Insulation

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Introduction

Many of the Region of Waterloo's heritage buildings were constructed before modern heating, ventilation and air conditioning (HVAC) systems were invented. Older buidlings were built to "breathe" as opposed to the current method of construction that aims for airtight structures with mechanical air circulation. Although, the use of insulation was limited, many old buildings incorporated passive energy features to help structures hold heat in the winter and stay cool in the summer, such as deep overhanging eaves, the position of opening windows, porches, and brick construction and they took into account natural light, airflow, heat retention and cooling. Many aspects of traditional design are thus inherently green and sustainable, with the result that many historic buildings actually have the potential to outperform modern buildings.

Heritage property owners wanting to improve the comfort and energy conservation of an older building can often do so by cafefully upgrading the thermal efficiency of a historic building's envelope by adding insulation to walls and roofs. Increasing the thermal efficiency of a building envelope may be achieved by adding insulation to walls and roofs. It is important, however, that modifications that improve energy efficiency do not alter the historic character of a structure and that methods and materials used do not create future maintenance problems. Traditional building assemblies that breathe (transpire) require a different approach from modern ones that are sealed and need help to breathe. New technologies offer ways to improve the performance of old building envelopes, while retaining their character and improving energy performance.

This Practical Guide provides advice on the various methods that can be undertaken to add insultation to your heritage building. It should be noted, however, that heritage conservationists have differing opinions about the best methods and materials used to insulate older buildings.

More research is needed to fully understand the passage of moisture thorugh buildings and how certain forms of construction and materials can mitigate these risks. Primarily, English Heritage's Energy Efficiency and Historic Buildings guides were relied upon given the heritage expertise of the organization and the recent publication date. A number of additional sources were also consulted and are included in the references list at the end of this guide to help you choose the most informed approach to insulating your heritage building. It would also be advisable to consult with a certified Energy Advisor, one who specializes in energy retrofits for traditional or heritage homes.

Typical Energy Problems

Addressing the typical energy problems experienced in detached structures built pre-1950 could significantly increase the thermal performance of your building. Common sources of heat loss include:

- Large air leaks (i.e. around windows and doors)
- Poor attic insulation
- Walls with little or no insulation
- Uninsulated foundations
- Uneven heating of rooms

Typical Energy Solutions

Typical energy solutions to heat loss in detached structures built pre-1950 include:

- **Air sealing**. Use caulk and weather stripping to close any cracks near baseboards, ceilings, around window and door openings, and foundation. The goal is to reduce the amount of air leaking in or out of the building. Air sealing can be considered a must-do upgrade because it is inexpensive and highly effective. The lowest impact measures, such as air sealing a window, must be completed first or else there is no benefit in improving or replacing more heritage sensitive features such as windows.

- **Insulation.** To avoid damaging historic fabric, insulation should begin with the hot water pipes, heating ducts, and hot-water heater. This should be followed by roof and attic insulation, which is extremely cost effective. Insulation should also be installed at the top of the basement walls. With wall insulation the impact of retrofitting depends on the type of insulation and how it is installed. Options are discussed throughout this Guide.

Air sealing and insulating can usually be completed without compromising a building's historic value. They are therefore the most important interventions that should be done prior to upgrading any other aspects of a heritage building. Air-sealing and insulation upgrades are safe for heritage houses if ventilation improvements are also planned.

Other energy solutions to heat loss in pre-1950 structures include:

- **Closing fireplace dampers** when not in use.
- **Upgrading duct work, and maintaining heating and cooling systems** so that they run efficiently. New energy-efficient domestic heating and hot water systems are cost-effective and can be retrofitted without damaging the special character of your home, but don't rush to get rid of hot water radiators. They provide efficient and inexpensive heat.
- **Adjusting the thermostat** to heat to a lower temperature in the winter and cool to a higher temperature in the summer; turning the water heater thermostat down.
- **Augmenting existing heritage windows with exterior or interior storm windows**. They can be attractive and removable and they do not compromise the character defining features of your home.

Planning and Assessment

Before you decide to improve the thermal performance of your heritage building by adding insulation, it is important to assess the structure to determine:

- The heritage significance of the building and the anticipated impact of the intervention on its heritage value
- The construction and condition of the building
- The existing hygrothermal behaviour of the building (the movement of heat and moisture through a building)
- If the effort and impact of improving energy performance will be worth the cost
- The technical risks associated with the chosen method

Considering these points will help to identify if insulation should be added to your building externally or internally, and will ultimately reduce the risk of accidentally creating long-term problems.

It is best to hire a certified Energy Advisor or auditor who specializes in retrofits for heritage homes to assess your home and recommend upgrades. He/she may suggest certain tests. For example, **thermal imaging** which displays the surface temperature of the building, is the ideal method for diagnosing hidden moisture, insulation and air leakage issues typical of older homes. A thermal imaging camera shows pictures of how the heat and cold is travelling through your home's walls, ceilings, and basement. This will lead to recommendations on how to control the flow of heat, air and moisture so that your indoor temperatures are more comfortable and stable.

An Energy Advisor can also suggest a blower door test which is a very effective way at modest expense to visualize air leaks. The blower creates a negative pressure and air enters through all the leaky points. Using a smoke puffer, the leaks are identified and sealed.

Other tests such as hygrothermal modelling, 'free water saturation' testing, 'vacuum saturation moisture content' testing, and frost dilatometry to determine 'critical degree of saturation' testing, though expensive, are available to analyze brick structures for any risks of freeze-thaw and embedded metal corrosion that could result from interior insulation retrofits on older brick buildings. Testing for freeze-thaw risk in brick structures will be discussed further under the Interior Insulation for Solid Brick Walls section of this Guide.

For listed or designated heritage buildings, a heritage permit application may need to be submitted to your municipality's Planning Department or Municipal Heritage Committee before you undertake any work, to ensure that your plans respect the integrity of the structure. Please refer to the Region's Heritage Conservation Toolbox for a list of municipal heritage contacts.

Image: Thermal Imaging of cold air leaking through the window trim (City of Vancouver, 2014, p. 18)

Types of Insulation

There are a number of different types of insulation to choose from when improving your heritage building's insulation. They can be broadly classified into **fibre** and **foam**. Fibre insulation types can be used in the form of batts (thick blanket-like pads that fit between studs), in rigid boards, or in loose-fill form which can be blown in. Foam insulation is typically a spray.

All are typically inserted into the air space between the inside or outside of wood or masonry walls. Each is quite different and should be explored with professional help to determine which has the properties best suited to your particular building. The chief measure of insulation performance is R-value, which is derived from tests that determine how well the material resists heat flow. The higher the R-value, the more effective the insulation. (Current US standards call for at least R-13 for exterior walls and R-38 for ceilings.) As a general rule, the better the material performs, the more it costs. Older materials are evolving and newer ones are appearing. An overview of some of the available types follows:

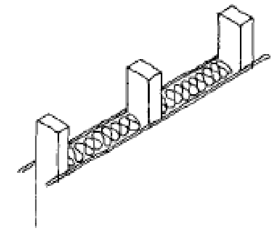
Fibre

Loose-fill Cellulose

Cellulose insulation is made from shredded, fluffed-up newsprint containing 85% recycled material and 15% borate based fire retardant, which also stops mold and pests. It can be blown into place dry or damp. It does have a tendency to settle over time but an added adhesive can reduce that tendency. Also when the blown in cellulose incorporates a borax additive there are positive reviews of it not slumping within the wall. Cellulose is good for retrofit work and attic insulation and has an R-value of 3.8 per inch.

Cotton Batts

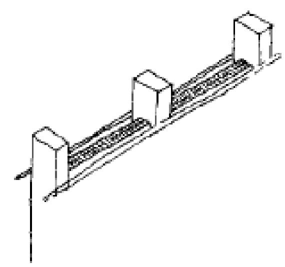
Recycled and shredded denim can be turned into thick batts and can be used to insulate walls and floors in open stud bays. It is treated with the same borate fire retardant as cellulose and is a low-chemical, green choice. The R-value is 3.7 per inch, and it is good for new construction and attics.



Batt insulation in wood studs.

Rigid Foamboard Insulation

Rigid foamboard insulation is made from expanded polystyrene and other materials. Due to the thin, compact nature of this type of insulation, it is best used in the attics of one-and-a-half storey houses or on walls where there is little room for ventilation once the insulation has been added. Two types to look for are Dow's Blue and Owens Corning's Pink. These products have an insulating factor of R5 per inch and can be effectively used in newer, air tight buildings.



Rigid insulation in wood studs.

Image: Types of insulation (District of Columbia, 2010, p. 6)

R-value is a term used to describe the thermal resistance to heat flow. The higher the R-value of an insulation product, the more effective the insulation properties.

A Note on Health and Safety Precautions

Health warnings accompany both fibreglass and Roxul insulations due to the potential inhalation of these materials.

An approved cartridge type respirator (rated for lead and asbestos) should always be used when handling these materials.

Loose-fill Fiberglass

This non-combustible material is a manufactured product composed of fluffy bits of spun glass. Up to 40% of it can have a recycled content, and many manufacturers have taken steps to reduce the problem of airborne fibres. The chopped fibreglass can be blown into floor and wall cavities. R-value is 4 per inch and it is good for attic insulation, new construction, or retrofit work. Fibreglass is an inexpensive choice.

Fibreglass Batts

Lightweight batts of spun glass offer a predictable R-value if they are not compressed. Fibreglass insulation gets its R-value from the amount of air it traps between its fibres, so if it's jammed too tightly into a cavity, it can't trap as much air and won't be effective. R-value is 3-4 per inch, and is best used between open studs in new construction and attics.

Mineral Wool (Roxul)

Mineral wool is made from recycled slag and mined basalt rock and is naturally resistant to fire and pests and is highly sound absorbent. It comes in batts or as a rigid board for foundation insulation, or can be blown into place wet. It is considered by some professional heritage conservationists to be the best candidate of all batt insulations to recover after being saturated with water. It has an R-value of 4 and is good for new construction and attics.

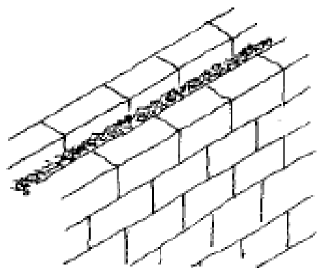
Sheep's Wool

Once cleaned this fibre sheared from sheep is formed into batts and lofty loose fill, then treated for moth and mildew proofing. Like cotton, it tends to be a health-related choice. Sheep's wool and cotton are good choices for insulation as the fabric can still breathe and buffer moisture without impairing performance, however they are more expensive and may be difficult to obtain.

Foam

Cementitious

This foam is made from magnesium oxide cement mixed with water, frothed with air, and pumped into cavities. It is efficient, naturally fireproof, and resists mold and pests.



Blown-in insulation in a masonry cavity wall.

Image: Types of insulation (District of Columbia, 2010, p. 6)

Polyurethane and Polyicynene

Polyurethane spray foam is a commonly used alternative to traditional building insulation. It is a two-component mixture of isocyanate and polyol resin that is combined and applied through the tip of a gun to form an expanding foam. They can be sprayed at the floor joists, floor slabs, wall cavities and around window and door perimeters to ensure the continuity of the air barrier and insulation system.

High-density polyurethane spray foam has a rigid closed-cell structure and forms a hard rigid foam surface that makes it impermeable to water. Although not flammable, it must be protected with drywall or plaster to stop offgassing during a fire. Its R-value is 7 per inch, and costs 4 times that of fibreglass batts. It is good for masonry basement walls but not recommended for external wall insulation in older homes.

Low-density polyurethane spray foam (polyicynene) has an open-cell structure and can be blown into wall cavities as a liquid and in a few seconds it expands to 100 times its volume and hardens. Its R-value is 4 per inch. It is the technology of choice by many for new construction or retrofitting in attics or crawl spaces, as it bonds with studs and sheathing and so seals against air movement, yet flexes enough to accommodate seasonal wood movement, and its open-cell structure still allows moisture to escape, thus reducing the possibility of trapped moisture. It costs however 4 times that of fibreglass batts. There is a tamer version of the foam, which is more suitable for retrofitting existing walls without exposed stud bays. Since it takes longer to expand, the threat of cracking existing plaster is minimized.

Extruded Polystyrene or Polyisocyanurate

Expanded polystyrene or polyisocyanurate foam is used to make rigid foamboard panels. It's closed-cell structure is an effective vapour barrier and it holds its R-value over time. It is flammable and must be protected from solvents and sunlight. It has a thin compact nature and is used for in-ground foundation insulation or in newer air tight buildings, attics or walls where there is little room for ventilation once the insulation has been added. It has an R-value of 5 per inch.

Agricultural Based

In some formulations of polyurethane, petroleum-based ingredients are partially replaced with those from agricultural resources like soybean oil, sugar cane, and corn. They are available as sprayed foam and, in the case of soy-based, a rigid board.

Summary

Most of the materials described above can be used in open stud bays. But in older houses where the interior finish is to be retained the most suitable materials for retrofitting walls are blown-in cellulose, loose-fill fibreglass, and open-cell foam (the tamer version). They are blown into the cavity of a wall through small holes (or larger holes for fibreglass fill) drilled either on the exterior or on the interior, at both the top and bottom of the walls. Obviously in a retrofitting procedure, a vapour barrier cannot be used. Blown cellulose is a 'preservation' approach as no major deconstruction is required to install it. It is sustainable since it is recycled from old newspaper, it moderates air infiltration, and can buffer moisture. However a draw-back of loose insulation stems from its tendency to settle and pack down over time, leaving a void on top where heat can escape. An added adhesive and a borax additive have been shown to reduce this tendency. Also both blown-in cellulose and fibreglass allow air to pass through them easily, and have the potential to become waterlogged through condensation, thus reducing their insulating capabilities.

New insulation products are always being developed, especially types with minimal thickness (10mm). It is important to keep in mind that these products may only slightly reduce energy consumption and can be expensive. However, they help to make a room feel more comfortable by raising the surface temperature of the walls, and possibly reducing the occurrence of condensation. It is important to understand the possible effects of your interventions at the design stage in order to avoid damage to the historic building fabric. An insulation professional who is experienced in heritage buildings would be helpful in these early stages.

Factors and Risks to Consider Before Insulating

Movement of Water Vapour

Consider the effect of insulation on the movement of water vapour through the building. The creation of condensation on a building's surfaces or between walls can lead to health problems from mold formation and decay of the building fabric. Avoiding the risk of condensation can be a challenge as there are many variables to consider and the solution may not be cut and dried. Many heritage practitioners recommend the addition of insulation that has hygroscopic properties (a material the readily absorbs moisture) to reduce the risk of condensation. To protect internal insulation from collecting condensation it is sometimes useful, for certain types of insulation, to separate it from the interior warm moisture-rich air by using a vapour barrier (like sheets of plastic or kraft paper), or a vapour retarder which blocks most moisture but still allows the insulation to breathe. This being said, adding vapour barriers and materials that resist the passage of water vapour are not generally appropriate or recommended for use on older buildings as they will trap moisture, increasing the risk of decay. In these older buildings, interior moisture is generally inhibited from entering the walls anyway by layers of paint, and moisture from the exterior tends to dry out by itself through evaporation and convection, all of which is why these buildings have been around so long. A useful rule of thumb regarding the passage of moisture is that all layers of an insulated solid wall become increasingly more permeable from the interior to the exterior.

Environmental Influences

Consider the environmental influences such as the location, orientation, and exposure of the building to direct sunlight, wind and rain. These factors have important influences on a building's condition and performance. Different parts of a building are affected by different micro-climates, which need to be considered before determining an approach to insulation.

Older Buildings Need to Breathe

Consider that older buildings 'breathe'. Most heritage buildings are constructed of permeable materials and do not include barriers to moisture movement commonly found on newer buildings, such as air cavities, rainscreens, damp-proof courses, vapour barriers and membranes. As a result, the permeable materials that compose historic buildings tend to absorb more moisture that is ultimately released by internal and external evaporation. When older buildings are performing as they were designed to, evaporation will keep dampness to a manageable level, preventing decay. For this reason, older structures are often referred to as 'breathing' buildings. Adding materials and systems that do not allow a building to breathe can exacerbate existing problems or create new ones. Incompatible materials that should be avoided are: closed cell foam and extruded plastic insulation, plastic vapour barriers, cement or acrylic based renders, cement pointing, plastic based external wall paints, vinyl wallpaper and emulsion paints. Adding these incompatible materials to an outside wall will trap moisture within the wall, leading to damp and decay and making the walls feel fold and clammy. Installed on the inside, they may do less damage, but will also reduce the ability to manage moisture levels in the internal air, reducing the comfort of the building's occupants who may compensate by turning the heat up.

Mixing Building Components

Consider therefore that traditional building assemblies that breathe require a different approach from modern ones that are sealed and need assistance to breathe. Avoid mixing building components made for sealed building envelopes (such as modern plastic and aluminum replacement windows) with traditional building envelopes. The effects on moisture movement at the boundary of the two can be unpredictable and could accelerate the decay of the building envelope.

Thermal Mass

Masonry buildings, especially those with thicker walls, have high thermal capacities. This means that they can absorb heat over time and release it slowly as the outside temperature cools. In the summer when strong sun can cause very high temperatures, the thermal mass of a brick building's walls cool the interior by absorbing the excess heat during the day and releasing it slowly during the night as the outside air cools. This phenomenon helps to reduce the need for air conditioning.

Dampness

Most types of insulation are designed to limit heat loss and avoid interstitial condensation from water vapour generated within a building. They do not take into consideration how insulation can affect the movement of water and salt already present in an older brick wall. For insulation applied both externally and internally, it is advisable not to apply it to damp walls. Insulation can make existing water problems worse, create new problems such as the displacement of damp and salts and the decay of timbers in contact with walls, create health risks for residents (mold), and be impacted by moisture that can reduce its performance. Walls that have been damp for a long time can take years to dry out completely. The selection of insulation and the method chosen to install it should take into account the drying-out process, both before and after installation, and the presence of remaining damp and salts. An energy audit conducted by an experienced professional will identify all the issues contributing to moisture, heat loss/gain and ventilation, and report detailed instructions on how to proceed.

Thermal Bridges

Thermal bridges cause heat loss and occur where insulation is not continuous because of gaps due to the presence of other building materials. With external insulation, these weak points are typically found around windows and doors, and with internal insulation they may occur where floors meet external walls. These areas with reduced or no insulation will be colder and will attract relatively more condensation. This can result in local decay, especially to wood members and finishes.

Care should be taken to avoid thermal bridges around window and door openings by installing additional insulation in the gaps between building materials. However this can increase the cost of both the design and installation. In some cases it may be impossible to add the level of insulation necessary, so depending on the potential severity of the consequences, it may be wiser not to install insulation at all.

Masonry Deterioration

Masonry will be more resistant to deterioration if it absorbs less water. The more water within brick pores typically means a greater risk for deterioration from freeze-thaw cycles. Brick that was previously kept warm and dry by heat losses will be colder following placement of interior insulation, leading to to a host of problems such as condensation and freeze-thaw cycles which can damage not just the bricks, but also the supporting framework. Many heritage buildings constructed before 1914 have vast timber framing which could be damaged. So minimizing moisture is essential.

Moisture in brick masonry walls can come from different sources:

- Water from rain will generally only dampen the exterior of the wall, which will dry out when the rain stops if it is in good condition.
- Rising ground moisture can affect masonry walls if a damp proof course is not in place.
- Resident uses internally, through breathing, cooking and washing.

A visual examination of parapets and chimneys, the wall components typically exposed to water and freezing, can provide initial indications of how other wall areas might perform once they are made colder by interior insulation. If parapets or chimneys are deteriorated, this might indicate the brick is porous and susceptible to degradation. The risks of installing insulation in heritage buildings can be analyzed by establishing your bricks' water absorption potential through material testing, regardless of its visual condition and this testing should be considered early on in the process. These types of tests are discussed later in this Guide under Interior Insulation for Solid Brick Walls.

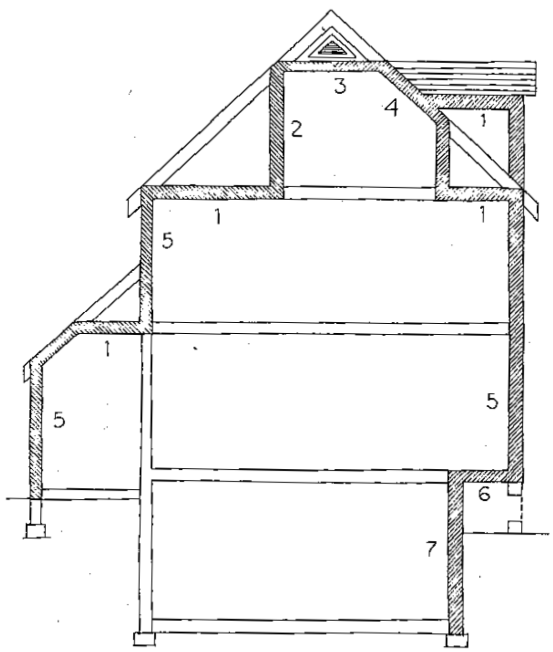
Note: Avoid using vapour-proof type insulations in direct contact with old masonry walls. Always leave an air space between vapour-proof insulations and the masonry.

Effects of insulating plaster walls

Consider the possible side-effects of insulating plaster walls. Some concerns have been expressed about 'pillowing' when using blown-in cellulose or foam. Installers may not be able to control the pressure of these products being crammed into a closed plastered wall cavity. Foam expands and the pressure used to install dense pack cellulose properly cannot be controlled within a closed wall, which can result in plaster failures in old homes. The pressure may also be great enough to loosen nails holding the wood or wire lath to the studs resulting in the plaster bowing inward and cracking. However a slower pouring version of polyicynene foam is available. It takes longer to expand, minimizing the threat of cracked plaster.

Focus More On: Roofs and Attics, Windows and Doors

Most free-standing buildings lose about 20-30% of their heated or cooled interior air through walls and foundations, with the remaining 70-80% of heat loss through roofs, windows and doors. It makes sense to concentrate energy efficiency measures on the attic, windows and doors if possible.



Roofs and attics

The key and the most cost effective way to insulate a heritage house is to focus on the attic, not the walls, as heat rises and this is where most heat is lost. Don't forget to air seal first. Then batt, rigid and blown-in insulation can usually be installed easily between attic rafters, often without professional assistance. You must still have proper ventilation in your attic to avoid condensation, so be sure not to place insulation over the soffit vents. These small round micro vents, found at most hardware stores are helpful to incorporate into the soffit of your heritage building to allow air to flow in and out of the attic.

Much heat loss occurs through ceilings located immediately below roofs, which can lead to damaging ice dams forming at the cold projecting eaves. Ice dams can force water from thawing rooftop snow up under the roof covering above and down through the eaves or into the interior. Improving the thermal performance of your roof will help avoid problems like this.

Windows and doors

When seeking to upgrade the thermal efficiency of your building, look for major drafts through cracks and joints around windows and doors, then install weatherstripping and caulking to reduce them. If existing weatherstripping is deteriorated, it should be replaced in-kind. If missing or if it never existed, new weatherstripping can usually be added without altering the existing character of the door or window. The same can be said for the addition of synthetic caulking when sealing the joints between window and door frames. Care should be taken when selecting caulking to ensure it is chemically compatible with the surrounding materials and is the right colour to blend with the existing walls, windows and doors.

It is preferable to upgrade the thermal efficiency of existing windows rather than replace them. The simplest course of action is to repair and maintain the original wooden windows and ensure the windows are well seated and sealed. Vinyl windows cannot be repaired and since the sealed units must be replaced after 15-20 years, they will cost more over the life of the house than you will save in energy. The original windows have lasted for decades if not centuries and with maintenance will likely last that much longer. Also, even though you can replace your heritage windows with new wooden windows, the quality of your heritage windows' old-growth lumber cannot be replaced. Wooden materials today are no longer as dense and will not provide the same protection against insect infestation and rot.

An important way to increase the thermal efficiency of existing windows and doors is to install storm windows and doors. A study by English Heritage found that using a storm window reduced heat loss through the window by 58%, and some wood window proponents say the storm window is all a homeowner really needs and at a fraction of the cost of new window replacement. Heritage windows dressed with an exterior storm window will perform equally if not better in R-value when compared to vinyl and aluminum counterparts. An exterior storm window will also protect your window from the elements. Storm windows and doors are non-invasive and do not detract from the character of the house if they are designed with care. Since they may be the most visible features, it is recommended they should be selected to match as closely as possible the size, shape, profile, colour and other character-defining features of the existing ones, and that clear glass, rather than reflective or tinted glass, be used. The same considerations should be given to interior storm windows; however, because they are installed inside, a single pane of glass can be used rather than matching the panes of the existing window. Care should be taken to ensure that the window is properly vented to avoid condensation.

For more information on repair and maintenance of older windows, please refer to the Practical Guide: Windows, Shutters and Doors.

Considerations for Insulating Brick Walls

There is still a great deal of debate within the building design and construction community over the addition of insulation to buildings with solid masonry walls in cold climates. The main challenge is finding a way to improve performance while not comprising durability. Adding materials and systems that do not allow a building to breathe can exacerbate existing problems or create new ones. In some cases the risks of adding insulation to solid walls will outweigh the benefits. If so, alternative ways of improving energy efficiency may be more appropriate.

The following sections discuss the current thinking on the addition of insulation to the interior and exterior of older brick buildings. Much of this advice similarly applies when insulating traditionally constructed wood frame structures.

Exterior Insulation of Solid Brick Walls

Structures built pre-1900 were often constructed with solid load-bearing clay-fired exterior brick with no insulation. This type of construction can be difficult and costly to insulate. Some of these structures can be over-clad with external insulation. The addition of external insulation will significantly alter the appearance of the building and will erode or eliminate its heritage features. This method is suitable for buildings without heritage designation and when changes to exterior appearances are acceptable or desired. For listed or designated heritage buildings, a heritage permit application may need to be submitted.

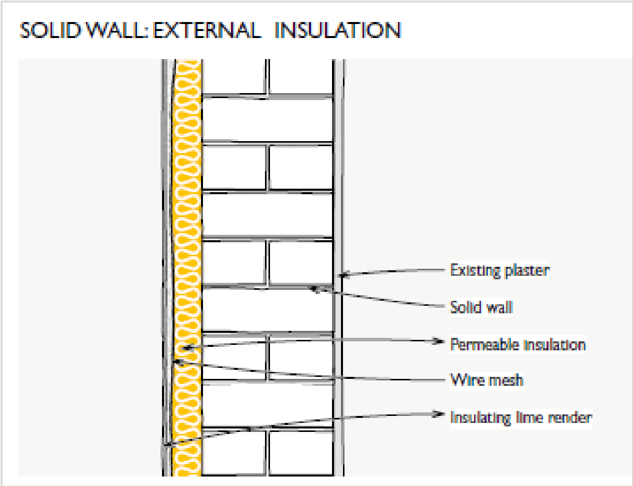
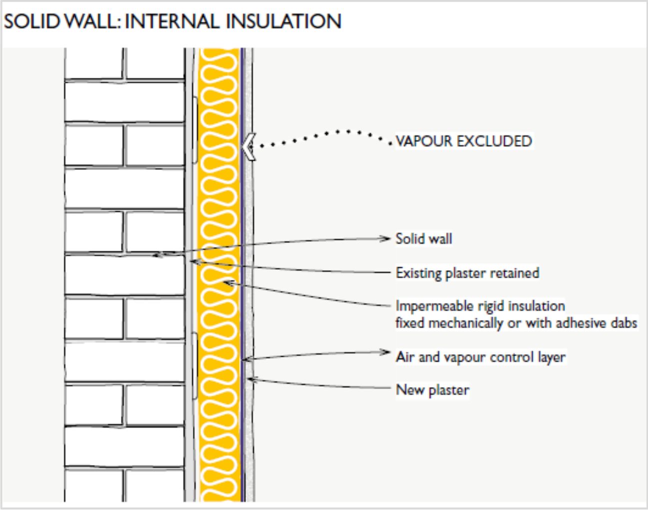


Image: Illustration of the addition of a permeable insulating solution with batts fixed to the masonry and finished with a 'breathable' lime render (English Heritage, 2012, p.14)

Care should be taken to avoid thermal bridges around window and door openings. Also the addition of vapour barriers to the outside or cold side of the wall should be avoided as this will form a vapour trap, encouraging condensation and deterioration of the building fabric. It is important that the insulation and protective finish installed externally still allow the building to 'breathe' and allow moisture to evaporate away without causing harm. Remember the rule of thumb that all layers of an insulated solid wall should become increasingly more permeable from the interior to the exterior.

Thus the use of modern closed-cell foam and other plastic based insulations that limit the movement of moisture should be avoided. As well, a moisture-permeable protective finish, such as a lime render, or rain-screen cladding with lapped joints, should be used to shelter the insulation from rain and damage. Cement or acrylic based renders, cement pointing, and plastic based external wall paints, however, should be avoided. External insulation should normally be considered as a two-component system where all the layers need to work together.

Interior Insulation of Solid Brick Walls



For heritage buildings where the unique architectural features of the façade are to be conserved, the addition of new insulation is best placed on the interior side of the building. This is thought of as a retrofit option to increase energy efficiency and resident comfort. However this method does have some pitfalls. Masonry freeze-thaw deterioration is a particular risk with interior insulation retrofits of old buildings. As discussed previously under Factors and Risks to Consider, brick that was previously kept warm and dry by heat losses will be colder following the placement of interior insulation, which can lead to problems such as condensation and freeze-thaw cycles that can damage the bricks and supporting framework. Incorporating a vented airspace is one technique to keep bricks below the critical moisture content level during freeze-thaw cycles.

Freeze-thaw risks can be analyzed by several methods. In the ‘free water saturation test’, bricks are placed in a container of water to determine how long it will take for the moisture to seep through them. Another is ‘vacuum saturation moisture content’ which determines the maximum amount of water than can be absorbed by a porous material and is conducted in a vacuum. Frost dilatometry is used to determine the ‘critical degree of saturation’. Below this critical moisture content level, masonry can experience unlimited freeze-thaw cycles. Above it, damage occurs quickly.

When the intention is to keep the existing internal finish intact as much as possible in order to preserve existing desirable historical or heritage features, retrofitting would involve inserting insulation between studs via holes drilled in the existing walls, top and bottom, and blowing in dry cellulose, fiberglass, or spraying in open-cell foam, then repairing the holes. The risks of doing so have already been discussed, and it might be more cost efficient to make sure efforts and money are first spent on sealing air leaks around windows and doors, and insulating the attic.

When the interior wall finish is to be replaced, retrofitting can take advantage of a larger selection of insulation options that are available for use between open studs, still taking into account the proper control of vapour and avoidance of sources of dampness. New internal finishes can then be used, either to copy the original or to introduce a new design.

The design and installation of internal insulation should be undertaken with care to avoid thermal bridging especially surrounding windows and doors and wall and floor junctions. It may also be necessary to relocate radiators, pipes, electric power outlets, light switches, baseboard, plaster cornices, picture rails, window and door surrounds, built in furniture etc. as they may be concealed or disturbed by the addition of insulation. Although possible to replicate these details, the room proportions will have changed. Careful attention should be paid when designing this work to ensure that the intervention does not significantly change the character of the room.

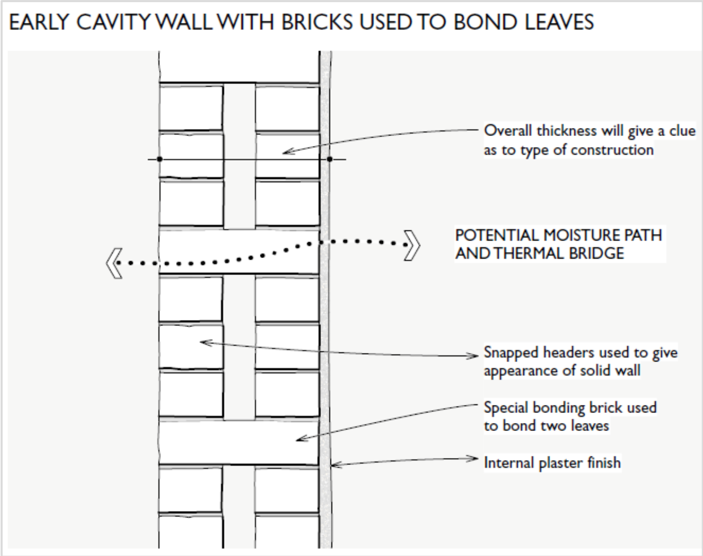
Regarding the movement of moisture, the same rule of thumb applies: all layers of an insulated solid wall should become increasingly more permeable from interior to exterior. Insulation systems that are hygroscopic and vapour permeable (i.e. wood fibre) can be used, or a vapour control layer for certain types of insulation, which also carries its own risks.

Brick Cavity Wall Insulation

This section provides guidance on how to improve the thermal performance of buildings constructed with early forms of masonry cavity walls pre-dating World War II.

Cavity or ‘hollow’ walls consist of two masonry leaves tied together but separated by a continuous airspace. The existence of a cavity can only be determined by looking at the overall depth of the wall. In a cavity wall, the outer leaf acts as protection against the elements and the inner leaf serves as a dry construction to support the interior walls. The two leaves are tied together to provide structural stability.

The cavity between the two leaves prevents moisture from passing from the outside to the inside of the wall. This prevents damage from damp and decay to any woodwork or other decorative elements in contact with the inner leaf. The cavity also allows for the evaporation of any condensation or rainwater that penetrates the outer leaf and ensures a more even temperature inside the building. The existence of a cavity can only be determined by looking at the overall depth of the wall. The cavity may be continuous throughout the wall, or, if bricks are used as ties, it may not be, as the bricks bridging the two leaves create direct contact and act as a thermal bridge allowing moisture to transfer across the cavity. The cavity wall then behaves as a solid brick wall. Just like solid masonry walls, early cavity walled buildings are also 'breathing' structures, exchanging moisture between the indoor and outdoor environment.



There are three ways to insulate a cavity wall – internally, externally, or placing insulation within the cavity. Sometimes a combination may be useful. Internal and external insulation were discussed in the previous section. Insulating the cavity, however, is the preferred alternative as long as the technical risks can be overcome, since it does not impact the internal or external appearance or character of the structure. Materials might include mineral wool, beads or granules, foam insulation, which are blown in or injected into the cavity. It is normally not cost effective to insulate cavities narrower than 50mm, since there is a risk that the insulation may allow water to cross the cavity, and the insulating material may not be effective in very narrow cavities.

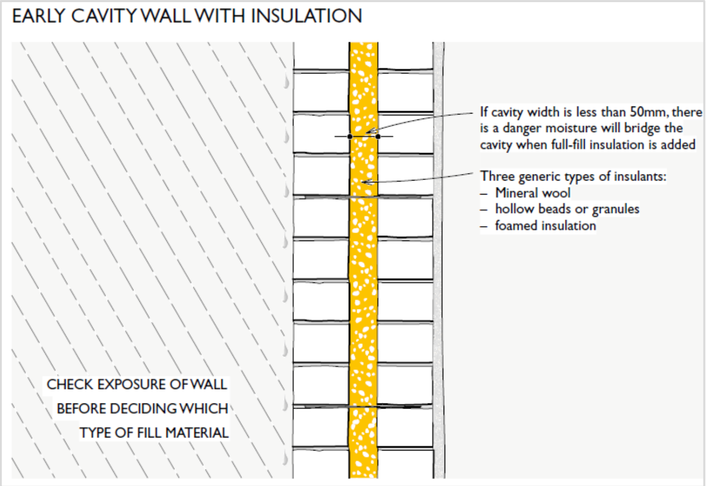


Image: Illustration of an early cavity wall with insulation (English Heritage, 2012, p.15)

Non-Brick Wall Insulation

Much of the advice discussed for insulating brick walls similarly applies when insulating traditionally constructed wood frame structures. They are also breathing buildings, and their traditional construction generally includes a cavity to act as a thermal chamber, which slows the movement of heat through a wall. Before adding external insulation to an older frame house, it should be considered that wood buildings can be maintained indefinitely with maintenance and conservation, in contrast to some building materials that have a limited life span and can only be replaced. For older post and beam structures, the same general advice for insulating walls applies, but it is recommended that a professional come on site to address the installation of insulation on an individual basis.

Foundations

Insulating crawl spaces and basements can provide good energy savings but special considerations should be taken to prevent the collection of moisture, as these areas can easily become damp. Insulation can be added relatively easily to newer basement walls, while older historic basements with rugged walls made from dirt, brick, or fieldstone may be more difficult. Simply ensuring that the foundation walls are in good repair and not in need of repointing will reduce drafts. If the walls are not suitable for insulating, it is recommended that basement or crawl space insulation be installed on the basement ceiling or between the first floor joists. Exposed piping and ductwork in these locations can also be wrapped in insulation.

Financial Implications and Payback

The addition of external and internal insulation to older buildings can be expensive, and the time associated with financial payback can be lengthy. It is key to not underestimate the costs associated with the level of care that should be taken to avoid thermal bridges. Full payback periods can be 30+ years, but they can vary greatly between individual buildings.

As a result, in many cases it would not be worth considering the insulation of external walls until the full range of easier and more immediate upgrades to older buildings have been done, like repairing and air-sealing windows and doors, or insulating attics and roofs and suspended ground floors.

You can use the Green Home Planner, an online calculator that allows you to compare the cost of savings of various renovation types. This is a helpful tool to use to determine how much energy savings you can accumulate through improving the insulation in your heritage building and if it will be worth the effort and expense.

Summary

The base of knowledge surrounding the insulation of heritage buildings is always progressing, enabling practitioners to avoid problems associated with insulating solid and cavity masonry walls along with wood frame buildings. This knowledge is furthering the effectiveness of retrofit strategies and is continually being advanced as new lessons are learned from observing past retrofit projects.

This Guide has attempted to help you become better informed on the many variables and complexities involved in the insulation of a heritage building. But when deciding on the best solution for your own situation, and because every heritage building has its own unique challenges, it is advisable to consult with the professionals before final decisions are reached.

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Alternate formats of this document are available upon request. Please contact Bridget Coady at BCoady@regionofwaterloo.ca, 519-575-4400, TTY 519-575-4608 to request an alternate format.

Disclaimer
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