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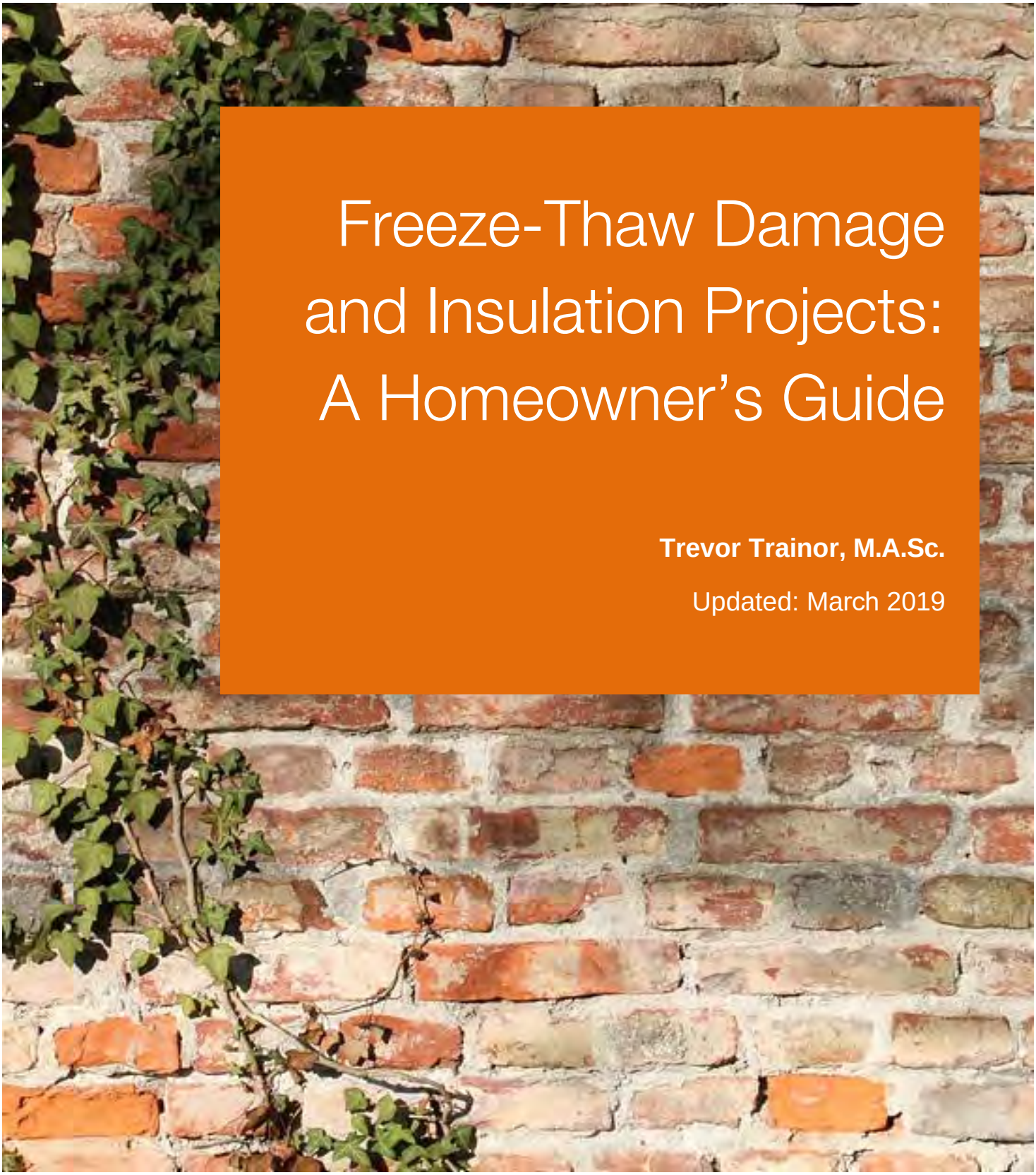

Freeze-Thaw Damage and Insulation Projects: A Homeowner's Guide

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Insulating Masonry Walls: The Problem

This guide was created for homeowners who are considering whether and how to insulate their homes' masonry walls. It describes the mechanics of freeze-thaw damage and some key issues related to this problem. Because freeze-thaw damage is a complicated problem that can be impacted by many different factors, it is not possible to provide comprehensive directions for a complete assessment of risk. However, this guide may help you understand your walls better and work more effectively with any professionals involved in your retrofit.

Adding insulation to your older home is an effective way to cut energy costs, increase comfort, and reduce your environmental impact. However, adding insulation where there was none will affect the way your house works: a building is a system, and the way that water, air, and heat move within the system is important. When insulation is added, less heat moves through the wall, and this can change the way that moisture moves.

This guide will focus on older masonry (clay brick or stone) buildings and one particular problem that can be caused by water as a result of adding insulation on the inside of your walls. This problem, called freeze-thaw damage, affects masonry walls in any climate with freezing winter temperatures, and can result in deterioration of the bricks or stones. However, if insulation projects are designed with care, freeze-thaw damage is very unlikely to occur.

Various insulation materials can be installed on the interior side of masonry walls.

What is Freeze-Thaw Damage?

Freeze-thaw damage is a structural deterioration in the brick or stone resulting in chipping or crumbling of the material. This damage is sometimes referred to as spalling.

For freeze-thaw damage to occur, two conditions must be present:

1) a sufficient amount of moisture must be trapped in the brick
2) the temperature of the brick must cycle above and below freezing

Unless both of these conditions are present at the same time, freeze-thaw damage will not occur.

When we add insulation to a building, whatever material is on the outside of the insulation gets colder in the winter, because heat is being trapped inside the building rather than traveling out through the walls. With less heat available to dry them, the materials to the outside of the insulation also take longer to dry when they get wet.

Freeze-thaw damage can be avoided completely by putting insulation on the outside of your masonry. In this situation, the masonry stays warm and is also protected from the rain. However, exterior insulation is not always an option – for example, it obviously can't be used if you want to be able to see your masonry.

Why Do Some Bricks Get Damaged When Others Don't?

The potential for damage is a combination of the characteristics of the brick (or stone, or concrete block, etc.) and the environmental conditions it is exposed to. Sometimes damage occurs because the masonry is not very durable. A house up the street, made with stronger masonry materials, may have no damage even though its walls get the same amount of rain and freezing weather.

In other cases, the exact same masonry material might perform differently on two different houses because it is exposed to more water in one house than the other. You can even have different levels of damage on different areas of the same wall, for example if water is pooling or otherwise being concentrated in some areas more than others.

In this situation, it is important to find out where the extra water is coming from and resolve the issue before you consider adding any insulation.

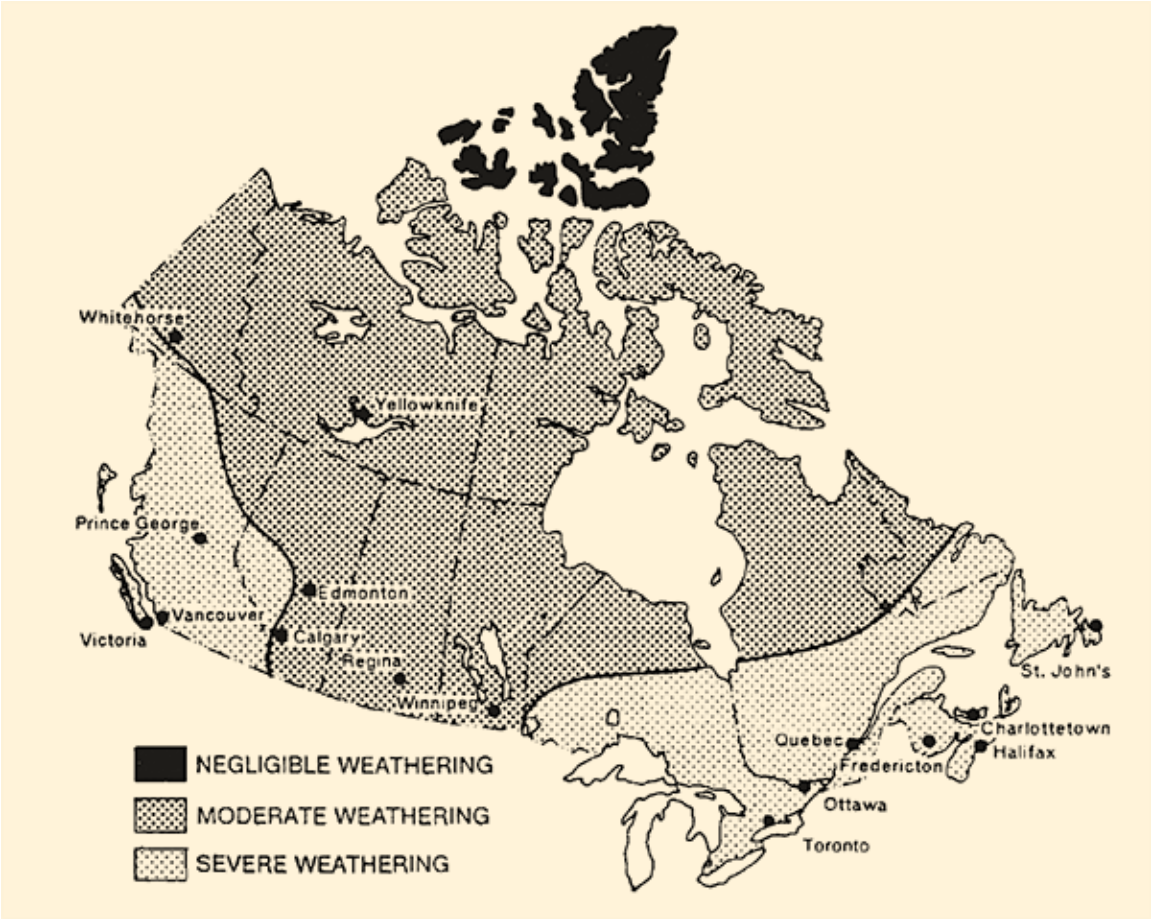
Wall showing damage where water has concentrated. This kind of damage can often be prevented by sloping the ground away from the building and using effective gutters and downspouts.

Should I Be Worried?

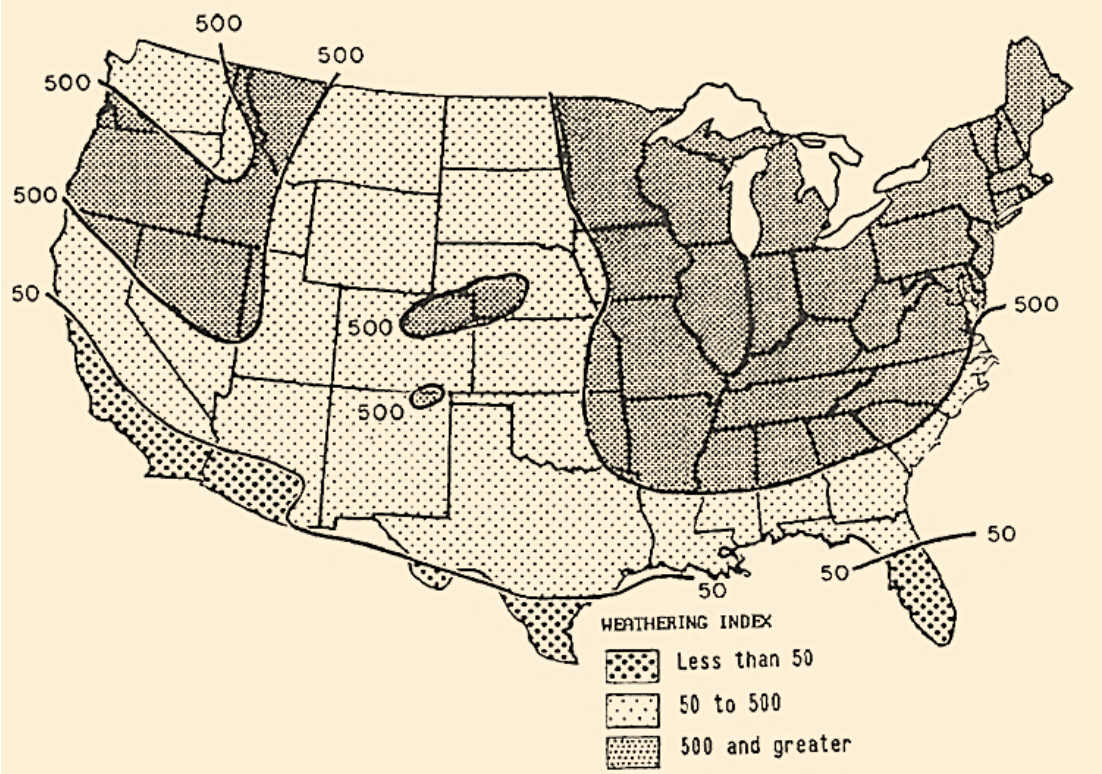
The first thing to consider is where you live. Freeze-thaw damage can't occur in areas where there is very little water or where the water never freezes. As the frequency and duration of freezing periods increase, the chances of damage increase.

Freeze-thaw damage is highly unlikely in southern climates that rarely or never experience freezing weather below 4°C (25°F). These conditions would have a weathering index of less than 50 as shown on the map below.

In areas with a weathering index higher than 50, almost any house wall could be at risk. In areas with an index over 500, one should give serious consideration to freeze-thaw risk. But remember that, in general, other factors are more important than where you live. Within the zones of risk, the amount of rain that hits your walls can make them up to ten times more susceptible to damage than another building in the same area.



Weather index for Canada showing areas of negligible (index = less than 50), moderate (index = 50 to 500) and severe (index = 500 or more) weathering. Source: Malhotra, Ashok: *Brick Veneer Concrete Masonry Unit Backing: Best Practice Guide.* CMHC, 1997.



Weather index for United States showing areas of negligible (index = less than 50), moderate (index = 50 to 500) and severe (index = 500 or more) weathering. Source: Malhotra, Ashok: Brick Veneer Concrete Masonry Unit Backing: Best Practice Guide. CMHC, 1997.

Can I Tell a Good Brick from a Bad Brick by Looking?

If you are looking at the brick by itself, then no. Bricks (and other masonry materials) are surprisingly complicated in the way they handle moisture. For example, bricks are porous and the size of the pores (or air pockets) within the brick can affect how easily water freezes. Water in larger pores will freeze at a higher temperature than water in small pores. Pores might also make a difference by creating space. One theory explains freeze-thaw damage as a result of unfrozen water being pushed through the brick by freezing water (as water freezes, it expands, taking up more space). If there is nowhere for the unfrozen water to go, it can crack the brick. Bricks with bigger pores might help prevent this problem. There are many other factors at play as well. It is simply not possible to guess, much less know for certain, how a given masonry material will perform under any and all circumstances.

This wall looks fine, but later became badly damaged when it was exposed to more water.

This wall has been exposed to water and multiple freeze-thaw cycles, but shows no sign of damage.

However, if you look at a brick (or other masonry material) in action, it is sometimes possible to estimate its performance *in the situation that matters*. Remember that interior insulation makes the outside of your walls colder and (in general) wetter. Carefully check the masonry in those areas of your home that are exposed to more water and/or receive less heat for drying. These areas will simulate the effects of adding insulation to the interior of a wall. Some examples of these areas are described next.

High-Exposure/Low-Heat Areas

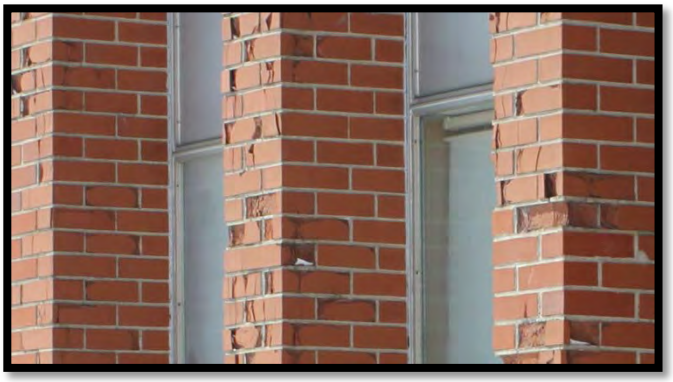
Parapets. Buildings with flat roofs often have parapet walls around the perimeter of the roof. This area is often the first to show masonry damage since it is exposed to the weather on both sides, is commonly affected by air leakage condensation and receives little drying heat from the interior of the building.

Chimney. Most older masonry buildings have an exterior chimney made of the same masonry as the walls. Above the level of the roof, this brick is exposed to weather and receives little heat from the interior for drying. In older buildings, the chimney is often replaced or removed due to freeze-thaw damage.

Grade level bricks. Some homes have brick very close to grade level, sometimes with driveways or sidewalks adjacent. These bricks may draw moisture from the soil, are often wetted by surface water and splash back from roof run-off, and can also be exposed to salt (which can draw greater amounts of water into the brick and complicate the freeze-thaw mechanisms).

Bricks near roof run-off or broken downspouts. These areas receive concentrated levels of water. They often show staining and have higher levels of moisture. Brick and/or mortar damage can often be found in these areas.

Buttresses. Some older brick homes have thickened structural brick posts that stick out from the building. These are especially common in remodeled churches and warehouses. Buttresses are exposed to the wet and cold from three sides and receive less heat from the interior.



Garage, fence or wing wall. Some older brick homes have an unheated garage or a section of fencing or landscaping wall made from the same brick as the house. If these areas are exposed to similar amounts of water, they can be used to simulate a cold house wall.

If these areas of your home show no signs of freeze-thaw damage, there is a good chance that your bricks have a high freeze-thaw tolerance and that insulating the walls will not cause future damage. The chances are even better if you have a brick façade built within the last 30 years, because modern bricks are generally more durable than older bricks.

Occasionally, you might be looking at a building that has been vacant and unheated for several years (for example, a warehouse being converted to housing). In this case, the masonry is as cold as it is ever going to get, so if there is no sign of freeze-thaw damage then it is a good ballpark indication that adding interior insulation will be safe.

What if I'm Not Sure?

If being able to see your home's masonry is not important to you, consider insulating on the outside. Spray foam, foam board insulation, and stone wool can all be installed on the outside of a building, which will keep your masonry warm and prevent freeze-thaw damage. Exterior insulation is also more effective because it allows insulation to cover all of the wall and floor intersections that cannot be easily insulated from the inside. It also has other benefits, such as leaving you with more usable floor space and leaving interior finishes intact (which may be important for historical buildings).

If you want to preserve the look of your house by insulating on the inside of the wall, consider the following key points.

Key Points About Freeze-Thaw Risk and Interior Insulation

- Freeze-thaw damage only occurs when walls get wet. Make sure you have addressed any avoidable sources of water accumulation by directing water away from the building using eavestroughs, downspouts, drip edges and proper window flashings.
- Liquid applied brick sealers are generally not recommended. Water often enters the wall through mortar cracks which are too big to be sealed with liquid sealer. Sealers can also reduce the ability of the bricks to dry out after they become wet.
- Repointing of deteriorated mortar joints is an effective way of reducing the water entering the wall without decreasing the drying capacity of the bricks
- Choose your insulation wisely, and make sure that it is air sealed on the inside. Remember, interior insulation leaves your masonry colder. Any moist, warm air that travels through that insulation and hits the masonry will condense there. For this reason, vapor-permeable insulations such as fiberglass or stone wool are not recommended for this type of retrofit. If they are used, it is critically important to air seal effectively.
- Using a lower R-value will allow a bit more warmth to reach the masonry and lower the risk of freezing. However, this strategy may not prevent damage, and also might not provide adequate comfort and energy efficiency improvements. Therefore it is not recommended.
- Continue to inspect and maintain your home after the insulation is installed.

As well, it never hurts to get some professional advice. The best value for money is to arrange a site visit with a building scientist who has experience in freeze-thaw risk assessment. This expert will carefully consider the factors affecting the freeze-thaw risk of your building. He or she will be able to identify existing water management issues and look for indications of the freeze-thaw resistance of your brick. Using this information, a renovation strategy can be developed to minimize freeze-thaw risk for your building.

If your situation requires a higher degree of certainty (for example, if you live in a historical building) it may be worthwhile to consider further testing. Building Science Laboratories recommends a test called frost dilatometry, which measures the critical degree of saturation, or S_{crit}, of a set of samples from your building. S_{crit} is the degree of saturation below which no freeze-thaw damage will occur. In other words, it tells you how wet your masonry can get before it is at risk. Using this information about the quality of the masonry as well as information about the building's climate, it is possible to use computer simulations to predict the likely risk of freeze thaw events.

There is always some uncertainty in assessing risk. However, the right information can help you to make an informed, low-risk decision. In addition to the information contained in this guide, we recommend the resources listed below to continue your learning.

Additional Resources

John Straube and Chris Schumacher, "Building Science Digest #114: Interior Insulation Retrofits of Load-Bearing Masonry Walls In Cold Climates"
Available at http://www.buildingscience.com/documents/digests/bsd-114-interior-insulation-retrofits-of-load-bearing-masonry-walls-in-cold-climates

Joseph Lstiburek "Building Science Insight #047: Thick as a Brick"
Available at http://www.buildingscience.com/documents/insights/bsi-047-thick-as-brick

Martin Holladay, "Insulating Old Brick Buildings"
Available at http://www.greenbuildingadvisor.com/blogs/dept/musings/insulating-old-brick-buildings

John Straube, Kohta Ueno, and Christopher Schumacher, "Building America Report: Internal Insulation of Masonry Walls"
Available at http://www.nrel.gov/docs/fy12osti/54163.pdf

After a Renovation

If you decide to go ahead and add insulation to the inside of your masonry walls, you can manage the risk involved by keeping an eye on things afterwards. By identifying early warning signs, you can take action before serious damage occurs. Regular maintenance can also go a long way towards avoiding trouble – in any kind of wall.

Monitoring and Maintenance Checklist

- ☐ Carefully inspect the mortar between bricks or stones. Mortar will usually show damage first, and so can act as a good warning sign that your wall is getting more moisture than it can handle. As well, damaged mortar will allow more moisture to get deeper into your wall.
- ☐ Check the masonry itself in key spots (at ground level, around windows and doors, near downspouts, etc.)
- ☐ Keep downspouts and gutters in good repair. Clean them at least annually.
- ☐ Repoint any damaged mortar (after identifying the cause of the damage).
- ☐ Check any caulking that is keeping water off your walls. Caulking is not highly durable and will need to be replaced regularly.
- ☐ Keep your masonry above ground. If you are going to raise the grade around your walls (e.g., to create a slope away from your house to manage rainwater), there must be a barrier protecting your wall from the ground.

If You Suspect a Problem

- ☐ Deal with underlying causes. Remember, freeze-thaw damage only happens when masonry is wet. Dealing with any existing moisture may prevent freeze-thaw damage, and will also prevent or solve many other problems with your walls.
- ☐ Call an expert when needed. A good home inspector may be able to help identify underlying problems (you can find a qualified inspector through the Canadian Association of Home and Property Inspectors (www.cahpi.ca) or the International Association of Certified Home Inspectors (http://www.nachi.org). A mason may be able to confirm freeze-thaw damage and recommend repair strategies; some masons specialize in historic masonry. For buildings that are historically significant it is recommended that an experienced building scientist be consulted.
- ☐ Consider removing insulation. Visibly wet insulation should be inspected and replaced and appropriately air-sealed once the area is completely dry. Note that some insulations (e.g. spray foam) don't need a separate air barrier.
- ☐ Note that once freeze-thaw damage has occurred, it is irreversible; damaged brick or stone will have to be removed and replaced. So it is important to take action while damage is minor.

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