Two hundred years on and the Industrial Revolution had led to poor living and working conditions in ever expanding, densely populated urban areas leading to slums **(Figure 3).** Outbreaks of Cholera and other serious diseases, through poor sanitation, damp conditions and lack of ventilation forced the Government to act and led to the first Public Health Act in 1875 (www.parliament.uk).

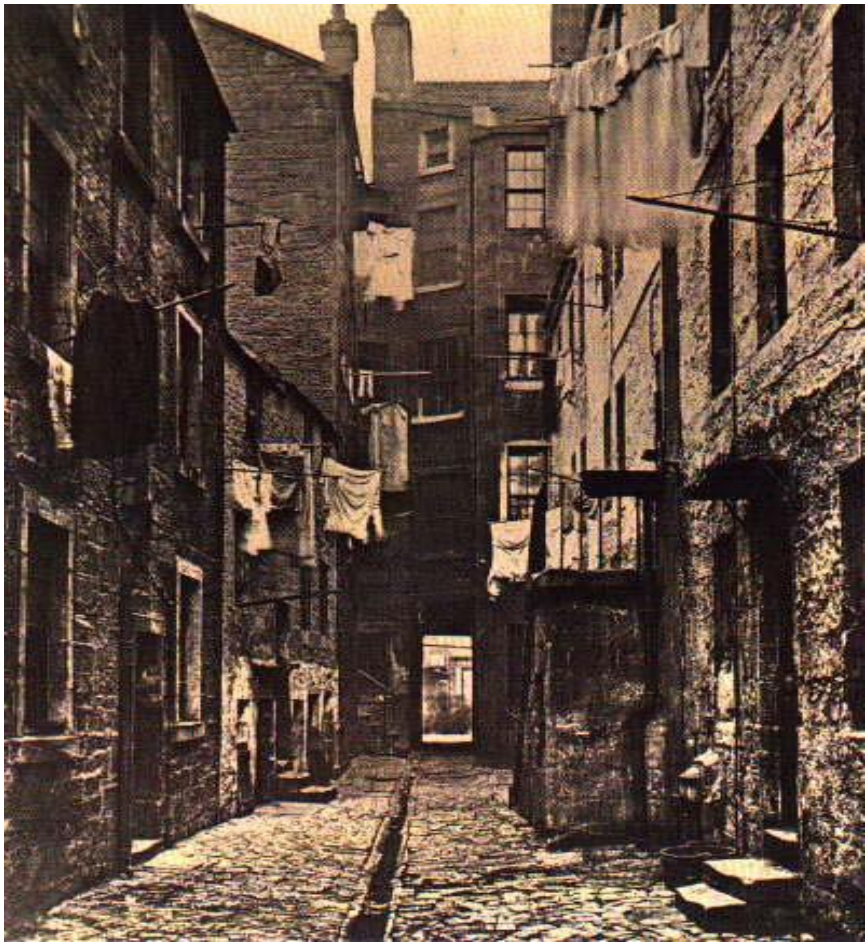


Figure 3: Slums of the Industrial Revolution (Source: www.historytoday.com).

3.2.2 Principles of traditional construction

The UK has the oldest building stock in Europe (Nicol et al. 2015) and nearly two-thirds of the building area that exist today will still exist in 2050 (www. architecture2030.org). Buildings built before 1919 make up approximately one third (34%) of the current buildings in Wales – well above the averages for England (28%), Scotland (19%) and Northern Ireland (12%) (CITB, 2013). Buildings built before 1919 are termed ‘traditional buildings’ and are differentiated from ‘modern buildings’ by virtue of their construction (Whitear and Duxbury).

Traditional buildings were constructed using methods handed down over the centuries, typically of solid wall construction using brick, stone, timber and earth, using lime-based mortars, plasters and renders. These materials are porous and naturally allow moisture to be absorbed and then evaporate away through walls, floor and roof, draughts through windows, doors and chimneys. This vapour permeability acted as a 'control' against dampness that can harm the building fabric and prevent mould growth that can affect people's health (www.lime.org.uk). Caring appropriately for traditional buildings requires an understanding of how they were constructed and how they function, only then is it possible to identify the right compatible materials to repair or renovate them. This is particularly important when dealing with historic or listed buildings which requires a sympathetic approach (www.lime.org.uk).

Certain works carried out to existing buildings may be regarded as repairs and will not require Building Regulations approval, however, other works may be regarded as 'building work' and will required Building Regulations approval and may have to comply with modern standards in compliance with the current Building Regulations (www.legislation.gov.uk). Such works should be specified and carried out by a suitably qualified and experienced conservation specialist.

3.2.3 Traditional 'breathing' (vapour permeable) construction

Buildings built before 1919 were constructed with technologies handed down through generations which allowed the building to breathe naturally through vapour permeation and is termed traditional construction (www.lime.org.uk). The building fabric was constructed in natural materials, typically with solid walls of stone in lime mortar or cob with lime render and plaster finishes providing good permeability and flexibility. Details of lime mortars, plasters and renders are provided in **Appendix D.** External surfaces were designed to deflect the rain, penetrating and rising damp was absorbed by the structure that allowed the moisture to evaporate away naturally through the porous surfaces preventing trapped moisture.

Natural ventilation was provided through gaps in poorly fitting windows and doors and through chimneys, keeping the building in a state of equilibrium **(Figure4)**.

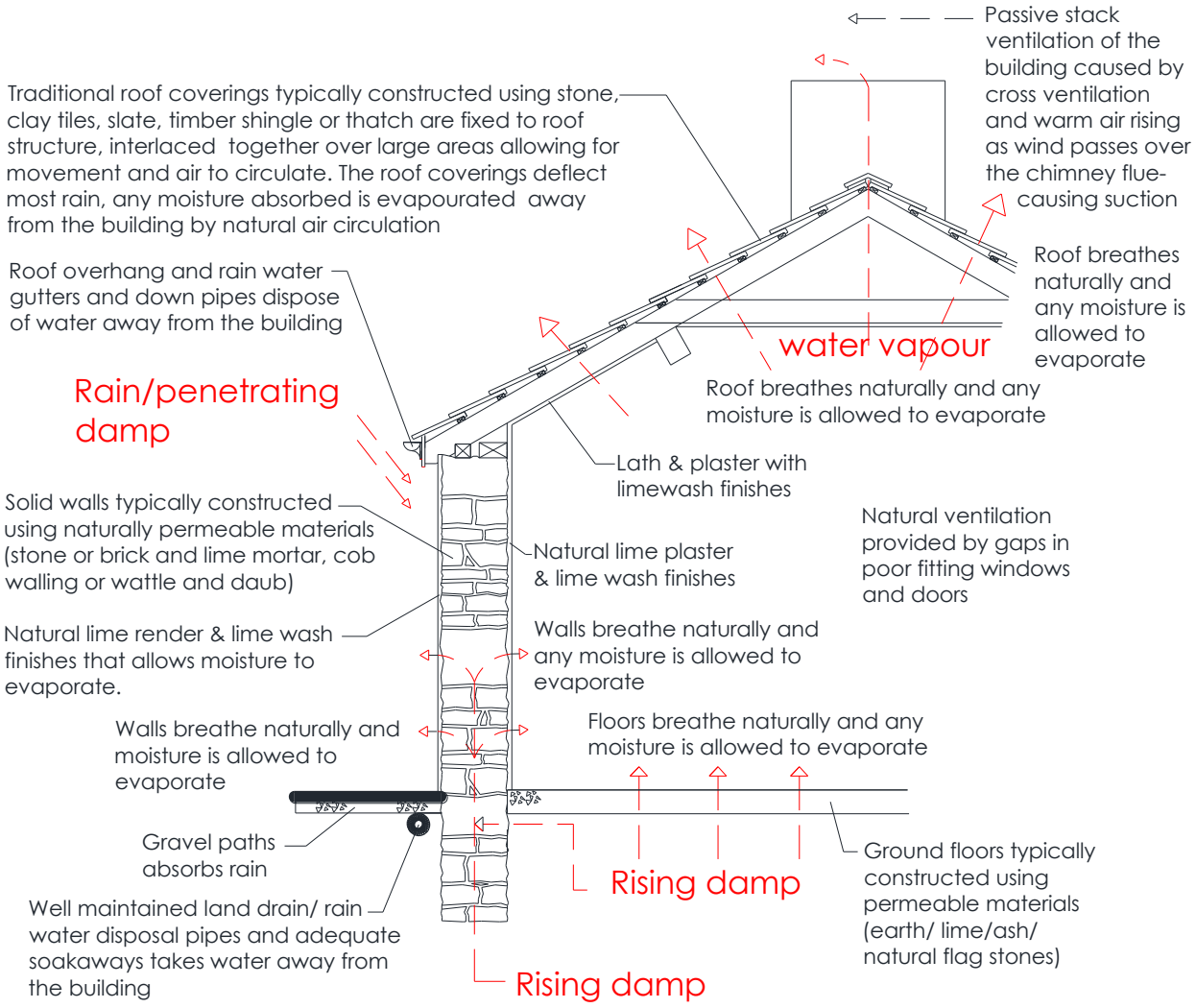


Figure 4: Typical section through a traditional 'breathing' building (Not to scale) (Source: Gwynne, 2013).

3.2.4 Inappropriate repair and renovation of traditional buildings

When traditional buildings are maintained and upgraded with inappropriate modern hard non- permeable materials for example cement based products or plastic membranes and finishes, they can trap moisture and potentially lead to the deterioration of the building fabric and finishes. Additional problems can occur with condensation and mould growth caused by high levels of water vapour produced by the occupants and lack of natural ventilation caused by sealing up of gaps and blocking up of open flues and chimneys **(Figure 5)**.

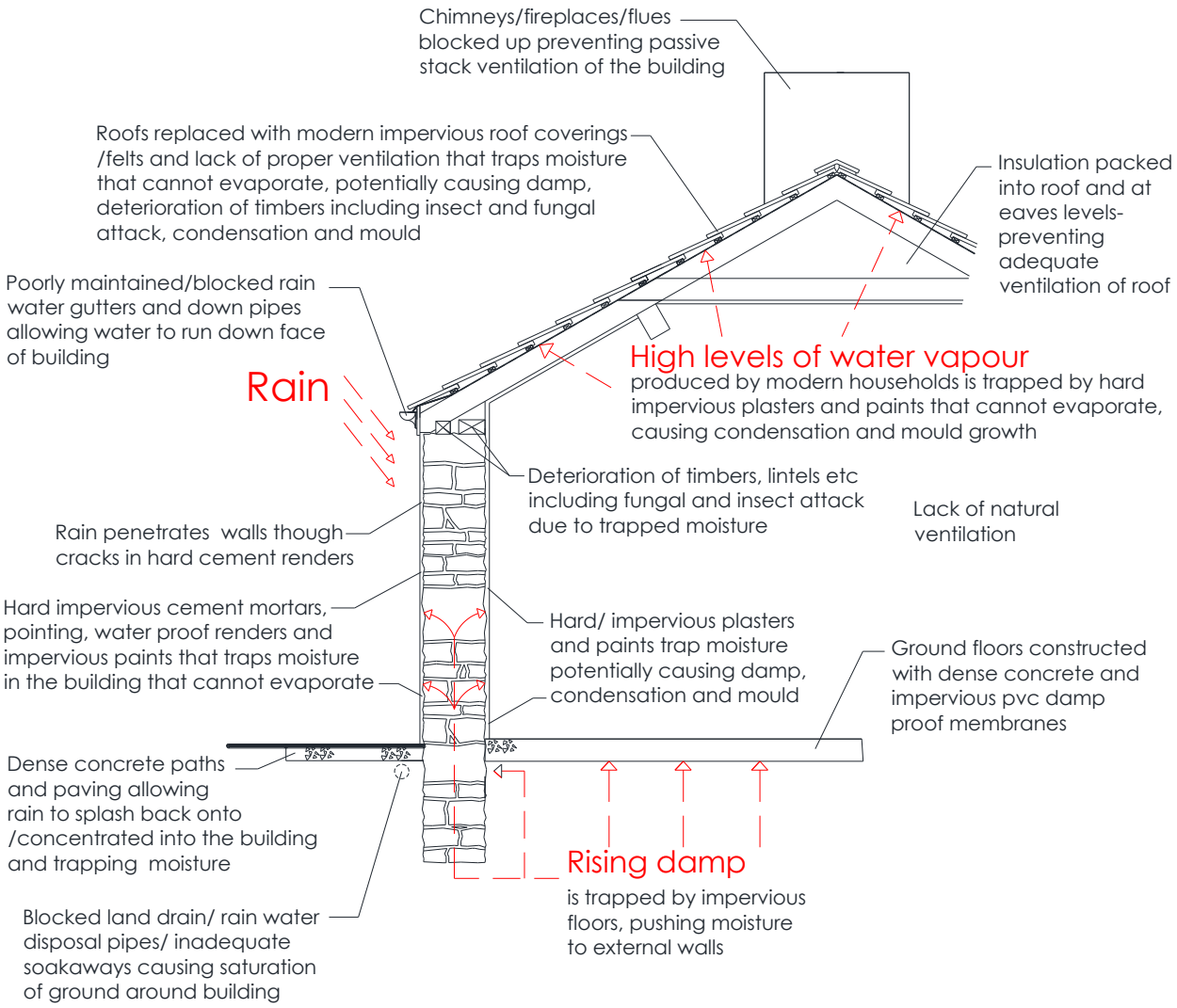


Figure 5: Inappropriate maintenance to old buildings (not to scale) (Source: Gwynne, 2013).

3.3.0 Modern construction (post 1919)

3.3.1 Legislation

Following the First Public Health Act in 1875 (www.parliment.uk), there were two major revisions in 1936 and 1961 (www.legislation.gov.uk). This led to the Building Regulations 1965, 1976 and 1983 (www.legislation.gov.uk). The Public Health Act was replaced by the Building Act 1984 (www.legislation.gov.uk) and provides the framework for today's Building Regulations. The current Building Regulations in Wales are the Building Regulations 2010 and The Building (Approved Inspector's etc.) Regulations 2010 (www.legislation.gov.uk). A separate system of building control applies in England, Wales, Scotland and Northern Ireland. The current legislation applicable to Wales is summarized as follows:

(i) The Building Act 1984 (Applies to England and Wales)

The Building Act 1984 provides the framework for the Building Regulations for the purposes of securing the health, safety, welfare and convenience of persons in or about buildings and of others who may be affected by buildings or matters connected with buildings, furthering the conservation of fuel and power, and preventing waste, undue consumption, misuse or contamination of water. It also introduced the use of Approved Documents to provide practical guidance in support of the Building Regulations(www.legislation.gov.uk).

It's interesting to note for this report that the question of whether Local Authorities are liable for negligence in the exercise of their powers in relation to the Building Regulations (i.e. can they be sued) has been subject to considerable recent case law culminating in the landmark decision of the House of Lords in Murphy v. Brentwood District Council (1990) where it was held that local authorities cannot be held liable for economic loss but only for actual damage to people's health and safety. This judgement halted 13 years of expansion of the tort of liability (Billington, M J. et al. 2017).

(ii) The Building Regulations 2010 (Wales)

The Building Regulations are themselves very short paragraphs that contain no technical details and are expressed as functional requirements and are difficult to interpret or understand. For this reason, the Welsh Government publishes practical guidance on meeting these requirements in a series of 20 documents known as Approved Documents (gov.wales). Therefore, it is the guidance in Approved Documents that are being questioned in this study and not the actual Building Regulation requirements that can be viewed in the front of each of the Approved Documents. Breach of the Building Regulations is a criminal offence and carried an unlimited fine on conviction.

(iii) The Approved Documents (Wales)

The Approved Documents **(Figure 6),** are available to download free of charge and provide practical guidance and refers to other standards applicable to modern buildings and if this guidance is followed it is deemed to satisfy compliance with the Building Regulations. For example, Approved Document C is for the resistance to the

passage of moisture and provides practical guidance on how floors, walls and roofs can be constructed to resist the passage of moisture into the building using impermeable water-resistant defenses. Diagrams and details are given for the construction of cavity walls, use of cement-based mortars, renders, and plasters, construction of concrete floors, installation of damp-proof courses, membranes and waterproof tanking etc.

Figure 6: Current Approved Documents for use in Wales

All Approved Documents can be downloaded free of charge at:
(www.gov.wales/building-regulations-approved-documents)

A: Structural safety (2015 edition)
B: Volume 1: Fire safety in dwelling houses (2006 edition with 2010 & 2016 amendments);
B: Volume 2: Fire safety in buildings other than dwelling houses (2006 edition with 2010, 2013 and 2016 amendments);
C: Resistance to contaminants and moisture (2017 edition);
D: Toxic substances (1992 with 2002 and 2010 amendments);
E: Resistance to the passage of sound (2003 with 2004 & 2010 amendments);
F: Ventilation (2010 edition with 2010 and further 2010 amendments);
G: Sanitation, hot water safety and water efficiency (2010 edition with 2018 amendments);
H: Drainage and waste disposal (2002 edition with 2010 amendments);
J: Combustion appliances and fuel storage systems (2010 edition with further 2010 amendments);
K: Protection from falling, collision and impact (1998 edition with 2000 & 2010 amendments);
L1A: Conservation of fuel and power in new dwellings (2014 edition with 2016 amendments);
L1B: Conservation of fuel and power in existing dwellings (2014 edition with 2016 amendments) ;
L2A: Conservation of fuel and power in new buildings other than dwellings (2014 edition with 2016 amendments);

L2B: Conservation of fuel and power in existing buildings other than dwellings (2014 edition with 2016 amendments);
Domestic Buildings Services Compliance Guide (2013 edition);
M: Access to and use of buildings (2004 edition with 2010 amendments);
N: Glazing- safety in relation to impact, opening and cleaning (1998 edition with 2000 & 2010 amendments);
P: Electrical safety (2006 edition with 2020 amendments);
Q: Security in dwellings (2018 edition);
R: Physical infrastructure for high – speed electronic communications networks (2016 edition);
Regulation 7: Materials and workmanship (2013 edition).

3.3.2 Principles of modern construction

In 1793, John Smeaton discovered a method for producing hydraulic lime for the use of cement. He used limestone containing clay that was fired until it turned into clinker, which was then ground into powder. This was mixed with sand and used as mortar for the construction of brick and stone walls. He used this material in the historic rebuilding of the Eddystone Lighthouse in Cornwall, England (www.giatecscientific.com).

In 1824, Joseph Aspdin invented Portland cement which replaced hydraulic lime and was produced by burning finely ground chalk and clay until the carbon dioxide was removed. Aspdin named the cement after the high-quality building stones quarried in Portland, England. In the 19th Century Portland cement was used to produce concrete for industrial buildings and mortar for the construction of homes (www.giatecscientific.com).

In 1875, the Public Health Act introduced the requirement for damp proof courses to be provided in walls (www.marshallsgroup.com).

In 1916, the UK Government created the Department of Industry and Scientific Research (DISR) to investigate materials research and by 1917 were established enough to create a sub-body called the Buildings Materials Research Committee (BMRC). After the first world war there was a shortage of building materials and skilled

labour. In 1918, the BMRC came up with the use of concrete as an alternative to brick and stone as a building material for the construction of walls and the use of a cavity between the wall leaves to prevent damp and retain heat. The outcome was the general use of cavity walls we know and use today www.socialhousinghistory.uk).

In 1965, prevention of energy waste for homes was first introduced into the Building Regulations when it became a requirement to reduce heat loss through the building fabric. For comparison, U-values (see 4.3 for an explanation of U-values) for walls in 1965 were 1.7 compared with 0.21 today; roof 1.5 compared with 0.15 today; ground floors had no requirement compared with 0.18 today; windows 4.8 compared with 1.6 today (www.thegreenage.co.uk). Plastic damp proof membranes also became a requirement in solid ground floors (fet.uwe.ac.uk).

In 1984, the Building Act first introduced the Approved Documents to provide practical guidance in support of the Building Regulations (Paragraph 3.3.1 (iii).

Changes in legislation led to the Building Regulations and Approved Documents we use to construct buildings in the UK today (Paragraph 3.3.1). For example:

Approved Document C states the resistance to moisture in buildings as follows:

(i) ***Ground supported floors*** *(moisture from the ground)*
Any ground supported floor will meet the requirement if the ground is covered with dense concrete laid on a hardcore bed and a damp-proof membrane is provided. Suitable insulation may be incorporated **(Figure 7**).

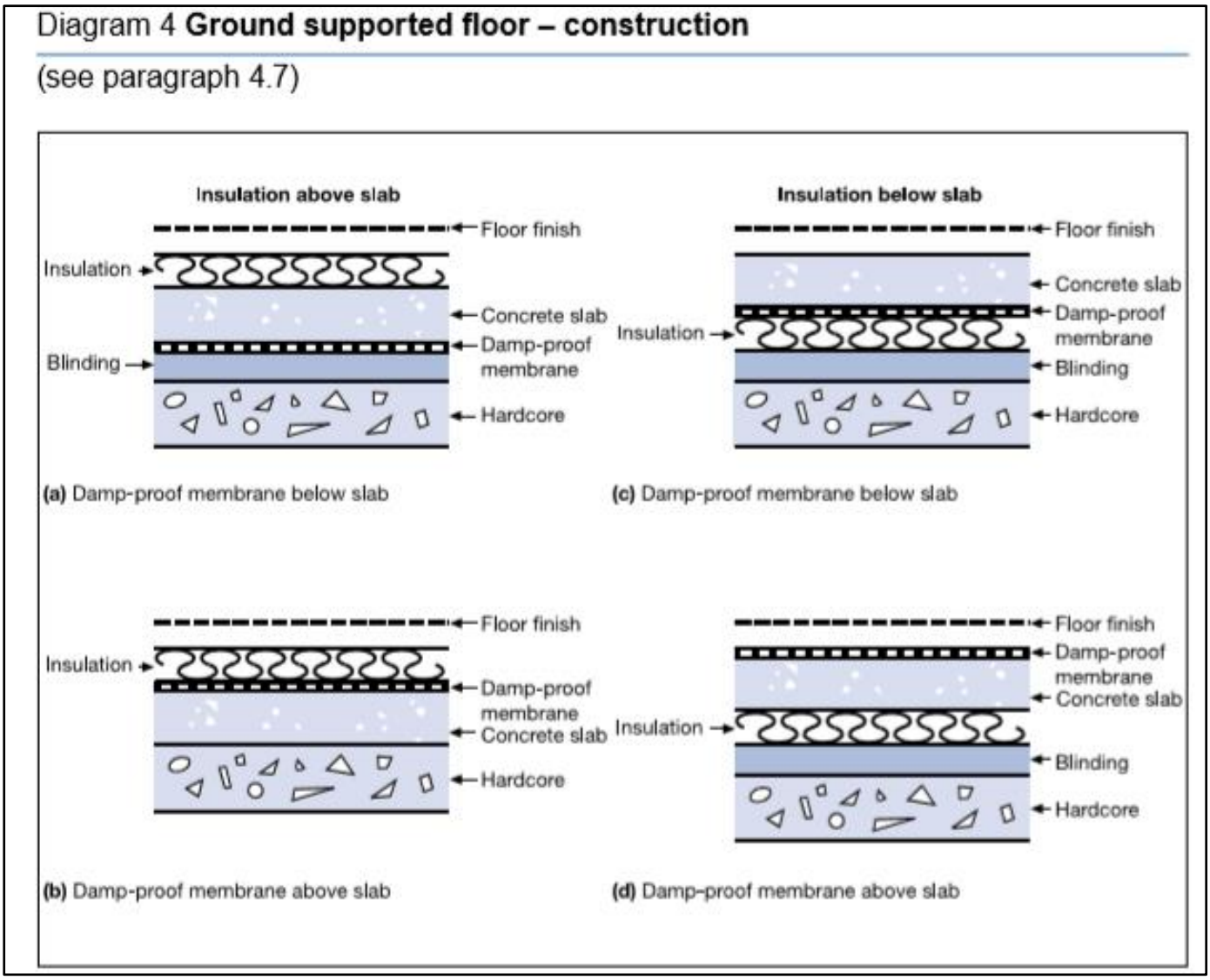


Figure 7: Ground supported floor construction diagram in Approved Document C (Source: www.gov.wales)

(ii) Insulated external walls- should be constructed as follows **(Figure 8**):

(a) resist the passage of moisture from the ground to the inside of the building; and

(b) not be damaged by moisture from the ground and not carry moisture from the ground to any part which would be damaged by it, and, if the wall is an external wall:

(c) resist the penetration of precipitation to components of the structure that might be damaged by moisture; and

(d) resist the penetration of precipitation to the inside of the building; and

(e) be designed and constructed so that their structural and thermal performance are not adversely affected by interstitial condensation; and

(f) not promote surface condensation or mould growth, given reasonable occupancy conditions.

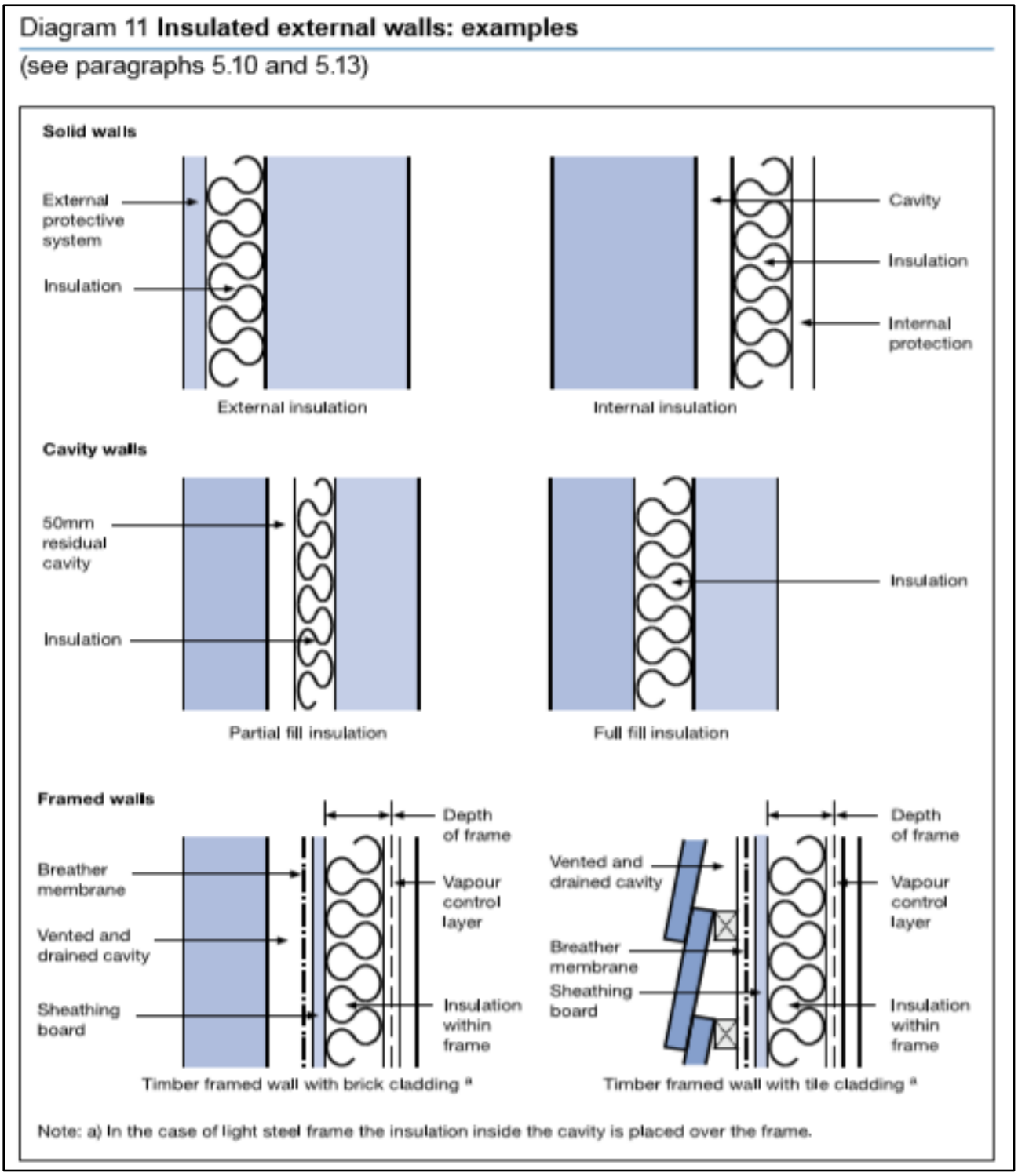


Figure 8: Examples of insulated external wall diagram in Approved Document C (Source: www.gov.wales)

(iii) Roofs - should be constructed as follows:

(a) resist the penetration of precipitation to the inside of the building; and

(b) not be damaged by precipitation and not carry precipitation to any part of the building which would be damaged by it;

(c) be designed and constructed so that their structural and thermal performance are not adversely affected by interstitial condensation.

It's interesting to note there are no diagrams in the Approved Documents for roof guidance details and a typical modern form of construction used today is illustrated in **Figure 9**.

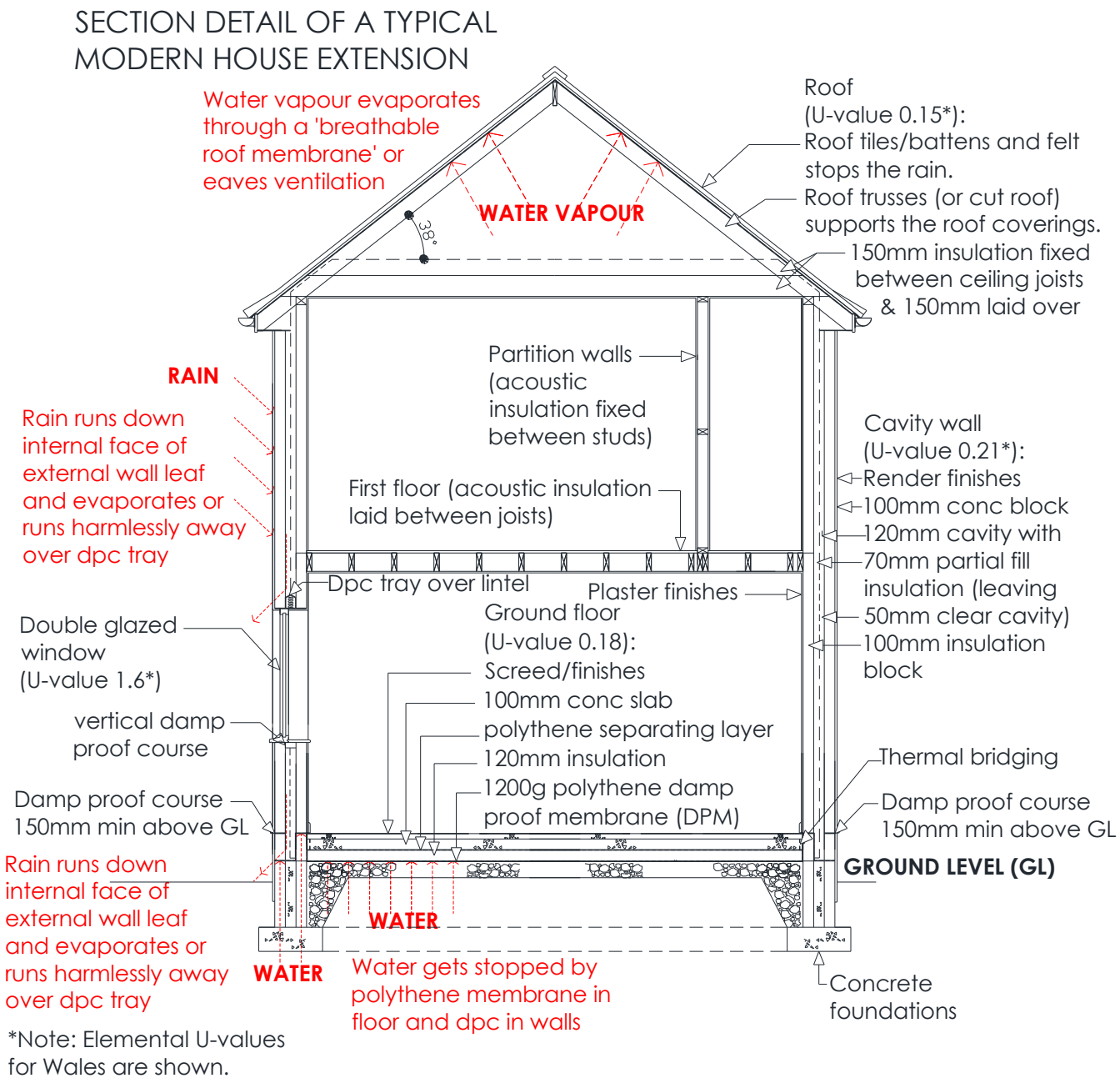


Figure 9: Principles of modern construction (Source: Gwynne, 2013).

3.4.0 Drivers of change

The drivers for making changes and improvements to the UK building stock and conserve traditional and historic buildings can take many forms, economic, social, environmental changes and building vulnerability (BS 7913, 2013). The following are examples of drivers of change applicable to this study:

(i) Changes in climatic conditions over recent years have had adverse effects on traditional buildings and they are less able to cope with changing weather patterns (www.metoffice.gov.uk), leading to penetrating and rising damp issues in a high percentage of these buildings (Prizeman et al., 2016). Occupants are suffering thermal discomfort, high humidity, damp and mold growth potentially effecting their health. Changes in climatic conditions and incentives offered by the Welsh Government (gov. wales) are driving improvement works to these traditional and historic buildings and these improvements works will require Building Regulation approval (www.nest.gov.wales).

(ii) Under the requirements of the Domestic Minimum Energy Efficiency Standard (MEES) Regulations 2018, landlords of cold homes in England and Wales will have to improve the insulation and/ or heating of property before they can rent it out to new tenants or issue a renewal of an existing tenancy agreement. These regulations apply to any privately rented home banded F or G (the bottom two bandings) on an Energy Performance Certificate (www.gov.uk/guidance/domestic-private-rented-property).

(iii) Building owners aspirations to improve energy efficiency, improve thermal comfort and reduce heat loss. In older buildings this heat loss can be typically: 35% through walls; 25% through roofs; 15% through ground floors and through draughts and 10% for windows and doors (www.theguardian.com).

(iv) Material change of use of a building. For example, the conversion of an agricultural barn into a residential dwelling or commercial building. Such work will most probably involve alterations, renovations and new works and will require Building Regulations approval (www.legislation.gov.uk).

(v) Increases in thermal insulation brought about by the European Union Energy Performance Directive adopted by the United Kingdom in 2002 requiring new buildings to have zero carbon by 2020 will have a significant impact on the thermal insulation of new dwellings (including conversion of buildings into new dwellings) (www.legislation.gov.uk/eudr/2018/2002).

(vi) More recently, the Committee on Climate Change (CCC) (set up under the Climate Change Act 2008 to advise the UK Government on tackling climate change), produced a report called 'Net zero: The UK's contribution to stopping global warming' (Committee on Climate Change. 2019). The report recommended a new emissions target for the UK of net-zero greenhouse gases by 2050. This led to the UK Government announcing net-zero greenhouse gases by 2050.

(vii) The Welsh Government are now exploring how to meet the 2050 decarbonisation targets (Green et al. 2019). To establish how the report would impact on the Building Regulations, this report author (AG) has carried out a face to face interview with Simmon Lannon (SL) one of the report authors. A copy off the full transcript is provided in **Appendix L.** A summary of the key questions raised and SL response are as follows:

Questions 1 and 2 are not key and not included here.

Question 3. AG- Does net zero carbon emissions by 2050 apply to new and existing buildings? I raise this as an email mail I received from Colin Blick (2019) states the review is of new dwellings only?

Answer: SL-

- *It applies to both new and existing dwellings*

Question 4. AG- How are the Welsh Government going to achieve net zero carbon emissions by 2050?

Answer: *SL-*

- *This is included in the stage 2 document, and an important aspect is exploring the impact of cleaner energy supply (Paragraph 4.3).*
- *This is demonstrated in Appendix A as the impact on carbon emissions and costed actions on 14 different dwelling types using scenario 1 and 2 to achieve 40-60% clean energy supply (scenario 3 was not considered possible and not included).*

Question 5: AG- How this will impact on the Building Regulations, with particular regard to upgrading the energy efficiency of existing traditional/historic/listed buildings built before 1919 with solid wall construction?

Answer: SL-

- *The wall upgrades are indicated on the pre 1919 dwellings as external and internal insulation thicknesses – which are modern non- vapour permeable insulations to achieve the required U-values.*
- *AG made the point that external and internal non- vapour permeable insulations will trap water and cause deterioration of the building fabric and possible mould growth which is detrimental to people's health.*
- *SL said this is something they will need to look at.*

Question 6: AG- Will the Welsh Government consider the use of vapour permeable materials and will the guidance in the Approved Documents be amended?

Answer: SL-

- *Not able to answer that.*

Question 7: AG- Will the Welsh Government consider reducing the energy efficiency of solid wall construction to industries concerns regarding

condensation/trapped moisture? Ty-Mawr (www.lime.org.uk) are already specifying 50mm Cork on internal wall upgrades with Hemp Lime finishes as it does not trap water and achieves a U-value of less than 0.6 instead of 0.3 required for upgrades under the requirements of the Building Regulations.

Answer: SL-

- *SL did not rule out the use of worse U-values and could be considered if it was technically achievable and didn't damage the building fabric/people's health. SL checked the Ty-Mawr U-value on SAP Version 6 as 0.59 (www.supportsap.com).*

Question 8: AG- What happens with Homes of Today for Tomorrow report now?

Answer: SL-

- *We will consult Registered Social Landlords and report will be revised on a carbon mix and will consult with DAG*

(viii) Julie James the Welsh Government's Minister for Housing and Local Government confirmed the Welsh Government are reviewing Approved Document L next year in line with the 2050 targets (**Appendix E1**, Blick, 2019). To establish how the Welsh Government, propose to make changes, this report author (AG) has carried out a telephone interview with Colin Blick (CB), the Welsh Government's Building Standards Technical Manager. A copy of the full transcript is provided in **Appendix E2**. A summary of relevant questions raised, and CB response are as follows:

Question 1: AG- How often do you review of the Approved Documents?
Answer: CB-

- *Approved Document L for the conservation of fuel and power in new and existing buildings will be reviewed this year and next year and will include Approved Document C as part of the review. Approved Document B for fire safety and Regulation 7 for materials and workmanship will be reviewed after*

the Hackett report into the Grenfell Tower tragedy (www.gov.uk/government/speeches/statement-on-the-hackitt-review).

Question 2: AG-How do you decide which Approved Documents to review?
Answer: CB-

- *Depends on what is topical- which at the moment is fire safety and conservation of fuel and power.*
- *If there are changes in England, Welsh ministers will look at it and see if it's a benefit to Wales. Most of the Approved Documents follow England except the additional requirement for sprinklers in Approved Document B.*
- *If a subject crops up time and time again, we will look at it.*

Question 3: AG- how do you review?
Answer: CB-

- *The Building Regulations Advisory Committee (BRAC) will advise Welsh ministers.*
- *Welsh ministers will advise what the building control technical working group are to review based on BRAC recommendations and resources (which is very limited as it is only a small team).*
- *Note: CB was asked who made up the building control technical working group but was reluctant to provide a list of attendees. Important note: Since this interview was conducted, information has been received confidentially there is no representation from any group representing the interests of traditional or historic buildings. To substantiate this, several attempts was made by this report author to Interview Phil Jones – Chair of the Welsh Government working Group- but the interview was cancelled on several occasions. A further interview was requested in January but to date no reply has been received (Appendix F is left for open for the response.)*

Question 4: AG- Who do you consult?
Answer: CB-

- *There is a public consultation for 12 weeks including with RICS, CIOB etc*

Question 5: AG- Who makes the final decision what is included in the

Approved Documents?

Answer: CB-

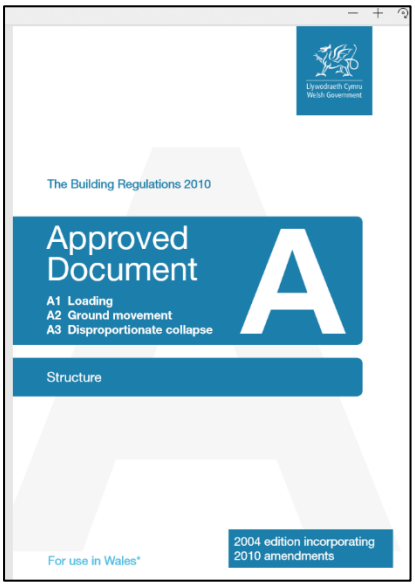
- *The minister for Housing and Local Government- currently Judy James.*

4.0 The problem

The Approved Documents to the Building Regulations provides practical guidance for works to modern buildings but provides very little guidance for those who carry out works to traditional, historic and listed buildings. By examination of the Approved Documents and procurement of work it is proposed to demonstrate the problem. As discussed in paragraph 2.4, the scope of this study will be limited to research of the Welsh Building Regulations in connection with:

- Approved Document A (Structure);
- Approved Document C2 (Resistance to moisture);
- Approved Document L1B (Conservation of fuel and power in existing dwellings);
- Regulation 7: Materials and workmanship.

4.1 Approved Document A



Approved Document A provides guidance for the structural stability of modern buildings constructed of masonry units. It provides practical guidance in the form of 24 diagrams, 11 tables and text over 59 pages on loading, ground movement and disproportionate collapse, all related to modern buildings. It mentions alternative forms of construction include prefabricated timber, light steel and precast concrete framed construction. The guidance currently provided by the Welsh Government is for modern forms of construction and there is no guidance or practical advice for traditional and historic buildings. A copy of Approved Document A can be downloaded free of charge at: (https://gov.wales/buildingregulations-approved-documents).

4.2 Approved Document C

Approved Document C is for site preparation and resistance to contaminates and moisture. It provides practical guidance in the form of 15 diagrams, four tables and text over 72 pages on how floors, walls and roofs can be constructed to resist the passage of moisture into the building using impermeable water-resistant defenses. Diagrams and details are given for the construction of modern cavity and solid walls, use of cement-based mortars, renders, and plasters, construction of concrete floors, installation of damp-proof courses, membranes and waterproof tanking etc. Diagrams illustrating potential problems from Approved Document C are reproduced in **Figures 10 and 11**. A copy of Approved Document C can be downloaded free of charge at: (https://gov.wales/buildingregulations-approved-documents).

Extracts of modern ground floor details contained in ADC and reproduced in **Figure 10** are designed to prevent the ingress of moisture into the building and can trap moisture below the damp proof membrane, concrete slab and non-vapour permeable insulations. Any trapped moisture/water will be pushed towards the external walls. this could lead to the build-up of excessive moisture in solid walls without a damp-proof course that many traditional buildings built before 1919 do not have, causing rising damp and the ingress of moisture into the building (**Figure 5).** This could cause deterioration of the building fabric and lead to mould growth on the wall finishes, producing mould spours hazardous to the health of the occupants (King and Weeks. 2016).

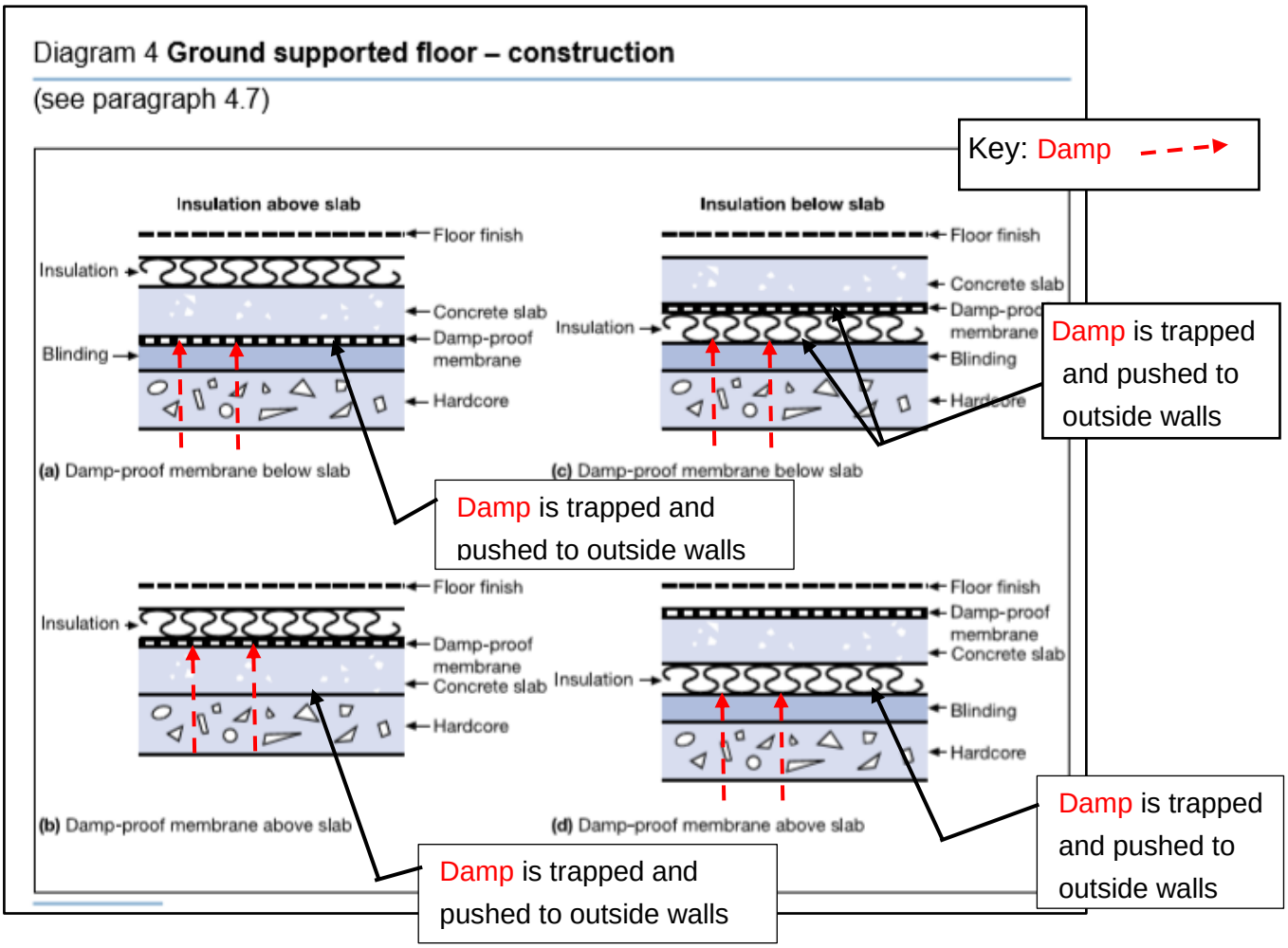


Figure 10: Extract of ground supported floor construction diagrams in Approved Document C and how they trap water
(Source: www.gov.wales/buildingregulations-approved-documents).

Extracts of modern ground floor details contained in ADC and reproduced in **Figure 11** does not specify the external or internal protective system or insulation system to be used. This can lead to non-vapour permeable systems being inappropriately fixed to vapour permeable brick, stone or cob walls, increasing the risk of condensation behind the insulation layer, trapping moisture and pushing it towards the internal face of the building. This could lead to unintended consequences (King and Weeks. 2016) including:

- Overheating – heat can no longer be buffered by the walls;
- Increased relative humidity, associated damp and mould growth;
- Reduction in indoor air quality;
- Short term concentrations of volatile organic compounds (VOC's);
- Elevated radon gas concentrations;

- Creation of new thermal bridge/condensation points behind highly insulated layers and interstitial condensation;
- Rot and/or insect attack on structural timbers;
- Frost damage within walls;
- Failure of internal surface finishes.

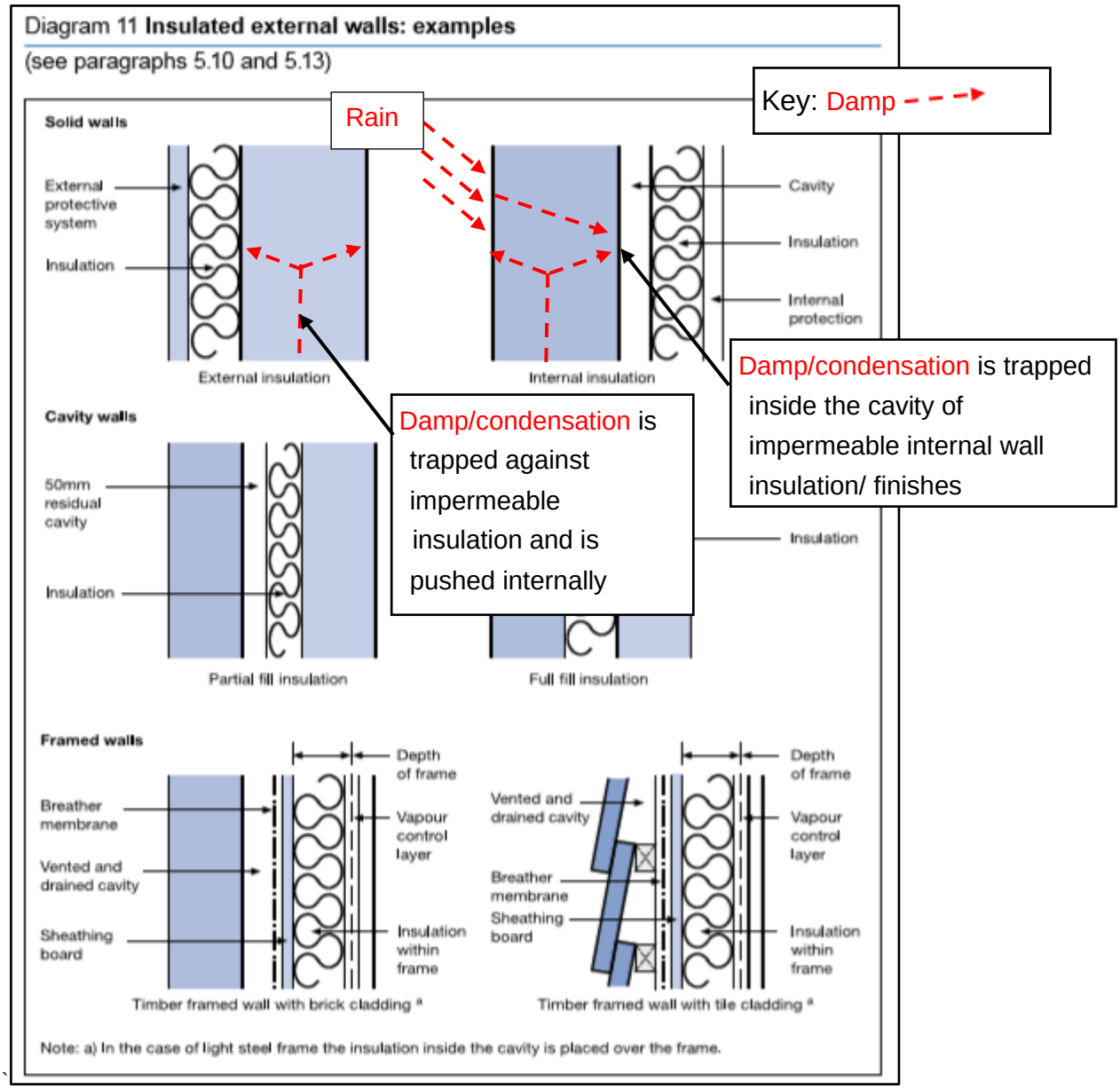


Figure 11: Extract of insulated external wall diagram in Approved Document C and how they trap water/condensation
(Source: www.gov.wales/buildingregulations-approved-documents).

The extract in **Figure 12** below illustrates the guidance provided by the Welsh Government for traditional and historic buildings is very limited, generic in nature and does not provide any practical advice for common situations, unlike that provided for modern forms of construction.

Approved Document C

C1 Site preparation and resistance to contaminants. C2 Resistance to moisture.

2004 edition incorporating 2010 Amendments (For use in Wales)

Historic buildings

Material change of use or alterations to existing buildings may include work on historic buildings. Historic buildings include:

(a) listed buildings;

(b) buildings situated in conservation areas;

(c) buildings which are of architectural and historical interest and which are referred to as a material consideration in a local authority's development plan;

(d) buildings of architectural and historical interest within national parks, areas of outstanding natural beauty and world heritage sites.

The need to conserve the special characteristics of such historic buildings needs to be recognised[1]. In such work, the aim should be to improve resistance to contaminants and moisture where it is practically possible, always provided that the work does not prejudice the character of the historic building or increase the risk of long-term deterioration to the building fabric or fittings. In arriving at an appropriate balance between historic building conservation and improving resistance to contaminants and moisture it would be appropriate to take into account the advice of the local planning authority's conservation officer. Particular issues relating to work in historic buildings that warrant sympathetic treatment and where advice from others could therefore be beneficial include the following: (a) avoiding excessively intrusive gas protective measures; (b) ensuring that moisture ingress to the roof structure is limited and the roof can breathe[2]. Where it is not possible to provide dedicated ventilation to pitched roofs it is important to seal existing service penetrations in the ceiling and to provide draught proofing to any loft hatches. Any new loft insulation should be kept sufficiently clear of the eaves so that any adventitious ventilation is not reduced.

In most cases the rate at which gas seeps into buildings, mainly through floors, can be reduced by edge located sumps or sub-floor vents. These are less intrusive than internal sumps or ducts that may involve taking up floors. If flagged floors are taken up the stones should be indexed and their layout recorded to facilitate relaying when work is completed[3]. Radon can be dispersed by ventilation strategies such as positive pressurisation. These systems can often be accommodated in an unobtrusive manner. If internal mechanical ventilation is used to disperse ground gases, it may affect the functioning of combustion appliances and may lead to the spillage of products of combustion into the building. Guidance on this can be found in Good Building Guide 25 Buildings and radon[4].

Footnotes;

1. *BS 7913:1998 Guide to the principles of the conservation of historic buildings. Provides guidance on the principles that should be applied when proposing work on historic buildings.*
2. *SPAB Information Sheet 4 The need for old buildings to 'breathe', 1986.*
3. *and 4 are omitted as not relevant to this dissertation*

Figure 12: Summary of guidance for historic buildings in Approved Document C (Source: www.gov.wales/buildingregulations-approved-documents).

4.3 Approved Document LB1 Conservation of fuel and power in existing dwellings

Approved Document B1 is for the conservation of fuel and power in existing dwellings (Figure 9). It provides guidance in the form of 11 tables and text over 14 sections and 53 pages on how the thermal elements of the building including windows, roof windows, doors and services can achieve the energy efficiency requirements of the Building Regulations. There are no diagrams and it provides very little guidance for works to traditional and historic buildings summerised in **Figure 13** below. A copy of Approved Document L can be downloaded free of charge at: (www.gov.wales/buildingregulations-approved-documents).

Approved Document L1B Conservation of Fuel and Power in Existing Dwellings. 2014 edition incorporating 2016 Amendments (For use in Wales).

12.1 Exempt historic and traditional buildings

12.1.1 Works to the following classes of building are exempt from the energy efficiency requirements where compliance would unacceptably alter the character or appearance of the buildings: a. listed in accordance with Section 1 of the Planning (Listed Buildings and Conservation Areas) Act 1990; or b. in a conservation area designated in accordance with Section 69 of the Planning (Listed Buildings and Conservation Areas) Act 1990; or c. included in the schedule of monuments maintained under Section 1 of the Ancient Monuments and Archaeological Areas Act 1979.

12.2 Historic and traditional buildings where special considerations apply

12.2.1 In addition, special considerations apply to works to the following three classes of non-exempt existing buildings:

a. of architectural and historic interest and are referred to as a material consideration in a local authority's development plan or local development framework; or

b. of architectural and historic interest and are within national parks, areas of outstanding natural beauty, registered historic parks and gardens, registered battlefields, the curtilages of scheduled ancient monuments, and world heritage sites; or

c. of traditional construction with permeable fabric that both absorbs and readily allows the evaporation of moisture.

12.2.2 Work to such buildings is required to comply with the energy efficiency requirements as far as is reasonably practicable. In considering what is reasonably practicable, the work should not unacceptably alter or mar the character of the building or increase the risk of long-term deterioration.

12.2.3 The detailed technical guidance on how to implement specific energy efficiency measures produced by English Heritage should be taken into account when determining appropriate energy performance standards for building work to existing dwellings. See list of available guidance documents at http://www.englishheritage.org.uk/professional/advice/advice-by-topic/climate-change/energy-efficiency/

12.2.4 In general, new extensions to dwellings of historic and architectural interest should comply with the energy efficiency requirements: guidance on how to comply is set out in Section 2. The only exception would be where there is a need for the extension to be consistent with the character of the existing building.

12.2.5 Particular issues relating to work to dwellings of historic and architectural interest warrant sympathetic treatment and would benefit from further professional advice. These issues include:

a. restoring the historic character of a building that has been subject to a previous inappropriate alteration, for example, replacement windows and doors; or

b. rebuilding a former historic building, for example, following a fire or infilling a gap site in a terrace; or

c. enabling the fabric of historic buildings to 'breathe' to control moisture and potential long-term deterioration.

12.2.6 When assessing dwellings of historic and architectural interest where special consideration may apply, it is important that the Building Control Body takes into account the advice of the local authority's conservation officer, particularly where the work requires planning permission and/or listed building consent.

Figure 13: Summary of guidance for historic buildings in Approved Document LB1 (Source: www.gov.wales/buildingregulations-approved-documents).

The above extract illustrates that the guidance provided by the Welsh Government for traditional and historic buildings is very limited, generic in nature and does not provide any practical advice for common situations.

The energy efficient requirements of new works and works to existing buildings contained in Approved Document LB1 is driven by the European Union Energy Performance of Buildings Directive adopted by the UK Government in 2002 (Bick 2019) and summerised as U-values in **Figure 14.** A building elemental U-value is extremely important as there are certain standards that should be reached according to Building Regulations. The U-value is a sum of the thermal resistances of the layers that make up an entire building element, for example, the roof, walls and floors. It also includes adjustments for any fixings or air gaps. A U-value value is expressed in units of $W/m^2 \cdot K$ and is the ability of an element to transmit heat from a warm space to a cold space in a building, and vice versa. The lower the U-value, the better insulated the building element (www.kingspan.com).

Element	New works	Works to existing buildings
	Maximum U-values[1] for new extension W/m². K	**Maximum U-values[1] for conversions, renovations and material chance of use. W/m². K**
Cavity walls (exposed and semi exposed) Solid walls	0.21 --	0.55 0.3
Floors	0.18	0.25
Roofs	0.15	0.18
Windows	1.6	1.6
Doors	1.6	1.6
Notes: 1. The U-value is a sum of the thermal resistances of the layers that make up an entire building element- see 4.3 for a full explanation of what is a U-value.		

Figure 14: Summary of maximum current U-values for new works (extensions) and works to existing buildings in Approved Document LB1- tables 1, 2 and 3 (Source: www.gov.wales/buildingregulations-approved-documents).

Comparison of insulation thickness to meet current U-values in **Figures 15 and 16** indicates non-vapour permeable insulations such as Kingspan which is much thinner in section than vapour permeable insulations such as cork and lamb's wool which have less thermal resistance and are thicker. Thinner insulations take up less usable floor area when thermally upgrading traditional/historic buildings which typically have smaller rooms. This leads to the inappropriate use of non-vapour permeable insulations on solid vapour permeable walls with the consequence of trapping moisture and associated problems indicated in **Figure 5.**

This is contrary to SPAB's findings **(paragraph 3.1.5)** that concludes *'excessive thicknesses of insulation and non-breathable materials should be avoided*. *Ultimately, this could have negative consequences for old buildings because the adoption of overly pessimistic theoretical U-values as the baseline for assessing the thermal performance of their walls may lead to disproportionate energy saving interventions that are not only unnecessary but also invasive and potentially harmful to historic fabric and people's health'.* SPAB suggest thinner vapour permeable insulations that are less high performing can achieve successful upgrades. The Welsh Governments net zero carbon emissions target by 2050 for new and existing buildings (paragraph 3.4.0) can only make this situation worse.

Insulation product	U-value no worse than 0.21 Minimum thickness (mm)	U-value no worse than 0.3 Minimum thickness (mm)
Non vapour permeable insulations		
Polyisocyanate insulation board (PIR), for example: Kingspan Kooltherm K18 Insulated Plasterboard or similar with a Lambda value[2] of 0.020 W/(m²k)	92.5mm fixed over battens	62.5mm fixed over battens
Notes: 1. Solid stone wall 500mm thick. 2. The lambda value, also portrayed as 'K-value' or 'λ-value', measures a product's thermal conductivity in units of W/(m²k). A good insulation will have as low a lambda value as possible to reduce heat loss (www.kingspan.com).		

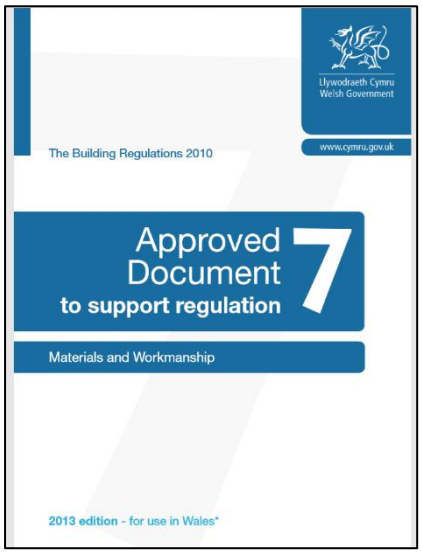
Figure 15: Comparison of non vapour permeable insulation thicknesses fixed to internal face of solid walls[1] for U-values no worse than 0.21 and 0.3 W/m²k in compliance with figure 14 (Source: Ty-Mawr).

Insulation product	U-value no worse than 0.21 Minimum thickness (mm)	U-value no worse than 0.3 Minimum thickness (mm)
Vapour permeable insulations		
Cork board Lambda value 0.40 W/(m²k)	180mm applied directly	120mm applied directly
Lamb's wool Lambda value[2] 0.038 W/(m²k)	220mm between studs	140mm between studs
Wood fiber board Lambda value[2] 0.040 W/(m²k	180mm applied directly	120mm applied directly
Notes: 1. Solid stone wall 500mm thick. 2. The lambda value, also portrayed as 'K-value' or 'λ-value', measures a product's thermal conductivity in units of W/(m²k). A good insulation will have as low a lambda value as possible to reduce heat loss (www.kingspan.com).		

Figure 16: Comparison of vapour permeable insulation thicknesses fixed to internal face of solid walls[1] for U-values no worse than 0.21 and 0.3 W/m²k in compliance with figure 14 (Source: Ty-Mawr).

Figures 15 and 16 demonstrates non vapour permeable insulations such as Polyisocynate (PIR) are more high performance and thinner in profile when compared to poor performing non vapour permeable insulations such as cork, lamb's wool and wood fiber. This makes PIR type boards more attractive when upgrading traditional solid walled buildings but is totally inappropriate.

4.4 Approved Document to support Regulation 7



The Approved Document to support Regulation 7 provides guidance on materials and workmanship to support other published Approved Documents and is presented in text over 22 pages. There are no diagrams, it provides no guidance for historic buildings and very little guidance for existing buildings, summerised in **Figure 17 below**. A copy of Regulation 7 to the Approved Documents can be downloaded free of charge at: (https://gov.wales/buildingregulations-approved-documents).

Approved Document to support Regulation 7. 2013 edition (For use in Wales)
Building work shall be carried out:
(a) with adequate and proper materials which:
(i) are appropriate for the circumstances in which they are used,
(ii) are adequately mixed or prepared, and
(iii) are applied, used /fixed adequately to perform the functions for which they are designed; and
(b) in a workmanlike manner

Section 1: Materials
1.18 Past experience, such as use in an existing building, may show that the material can perform the function for which it is intended.

Section 2: Workmanship
2.7 Past experience, such as use in an existing building, may show that workmanship is appropriate for the function for which it is intended.

Figure 17: Summary of guidance for existing buildings in Approved Document supporting Regulation 7 (Source: www.gov.wales/buildingregulations-approved-documents**).**

The above extract illustrates there is no guidance provided by the Welsh Government for traditional and historic buildings. The actual guidance for materials and workmanship in existing buildings is limited to a statement that '*past experience, such*

as used in an existing building, may show it can perform the function for which it is intended' **(Figure 17).** These statements are generic in nature and do not provide any practical advice.

4.5 Summary of the problems

The guidance provided by the Welsh Government for traditional, historic and listed buildings is non-existent in Approved Documents A and Regulation 7. Guidance is very limited in Approved Documents C and LB1, it is brief and generic in nature and does not provide any practical advice for common situations. The Approved Documents tend to favour guidance for modern forms of construction which are being adopted by designers, builders and property owners and inappropriately applied to traditional historic and listed buildings, as demonstrated in the case studies below (paragraph 4.6). The Welsh Governments net zero carbon emissions target by 2050 states: '*There should be no distinction between performance standards between retrofit and new build'* (Green, E. et al. 2019). This will only make this situation worse unless proper guidance for traditional, historic and listed buildings is provided.

4.6 Case studies highlighting the potential problems of the Approved Documents

The following recent five case studies have been dealt with by this report author in his professional capacity as a building control surveyor and is held up to demonstrate how the guidance for modern forms of construction in the Approved Documents is being inappropriately applied to traditional, historic and listed buildings by designers, builders and property owners.

Case study 1: Conversion of listed dovecote into holiday let in 2018.

The building owner proposed to convert a curtilage listed dovecote into a holiday let (**Figure 18**). This report author was the supervising building control surveyor.

Figure 18: Elevation of a curtilage listed dovecot to be converted into a holiday let (Source: Gwynne, 2018).

Design stage

The building owner contacted a non-conservation accredited designer who prepared the clients brief and scheme design. The design concept was based on experience with modern buildings and pre-planning discussions with the planning officer who advised Listed Building Consent (LBC) was required under the Planning (Listed Buildings and Conservation Area) Act 1990. Based on the client's requirements, the designer developed the design and incorporated the following into the project:

- Cost implications – vapour permeable materials were considered but not specified due to budget constraints and modern non-vapour permeable insulations and cement-based mortar and renders were cheaper and readily available locally and there were no delays on supply or delivery.
- Time implications – vapour permeable materials were considered but not specified as it required skilled, experienced building contractors. Lime based renders and

plasters could not be used in the winter (when this project was planned to commence), and lime based products had delays in curing times compared with cement based products (www.lime.org.uk).

- Listed building consent was submitted and approved subject to the use of natural stone roofing tiles and lime pointing externally.
- Upgrading of the fabric to Building Regulation standards- using Approved Documents for guidance
- The designer prepared the technical design based on Approved Document L thermal insulation requirements **(Figure 14**), and incorporated planning and LBC conditions into the scheme and discharged the planning and LBC conditions.

Works phase and unintended consequences

A Building Regulations application was submitted by the designer as a Building Notice instead of a Full Plan's application **(Appendix G).** A Building Notice is a simple form of application that can be submitted without the deposit of plans or specification, there is no plan checking and is normally accepted without question. The designer is sent an inspection schedule **(Appendix H)** which requires the builder to notify building control at certain stages of the works. Once the Building Notice had been accepted the builder started work on site. The builder was recommended by the designer and appointed by the building owner. Under the requirements of the inspection schedule, the builder notified building control of his intention to lay the new concrete floor. Unfortunately, this was the first-time building control became aware of this project and visited the site. At this point in time it become apparent that the building was constructed with solid stone walls that should be upgraded using vapour permeable materials. However, the builder confirmed he had very little experience of using lime or vapour permeable materials and the building was being converted using non-vapour permable materials and insulations as follows, indicated in **Figures 19, 20 and 21**:

- Ground floor had a polythene damp proof membrane laid over the floor area and returned up the walls, with a 100mm thick concrete slab laid, ready to lay 100mm thick high density polyisocyanurate insulation board, 75mm cement/sand screed and stone flags.
- Plastic damp proof membrane tanking system had been fixed to the internal face of the ground floor to prevent damp and a high density polyisocyanurate insulation board was on site ready to line the walls. The plastic lining is shown in **Figure 19**.

Building control had no enforcement powers to require the non-vapour permeable insulation to be removed and replaced with vapour permeable materials as it complied with the Building Regulations and Approved Documents. At this point building control was not aware of the planning or listed building consent requirements and building control would not have required detailed plans or specification as the application had been submitted as a Building Notice.

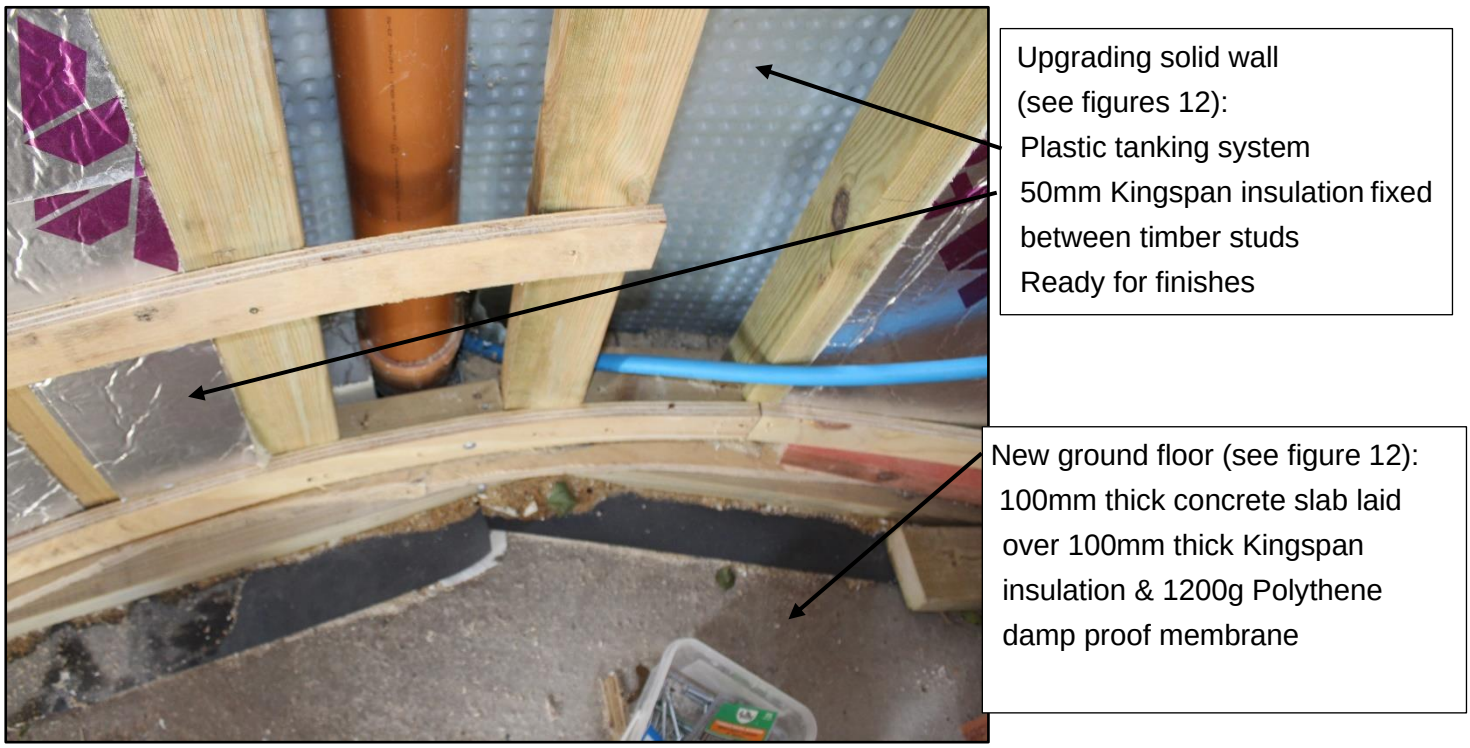


Figure 19: New non-vapour permeable concrete floor, laid over polythene membrane and tanking membrane applied to walls (Source: Gwynne 2018).

Figure 20: Upgrading of solid walls with modern non-vapour permeable tanking membranes and high density polyisocyanurate insulation board

(Source: Gwynne 2018).

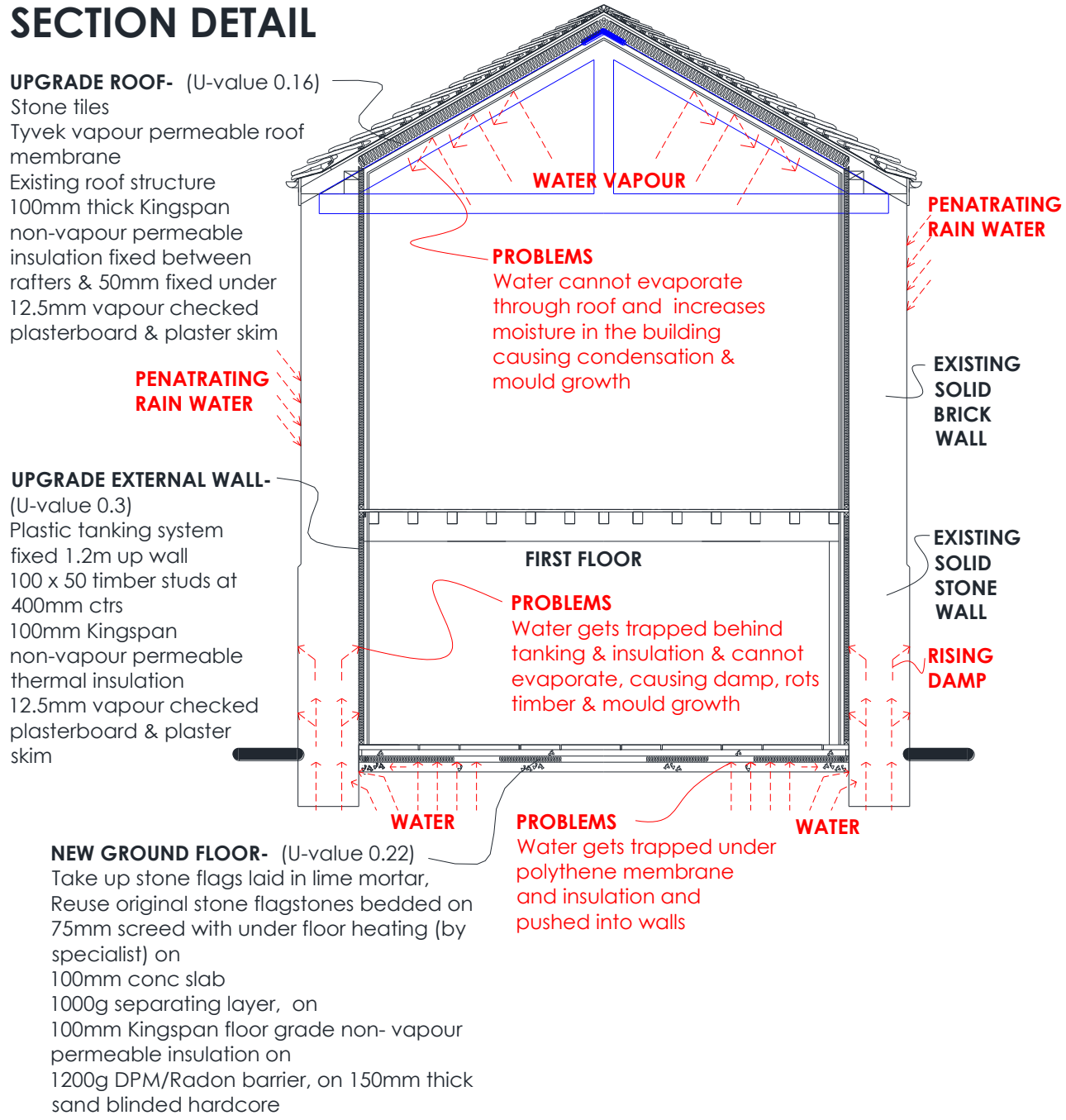


Figure 21: Section detail of dovecot to be converted into holiday let indicating problems of trapped water associated with modern forms of upgrading works (Source: Gwynne, 2017).

Summary

Building control have no enforcement powers to require the use of non-vapour permeable insulation and replace it with vapour permeable materials as it complies with the Building Regulations and Approved Documents.

Case study 2: New ground floor to grade II listed church in 2019.

The building owner proposed to take out the old ground floor in a grade II listed Church and replace it with a modern ground floor (**Figure 22**). This report author was the supervising building control surveyor.

Figure 22: Elevation of grade II listed Tidenham Church (Source: Gwynne, 2019).

Design stage

The Diocese of Gloucester instructed a local architect who in this case was conservation accredited to prepare the clients brief and produce a design. Although the architect had experience with listed buildings and using vapour permeable materials, he prepared the design concept based on his experience using non-vapour permeable materials and insulations. The architect had pre-planning discussions with the Diocese of Gloucester and the proposed works were granted consent in the form of a faculty which is a permissive right to undertake works to a church building or its contents issued by the Church of England (www.churchofengland.org). Based on the client's requirements, the designer developed the design and incorporated the following into the project:

- Cost implications – vapour permeable materials were not considered due to budget constraints and modern non-vapour permeable insulation; concrete slab and

porcelain tiled finishes were cheaper and readily available locally and no supply/delivery delays.

- Time implications – vapour permeable materials were not considered as it required skilled, experienced building contractors, lime based renders and plasters cannot be used in the winter (when this project was planned to commence), and lime based products have delays in curing times compared with cement based products.

Works phase and unintended consequences

` A Building Regulations application was submitted by the architect as a Full Plans application instead of a Building Notice **(Appendix G)**. A Full Plans application requires a full set of plans and specification to be deposited with building control to show compliance with the Building Regulations and Approved Documents.

On checking the plans and specification it become apparent that the proposals were to take up the old lime-based ground floor slab and clay tiles and replace it using modern non-vapour permeable materials. Building Control did question why the architect was proposing to use inappropriate non-vapour permeable materials when vapour permable materials would have been more appropriate and not be detrimental to the building. The architect's response was that the proposed works had been approved by the Diocese of Gloucester technical panel and they had granted a faculty to proceed. Unfortunately, as the Building Regulations and Approved Documents has no guidance for the use of vapour permeable materials and a faculty had been granted, there was no alternative but to approve the works under the requirements of the Building Regulations.

Once the building works started on site, building control met the builder appointed by the architect and he confirmed he was only familiar with modern forms of construction and had very little experience of using lime or vapour permeable materials and didn't question the architect design.

When the works commenced on site, it become apparent that the church building had solid stone walls that already had rising damp issues internally. Building control did point this out to the architect and builder that vapour permeable materials would be

more appropriate to prevent trapping of any water that could make the situation worse. This advice was ignored by the architect who instead instructed the builder to dress and fix a polythene damp proof membrane 1.0m up the internal wall face and to cover it with timber panelling to mask the damp issues instead of resolving them.

Building control inspected the works which were carried out using inappropriate non-vapour permeable materials as follows:

- the original lime-based ground floor slab and clay tiles and timber floorboards were taken up and removed **(Figure 23)**
- hardcore laid (**Figure 24)**
- polythene damp proof membrane was laid over the floor area and 1.0m up the walls **(Figure 25),** although there was rising damp evident in walls **(Figure 26)**
- high density polyurethane insulation board 100mm thick was laid over the polythene membrane **(Figure 27),** confirmed by information sheet **(Figure 28)**
- 150mm thick reinforced concrete slab was laid over the insulation
- porcelain floor tiles were laid over the concrete floor slab **(Figure 29)**
- timber panelling was constructed around the perimeter of the internal wall face to hide the polythene membrane fixed up the walls as a tanking system.

Figure 23: Original ground floor was taken up and removed (Source: Gwynne, 2019).

Figure 24: Hardcore being laid (Source: Gwynne, 2019).

Figure 25: Polythene damp proof membrane laid over the floor area and dressed up walls (Source: Gwynne, 2019).

Figure 26: Rising damp evident in walls (Source: Gwynne, 2019).

Figure 27: High density polyurethane insulation board 100mm thick was laid over the polythene membrane (Source: Gwynne, 2019).

Figure 28: High density polyurethane insulation board information sheet (Source: Gwynne, 2019).

Figure 29: Proposed porcelain floor tiles to be laid over the concrete floor slab (Source: Gwynne, 2019).

Summary

Building control have no enforcement powers to require the use of non-vapour permeable insulation and replace it with vapour permeable materials as it complies with the Building Regulations and Approved Documents.

Case study 3: Conversion of stables into holiday let in 2018.

The building owner proposed to convert a range of derelict farmyard stables into holiday lets **(Figure 30)**. This report author was the supervising building control surveyor.

Figure 30: Elevation of stable building being converted into holiday lets (Source: Gwynne, 2019).

Design stage

The design stage was similar in circumstance to Case Study 1, except the building was not listed and listed building consent was not required.

Works phase and unintended consequences

As Case Study 1, a Building Regulations application was submitted by the designer as a Building Notice **(Appendix G)**. Once the Building Notice had been accepted the builder started work on site. The builder was recommended by the designer and appointed by the building owner. The builder was only familiar with modern forms of construction and had very little experience of using lime or vapour permeable materials.

Under the requirements of the inspection schedule, the builder notified building control of his intention to lay a new concrete floor. Unfortunately, this is first time building control become aware of this project and visited the site. At this point in time it become apparent that the building has traditionally built solid stone walls that should be upgraded using vapour permeable materials. However, the builder proposed to upgrade using inappropriate non-vapour permeable materials and works had already commenced on site indicated in F**igures 31 and 32,** as follows:

- Steel frame erected to support some of the roof areas due to the unstable condition of some of the stone walls.
- Original floors had a new plastic damp proof tanking membrane laid over the floor area (and up the original walls) to prevent the ingress of damp into the building **(Figure 31).**
- High density polyisocyanurate insulation board (PIR) and 2000g damp proof membrane was laid over the floor tanking system ready to receive 100mm thick concrete floor slab **(Figure 32).**
- Plastic tanking system had been fixed to the internal face of the ground floor to prevent damp ready to receive a high density polyisocyanurate insulation board fixed between timber stud walls fixed around the perimeter **(Figures 31 and 32).**

Summary

Building control have no enforcement powers to require the non-vapour permeable insulation to be removed and replaced with vapour permeable materials as it complies with the Building Regulations and Approved Documents. At this point building control will not be aware of the planning consent requirements and building control cannot require detailed plans or specification as the works were submitted on a Building Notice **(Appendix G)**.

Figure 31: Tanking system fixed to top of original floor and internal face of solid walls (Source: Gwynne, 2018).

Figure 32: Modern insulation fixed over tanking system ready for concrete floor slab (Source: Gwynne, 2018).

Case study 4: Damp in solid house walls renovated with hard non- permeable cement render and plaster finishes (works originally carried out in 2009).

The building owner renovated this traditional stone-built cottage circa 10 years ago **(Figure 33)**. This work had Building Regulations approval. This report author became involved when the building owners complained of damp and mould issues within the house.

Figure 33: Traditional stone-built cottage renovated with hard non- permeable cement roughcast render applied externally (Source: Gwynne, 2017).

Design stage

The owners claim the renovation works consisted of the following:

- External rough cast render applied to natural sandstone stone walls approximately 450mm thick, with waterproof paint finishes
- Gypsum plaster applied to internal walls with non- permeable paint finishes
- New pitched roof and rainwater goods
- New dormer roofs
- New kitchen and bathrooms etc

Works phase and unintended consequences

The owners claim a local builder carried out the works about 10 years ago. The hard non- permeable finishes applied 10 years ago had trapped rising damp **Figure 5)** causing deterioration of the surfaces through efflorescence **Appendix K1, Figures 34 and 37),** damage of internal finishes through crypto fluorescence **(Appendix K2, Figures 35 and 37)**. This led to mould growth and was hazardous to the occupant's health **(Figure 36).**

Figure 34: Efflorescence causing damage to hard gypsum plaster and finishes (Source: Gwynne, 2017).

Figure 35: Rising damp and Crypto fluorescence pushing off hard gypsum plaster (Source: Gwynne, 2017).

Figure 36: Black mould growth evident on internal plaster finishes (Source: Gwynne, 2017).

Summary

This is a good example of the unintended consequences of applying hard non-permeable finishes to vapour permeable walls that traps rising and penetrating moisture that eventually pushes through the finishes. This causes damage and deterioration of the building fabric, rotting timber embedded (joists/rafters) or attached to it (skirting boards etc). The dampness reduces the thermal insulation of the wall and eventually leads to mould growth.

Case study 5: Collapsed cob walling renovated with hard non- permeable cement render and internal plaster board finishes in December 2019.

In December 2019, this report author became involved with this project when asked for advice by the insurance loss adjuster's surveyor how to reinstate the collapsed cob walls for this property using vapour permeable materials. According to the owner the semi-detached cottage is unlisted and was built between 1790 and 1830. The first-floor walls are constructed of mud **(Appendix M1),** also called cob built over ground floor stone walls. Cob consist of mixtures of locally sourced clay soils, chalk, and sand, with straw to bind it all together (www.historicengland.org.uk). The walls are approximately 400mm thick built over the ground floor stone walls. The owner claims the cottage was renovated about 8 years ago **(Figure 37)**.

Figure 37: Cob walls renovated with non- permeable finishes

(Source: Gwynne, 2019).

Renovation stage

The owner claims the renovation works were completed approximately 8 years ago by a local builder and consisted of the following:

- Non- permeable smooth cement/sand render was applied externally to original first floor cob walls (approximately 400- 450mm thick), with waterproof paint finishes seen in **Figure 37.**
- Original stone walls on the ground floor were repointed externally in hard non-permeable cement/sand mortar seen in **Figure 37.**
- Gypsum plaster board applied to internal walls with non- permeable paint finishes
- New double glazed Upvc windows and doors **(Figure 37),** new pitched roof coverings and rainwater goods

Unintended consequences

Following collapse of the cob wall in December 2019 **(Figures 37 and 38),** a structural report was instructed by the insurance company's loss adjuster on behalf of the building owner.

Figure 38: Collapse of the cob wall (Source: Gwynne, 2019).

The report carried out by a structural engineer **(Extract of report is provided in Appendix M1 and M2)** concluded the hard-non- permeable finishes applied 8 years ago, had cracked externally (cracking is evident in **Figure 38),** allowing the ingress of rainwater into the cob. The report went on to say the water trapped by the hard non-permeable finishes were unable to evaporate harmlessly away, leading to deterioration and total collapse of the cob **(Figure 39).**

Figure 39: Collapse of the cob wall (Source: Gwynne, 2019).

Summary

This is a good example of the unintended consequences of applying hard non-permeable finishes to vapour permeable cob walls that traps penetrating moisture that cannot evaporate away. This causes deterioration and collapse of the building fabric, rotting timber embedded (joists/rafters) or attached to it (skirting boards etc). The dampness reduces the thermal insulation of the wall and eventually leads to mould growth.

Conclusion of case studies

The designs and specifications produced for the case studies and applied in the works phases are based on non- permeable modern methods of construction contained within the guidance in the Approved Documents. These are inappropriate for traditional, historic and listed buildings and can harm the building fabric and the health of its occupants. Examples of the inappropriate specifications used in the case studies and the problems of potential harm are given in **Figure 40** below.

Specification	**Potential harm**
Ground floors taken up and replaced with concrete, incorporating a plastic damp proof membrane and closed cell insulation such as polyisocyanurate (Kingspan/Celotex) and polyurethane (Hexatherm).	Traps moisture, prevents evaporation, reduces thermal performance. Moisture is pushed to the external walls, compounds rising damp problems which manifest within the building, degrading fabric and producing mould growth hazardous to the occupant's health.
Repointing and external rendering/internal plastering carried out using hard non- permeable cement-based mortars/gypsum plasters.	Traps the moisture and prevents evaporation causing penetrating damp, degrading fabric and producing mould growth.
New windows and doors, draught proofing including blocking up chimneys.	Prevents natural ventilation and increased risk of condensation and mould growth
Upgrading solid wall insulation (externally or internally fixed) carried out using non-vapour permeable closed cell insulation such as polyisocyanurate (Kingspan/Celotex) with non-vapour permeable finishes for example painted hard cement/sand render or painted gypsum plaster/board internally.	Traps moisture, prevents evaporation, reduces thermal performance, degrades fabric, leads to efflorescence **(Appendix K1**), crypto fluorescence **(Appendix K2)** and produces mould growth. The risk of collapse to cob walling is high. Damage to structural timbers from fungal infestation (for example, dry rot and wet rot, **Appendix K3)** and insect infestation (beetle attack, **Appendix K4)** is high.

Figure 40: Examples of inappropriate specifications and potential harm

5.0 Literature review

The purpose of this literature review is to search and evaluate relevant, reliable, accurate and up to date information and material on the topic area of this dissertation research of whether the Building Regulations are fit for purpose or not when upgrading of traditional, historic and listed buildings using modern applications. It hopes to gain a better understanding of how scholars view this topic area, how upgrading works are driven and focuses on how it impacts on this research topic. The key points from this literature review is summarised in **Figure 41** below.

Figure 41: Summary of literature review and summary of findings relevant to dissertation

Title of literature reviewed[1]	Summary of literature content	Summary of findings relevant to dissertation
1. Drivers of change		
1.1 All Party Parliamentary Group (APPG) for Healthy Homes and Buildings. B*uilding our Future Laying the Foundations for Healthy Homes and Buildings.* White Paper October 2018.	The all-party parliamentary group for Healthy Homes and Buildings was created to shed light on the many problems caused to the nation's health and economy as a result of people living and working in unhealthy homes and buildings.	Recommendation 3.2: '*The Government should adopt a holistic approach and ensure that future renovation of homes and buildings*, *in addition to making them energy efficient, improves other elements vital for health and wellbeing. This approach should… be adopted in the Building Regulations'.* Recommendation 3.8, '*It is recommended that the Building Regulations for new and renovation of existing buildings should be reviewed to ensure they reflect the best standards. More robust standards are required …to close the gap between design and actual performance'*
1.2 Global Warming of 1.5 degrees. Published by Intergovernmental Panel on Climate Change (IPCC). 2018.	Special report prepared by 91 authors from 40 countries on climate change and global warming led to the modelling that emissions from carbon dioxide would need to fall by 45% from 2010 levels by 2030 and 'net zero' by 2050.	This led to the UK Government commissioning a report on new emissions target for the UK:
1.3 The Clean Growth Strategy – Leading the way to a low carbon future. Published by HM Government. 2018.	An ambitious clean growth strategy setting out how the UK is leading the world in cutting carbon emissions to combat climate change while driving economic growth	This led to all fuel poor homes to achieve EPC band C by 2030- 70% of homes are affected.

1.4 Net zero: The UK's contribution to stopping global warming. Published by Committee on Climate Change. 2019.	Committee on Climate Change recommends a new emissions target for the UK: net-zero greenhouse gases by 2050.	This report led to (i) UK Government announcing net-zero greenhouse gases by 2050. (ii) Welsh Government announcing review of Approved Document L next year in line with announcements (Blick 2019)
1.5 Homes of Today for Tomorrow: Decarbonising Welsh Housing between 2020 and 2015. Stage 1: Scoping review. Stage 2: Exploring the potential of the Welsh housing stock to meet 2050 decarbonising targets. Published by Cardiff University. Green et al. 2019.	Cardiff University investigated the decarbonisation of Welsh housing by 2050 with massive improvements to the existing housing stock. It identified: 14 different dwelling types including four dwelling types pre 1919; 84% of the housing stock has already been built; much of it is far from efficient.	The report fails to identify special measures for the upgrading of solid wall houses built before 1919 using vapour permeable materials. The report proposes no distinction between performance standards for the retrofit of existing homes and new build homes.
2. Concept design		
2.1 Energy performance of heritage buildings: predictions and performance. Published by BRE. 2011.	The BRE investigated improving thermal performance in traditional buildings.	BRE concluded that national guidelines are required, including: (i) how buildings are intended to function and (ii) which interventions are appropriate for a construction.
2.2 Responsible Retrofit of Traditional Buildings. Published by Sustainable Traditional Buildings Alliance (STBA). 2012.	The STBA investigated concerns raised into the application of retrofit measures into the UK traditional building stock, including those incorporated into the Green Deal.	The STBA key findings included: '*There is a lack of understanding of traditional building performance in industry and policy, and a lack of connection between good research, certification process, guidance and practice'.*
2.3 BS 7913:2013. *Guide to the conservation of historic buildings*. Published by British Standards Institution (BSI). 2013.	BS 7913 is a standard of good practice for works to older, traditional buildings. The standard is intended for those who own, use, occupy and manage historic buildings, the professional team's contractors and others employed to work on their behalf, and can be used by decision makers and funders.	Although BS 7913 covers the conservation process from drivers of change to post project review it does not make any reference to the Building Regulations or Approved Documents. It does not provide any guidance on solid walled construction or use of vapour permeable materials. A major problem with BS 7913 is the public must pay to use it, putting it out of the reach of most people who will not be able to use it (and likely to default to the Building Regulations and Approved Documents for guidance).
2.4 *Energy efficiency in old buildings*. Published by SPAB. 2014.	Understanding old buildings – SPAB is at the forefront of research into the energy efficiency of old buildings.	SPAB concluded that natural (vapour permeable) insulation and other traditional materials are performing best in old buildings (constructed of vapour permeable materials).
2.5 *Solid wall heat losses and the potential for energy saving*. Published by Department of Energy and Climate Change (DECC), 2015.	DECC commissioned BRE to undertake research to improve understanding of the performance of solid wall properties in the UK.	BRE concluded that traditional buildings were built to be breathable and so installing impermeable insulation materials and vapour barriers increase the likelihood of moisture problems. Natural (vapour

		permeable) insulation materials (such as cellulose or sheep's wool) would be more suitable.
2.6 *PAS 2030. Specification for the installation of energy efficient measures in existing dwellings and insulation in residential park homes, and* *2.7 2035. Retrofitting dwellings for improved energy efficiency- specification and guidance.* Both published by British Standards Institution (BSI). 2019.	PAS 2020 and 2035 is publicly available specifications (PAS) of recommended procedure, quality of output, terminology, and other details, for the retrofitting of dwellings for improved energy efficiency.	Although PAS 2020 and 2035 provides theoretical specifications and guidance, it fails to provide any practical guidance or diagrams on retrofit of dwellings using vapour permeable materials fixed to solid walled dwellings. PAS 2035 refers to the Building Regulations 172 times and the Approved Documents 46 times – advising the reader to comply with these standards (which in themselves provide very little or no guidance). A major problem with PAS 2035 is the public must pay to use it, putting it out of the reach of most people who will not be able to use it (and likely to default to the Building Regulations and Approved Documents for guidance).
3. Opportunities		
3.1 *Skills Needs Analysis- Repair, Maintenance and Energy Efficiency Retrofit of Traditional (Pre 1919) Buildings in England And Scotland.* Published by Historic England. 2013.	Historic England, Historic Scotland and CITB commissioned researched into the supply of and demand for traditional building skills, materials and training provision for the repair and maintenance of traditional (pre 1919) buildings in England and Scotland.	The main findings concluded the economic recession has affected supply and demand and resulted in a shortfall of skills and training provision.
3.2 Green Deal- Energy saving home improvements. Published by HM Government. (no date)	The Green Deal helps people make energy-saving choices and improvements to homes and find the best way to pay for them.	The Green Deal fails to identify special measures required for the upgrading of solid wall houses built before 1919 using vapour permeable materials.
3.3 Renovating the EU building stock. Published by The Building Performance Institute (BPIE), Europe. 2019.	The BPIE is Committed to increasing the energy performance of buildings across Europe.	The BPIE develops recommendations and technical advice for overcome major barriers to renovation- all free of charge.
3.4 Building renovation passport. Published by BPIE. 2019.	A Building Renovation Passport is a Document outlining a long-term (up to 15-20 years) step-by – step renovation roadmap to achieve deep renovation for a building.	It supports owners across Europe with free of charge personalised advice on their renovation options and clarifies the renovation stages for all involved parties.
4 Technical design and specification		
4.1 Energy Efficiency and Historic Buildings: Insulating Solid Walls. Published by Historic England. 2012.	The guidance by Historic England provides advice on the principles, risks, materials and methods for insulating solid masonry walls.	The guidance dates to 2012 and advises the use of vapour barriers which has been superseded in recent research (SPAB, 2017). The guide does states that more research is needed.

4.2 A Bristolian's guide to solid 4.3 Wall insulation: A guide to the responsible retrofit of traditional homes in Bristol. Published by Bristol City Council. 2015.	This guidance commissioned by Bristol City Council is for people living in and people working on solid walled houses in Bristol built before 1919. It provides practical guidance and sketches on how to retrofit solid walled buildings including the use of vapour permeable insulations.	The guidance concluded that responsible retrofit is required when improving the comfort and energy efficiency of older solid walled buildings to avoid inappropriate and potentially damaging (non vapour permeable) measures being installed.
4.3 Retrofit insulation systems for old buildings. Published by Ty-Mawr. 2019.	Ty-Mawr have developed several vapour permeable insulation systems and finishes for roofs, solid walls and ground floors in compliance with the Building Regulations.	Nigel Gervis -technical director of Ty-Mawr has through practical research concluded that the thermal insulation requirements of the Building Regulations for solid wall insulation is unrealistic and problematic as it causes cold spots behind internal wall insulation, traps water and increases the risk of condensation and mould growth. Instead of a U-value of 0.3 for upgrading existing walls he increased the U-value to 0.7 and confirmed they have experienced less problems of trapped water, condensation and mould growth. In his opinion, design flexibility would allow higher insulation levels in the roof and floor to offset the lesser wall insulation levels.
5 Works phase	No relevant documents.	
6 Post project reviews		
6.1 100 unintended consequences of policies to improve the energy efficiency of the UK housing stock. Published by UCL Discovery. 2014	The authors undertook a scoping review of the UK Government policies to improve the energy efficiency the UK housing stock. They identified more than 100 un-intended consequences impacting building fabric, population health and the environment, thus high-lighting the urgent need for government and society to reconsider its approach.	The authors concluded a pressing need for the involvement of multiple stakeholders from a variety of disciplines to investigate the issues raised in the report holistically. Key issues could be highlighted, and regulatory measures framed to achieve UK Government policy goals without unduly jeopardising general health, well-being and the damage to building fabric, contents and the environment that is otherwise likely to occur.
6.2 Solid Wall Insulation: Unlocking Demand and Driving Up Standards. A report to the Green Construction Board and UK Government by the Chief Construction Advisor. Published by HM Government. 2015.	The Green Construction Board commissioned the Chief Construction Advisor to the UK Government to investigate: - why current demand for solid wall insulation is depressed and - why solid wall insulation has a poor reputation of inadequate installation and poor workmanship.	The Chief Construction Advisor to the UK Government grouped his findings into several themes, but the key findings for this dissertation are: -Proper design is frequently absent -There is an unacceptable risk of unintended consequences including damp, mould, poor air quality and poor building performance -Some standards are insufficiently detailed in respect of solid wall insulation and may

		not be fit for purpose including aspects of the Building Regulations, BS 5250, the RdSAP tool and PAS 2030. -The Building Regulations do not specifically address a national retrofit strategy or programme…guidance in the Building Regulations on renovation targets could be expanded. -There is a general lack of knowledge and skills -Building Control should be involved in the creation of a retrofit hub.
6.3 Each Home Counts: An Independent Review of Consumer Advice, Protection, Standards and Enforcement for Energy Efficiency and renewable Energy. Published by Department for Business, Energy & Industrial Strategy. Department for Communities and Local Government. 2016. Note: this is a follow up to the report on *Solid Wall Insulation: Unlocking Demand and Driving Up Standards. A report to the Green Construction Board and UK Government by the Chief Construction Advisor. Published by HM Government. 2015.*	The Government commissioned this document to determine ways of improving the confidence of consumers in the retrofit industry and quality of retrofit work. The report contains 27 recommendations including the establishment of a quality mark for the retrofit supported by an industry code of conduct, a consumer charter and a framework of technical standards for retrofit.	The authors key findings for this dissertation were -There are too many instances of poor-quality installations -Installations are being carried out by companies who do not have the skills, quality levels or core values to operate in this market -There should be a new framework of technical standards
6.4 Designing out unintended consequences when applying solid wall insulation. Published by BRE. 2016	The BRE found that green-house gas reduction policies and financial incentives resulted in an uptake in improvements to the existing housing stock. Attention is now turning to dwellings that are harder to treat that comprise of solid wall (brick and stone) dwellings. This has raised concerns of reports to the BRE of condensation, mould growth and other undesirable effects following solid wall insulation improvements.	The BRE concluded that environmental and financial benefits of insulating the UK's older building stock are significant. However, if this is implemented badly, several unintended consequences could be introduced that could jeopardise the integrity of the building elements and the health and wellbeing of the occupants as follows: -Overheating – heat can no longer be buffered by the walls -Increased relative humidity, associated damp and mould growth -Reduction in indoor air quality -Short term concentrations of volatile organic compounds (VOC's) -Elevated radon gas concentrations -Creation of new thermal bridge/condensation points -Rot and/or insect attack on structural timbers

		-Frost damage withing walls -Failure of internal surface finishes -Interstitial condensation. U-value targets from national Building Regulations may be too demanding in some cases. For example, to achieve the target values in breathable, historic structures, there may be an unnecessarily high risk of introducing problems.
Notes: 1. Literature review excludes the legislative requirements of the Climate Change Act 2008 and Energy Act 2013.		

5.1 Conclusion of the literature review

The review has achieved its overall aim to gain a better understanding of how scholars view the Building Regulations and Approved Documents as providing enough guidance for new works applied to traditional, historic and listed buildings. With Governments driving to achieve net zero carbon by 2050 and insulation standards continually improving, this review has found convincing evidence to support the fact that some standards are insufficiently detailed in respect of solid wall insulation and may not be fit for purpose, including aspects of the Building Regulations. There is also evidence that the Building Regulations and Approved Documents are not providing enough guidance to support the retrofit of traditional, historic and listed buildings. Where this guidance is not forthcoming, the task of practical technical design and specifications suitable for vapour preamble solutions seems to be left to the private sector. This can lead to unregulated solutions that may be unsuitable or inappropriately applied to traditional, historic and listed buildings with unintended consequences and problems highlighted in the post project literature reviews.

6.0 Questionnaires

6.1 Purpose

This survey was carried out to assess how the construction industry view the Approved Documents to the Building Regulations as providing enough guidance for new works applied to traditional/historic/listed buildings. The purpose of using questionnaires for this research is to gain a better understanding of how traditional, historic and listed buildings in Wales are upgraded using modern methods of construction. The main advantages of using a questionnaire is being able to reach a large number of building professionals relatively easily and economically. The questionnaires were specifically designed to be exploratory with the approach of researching 'what is going on', 'why is it going on' and by whom. A copy of the questionnaire is provided in **Appendix J1 and J2.**

The study was designed to provide quantifiable answers that could be easily analysed to determine how building professionals, view the Building Regulations and Approved Documents as being fit for the purposes when carrying out works to traditional and historic buildings.

6.2 Ethics approval

The survey was approved by the Research Ethics Committee of the Welsh School of Architecture - Reference 190503 (002) on 8th May 2019 **(Appendix C).**

6.3 Questionnaire distribution list

The distribution list consisted of persons normally engaged in designing, preparing specifications, submitting and making decisions on planning and building control applications. The list included building contractors, building owners, building control surveyors, conservation officers, designers (including architects, surveyors, structural engineers etc). A copy of the distribution list is provided in **Appendix J3.**

6.4 Questionnaire analysis

The survey was sent out on 16th May 2019 with a return date of 1st July 2019. 149 questionnaires were sent out to a range of building professionals including building control surveyors, building contractors, building owners, conservation officers, structural engineers, designers and architect. 15 completed questionnaires were returned equating to 10% indicated in **Figure 42.**

Figure 42: Questionnaires returned

Received from	**Number returned**
Building contractor	3
Building owner	1
Conservation officer	2
Designer (including Architect/surveyor/structural engineer)	6
Other (manufacturer & supplier)	1
Building control surveyor	2
Total returned	**15**

The questionnaires were analysed in twelve main topic areas identified in **Figure 43.**

Figure 43: Analysis of questionnaires returned (Copies of questionnaires are available to view on request to report author).

Question	**Question asked for project carried out**	**Number who answered no (%)**	**Number who answered yes (%)**	**Number who declined to comment (%)**
1 to 3	Was the building professional involved with project a carried out to a traditional, historic or listed building within the last two years?	0 (0%)	15 (100%)	0 (0%)
4 to 6	Are you conservation accredited?	11 (73%)	4 (27%)	0 (0%)
7	Are you aware of what vapour permeable construction/ materials are?	0 (0%)	15 (100%)	0 (0%)
8	Are you aware of that non- vapour permeable construction can harm traditional and historic buildings in certain situations	1 (7%)	14 (93%)	0 (0%)
9 to 11	If planning/listed building consent /building regulations or	7 (47%)	8 (53%)	0 (0%)

	faculty was required were there conditions requiring the use of vapour permeable materials?			
12 to 14	Was there a vapour permeable design specified for the works?	2 (13%)	13 (87%)	0 (0%)
15	Were future maintenance requirements considered?	4 (27%)	10 (67%)	1 (7%)
16	Did cost influence the use of materials used? (assuming vapour permeable solutions are more costly)	9 (60%)	5 (33%)	1 (7%)
17	Did the time taken to complete the works influence the materials used? (assuming vapour permeable solutions take longer)	10 (67%)	4 (27%)	1 (7%)
18	Were there any problems evident after the works were carried out? (for example, damp)	10 (67%)	5 (33%)	0 (0%)
19	Do you consider the Approved -Documents to the Building Regulations provide enough guidance for new work applied to traditional/ historic/ listed buildings?	14 (93%)	1 (7%)	0 (0%)
20	Any other information considered relevant?	0 (0%)	9 (60%)	6 (40%)

A summary of the questionnaires results is provided in **Figure 44.**

Figure 44: Summary of questionnaire results (Copies of questionnaires are available to view on request to the report author).

Question	Summary of results and authors comments
Questions 1 – 3: *Was the building professional involved with a project a carried out to a traditional, historic or listed building within the last two years?*	The results indicate that 100% of building professionals were involved with a project carried out to a traditional, historic or listed building built before 1919 with solid wall construction within the last two years. *Comment: This is an important part of this research as it reflects the building professionals' views of current legislation and how it impacts on their project.*
Questions 4-6: *Was the building professional conservation accredited?*	*The results indicate that 73% of building professionals are not conservation accredited and 27% are.* *Comment: There are a number of conservation accreditation schemes that identify individuals who have achieved a recognized level of competence in building conservation (BS 7913, 2013). In this survey 73% percentage of property professionals are not conservation accredited although they undertake such work. It is important to note that there is no requirement for property professionals undertaking such work to be conservation accredited or a competent person and BS 7913 (2013) only advises users to consider the desirability of accreditation or competency schemes.*
Question 7: *Is the building professional aware of what vapour permeable construction /materials are?*	The results indicate that 100% of building professionals claim to be aware of what vapour permeable construction/ materials are. *Comment: Often referred to as breathability, vapour permeability describes a material's ability to allow water vapor to pass through it. This report will examine the extent of how the Approved Documents to the Building Regulations relies on building professional's awareness of this when they are specifying works to traditional/historic/listed buildings when there is no legislative requirement for it (see question 8 below).*

Question 8: *Is the building professional aware that non-vapour permeable construction can harm traditional and historic buildings in certain situations?*	The results indicate that 93% of building professionals claim to be aware that non- vapour permeable construction can harm traditional and historic buildings and 7% were not.
Questions 9-11: *If planning/listed building consent /Building Regulations or faculty was required were there conditions requiring the use of vapour permeable materials?*	The results indicate that 53% of building professionals claim there were conditions attached to planning/listed building consent /Building Regulations the use of vapour permeable materials and 47% claim they were not. *Comment: Examination of the questionnaires revealed that 11 of the projects were listed buildings and from the information available would have required listed building consent. Its interesting to note that from the results only 8 out of 15 of those projects had listed building consent and at least three of those projects had no conditions attached requiring the use of vapour permeable materials. There was no mention of any conditions attached to any Building Regulations consent.*
Question 12 -14: *Was there a vapour permeable design specified for the works?*	The results indicate that 87% of building professionals claim there was a vapour permeable design specified for the works and 13% claim there was not. *Comments: It's interesting to note that in question 9-11 only 8 out of 15 projects had conditions for the use of a vapour permeable design and in question 12-14 that 13 projects had a vapour permeable design. It is assumed this is down to the conservation officer's early involvement with the project at the planning stage and close liaison with the project designer. Non-listed traditional/historic buildings do not have the benefit of early involvement of the onservation officer who would normally require a vapour permeable design as non- vapour permeable materials could harm the building fabric and is contrary to the Planning (Listed Buildings and Conservation Area) Act 1990. From the experience of this project author, building control normally only become aware of the project when works start on site and if no*

	vapour permeable design has been agreed between the owner and builder, a modern non-vapour permeable solution is normally applied as it is cheaper and construction time is less as highlighted in the case studies in this report.
Question 15: *Were future maintenance requirements considered?*	The results indicate that 67% of building professionals claim that future maintenance requirements were considered, 27% claim they were not and 7% declined to comment. *Comments: Routine maintenance is an important consideration for vapour permeable materials as they require regular planned repair (www.lime.org.uk). For example, the lime washing of lime render or repointing of stonework in a planned maintenance schedule will prevent disrepair and the cost of unnecessary repairs. Consideration of future regular maintenance checks can help plan for the future and predict any potential problems and repair costs that could lead to deterioration and harm of the building fabric.*
Question 16: *Did cost influence the use of materials used? (assuming vapour permeable solutions are more costly).*	The results indicate that 60% of building professionals claim that cost did not influence the use of materials used, 33% claim they did and 7% declined to comment. *Comments: It is clear from the results that cost in just under two thirds of cases did not influenced the use of materials used. This is supported in question 12 to 14 of this survey that 87% of building professions claim to have used a more costly vapour permeable solution and the cheaper option of non-vapour permeable solution was not used in most cases. This is ignificant to this survey as in question 9 to 11, only 53% of planning/listed building/building control applications had conditions requiring the use of vapour permeable solutions and 87% of building professionals chose to use them. Further research would be required to establish if cheaper vapour permeable options were used instead of others, for example the use of cheaper Rockwool insulation (www.rockwool.co.uk)*

	instead of more expensive sheep's wool insulation (www.lime.org.uk).
Question 17: *Did the time taken to complete the works influence the materials used? (assuming vapour permeable solutions take longer*).	The results indicate that 67% of building professionals claim that the time taken to complete the work did not influence the use of materials used, 27% claim they did and 7% declined to comment. *Comments: It is clear from the results that time taken to complete the works in over two thirds of cases did not influence the use of materials used. This is supported in question 12 to 14 of this survey that 87% of building professions claim to have used a vapour permeable solution that is more time consuming to apply and the option of non-vapour permeable solution that is quicker to apply were not used in most cases. This is significant to this survey as in question 9 to 11, only 53% of planning/listed building/building control applications had conditions requiring the use of vapour permeable solutions and 87% of building professionals chose to use them*.
Question 18: *Were there any problems evident after the works were carried out? (for example, damp*).	The results indicate that 67% of building professionals claim that there were no problems evident after the works were carried out and 33% claim there were. It's interesting to note that in survey question 2, one job had commenced, nine were in progress and only four had been completed. Out of the four jobs completed, three complained of actual problems one of which were related to the performance of the vapour permeable solution other than poor detailing, slight shrinkage cracking of render and discolouration of lime wash. It is clear from the results of the complete works that vapour permeable solutions perform well, however, further research would be required to establish if the other projects in progress perform the same.

Question 19: *Do you consider the Approved Documents to the Building Regulations provide enough guidance for new work applied to* traditional/ historic/ listed buildings?	The results indicate that 93% of building professionals consider that the Approved Documents to the Building Regulations do not provide enough guidance for new work applied to traditional/ historic/listed buildings and 7% consider they do. Those who consider they do not provide enough guidance have made the following comments: *'Although guidance is available and referred to in AD (Approved Document) Part C and L – in my opinion there should be clauses added in the required section specifically for heritage buildings'.* *'They primary apply to new build and are driven by solutions appropriate to new construction'.* *'This primarily reflects a lack of research and understanding and development of appropriate solutions for historic buildings'.* *'The guidance is loose and building inspectors don't often understand the exemptions or reasoning behind them'.* *'The Building Regulations provide no solutions to any issues experienced by historic constructions'.* *'The regulations are suitable for new construction works. They do not address historic building techniques, materials and their interface with modern building concepts'.* *'Not much information relating to traditional construction'.* *'I have been in building design for 50 years and although I understand the concept of breathability, I cannot take the chance in applying materials which may lead to my client making a claim against me if any damp becomes evident as a result. If the*

	planning permission or listed building consent does not require the use of breathable materials I will not specify them. Also, the Building Regulations and supporting Approved Documents have no practical guidance or requirement of their use, there is only mention of them in the Approved Documents and building control surveyors seem to prefer you to use modern materials instead of breathable materials as they understand them and their use. Again, I believe that the building inspectors are concerned that using breathable materials may cause damp and health issues for which they can be sued'. *'They do not fully recognise the difference between cavity wall and solid construction'.* *'Information very limited and woolly'.* *'At the time the following contradicted with the regs:* • *Cylinder glass did not comply* • *Window glazing did not comply (thermally and thickness)* • *Issues between building control and Cadw not resolved'.* *'Current documents do not take into account the effect of modern impermeable materials have on traditional construction'.* *'Not enough detail given to the breathability requirements of traditional buildings. Too much emphasis on sealing the building and reducing draughts which are important in maintaining fabric breathability (bidirectional) as well as ensuring optimal performance of any open fires'.* *'They only tend to deal with things on a seal them up and apply a raincoat basis….no allowance for thermal mass, breathability, solid walls…. The overcoat basis'.*

Question 20: *Any other information considered relevant?*	The results indicate that 60% of building professionals provided additional information they claimed was relevant and 40% declined to comment. Those who provided additional information made the following comments: *'Much of the problems arise from inadequate training and understanding amongst those in the various professions and in the field'.* *'Upgrading for EPC in rented accommodation is causing un-authorised changes sometimes by building control officers who don't understand solid wall construction and or listed buildings'.* *'Historic buildings are not in any way generic…. were constructed in a trial and error way…it is common to find that the building is not as predicted. 'Specifications and detailing need to change. These changes are often not addressed or even appropriate to the Building Regulations'.* *'The builder was largely ignorant of traditional building construction until specified and notified by Us'.* *'The insulation requirements for existing historic solid wall buildings is too much and can lead to condensation issues and these levels in my opinion should be reduced for the sake of the building'.* *'Patented solutions provided by the private sector are exclusive and expensive'.* *'There is too much emphasis on thermal value rather than building health. The usual unintended consequence is a poorer functioning, damp, colder building'.* *On receipt of this questionnaire the author of this report rang Nigel Gervis technical director at Ty-Mawr (www.lime.org.uk) to explain the above reply. He claims that Ty-Mawr has through practical research concluded that the thermal insulation*

	requirements of the Building Regulations for solid wall insulation is unrealistic and problematic as it traps water and increases the risk of condensation and mould growth (This was also the conclusion of SPAB – see paragraph 3.1.5). Instead of a U-value of 0.3 for upgrading existing walls they increased the U-value to 0.6 and has had less problems of trapped water, condensation and mould growth. In his opinion, design flexibility would allow higher insulation levels in the roof and floor to offset the higher wall U-values. *'No completion certificate issued on this project as some of the requirements of building control officer too difficult to achieve without harmful damage to historic fabric'.* *'The Building Regulations are guidelines, and this should be remembered'.*

6.5 Conclusion of questionnaire analysis

The questionnaire survey summarised in **Figure 44** has achieved its overall aim to gain a better understanding of how property professionals (architectural designers, builders and property owners etc) view the Building Regulations and Approved Documents as providing enough guidance for new works applied to traditional, historic and listed buildings. All those surveyed had carried out at least one project to a traditional, historic or listed building within the past two years. Less than one third was conservation accredited but most were aware of what vapour permeable materials were and the harm that using non-vapour materials did when applied vapour permeable construction. Although most property professionals produced a vapour permeable specification for the works, less than half of the consents issued formally through the planning/listed building/building control processes required the use of vapour permeable materials. Almost all those surveyed expressed concerns that the Approved Documents to the Building Regulations did not provide enough guidance for new works to traditional/historic/listed buildings- they favour modern building solutions. In one instance, it was claimed that property professionals and building control surveyors favoured the application of modern materials to that of breathable materials as it can be used is a defence against litigation if problems occur.

7.0 Solutions to the problems

7.1 Do nothing

One way to avoid some of the problems and unintended consequences detailed in sections 4, 5 and 6 may be to decide not to undertake the new works (e.g. to do nothing). However, with Governments driving net zero carbon targets by 2050 and making changes to legislation for improved insulation standards with no distinction between performance standards for retrofit and newbuild (Green et al. 2019), to do nothing is not an option. This is particularly important when considering how pre 1919 solid walled vapour permeable buildings are to be upgraded to insulation standards well above those of today. As already seen in section 4, to achieve todays U-value of 0.3 for upgrading existing building walls already requires at least 150mm thickness of vapour permeable insulation which could be far more if we have to achieve net zero carbon reduction with no distinction between retrofit and new build. The additional thickness of insulation would be impractical and to use thinner more energy efficient non-vapour permable insulations on vapour permeable construction would cause disastrous consequences already discussed in section 4.

7.2 Make changes to the Approved Documents

Making changes to the Approved Documents to the Building Regulations, by the addition of more guidance for traditional, historic and listed buildings. For example, each Approved Document could have a paragraph included under the heading of '*General guidance'* at the front of the document as follows:

General Guidance

Traditional buildings (built before 1919)

Buildings built before 1919 are normally constructed with solid walls typically of natural stone or brick in lime mortar (or cob) with lime render and plaster finishes. This type of construction is termed 'traditional construction' which is naturally porous and allows the building fabric to 'breath' naturally through the permeation of water vapour. It does not incorporate the barriers to external moisture such as cavities, rain-screens, damp-proof courses, vapour barriers and membranes which are standard in modern construction. As a result, the permeable fabric in traditional structures tend to absorb more moisture, which is then released by internal and external evaporation. When traditional buildings are working as they were designed to, the evaporation will prevent trapping of water and keep dampness levels in the building fabric below the levels at which decay can start to develop. This is often referred to as 'vapour permeability' or a 'breathable building'.

As traditional buildings need to 'breathe' the use of vapour barriers, non vapour permeable insulations, cement renders, gypsum plasters and other impermeable materials commonly found in modern buildings must be avoided when making improvements to energy efficiency, as these materials can trap and hold moisture and create problems for the building and potential health issues for the occupants. The use of new materials for any upgrading works to traditional buildings should be vapour permable and need to be based upon an informed analysis of the full implications of their inclusion in order to minimise the risk of problems arising. Further guidance on the use of vapour permeable construction is provided in the ***'Traditional Buildings Compliance Guide'*** *in support of this Approved Document.*

In addition to the compliance guide (**see paragraph 7.3**), additional information in the form of simple diagrams for the upgrading of vapour permeable construction could be included in the Approved Documents. This additional information should be kept very plain and clear and very simple as those already contained in the current Approved Documents, not to make it too complicated. An example of what the additional guidance could look like in Approved Document C is illustrated in **Figures 45 and 46.**

Each diagram would be supported by a technical solution which would be subject to further research beyond the scope of this dissertation.

Diagram 5 **Ground supported floor – vapour permeable construction**

(see paragraph 4.8)

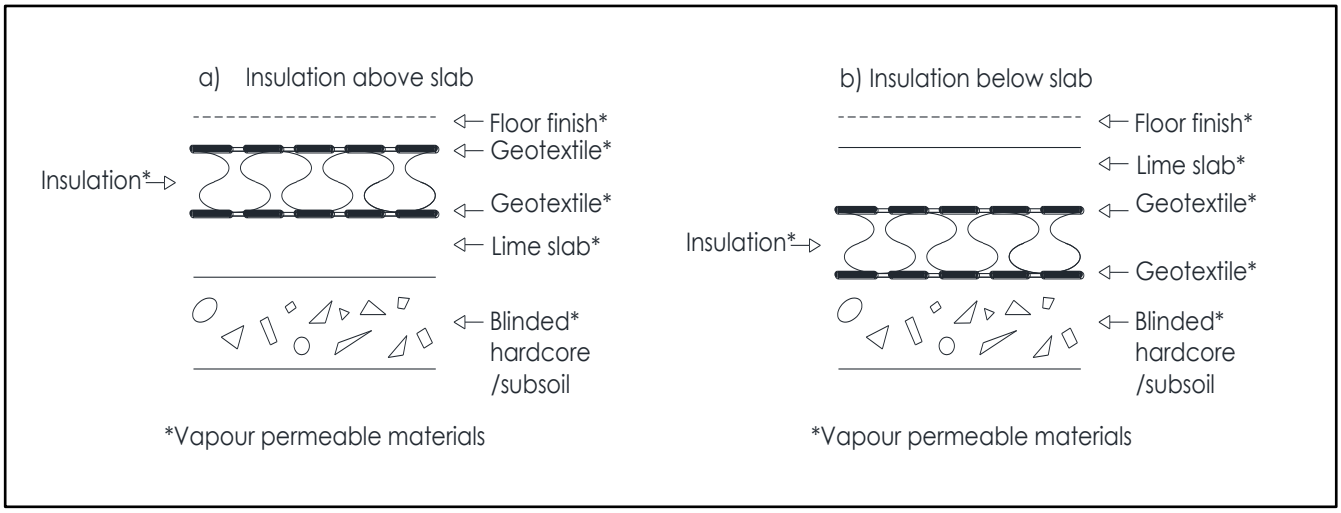


Figure 45: How vapour permeable guidance for ground floors could look in Approved Document C (Source: Gwynne, 2019).

Diagram 12 **Insulated external walls – vapour permeable construction**

(see paragraph 5.18)

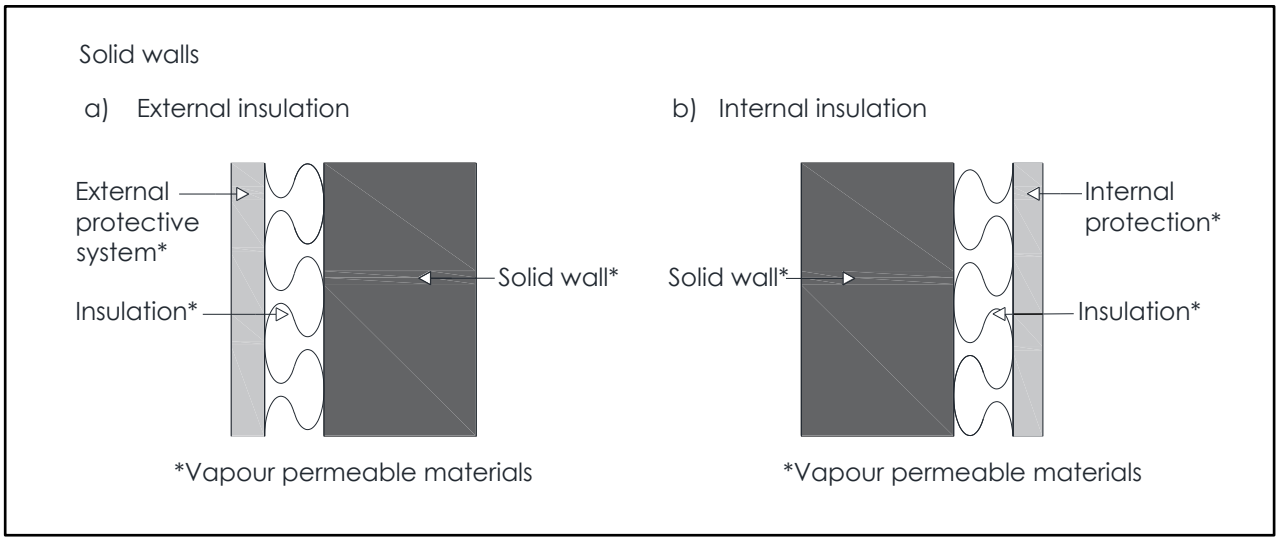


Figure 46: How vapour permeable guidance for insulated external walls could look in Approved Document C (Source: Gwynne, 2019).

7.3 Produce a National Compliance Guide

The Government could produce a National Compliance Guide in support of the Approved Documents. It should contain technical solutions presented in a generic form as simple design specifications and sketches that can be applied to most common building situations involving vapour permeable solutions. This additional guidance should be easily available at no cost. It would give public confidence to apply these details to traditional buildings without fear of repercussions and litigation (see Figure 44, Question 19 and paragraph 10) as compliance with an Approved Document tends to demonstrate compliance with the Building Regulations (stated in the front of each Approved Document). An example of a how the compliance guide could be presented is illustrated in Figure 47. This subject to further research and is not in the scope of this dissertation.

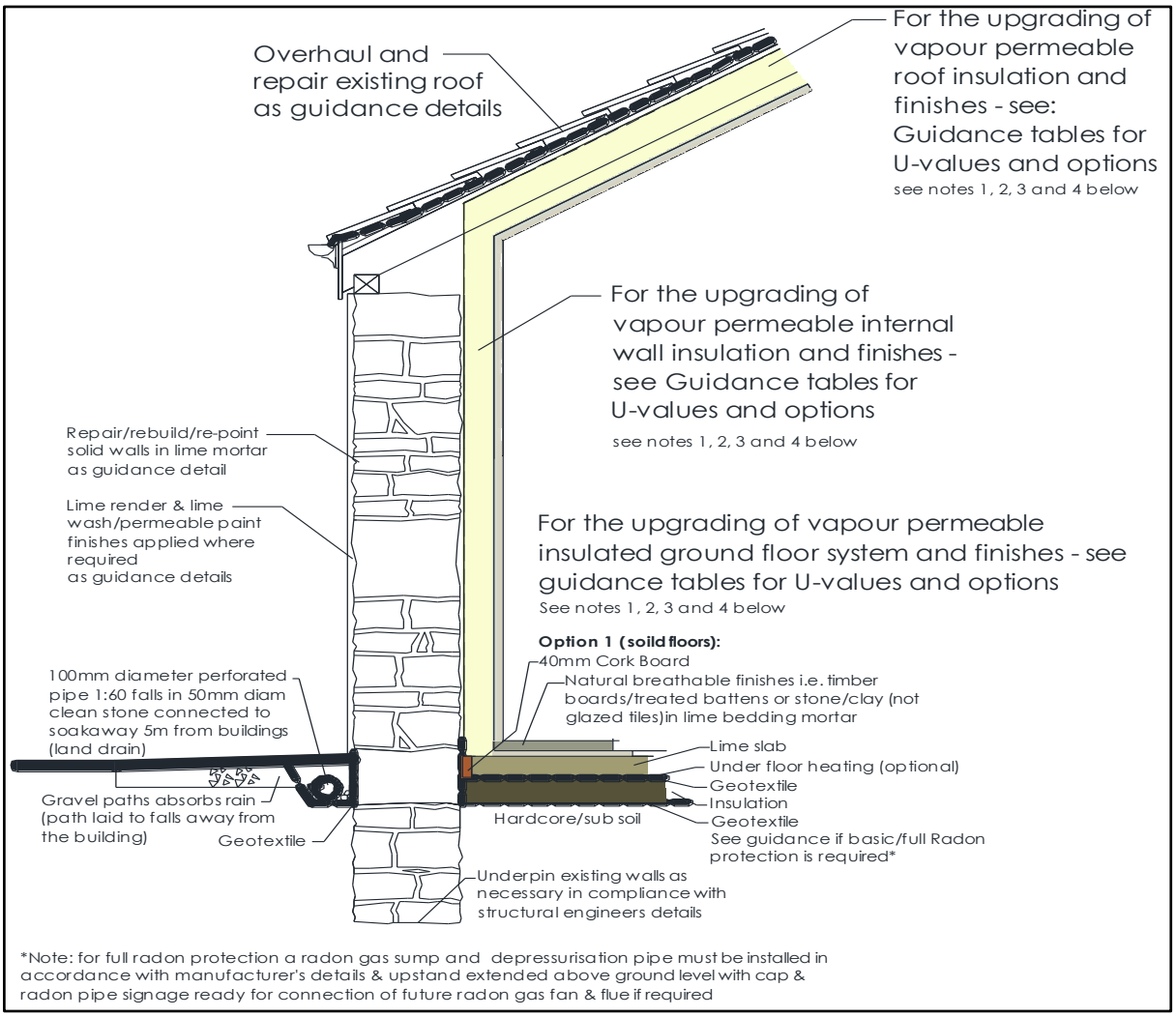


Figure 47: Example of how the national compliance guide could be presented (Source: Gwynne, 2019).

7.3 Invest in technical solutions and information Hub

Technical generic solutions for the compliance guide could be provide by industry and specialists investing in the latest research and development of energy efficient vapour permeable products for traditional buildings. This could be Government supported. The companies providing the technical solutions would benefit from sales of their patented solution. This would open the market for competition and address concerns that patented designs are exclusive and expensive. This could lead to the setting up of an information Hub for the benefit of the construction industry and owners of traditional, historic and listed buildings.

For example Ty-Mawr (www.lime.org) are national and international industry leaders on this subject, based in Wales they research, design, manufacture and test retrofit energy efficient vapour permeable systems for traditional buildings. They provide technical support, seminars and training for their products. Examples of Ty-Mawr's technical solutions are illustrated in **Figures, 48, 49, 50 and 51.** A note of caution - the technical solutions shown here are for illustration only and are not an endorsement of their suitability. Other technical solutions are available and are not covered in this study.

Figure 48: Vapour permeable ground floor solution (Source: Ty-Mawr, 2019).

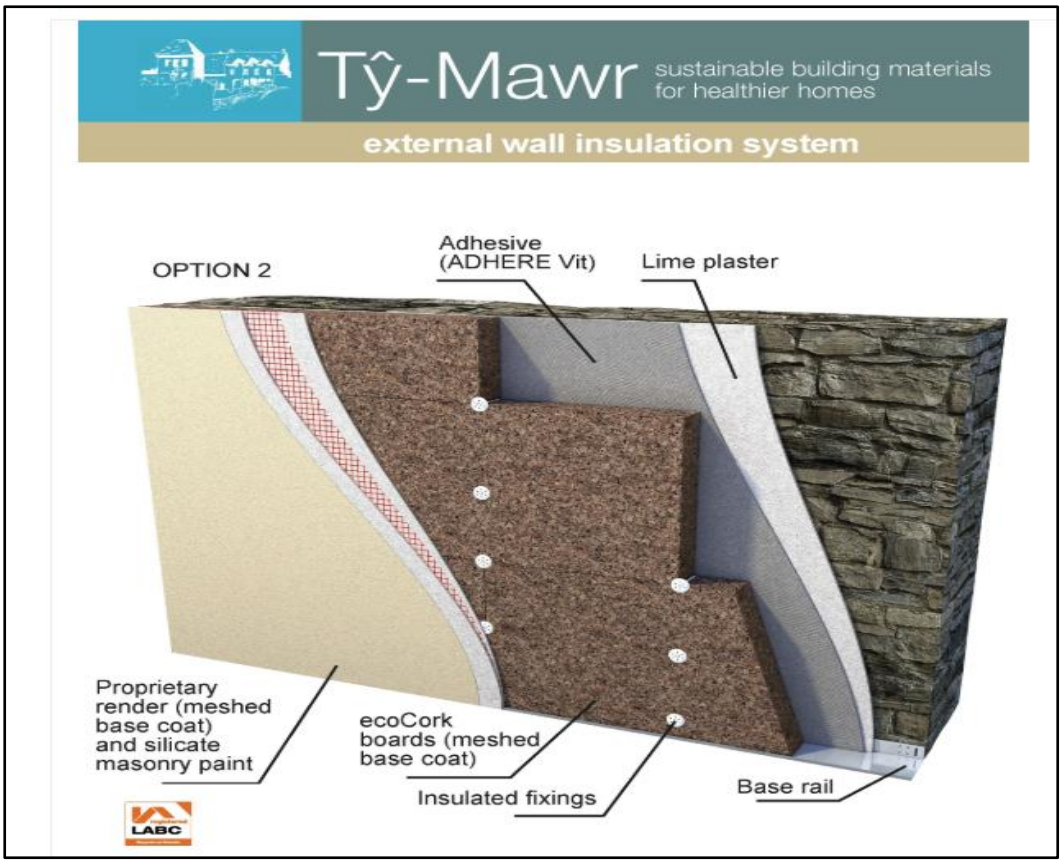


Figure 49: Vapour permeable external wall solution (Source: Ty-Mawr, 2019).

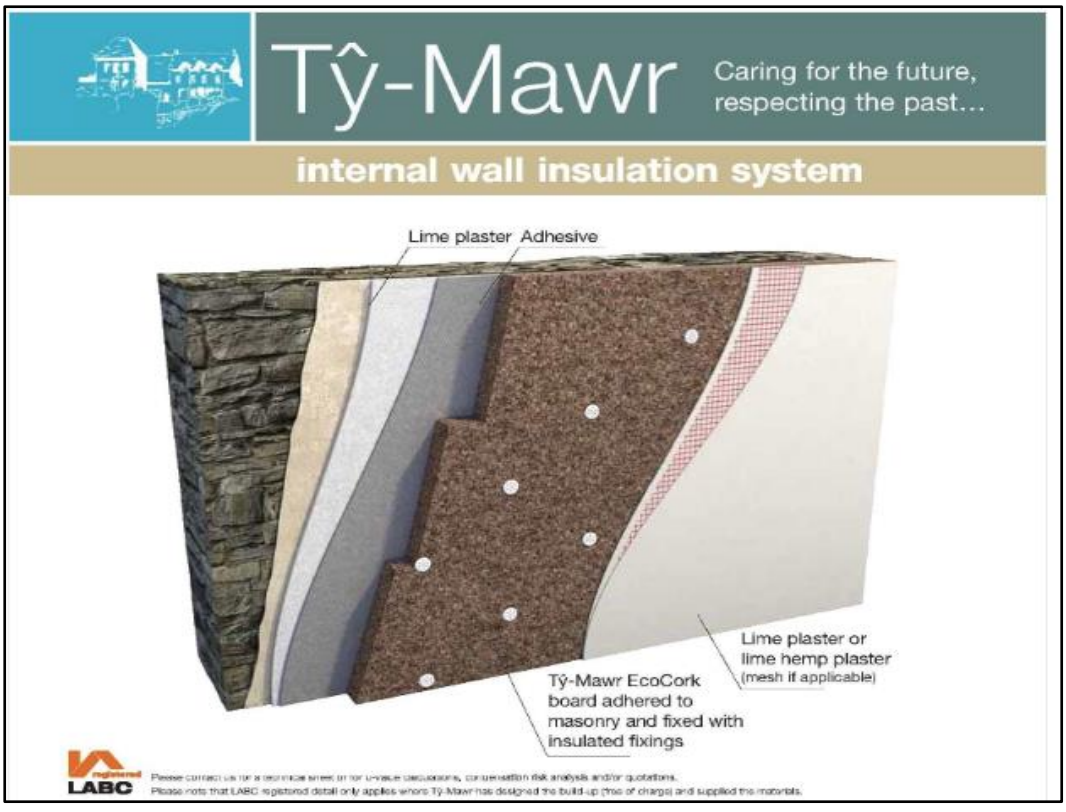


Figure 50: Vapour permeable internal wall solution (Source: Ty-Mawr, 2019).

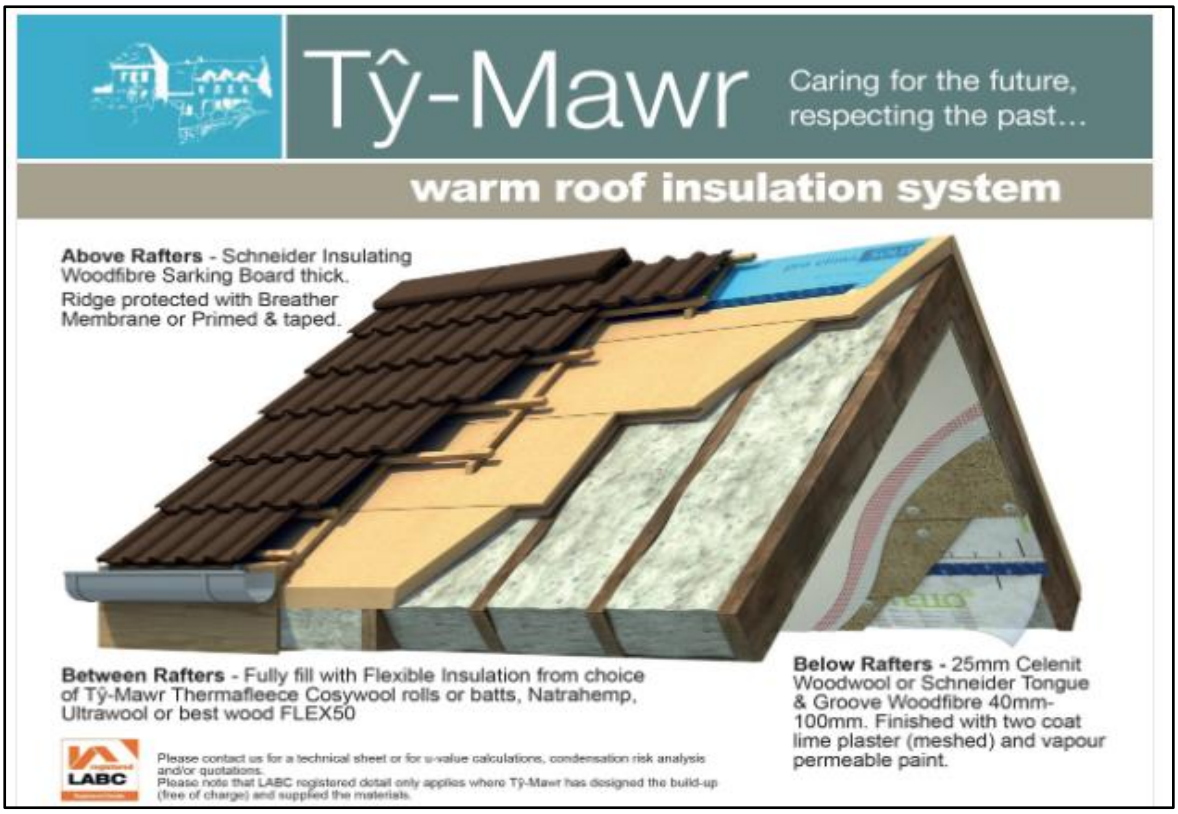


Figure 51: Vapour permeable warm roof solution (Source: Ty-Mawr, 2019).

8.0 Key findings

8.1 Background

(i) Traditional buildings built with solid walls must have the ability to absorb and Release water and water vapour as humidity levels change through hygroscopicity and capillary attraction otherwise it cannot function as intended and traps water.

(ii) Modern non-vapour permeable insulations and finishes are being inappropriately applied to upgrade solid stone vapour permeable walls.

(iii) Inappropriate upgrading of traditional buildings has resulted in disastrous consequences of trapped moisture and rises in relative humidity levels preventing solid walls from drying out. This is causing deterioration of the building fabric, rotting of structural timbers embedded in walls and mould growth

on internal wall surfaces hazardous to occupant's health. It has also caused the collapse of cob walling illustrated in case study 5 and **Figures 37, 38 and 39**.

8.2 The Problem

(i) Approved Documents to the Building Regulations do not provide practical guidance for traditional buildings built with solid walls or vapour permeable construction and advice is very limited for historic and listed buildings.

(ii) The Welsh Government have said they have already made changes to improve guidance in the Approved Documents and they are unlikely to make any more unless there is good reason.

(iii) Non-vapour permeable applications are being inappropriately applied to traditional forms of vapour permeable construction with disastrous results.

(iv) Current U-value calculations underestimate the actual thermal performance of traditional solid walls.

(v) Current U-value requirements for upgrading traditional buildings are unrealistic and problematic as it traps water and increases the risk of condensation and mould growth. Wall areas behind internally applied insulation becomes a cold bridge and compounds this problem. The current U-value of 0.3 for upgrading existing solid walls should revised to 0.7 to reduce these risks.

(vi) If Government revisions for Approved Document L improves U-value requirements for traditional buildings, the thickness of insulation required will be technically difficult to achieve if using appropriate vapour permeable solutions and there is concern that without guidance, thinner inappropriate non-permeable insulation would be used with disastrous results.

(vii) New standards being produced for guidance are too expensive to buy (PAS 2030, 2035 and BS 7913). These costs are putting guidance out of the reach of most people who will not be able to use them and likely to default to the free

of charge Approved Documents for guidance.

8.3 Drivers of change

(i) Home improvements and energy efficiency measures are being driven by building owners through:

- Aspirations of improved thermal comfort
- Changes in climatic conditions (wetter winters and dryer/hotter summers and increased humidity).
- Changes in legislation and the Building Regulations

(ii) Improvements to insulation standards and energy efficiency targets to the existing building stock is being driven by the UK Governments to achieve net zero carbon by 2050.

(iii) Decarbonization of Welsh housing by 2050 is being driven by the Welsh Government and have produced reports making the following recommendations:

- Existing housing stock is to be made more energy efficient.
- There should be no distinction between performance standards for retrofit and newbuild.
- There should be no distinction between standards based on tenure or housing type.

8.4 Case studies

The five case studies in section 4 demonstrate how the guidance for upgrading modern buildings in the Approved Documents is being inappropriately applied to traditional, historic and listed buildings by designers, builders and property owners. Case studies 1, 2 and 3 are good examples of how inappropriate upgrading is being carried out. Case studies 4 and 5 are good examples of the unintended consequence of applying inappropriate upgrading to a vapor permeable walls, causing caused deterioration (and even collapse in case study 5) of the building fabric, leading to mould growth hazardous to the occupant's health.

8.5 Literature review

The review found:

(i) Some standards produced for retrofit are insufficiently detailed in respect of solid wall insulation and may not be fit for purpose including aspects of the Building Regulations.

(ii) The Building Regulations and Approved Documents are not providing enough guidance to support the retrofit of traditional, historic and listed buildings.

(iii) Where guidance for retrofit is not forthcoming, the task of practical technical design and specifications suitable for vapour preamble solutions are provided by the private sector. This has led to criticism that patented solutions are exclusive and expensive.

(iv) The public must pay to use Publicly Available Specifications PAS 2030, 2035 and BS 7913. These costs are putting these standards out of the reach of most people who will not be able to use it and are likely to default to the Building Regulations and Approved Documents for guidance. This can lead to unregulated solutions that may be unsuitable or inappropriately applied to traditional, historic and listed buildings with unintended consequences and problems highlighted in the post project literature reviews.

8.6 Questionnaires

The questionnaire survey found:

(i) Almost all those surveyed expressed concerns that the Approved Documents to the Building Regulations did not provide enough guidance for new works to traditional/historic/listed buildings.

(ii) Property professionals and building control surveyors favoured the application of modern materials to that of breathable materials for the following reasons;

a. They are contained in the Approved Documents

b. Modern applications are well understood by the industry (vapour permeable solutions are not).

c. What is stated in the Approved Documents can be used as a defence against litigation if problems occur. There is reluctance to use vapour permeable solutions if specific guidance is not provided in the Approved Documents.

8.7 Solutions to the problems

Four solutions to the problems were considered:

(i) **Do nothing** - with Governments driving net zero carbon targets by 2050 and making changes to legislation for improved insulation standards which has no distinction between performance standards for retrofit and to do nothing is not considered as a viable option.

(ii) **Make changes to the Approved Documents-** Making changes to the Approved Documents is a good viable option which could include the provision of:

- Make changes to the Elemental U-values of traditional buildings
- General guidance on traditional buildings built before 1919 located in the front of all the Approved Documents.
- Simple diagrams in selected Approved Document for vapour permeable solutions - kept plain, simple and clear like those that already exist.

(iii) **Produce a National Compliance guide** – Technical solutions could be produced as a supplementary (free of charge) compliance guide in support of the Approved Documents. This could be presented in a generic form as simple design specifications and sketches that can be applied to most common building situations involving vapour permeable solutions. This additional guidance would be easily available at no cost. It would provide public confidence to apply these details to traditional buildings without fear of repercussions and litigation as compliance with an Approved Document tends to demonstrate compliance with the Building Regulations.

(iv) **Invest in technical solutions -** Technical generic solutions for the compliance guide could be provide by industry and specialists investing in the latest research and development of energy efficient vapour permeable products for traditional buildings. The companies providing the technical solutions would benefit from their patented solution. This would open the market for competition and address concerns that patented designs are exclusive and expensive.

9.0 Conclusion

The key findings of this dissertation have concluded that the Building Regulations and supporting Approved Documents produced by the Welsh Government are not fit for purpose when carrying out building works to traditional, historic building and listed buildings.

10.0 Recommendations

Recommendations are as follows:

1. **Make changes to the Approved Documents**

- Review Elemental U-value requirements for upgrading traditional buildings. The current U-value of 0.3 for upgrading existing solid walls should be raised to 0.7 to reduce risk of condensation and trapped water.
- Provide general guidance on traditional buildings built before 1919- located in the front of all the Approved Documents.
- Provide simple diagrams in selected Approved Document for vapour permeable solutions - kept plain, simple and clear like those that already exist.

2. **Produce a National Compliance Guide**

- The Government should produce a National Compliance Guide in support of the Approved Documents. It should contain technical solutions presented in a generic form as simple design specifications and sketches that can be applied to most common building situations involving vapour permeable solutions. This additional guidance should be easily available at no cost.

3. **Invest in technical solutions and information Hub**

- Industry and specialists in energy efficient vapour permeable products for traditional buildings could provide technical generic solutions for the national compliance guide. This could be Government supported. The companies providing the technical solutions would benefit from sales of their patented solutions. This would open the market for competition and address concerns that patented designs are exclusive and expensive. This could lead to the setting up of an information Hub for the benefit of the construction industry and owners of traditional, historic and listed buildings.

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12.0 Appendices

Appendix A: Building Control statistical evaluation of figures

FW: re historic/traditional buildings

Tony Gwynne <tony.gwynne@publicagroup.uk>
To Anthony Gwynne

1 attachment View Open in browser Download

Copy

Sent with BlackBerry Work (www.blackberry.com)

From: Jennie Hart <Jennie.Hart@publicagroup.uk>
Sent: 4 Dec 2019 20:43
To: Tony Gwynne <Tony.Gwynne@publicagroup.uk>
Cc: Anthony Gwynne
Subject: re historic/traditional buildings

To whom it may concern,

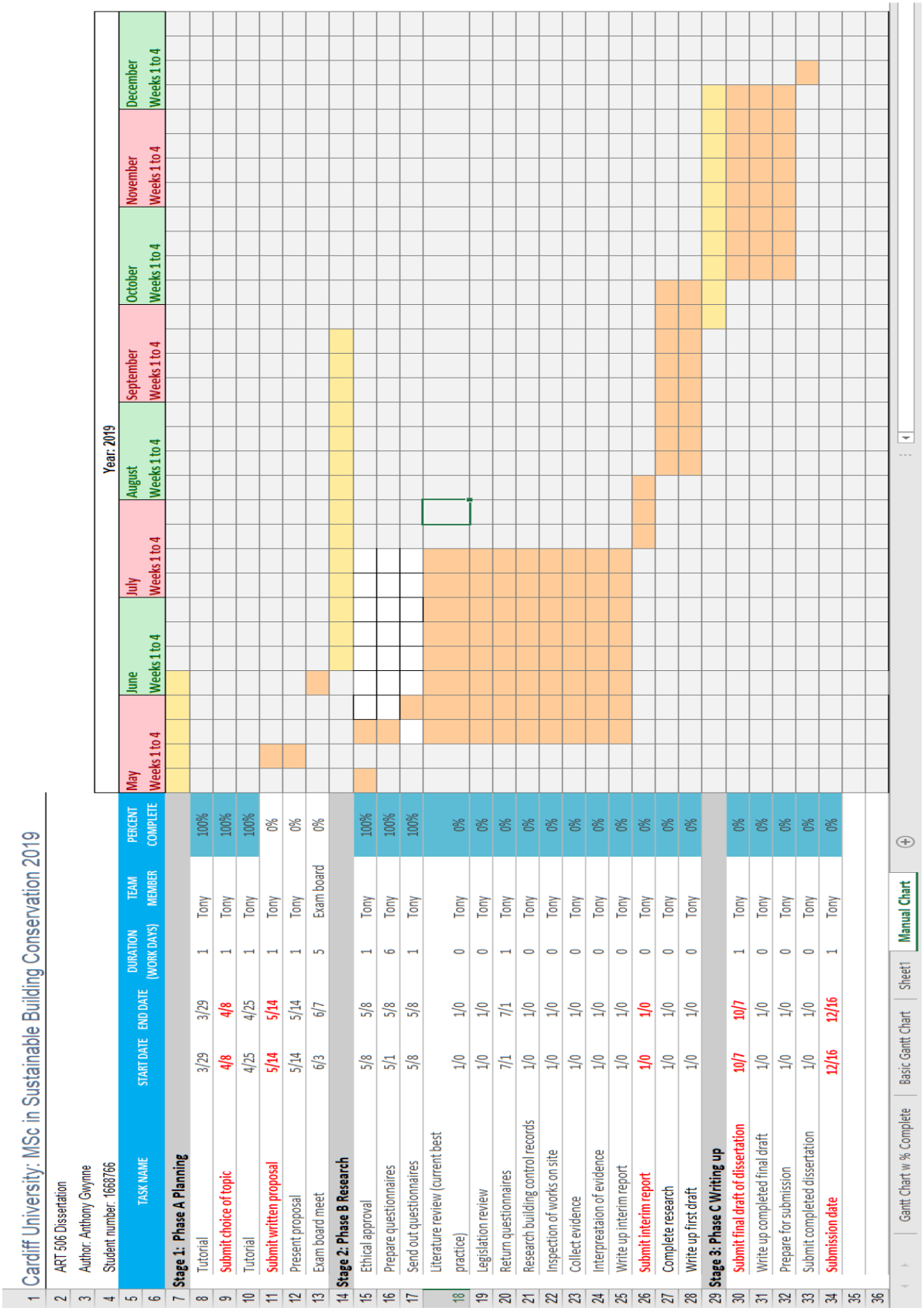
I have run a program through the CAPS/Uniform system at The Forest of Dean District Council and the building control records indicate that Tony Gwynne has dealt with 3,424 Building Regulation applications in the past 15 years of which 750 have been works in connection with traditional and historic buildings.

Of those 750, it appears only three have been submitted by conservation accredited designers and works carried out by two conservation accredited builders.

Kind regards,

Jennie Hart
Building Control Technical Officer
Jennie.Hart@publicagroup.uk

Appendix B: Gantt Chart



Appendix C: Ethics Approval

WELSH SCHOOL OF ARCHITECTURE
ETHICS APPROVAL FORM FOR STUDENT PROJECTS

Tick one box:	☐ UNDERGRADUATE ☐ M.ARCH X☐ MASTERS
Title of project:	
Name of student(s):	Anthony Gwynne
Name of supervisor:	Dr Bruce Induni
Contact e-mail address:	anthony.gwynne@tiscali.co.uk
Date:	30th March 2019

Participants		YES	NO	N/A
Does the research involve participants from any of the following groups?	• Children (under 16 years of age)		x	
	• People with learning difficulties		x	
	• Patients (NHS approval is required)		x	
	• People in custody		x	
	• People engaged in illegal activities		x	
	• Vulnerable elderly people		x	
	• Any other vulnerable group not listed here		x	
• When working with children: I have read the Interim Guidance for Researchers Working with Children and Young People (http://www.cardiff.ac.uk/archi/ethics_committee.php)				x

Consent Procedure	YES	NO	N/A
• Will you describe the research process to participants in advance, so that they are informed about what to expect?	x		
• Will you tell participants that their participation is voluntary?	x		
• Will you tell participants that they may withdraw from the research at any time and for any reason?	x		
• Will you obtain valid consent from participants? (specify how consent will be obtained in Box A)[1]	x		
• Will you give participants the option of omitting questions they do not want to answer?	x		
• If the research is observational, will you ask participants for their consent to being observed?			x
• If the research involves photography or other audio-visual recording, will you ask participants for their consent to being photographed / recorded and for its use/publication?			x

Possible Harm to Participants	YES	NO	N/A
• Is there any realistic risk of any participants experiencing either physical or psychological distress or discomfort?		x	
• Is there any realistic risk of any participants experience a detriment to their interests as a result of participation?		x	

Data Protection		YES	NO	N/A
• Will any non-anonymous and/or personalised data be generated or stored?			x	
• If the research involves non-anonymous and/or personalised data, will you:	• gain written consent from the participants	x		
	• allow the participants the option of anonymity for all or part of the information they provide	x		

Health and Safety	YES
Does the research meet the requirements of the University's Health & Safety policies? (http://www.cf.ac.uk/osheu/index.html)	x

Research Governance	YES	NO	N/A
Does your study include the use of a drug? You need to contact Research Governance before submission (resgov@cf.ac.uk)		x	
Does the study involve the collection or use of human tissue? You need to contact the Human Tissue Act team before submission (hta@cf.ac.uk)		x	

Prevent Duty	YES	
Has due regard be given to the 'Prevent duty', in particular to prevent anyone being drawn into terrorism? https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/445916/Prevent_Duty_Guidance_For_Higher_Education_England_Wales_.pdf http://www.cardiff.ac.uk/publicinformation/policies-and-procedures/freedom-of-speech	x	

If any of the shaded boxes have been ticked, you must explain in Box A how the ethical issues are addressed. If none of the boxes have been ticked, you must still provide the following information.
The list of ethical issues on this form is not exhaustive; if you are aware of any other ethical issues you need to make the SREC aware of them.

Box A The Project (provide all the information listed below in a separate attachment)

1. Title of Project
2. Purpose of the project and its academic rationale
3. Brief description of methods and measurements
4. Participants: recruitment methods, number, age, gender, exclusion/inclusion criteria
5. Consent and participation information arrangements - please attached consent forms if they are to be used
6. A clear and concise statement of the ethical considerations raised by the project and how is dealt with them
7. Estimated start date and duration of project

All information must be submitted along with this form to the School Research Ethics Committee for consideration

PLEASE SEE ATTACHED

Supervisor's declaration (tick as appropriate)	
• I consider this research project to have **negligible ethical implications** and **the student can proceed with the research immediately** (*can only be used if none of the grey areas of the checklist have been ticked*).	✓
• I consider this project research to have **some ethical implications. Box A** clearly describes the ethical issues and how they are addressed. **The student has to await feedback whether the research has been approved by the SREC Chair or whether it will have to be considered by the Committee**. The student will receive feedback within 7-10 days.	
• I consider this project to have **significant ethical implications** and should be brought before the Ethics Committee. **Box A** clearly describes the ethical issues and how they are addressed. **The student MUST NOT proceed until the project has been approved by the Ethics Committee.**	

Signature Dr B Induni **Name** Bruce Induni **Date** 03/05/19

Advice from the School Research Ethics Committee

The application is approved subject to following the recommendations below:

-If you do not need to ask general information about name/contact details (personal identifiers), please delete them from the questionnaires- could you ask for initials instead of name? do you need to have contact details?. If you need the respondent to include this information, explain why and confirm that the personal information will be anonymised and will not be shared.

-The questionnaire is unlikely to take 10 min (it involves at least 20 questions per project), please amend the estimated time to complete it.

-Please keep in mind that according to new General Data Protection Regulation, consent should be explicitly gained for participation and use of data.

STATEMENT OF ETHICAL APPROVAL

This project had been considered using agreed Departmental procedures and is now approved

Signature **Name** **Date**

Chair, School Research Ethics Committee

Appendix D: Lime mortar, plaster and render

(Source: Gwynne, 2013.)

Types of lime mortars, lime renders/ plasters and decorative finishes suitable for breathable (vapour permeable) buildings

There are two main types of lime binder used in mortars, renders and plasters***, non hydraulic*** and ***hydraulic lime*** as detailed below:.

D1. Non- hydraulic lime (known as lime putty or fat lime)

Consists of pure limestone, burnt in a factory process to drive off carbon dioxide, an excess of water is added to slake the resulting quick lime into a lime putty. It hardens by exposure to the air, in the presence of water, in order to carbonate, and over a long period of time it reverts to a limestone. Air can pass through the open pours in a lime binder which makes it vapour permeable in a way that doesn't happen with a denser material like cement that is non vapour permeable (www.lime.org.uk).

Non-hydraulic lime mortar mixes

The lime putty to be pre-mixed with aggregates to match the existing mortar in the required ratio depending on the type of stone or brick and degree of exposure in accordance with the guidance table below. Turn, beat and ram the mortar as necessary to make it more plastic without the addition of water in most cases. For walls to be rendered, leave the pointing finished 6mm back from the stone/brick face to provide a key.

Non-hydraulic lime may be more appropriate for use on historic buildings where a slower set and soft mortar is required to maximum permeability and flexibility of the wall structure. Lime mortars can take several months to a year to cure and should be left to weathered naturally without the application of any artificial weathering which may damage the mortar.

Only breathable paints as detailed in this guidance should be applied to breathable walls and breathable buildings.

Pozzolanic materials can be added to the non-hydraulic mortar mix to increase initial set times where specified/required and carried out in strict consultation with an experienced conservation specialist detail. Note: Hydrated or bagged lime is normally as a plasticizer and is added to a cement mortar mix, it can be used as a mortar but not always with good results.

Guidance Table 1: Typical non hydraulic lime putty mortar mixes

	Non hydraulic lime putty mortar mix (gauged)	
Type of material in wall	**Sheltered application Lime putty: Mortar**	**Exposed application Lime putty: Mortar**
Stone/brick - poor durability	1 : 3	1 : 2
Stone/brick - medium durability	1 : 3 (use hydraulic lime table for sand stone)	Use hydraulic lime table
Stone/brick - good durability	1 : 3 (use hydraulic lime table for sand stone)	Use hydraulic lime table
Fine joints (up to 3mm)	1 : 1	1 : 1

Notes: Above mortar mixes are only suggested mixes and the actual mortar mix is to be specified by a suitably qualified and experienced conservation specialist- suitable for the type of wall material and degree of exposure; The exact ratio will depend on the sand/ aggregate used; The colour, texture and workability of the mortar is influenced by the sand/ aggregate; The softer the stone/brick, the softer the mortar mix required.

D2. Hydraulic lime

Consists of limestone containing a natural proportion of clay in addition to calcium and magnesium carbonates, which is burnt in a factory process to produce chemical compounds similar to Portland cement, which are stronger but less workable than non-hydraulic limes. It hardens by chemical reaction with water and by carbonation. The higher the percentage of natural clay and minerals in the lime - the higher the strength and initial set times but the poorer the permeability and flexibility. Air can pass through the open pours in a lime binder which makes it vapour permeable in a way that doesn't happen with a denser material like cement that is non vapour permeable (www.lime.org.uk).

Hydraulic lime mortar mixes

The lime used for re pointing and building has to be mixed with aggregates to match the existing mortar in the required ratio depending on the type of stone or brick and degree of exposure in accordance with the guidance table below.

Mortar must not be allowed to dry out too quickly and surrounding masonry must be kept damp. Pointing should be kept moist for 7 days- the carbonation set can only complete in the presence of moisture. Building can be carried out at the same rate as Portland cement, depending on hydraulic lime used and weather conditions.

Hydraulic lime is more appropriate where a strong rapid set is required. Lime mortars can take several months to fully cure and should be left to weathered naturally. The application of artificial weathering finishes may reduce the life of the mortar.

Only breathable paints as detailed in this guidance should be applied to breathable walls and breathable buildings.

Guidance Table 2: Typical hydraulic lime mortar mixes

	Hydraulic lime mortar mix (gauged)	
Type of material in wall	**Sheltered application Lime: Mortar**	**Exposed application Lime: Mortar**
Stone/brick - poor durability	1^{NHL2} : 3 or softer (use non hydraulic lime table for lime stones)	1^{NHL2} : 3 or softer (use non hydraulic lime table for lime stones)
Stone/brick - medium durability	$1^{NHL3.5}$: 3	$1^{NHL3.5}$: 2.5
Stone/brick - good durability	1^{NHL5} : 3	1^{NHL5} : 2.5
Fine joints (up to 3mm)	Use non hydraulic lime table	Use non hydraulic lime table

Key: ^{NHL2} Natural hydraulic lime containing up to 12% clay (slow set); $^{NHL3.5}$ Natural hydraulic lime containing 12-18% clay (moderate set); ^{NHL5} Natural hydraulic lime containing up to 25% clay(faster set). All are natural hydraulic lime.

Notes: Above mortar mixes are only suggested mixes and the actual mortar mix is to be specified by a suitably qualified and experienced conservation specialist- suitable for the type of wall material and degree of exposure; The exact ratio will depend on the sand/aggregate used; The colour, texture and workability of the mortar is influenced by the sand/aggregate; The softer the stone/brick, the softer the mortar mix required.

Non- hydraulic/ hydraulic lime render/plaster mixes.

Type of lime binder and number of coats

Non-hydraulic or hydraulic lime used for external renders and internal plasters should be suitable for the wall type and degree of exposure and mixed with aggregates (to match the existing where necessary) in accordance with the guidance tables below: Lime render/plasters can take several months to fully cure and should be left to weather down naturally without the application any artificial weathering which could damage the render/plaster. Only breathable paints as detailed in this guidance should be used on breathable renders/ plasters and should be applied in accordance with the paint manufacturer's details.

Guidance Table 3: Lime render/plaster mixes (suggested mixes)

Wall Construction	Internal plaster or External render	Base /leveling Coat(s)	Number and thickness of base/leveling coat(s)	Top /finishing coat (top/finishing coat should not be harder than the base coat)	Number and thickness of top coat
Cob, rammed earth, straw bale[1] (Haired base coats)	Internal plaster	Fat Lime Base Coat Plaster	2 x 9mm	Fat Lime Top Coat Plaster	1 x 3mm
	External render	Fat Lime Base Coat Plaster or Hydraulic Lime NHL2	2 x 9mm 2 x 9mm	Fat Lime Top Coat Plaster or Hydraulic Lime NHL2	1 x 6mm 1 x 6mm
Reed mat, reed board (Haired base coat)	Internal plaster**	Fat Lime Plaster for Boards	2 x 9mm	Fat Lime Top Coat Plaster	1 x 3mm
	External render	N/A		N/A	
Celenit Wood Wool boards (Mesh base coat)	Internal** walls and ceilings	Fat Lime Plaster for Boards (un haired) or Hydraulic Lime NHL3.5/ NHL2 (with beach aggregate)	2 x 6mm 1 x 6mm	Fat Lime Top Coat Plaster or Hydraulic Lime NHL 3.5	1 x 3mm 1 x 6mm
	External render	Hydraulic Lime NHL3.5 (with beach aggregate)	1 x 9mm	Hydraulic Lime NHL 3.5	1 x 9mm
Wood fibre boards (Mesh base coat)	Internal plaster**	Fat Lime Plaster for Boards or Hydraulic Lime NHL3.5 (with beach aggregate)	2 x 6mm 1 x 6mm	Fat Lime Top Coat Plaster Hydraulic Lime NHL 3.5	1 x 3mm 1 x 6mm
	External render	Hydraulic Lime NHL3.5 (with beach aggregate)	1 x 9mm	Hydraulic Lime NHL 3.5	1 x 9mm
Lath (internal only) or soft stone (haired base coats)	Internal plaster	Fat Lime Base Coat Plaster	2 x 9mm	Fat Lime Top Coat Plaster	1 x 3mm
	External render	Hydraulic Lime NHL 3.5/ NHL2	2 x 9mm	Fat Lime Top Coat Plaster or Hydraulic Lime NHL 3.5 / NHL2	1 x 6mm 1 x 6mm
Soft brick (haired base coats	Internal plaster	Fat Lime Base Coat Plaster	2 x 9mm	Fat Lime Top Coat Plaster	1 x 3mm
	External render	Fat Lime Base Coat Plaster or Hydraulic Lime NHL 3.5/ NHL2	2 x 9mm 2 x 9mm	Fat Lime Top Coat Plaster or Hydraulic Lime NHL 3.5 / NHL2	1 x 6mm 1 x 6mm
Hard stone (haired base coats	Internal plaster	Hydraulic Lime NHL 2	2 x 9mm	Fat Lime Top Coat Plaster	1 x 3mm
	External render	Hydraulic Lime NHL 3.5	2 x 9mm	Hydraulic Lime NHL 3.5	1 x 6mm
Hard engineering brick or dense concrete blocks (10mm mesh or haired base coat)	Internal plaster	Hydraulic Lime NHL 3.5/ NHL2	2 x 9mm	Fat Lime Top Coat Plaster or Hydraulic Lime NHL 3.5 / NHL2	1 x 3mm 1 x 6mm
	External render	Hydraulic Lime NHL 3.5	2 x 9mm	Hydraulic Lime NHL 3.5 / NHL2	1 x 6mm
Insulation blocks* (10mm mesh or	Internal plaster	Hydraulic Lime NHL 3.5/ NHL2	2 x 9mm	Fat Lime Top Coat Plaster	1 x 3mm

haired base coat	External render	Hydraulic Lime NHL 3.5	2 x 9mm	Hydraulic Lime NHL 3.5 / NHL2	1 x 6mm

Key: Fat Lime = non hydraulic lime;
NHL 1 or 2: Natural hydraulic lime containing up to 12% clay (slow set);
NHL 3.5: Natural hydraulic lime containing 12-18% clay (moderate set);
NHL 5: Natural hydraulic lime containing up to 25% clay (faster set).
[o]Dub out uneven surfaces prior to applying first coat. [1]May require more coats due to waviness of bales
* Insulation blocks have very high suction, be careful to maintain moisture content in render/plaster mixes in accordance with manufacturer's details. **Lime Hemp plaster is preferred in these situations applied in accordance with lime specialist's details (available from Ty-Mawr at: www.lime.org.uk).
Notes: Above table contains suggested mortar mixes only and the actual mortar mix, build up ant thickness of coats is to be specified by a suitably qualified and experienced conservation specialist- suitable for the type of wall material and degree of exposure. Exposed elevations may require additional coats

Guidance Table 3.1: Hemp lime plaster mixes (internal use only)

Building Material	Site Type	Suggested *Base Coat / Levelling Coat*	Suggested Build-up	Suggested Top Coat – *please note the top coat should not be stronger than the base coat*	Suggested Build-up
Cob, Rammed Earth, Strawbale	Internal	Lime Hemp Plaster (medium)	1 x 15mm	Lime Hemp Plaster (fine)	1 x 6mm**
Lath, Reed Mat, Reed Board	Internal	Lime Hemp Plaster (medium)	1 x 15mm	Lime Hemp Plaster (fine)	1 x 6mm**
Celenit Wood Wool Boards	Internal	Lime Hemp Plaster (fine)	1 x 6mm	Lime Hemp Plaster (fine)	1 x 6mm**
	Ceilings Heavy Stress Light Stress	Lime Hemp Plaster (fine) (coarse mesh) Lime Hemp Plaster (fine)	1 x 6mm	Lime Hemp Plaster (fine)	1 x 6mm**
Woodfibre Board	Internal	Levelling coat: level background with standard hydraulic lime plaster (min 2 x 10mm), for adhering boards 5mm to back of board. Base coat Lime Hemp Plaster (fine)	1 x 6mm	Lime Hemp Plaster (fine)	1 x 6mm**
Soft Stone, Brick	Internal	Lime Hemp Plaster (medium)	1 x 15-25mm°°	Lime Hemp Plaster (fine)	1 x 6mm**
Hard Stone, Hard Engineering Brick, Concrete Blocks	Internal	Lime Hemp Plaster (medium)	1 x 15-25mm	Lime Hemp Plaster (fine)	1 x 6mm**
Insulation Blocks*	Internal	Lime Hemp Plaster (medium)	1 x 10-15mm	Lime Hemp Plaster (fine)	1 x 6mm**

•May require more coats due to waviness of bales. °°Depending on suction. Could be greater on well keyed, high suction backgrounds. **For a smoother finish, a Lime Top Coat Plaster (standard) can be applied in 1 x 3mm coat. *Insulation blocks have very high suction, be careful to control the suction. N.B. Drying times will be extended with thickness.

Guidance Table 4: Mix ratio for lime render/plaster coats

Application	Type of lime	Lime: aggregate mix ratio by volume	Comments
Internal plaster			
Base/levelling coats	As above table	1 : 2.5 or 1 : 3 sand/aggregate	Add hair/fibre at 1.5kg per tonne to provide tensile strength (unless using polypropylene render mesh, and that it is towelled into the first coat.)
Top/finishing coat	As above table	1 : 2.5 or 1 : 3 fine sand	Use finer sand
External render			
Base/levelling coats	As above table	1 : 2.5 or 1 : 3 sand/aggregate	
Top/finishing coat	As above table	1 : 2.5 or 1 : 3 fine sand	Use finer sand
Harling/roughcast finish coat	As above table	1 : 2.5 or 1 : 3 course sand	Apply to external render with Harling trowel or Tyrolene machine

Notes: Above are suggested render/plaster mixes only and the actual mix is to be specified by

a suitably qualified and experienced conservation specialist- suitable for the type of wall material and degree of exposure.

Guidance Table 5: Compressive strengths for lime

Type of lime	**Typical compressive strength (N/mm^2)** (tested at 28 days- greater strengths achieved thereafter)
Traditional Fat Lime (non hydraulic)*	0.3 - 0.5
Hydraulic lime*	
NHL 2	1.3 - 2.0
NHL 3.5	2.0 - 4.5
NHL 5	5.0 - 10.0
Limecrete floors	4.0 (increases to 6.5 at 56 days and 8.3 at 90 days)

Notes: * Increased strength reduces permeability and flexibility.

Haired lime plaster

Hair/fiber (typically goats/ horse hair or synthetic hair or other approved at 1.5kg per tonne) to provide tensile strength where necessary, cut into 50mm lengths and added (teased) into the mix to the proportion/ratio as specified by a suitably qualified and experienced conservation specialist. Note: Synthetic hair is often used in premixed plasters as natural hair will degrade in un-carbonated lime after a few weeks.

Pozzolanic materials for lime plaster

Pozzolanic materials containing silica and alumina such as brick dust, pulverized fuel ash (PFA) and calcined clay can be added to non hydraulic lime putty (also known as fat lime) where necessary to increase the setting time similar to that of hydraulic lime. The type and ratio of pozzolanic material is to be specified by a suitably qualified and experienced conservation specialist.

Appendix E1: Emails

Judy James - Minister for Housing and Local Government and Colin

Blick - Building Standards Technical Manager, Welsh Government

Email sent 3 November 2019

MSc Research Dissertation into Sustainable Building Conservation- Cardiff University

Anthony Gwynne <anthony.gwynne@tiscali.co.uk>
To julie.james@assembly.wales

Dear Ms James,

I was hoping that you might be able to provide me with any information you might have on how the Welsh Government are going to achieve the UK governments announcement that it is going to achieve zero carbon energy emissions by 2050- This would be applicable to new and existing buildings.

I am a student at Cardiff University in the School of Architecture studying for my MSc in sustainable building conservation under Dr Oriel Prizeman who is the Director of Postgraduate Research Studies and Course Director for the MSc. I am due to start a dissertation research project on whether the building regulations are fit for purpose or not when upgrading traditional, historic or listed buildings using modern applications.

I have been speaking recently to Colin Blick who you may know is the building control manager for the Welsh Government and he mentioned that you might be interested in my project.

I believe that Lesley Griffiths AM said the Welsh Government would bring regulations to the assembly to amend its target. Ms Griffiths, the minister for environment, energy and rural affairs, said: "I want to go further, and I am declaring our ambition to bring forward a target for Wales to achieve net zero emissions no later than 2050."

For my dissertation I was hoping that you might be able to advise me how the Welsh Government proposes to make changes (and time scale) to the building regulations and approved documents in line with these proposals?

The overall aim of my dissertation is to gain a better understanding of how traditional, historic and listed buildings in Wales are upgraded using modern methods of construction. The results of the study will be examined to learn about how building control surveyors, designers, builders and property owners and conservation officers etc. view the Building Regulations and Approved Documents as being fit for purpose when carrying out works to traditional and historic buildings. I am happy to provide you with the results if you are interested?

Using this information, I am proposing to carry out a PhD research thesis at Cardiff University, offering a new contribution to knowledge in this area of conservation that could have a positive impact on how we view the Approved Documents to the Building Regulations. I have discussed the with Dr Prizman and she is very supportive.

Thank you in anticipation of your help.

Yours sincerely

Anthony Gwynne

Email received 15th November 2019

RE: MSc Research Dissertation into Sustainable Building Conservation- Cardiff University

colin.blick@gov.wales
To anthony.gwynne@tiscali.co.uk

Hi Tony

Hope things are all good with you. The Minister has asked me to respond to your e mail.

In relation to our Part L review, it is proposed that we will go out to consultation on new dwellings before the end of the year. Let me if you need anything further.

Regards

Colin

Email sent 16th November 2019

RE: MSc Research Dissertation into Sustainable Building Conservation- Cardiff Ur

Anthony Gwynne <anthony.gwynne@tiscali.co.uk>
To colin.blick@gov.wales

Dear Colin,

Thank you for the information, its is very helpful.

I had a few more questions as follows if you have the time to reply:

1. I thought the zero carbon emissions by 2050 applied to new and existing buildings?
2. How are the Welsh Government are going to achieve net zero carbon emissions by 2050?
3. How this will impact on the building regulations, with particular regard to upgrading the energy efficiency of existing traditional/historic/listed buildings built before 1919 with solid wall construction?
4. Will the Welsh Government consider the use of vapour permeable materials and will the guidance in the Approved Documents be amended?
5. Will the Welsh Government consider reducing the energy efficiency of solid wall construction to industries concerns regarding condensation/trapped moisture?
6. Will the Welsh Government consult with those representing the interest of traditional/historic/listed buildings (for example SPAB/Cadw) and if so who will they (or who have they) consulted?
7. Any other information you think might be relevant.

Thank you in anticipation of your help.

Kindest regards.

Tony

Note- No reply was received at the time of submitting this dissertation.

Appendix E2: Transcript of Telephone conversation with Colin Blick

Telephone conversation Friday 7th June at 10am

Interview carried out by Tony Gwynne (TG)

Interviewee: Mr Colin Blick (CB) (Building Standards Technical Manager, Welsh Government)

Questions

1. TG- What is the process of reviewing AD's? I am researching ADC 2004 with 2010 amendments, ADL1B 2014 with 2016 amendments & REG 7 2013

CB-

- Currently the Welsh Government are reviewing Part L of the Building Regulations as part of the 2020 review. It will be revised by the Building Regulations Technical Working Group and are due to meet in July 2019.
- The conclusions of this review are passed onto the Welsh Governments Building Regulations Advisory Committee (BRAC).

2. TG- How often do you review AD's?
   CB-
   - ADC 2004 with 2010 amendments will be reviewed and integrated as part of ADL
   - ADL1B 2014 with 2016 amendments- the review is driven by the EU Energy Performance of Buildings Directive adopted in 2002 for new buildings to have zero carbon by 2020
   - Welsh revision is at early stages of review next meeting 9th July will go for public consultation in Sep 2019 and will last for about 1 year
   - REG 7 2013 – May be reviewed as part of Hackett report into Grenfell Tower tragedy.

3. How do you decide which AD's to review?
   CB-
   - The depth of review depends on resources and what is topical- for example now its fire and energy (Approved Documents B and L)
   - If there are changes in England, the Welsh Ministers will look at it and see if it's a benefit to Wales. Most of the AD's follow England except sprinklers
   - If a subject crop up time and time again they will look at it

.

4. TG- How do you review?
   CB-
   - Building Regulations Technical Working Group review the regulations and Approved Documents. The working group consists of technical representatives from a broad range of backgrounds and professions. (This list is confidential).
   - Building Regulations Advisory Committee (BRAC) will advise Welsh Ministers of the technical working groups findings.
   - Welsh Minsters will advise what to review based on BRAC recommendations and resources (which is limited as is a small team)

5. TG- Who do you consult?
   CB-
   - There is a public consultation for 12 weeks, which include:
   - Professional administrations (for example RICS, CIOB etc)
   - Have a chat with Colin King

6. TG- how do you intend to achieve the 2050 carbon reduction requirements

and who makes the final decision when to consult and what is included in AD's?

CB-

- Judy James- current Minister for Housing and Local Government
  Email: Julie.James@assembly.wales
  Phone: 0300 200 7137
  Office Address: 1st Floor, 11 Wind Street, Swansea.SA1 1DP.

  Phone: 01792 460 836. Assembly Address: National Assembly for Wales,

  Cardiff Bay, Cardiff, CF99 1NA.

Note: TG emailed Judy James regarding how they intend to achieve the Welsh Governments carbon reduction targets for 2050 (Appendix E1). I received an email from CB 15th November 2019 (Appendix E1), *stating 'In relation to the part L review, it is proposed that we go out for consultation on new dwellings before the end of the year. Let me know if you need anything further'.* TG send CB a further email dated 16 November 2019 (Appendix E1), but there was no reply at the time of submitting this dissertation.

7. TG- Would you be interested in my research and would it contribute to any review of Approved Documents (AD's)?
   CB-
   - From a personal view, I would be interested in your research
   - You should channel any views or ideas through Nick Alfieri (Monmouthshire Building Control Surveyor) who is part of the technical working group. The working group is made up of a number of representatives, Nick A has been invited as a LABC Wales representative.
   - You would not be invited as an individual to view the procedure as you do not represent a body.

8. TG- Would you consider improving guidance in the Approved Documents? (I have sent out 150 questionnaires – 15 returned to date & all say AD don't provide enough practical guidance)
   CB-
   - I have already discussed this with John Edwards who produced BS 7913 and some reference to this BS has been put into AD's
   - It is unlikely we will change the AD to include specific guidance, however (there was some hesitation) if a good idea was put forward it could be considered (see item 9 below)

9. TG- Could BS 7913 be improved to include practical guidance and crossed referenced to AD
   - John Edwards (author of BS79130 has already discussed this Colin Blink.
   - CB thought it might be possible to slightly improve guidance and link it to practical guidance in BS 7913- industry standards that could be adopted

10. TG- Who is your counterpart in England & contact details
    - Brian Martin – Head of Technical Policy at Ministry of Housing, Communities and Local Government
    - Peter Ranking

Note: Emails were sent to both Brian Martin and Peter Ranking but at th3e time of submission of this dissertation there were no replies.

Appendix F: Attendees of the Building Regulations Wales Technical Working Group

Important note: This appendix was to record the interview with Phil Jones – Chair of the Welsh Government working Group regarding his comments on unsubstantiated claims there is no group representing the interests of traditional or historic buildings in the Governments review of the Building Regulations and Supporting Approved Documents. Several interviews were arranged and cancelled. This appendix remains open in case of a last-minute interview - requested in January 2020.

Appendix G: Obtaining Building Regulations approval

(Source: www.fdean.gov.uk/building regulations/approval).

Obtaining Building Regulations approval

There are two alternative routes available to the building owner to obtain Building Regulations approval as detailed below, option 1 is the local authority route and option 2 is an Approved Inspector route and is a private system of certification.

Local Authority route

The building owner or agent must make a Building Regulations application and pay a fee for the construction of new works. All work must comply with the 2010 Building Regulations.

The person carrying out the building works is to liaise with and meet the requirements of the Local Authority Building Control and give the required notice for certain key stages of works as detailed in the guidance below

There are two methods of making a Building Regulations application as follows:

(i) Full Plans application

This is often thought of as the traditional way of applying for Building Regulations Approval. The building designer will draw up detailed plans, specification and supporting information for the proposed scheme and will send them to the local authority together with a completed application form and the necessary fee. Building Control will then check the details and following any necessary consultations and liaisons with the building designer, a building regulations approval or conditional approval will be issued. The approvals can also be dealt with in stages when design information becomes available, this can be on a rolling program agreed between the parties as the information becomes available. Applications can be rejected in certain instances. Work can start any time after the application together with the correct fee has been accepted as a valid application, although it is wise to wait until the scheme has had its initial check under the Building Regulations, this usually takes between two and three weeks (works carried out before formal approval is given is carried out at the building owners risk). The building control surveyor will normally liaise with the builder/owner and inspect the work as it progresses on site. When the project is satisfactorily completed a Building Regulations Completion Certificate will normally be Issued. Information required:

- One copy of this form should be complete and returned to Building Control together with the appropriate fee (see appropriate fee table for type of work carried out) and one copy of the detailed plans and full constructional specification (guidance documents are available) and site plan (1:1250 or 1: 2500)
- Additional set of plan layouts is required for non dwellings for consultation with the Fire Authority- indicating the escape routes in red.

(ii) Building Notice application

This system is best suited to minor domestic work carried out by a competent builder. Under this scheme no formal approval of plans is issued, and work is approved on site as it progresses.

Building notices cannot be used in the following circumstances:

- The building is a 'designated use' under the Fire Safety Regulatory Order (i.e. offices, shops, industrial buildings and residential buildings) and or is a workplace subject to the Fire Precautions (Workplace) Regulations 1997 which will require consultation with the relevant Fire Authority
- The building work is over or near a public sewer (see notes in application form)
- Proposed new dwellings front onto a private street

To use the Building Notice process, the owner or agent will need to submit a completed Building Notice application form together with a site location plan and the required fee. Work can commence 48 hours after the notice has been received. When work commences, the Councils surveyor will normally meet with the owner/builder to discuss the proposals and to agree how the work should be carried out, agree when the work will need to be inspected and to establish whether any further information will be required e.g. drawings, specifications or other information. When the project is satisfactorily completed a Building Regulations Completion Certificate will normally be Issued.

Information required:
One copy of this form should be complete and returned to Building Control together with the appropriate fee (see appropriate fee table for type of work carried out) and site plan (1:1250 or 1: 2500) indicating drainage layouts and site boundaries. Additional information may also be requested depending on the complexity of the works. i.e. structural calculations and details. Guidance are available on the relevant web site.

Appendix H: Building Regulations- Notices of stages of works

Site inspections are normally carried out by Building Control at key stages to ensure the works are being carried out in compliance with the Building Regulations. Please note it is your responsibility to ensure that Building Control is called at commencement of work, as well as the stages of work they have asked to inspect which are typically shown below in **figure H1**. Inspections are made at the discretion of the Building Control Surveyor for your area and can be contacted as shown below. Additional inspections may be requested or carried out at the same time as others or omitted depending upon the type, scope and scale of the works.

Figure H1: site inspection schedule

Typical site inspections for stage of work and notice required		
	Stage of Work	**Notice required**
1.	Commencement	2 working days before
2.	Foundation excavation before pouring concrete	1 working day before
3.	Ground floor oversite before covering or pouring concrete	1 working day before
4.	Before covering drainage over	1 working day before
5.	Before covering over structural elements, upper floors and roof	1 working day before
6.	Other inspections required or requested by the Building Control Surveyor	1 working day before
7.	Occupation or completion of the works	5 working days before
Note: More than one inspection may be carried out for each key stage and where possible additional items for inspection are normally carried out at the same time as the key stages. i.e. dpc's etc.		

Appendix J: Questionnaires

Appendix J1: Questionnaire covering letter

Dear Sir/Madam,

You are invited you to participate in an MSc dissertation research project on whether the building regulations are fit for purpose or not when upgrading traditional, historic or listed buildings using modern applications.

The overall aim of this project is to gain a better understanding of how traditional, historic and listed buildings in England and Wales are upgraded using modern methods of construction. The results of the study will be examined to learn about how designers, builders and property owners view the Building Regulations and Approved Documents as being fit for the purposes when carrying out works to traditional and historic buildings.

It is hoped that you can help my research by completing the enclosed questionnaire and return it by email to: tony.gwynne@publicagroup.uk

The questionnaire should not take longer than 10 minutes to complete.

Your participation in this project is entirely voluntary and you can withdraw from the study at any time. If you would like to receive the results of the survey you can write down your name and contact details at the end of the questionnaire or send me an email.

The information you provide will be treated confidentially and the data will be anonymised. Your name will not be used in the reporting or analyses in any way. The survey has been approved by the Research Ethics Committee of the Welsh School of Architecture - Reference 190503 (002), 8 May 2019.

If you have any questions about this survey, please do not hesitate to contact me and I happy to respond to any queries you may have.

Thank you very much in advance for your help.

Yours faithfully,

Tony Gwynne

Welsh School of Architecture Cardiff University Bute Building, King Edward VII Avenue Cardiff, Wales, CF10 3NB Tel: 029 2087 0643 Email: GwynneAL@cardiff.ac.uk

Appendix J2: Copy of blank questionnaire sent out

Questionnaire

A. General Information

1. Your Name:
2. Your Position:

[ ] Building control surveyor
[ ] Building contractor
[ ] Building owner
[ ] Conservation officer
[ ] Designer (including Architect/surveyor/structural engineer)
[ ] Other (please state)

3. Your contact details (optional):

B. Project carried out

3. Please completed the following for a project carried out on a traditional, historic or listed building you have you been involved with in the last 2 years. (Note: This only includes work carried out to an existing building with solid wall construction built before 1919 and excludes new extensions).

Project

Item	Question	Answer (please use continuation sheet below if required)	
1	Description of the work		
2	Status of the work	[ ]Commenced [ ] In progress [ ] Completed	Date commenced Date if still in progress Date completed
3	Why was the work undertaken and why? (please state reasons)		
4	Are you conservation accredited or have you carried out any form of conservation training?	[ ]No [ ] Yes (If yes please state below what form of conservation accreditation/ appropriate training was undertaken and when)	
5	Was a survey/condition survey /investigation of the building carried out to establish type of construction?	[ ] No [ ] Yes	
6	State existing form of construction and materials used (or attached plan details/specification/other)		
7	Are you aware of what vapour permeable construction/materials are?	[ ] No [ ] Yes	
8	Are you aware that non- vapour permeable construction can harm traditional and historic buildings in certain situations?	[ ] No [ ] Yes	
9	Was planning permission/listed building consent/Building Regulations approval required/applied for this project?	[ ] No [ ] Yes (if yes please state below the planning/listed /Building Regulations reference numbers)	
10	If planning permission/listed building consent/Building Regulations approvals were issued did it have conditions regarding the use of vapour permeable materials?	[ ] No [ ] Yes (if yes please state below the conditions on the planning/ Building Regulations or attach a copy)	
11	Was a faculty required? (Applies to churches etc)	[ ] No [ ] Yes (if yes please attach a copy of the Faculty including conditions)	

12	How was the design solution determined	
13	What was the work specified	
14	Was the works recorded including photographs?	[ ] No [ ] Yes (if yes, please attach any records/photos etc)
15	Were any future maintenance requirements considered?	[ ] No [ ] Yes (if yes please state what)
16	Did cost influence the use of materials used?	[ ] No [ ] Yes (if yes please state why)
17	Did the time taken to complete the work influence the materials used?	[ ] No [ ] Yes (if yes please state why)
18	Are there any problems evident after the work was carried out? (for example, damp)	[ ] No [ ] Yes (if yes please state below what problems and any mitigation that was considered)
19	Do you consider the Approved Documents to the Building Regulations provide enough guidance for new work applied to traditional/historic/listed buildings? *Approved documents are available to view at:* **Wales**: weddill.gov.wales/topics/planning/buildingregs/approved-documents/?lang=en **England:** www.gov.uk/government/collections/approved-documents	[ ] No (if no, please state why below) [ ] Yes (if yes, please state why below)
20	Please state opposite any other information considered relevant	

This is the end of the questionnaire.

Please can you return the questionnaire to tony.gwynne@publicagroup.uk

If you have any queries, please can you contact Tony Gwynne by email or ring me on 07796548682.

Thank you very much for your help.

Continuation sheet

Figure J3: Questionnaire distribution list and number distributed

Name	Organisation/contact	Number sent	Organisation address & notes	Date sent
Pembrokeshire County Council	Building Control & Conservation 01437 764551	0	Contacted organisation 16/5/19 – no one contacted me back	16/5/19
Carmarthenshire County Council	Building Control 01267 246044	0	Contacted organisation 16/5/19 – no one contacted me back	Not sent
Swansea City Council	Building Control 01792 635622 Peter Richards BCM	4	bcon@swansea.gov.uk	16/5/19
Neath Port Talbot County Borough Council	Building Control 01639 686820	3	building.control@npt.gov.uk	16/5/19
Bridgend County Borough Council	Building Control 01656 643408	0	Contacted organisation 16/5/19 – no one contacted me back	-
Vale of Glamorgan Council	Building Control 01446 704842	5	buildingcontrol@valeofglamorgan.gov.uk	16/5/19
Rhonda Cynon Taf County Borough Council	Building Control 01443 494746	0	Contacted organisation 16/5/19 – no one contacted me back	Not sent
Merthyr Tydfil County Council	Building Control 01685 725000	4	building.control@merthyr.gov.uk	16/5/19
Caerphilly County Borough Council	01443 866779 or 01443 866776	5	learj@caerphilly.gov.uk	16/5/19
Cardiff City and County Council	Building Control 02922 330382	4	buildingcontrol@cardiff.gov.uk	16/5/19
Torfaen County Borough Council	01633 647300	4	buildingcontrol@torfaen.gov.uk	16/5/19
Newport City Council	Building Control 01633 851714	4	Building.control@newport.gov.uk	16/5/19
Cadw	Spoke to Conservation Principles	1	https://cadw.gov.wales/ Nothing returned	16/5/19
Institute of Historic Building Conservation	Charlotte Bowles Lewis (SW area rep)	30*	**Charlotte Bowles-Lewis**charlotte.bowles-lewis@gloucester.gov.uk	16/5/19
Monmouth County Council	Nigel George, building control manager	35*	buildingcontrol@monmouthshire.gov.uk	16/5/19
Forest of Dean District Council	Jenny Hart, building control technician	50*	Building.control@publicagroup.uk	16/5/19
	Total	**149**		
Notes: *Distribution list consists of building contractors, building owners, building control surveyors, conservation officers, designers (including architects, surveyors, structural engineers etc				

Appendix K: Damage caused by the trapping of water

K1: Efflorescence (Everett and Dean. 2000. *Finishes- Mitchells Building Series*. Oxford: Routledge).

Efflorescence is a crystalline deposit of salts that can form when water is trapped in or on brick, concrete, stone, stucco or other building surfaces. It has a white or greyish tint and consists of salt deposits left behind when water evaporates. In addition, efflorescence can appear as a powdery substance on floors and walls and requires special care to treat.

The movement of moisture upward through permeable building materials by capillary action is called rising damp and it becomes a problem if the moisture penetrates vulnerable materials or finishes, particularly in the occupied parts of a building. This moisture can dissolve soluble salts from the building materials such as calcium sulphate and may also carry soluble salts from its source. If the moisture evaporates through a permeable surface, these salts will be left behind and form deposits on or within the evaporative surface. Where there is a large evaporative surface, salt crystals are deposited as a harmless flour-like dusting on the surface and this is termed efflorescence. If evaporation is restricted to localised areas such as defects in an impermeable paint finish, then salt deposition is concentrated, forming thick crystalline deposits with the appearance of small flowers; hence the term 'efflorescence'.

K2: Crypto fluorescence (Everett and Dean. 2000. *Finishes- Mitchells Building Series*. Oxford: Routledge).

When evaporation of trapped moisture occurs within the material, salts can be deposited within the pores. The expanding salt crystals in these locations may result in fractures forming in the material and spalling of the surface. This is termed crypto fluorescence. This type of decay may be seen in porous brickwork or masonry.

When there has been a long-term problem with moisture penetration, evaporation at the edge of the damp area leads to a distinctive 'tide mark' as a result of salt deposition. Where this occurs at the base of a wall, the tide mark is often taken as a typical diagnostic feature of 'rising damp'. However, these salt accumulations may remain even when the water penetration that originally caused them has long gone. Similarly, water penetration may have occurred from causes other than 'rising damp'.

Causes of timber decay

K3: Wet rot and dry rot (www.timberwise.co.uk/)
What is the Difference Between Wet and Dry Rot?
Dry rot is the most serious form of fungus decay in a building, spreads onto and destroys much of the timber. On the other hand, the wet rot fungus occurs more frequently but is less serious, the decay is usually detained to where the timber becomes and stays wet.

The Wet rot fungus tends to grow on porous surfaces, for example, timber with a high moisture content of around 50% while for dry rot to grow moisture of around 20% needs to be present. If left untreated wet rot can cause major structural problems as it can lead to weakened timbers.

For moisture content to be suitable for wet rot growth there has to be a source of constant moisture – this could be as a result of defective plumbing or damaged guttering. Wet rot cannot spread through masonry and will cease to grow when the source of moisture is taken away. Due to the parts of the building that tend to have the correct moisture levels, for example, underfloor areas, dry rot can often cause significant damage before the homeowner is aware that there is even a problem with dry rot in the property.

K4: Wood boring insects (www.spab.org.uk/advice/wood-boring-insects)

They are species, including certain beetles ('woodworm'), that feed on wood and may seriously damage building timbers. In the UK, they include the furniture beetle (Anobium punctatum), closely related death watch beetle (Xestobium rufovillosum) and other, more minor, decay insects such as the house longhorn beetle (Hylotrupes bajulus), which is found in some southern areas. It is the beetle larvae (grubs) that burrow into wood. Eventually the larvae pupate, and adult beetles emerge to mate via flight holes or fissures. Females lay eggs in crevices, maybe old flight holes, to repeat the cycle.

Termites, another form of wood-boring insect, could gradually become more prevalent in this country due to global warming. Wood-boring insects, like timber-decaying fungi, only establish themselves where dampness exists. Beetle damage in buildings is usually confined to sapwood, although heartwood is vulnerable too if fungus is present. Sometimes active death watch infestation is inadvertently reported in dry timbers where dust is dislodged from old flight holes, perhaps by building work.

Good preventative maintenance and moisture monitoring can avert dampness and, therefore, ensuing damage caused by woodborers. However, over-reliance should not be placed on surface readings from electrical moisture meters. False readings may occur, for instance, because of surface deposits or past chemical treatments.

Appendix L: Transcript of Interview with Simon Lannon

Place and date of interview: Cardiff University on 18 Nov 2019

Subject- report on: Homes of Today for Tomorrow

Stage 1 & Stage 2: Questions.

Questions were asked by Anthony Gwynne (AG) and answered by Simon Lannon (SL).

Question 1. AG- How may pre 1919 homes equates to 23%?

Answer: SL - Total Welsh housing stock is 1.4m, 23% was built before 1919 which equates to 322,000. Cadw confirmed there are 30, 000 listed building in Wales (cadw.gov.wales).

Question 2. AG- Does the discussions on building fabric for example wall upgrades etc consider the use or vapour or non-vapour permeable materials on pre 1919 solid wall buildings.

Answer: SL- No. AG made the point that this is concerning as it states in the executive summary that '*there should be no distinction between performance standards for retrofit and newbuild'. I explained that* Non-vapour permeable materials can trap moisture and cause deterioration of the building fabric.

Question 3. AG- Does net zero carbon emissions by 2050 apply to new and existing buildings? I raise this as an email mail I received from Colin Blick (2019) states the review is of new dwellings only?

Answer: SL- It applies to both new and existing dwellings.

Question 4. AG- How are the Welsh Government are going to achieve net zero carbon emissions by 2050?

Answer: SL This is included in the stage 2 document, and an important aspect is exploring the impact of cleaner energy supply (Paragraph 4.3). This is demonstrated in Appendix A as the impact on carbon emissions and costed actions on 14 different dwelling types using scenario 1 and 2 to achieve 40-60% clean energy supply (scenario 3 was not considered possible and not included).

Question 5. AG- How this will impact on the building regulations, with particular regard to upgrading the energy efficiency of existing traditional/historic/listed buildings built before 1919 with solid wall construction?

Answer: SL- The wall upgrades are indicated on the pre 1919 dwellings as external and internal insulation thicknesses – which are modern non- vapour permeable insulations to achieve the required U-values. AG made the point that external and internal non- vapour permeable insulations will trap water and cause deterioration of the building fabric and possible mould growth which is detrimental to people's health. SL said this is something they will need to look at.

Question 6. AG- Will the Welsh Government consider the use of vapour permeable materials and will the guidance in the Approved Documents be amended?

Answer: SL- Not able to answer that.

Question 7. AG- Will the Welsh Government consider reducing the energy efficiency of solid wall construction to industries concerns regarding condensation/trapped moisture? Ty-Mawr are already specifying 50mm Cork on internal wall upgrades with Hemp Lime finishes as it does not trap water and achieves a U-value of less than 0.6 instead of 0.3 required for upgrades under the requirements of the Building Regulations.

Answer: SL- did not rule out the use of worse U-values and could be considered if it was technically achievable and didn't damage the building fabric/people's health. He checked the Ty-Mawr U-value as 0.59.

Question 8. AG- What happens with Homes of Today for Tomorrow report now.

Answer: SL- will consult Registered Social Landlords and report will be revised on a carbon mix and will consult with DAG.

End of questions.

Appendix M: Extract of structural engineer's report into cause of collapsed cob walling (case study 5)

2 STRUCTURAL INSPECTION

2.1 DAMAGES

Nos. 2 and 1 of Hillcrest are adjacent semidetached houses occupying the area shown in the Sketch No.1 as Hillcrest. The south elevation faces Chacewater Hill. The affected rear north elevation is facing the garden. The building offers generally a well-maintained condition, with exposed stonework adding some character. No.2 has an extension towards its south elevation. Nothing would lead to suspect of sudden wall failure. The party wall between both properties is not aligned with the external boundary gates dividing both gardens and the party wall encroaches approximately 1.5 metres into No.1. as part of the original house division. The party wall between both properties is solid construction at ground floor level, probably cob, whereas at first floor level there is a stud wall arrangement.

The upper level of the rear elevation shows a pattern which can be recognised by a trained eye in construction methods. There is a concrete block effect render covering the walls above the exposed stonework. This arrangement is usually observed in other properties where cob has been used as a construction material. The perimeter stone walls at ground floor level, have been topped with cob to add the upper level. Earth buildings are found throughout Europe, from Scandinavia and Russia to the Mediterranean. In Britain, this tradition is represented by earth buildings in the South West, where the county's clayey sub-soil was mixed with straw to form what is commonly known as cob.

When old cob walls are examined straw is found. The straw helps to bind the material into workable clumps for builders to use. The other function of the straw is to distribute shrinkage cracks throughout the wall during the drying process. This helps to reduce large cracks in the material thus reducing the likelihood of future structural failure.

The collapsed rubble from the portion of the upper-level cob wall, approximately 3m in length, shows a large proportion of clay, very few stones and a total absence of straw, hinting signs of poor original construction.

Picture 2 The render above the stonework at ground floor level and the partially collapsed section of the wall.

Figure M1: Description of damage

Concrete is not permeable and lets water through, which can lead to cob walls reaching a high level of moisture due to the ineffective capacity of the concrete render to allow evaporation of accumulated moisture. The best render for a cob wall is a lime render which would allow for the evaporation of the moisture trapped within the cob wall.

Once a critical level of moisture is reached cob walls become a plastic material which virtually loses its consistency, flowing downwards.

The reason why only a particular section of the wall has been affected doesn't have a straight forward answer. The remaining section of the wall adjacent to the failed part appears to be dry and solid. The roof truss is restraining vertically the wall near to the failed section. The failed section could have been the most exposed to the elements.

The loft inspection shows the absence of any water presence or leaks above the affected area, leaving the cause of the collapse to the poor original construction of the cob wall in the first place and subsequent deterioration suffered over time.

Picture 5 The window frame propped by a short timber stud

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Figure M2: Cause of damage

End of Dissertation

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