Musings of an Energy Nerd

Contemplating residential energy use

Insulating Old Brick Buildings

If you're thinking of insulating the interior of a load-bearing brick wall, proceed with caution

POSTED ON AUG 12 2011 BY **MARTIN HOLLADAY, GBA ADVISOR**

Older buildings with load-bearing brick walls are common in many northern U.S. cities. While these thick (muti-wythe) brick walls were often plastered on the interior, they were rarely insulated.

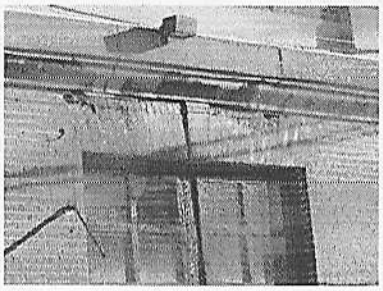

Image 1 of 3

Wet bricks can be damaged by repeated cycles of freezing and thawing. The saturated bricks on this old building were unable to handle the stresses created by repeated freeze/thaw cycles. If a brick building is insulated on the interior, the bricks will be colder and wetter in winter, and therefore more vulnerable to freeze/thaw damage.

Load-bearing brick walls are tricky to insulate. Here's why: If you insulate the wall on the interior, you'll make the bricks colder during the winter. As we know from the psychrometric chart, cold bricks are always wetter than warm bricks. Once the wall is insulated, the escaping heat that formerly passed through the bricks is no longer available to drive out the moisture. So your wet bricks stay wet for a long time. In some cases, repeated cycles of freezing and thawing can permanently damage the bricks, causing them to fall apart.

After I began researching and writing this article, I received an invitation to attend the Department of Energy's Expert Meeting on Interior Insulation Retrofit of Mass Masonry Wall Assemblies, held on July 30, 2011 in Westford, Mass. (The meeting was sponsored by the Building America program.) The presenters at that meeting — John Straube, Henri Fennel, Terry Brennan, Bill Rose, Mark Bomberg, Christopher Schumacher, and Kohta Ueno — all contributed valuable information that helped with this article.

It's possible to insulate a brick building on the interior

If insulating a brick wall on the interior can make the wall vulnerable to freeze/thaw damage, does that mean such walls should never be insulated? No. But builders who want to insulate an old brick wall should proceed cautiously.

There are no simple rules of thumb when it comes to assessing the vulnerability of an existing brick building to freeze/thaw damage. However, here are the most important points to remember:

- Most, but not all, existing brick buildings can be safely insulated on the interior.
- The colder the climate, the greater the risk of freeze/thaw damage.
- The thicker the insulation, the greater the risk of freeze/thaw damage.
- The more rain that falls on the wall, the greater the risk of freeze/thaw damage.
- Some bricks are more vulnerable to freeze/thaw damage than others; there are tests to determine whether your building has good bricks or bad bricks.
- If you insulate the interior of a brick building, the ends of joists and beams that are embedded in the exterior walls can rot.
- The first step in assessing the vulnerability of any brick building to freeze/thaw damage is a site visit by a smart observer.
- If all of this sounds complicated and confusing, you may want to hire a consultant to help you determine the best way to proceed.

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The best strategy is to insulate on the exterior

There is a simple way to avoid all of the problems listed above: just insulate your brick building on the exterior. The easiest way to do this is to cover the brick walls with EIFS — that is, a layer of rigid foam covered with synthetic stucco.

MORE INFORMATION

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"Exterior retrofit is the preferred building science solution," says John Straube, a principal at Building Science Corporation in Somerville, Mass. "It's a great solution for ugly buildings."

Of course, most owners of historic brick buildings are reluctant to cover up their bricks. As Terry Brennan, the president of Camroden Associates in Westmoreland, New York, explains, "If you can't do the smart thing — insulate on the outside — then you have to do other smart things to enable you to do the silly thing — that is, to make insulating on the inside work."

Hiring a consultant

Because of all the uncertainties associated with insulating brick walls, many building owners hire a consultant to advise them. Rather than trusting your neighborhood architect, it's best to invest in a consultant who specializes in such projects. "The most important thing and the cheapest thing an owner can do is to get Building Science Corporation to send one of our guys to the job site to look at the building," says Straube.

According to Brennan, "It's definitely worth hiring an expert, but remember: the experts are still learning."

Inspecting the building

Don't assume that the first step in this process is getting your bricks tested. Using a sharp set of eyes, the first step is to inspect the building. "Walk around and look," says Straube. "Look for stains and rot. Talk to people who have been in the building. Ask them if it has been leaking."

A humble inspector will speak little and listen much. "The site visit is the most important thing we can do," says Straube. "Walk around the exterior and interior. The information you gather is invaluable. Look for wetting patterns, signs of erosion. Look where dust is accumulating. Look for rain leaks. Open up walls and look inside of them. Put a hole in the wall — bash some holes in the wall with a hammer. Look at the bricks at grade. Look below windows. Look for freeze/thaw damage. Look at unused chimneys. If the parapet is in good shape, that's a good sign."

Since the bricks in unused chimneys and parapets don't benefit from the heat that usually flows through walls, they act as tell-tales. "You walk around the building, and you notice there is an unused chimney integrated into the exterior wall," says Straube. "So you ask, 'How many years has the chimney been not been in use? Oh — twenty years?' These are bricks in the most exposed part of the building, with no heat flowing through. That's what I call a full-scale test. Maybe it turns out that this brick in this situation is quite tolerant. If you have tall parapets, they get twice as much rain and no heat flowing from the inside — especially if the parapet is tall. The taller it is, the less heat it sees. In other cases, you might have a building that has been left abandoned, or kept at 40 degrees." In all of these cases, the bricks have been cold and exposed to freezing weather for years. If they are in good shape, you will probably be able to insulate the building.

"If there are splotches on the bricks away from concentrating rainwater, if you see flaking, then you can tell that the brick is already failing, and you are on the edge," Straube continued. "Or perhaps you are looking at an in-between case — a building with no parapets or chimneys, where maybe you see some damage at the window corners, some signs of drooling. Maybe there is some metal flashing on the window sills from the last time the windows were replaced, and all the flashing does is direct water to the ends where it dribbles on the walls. Then maybe you see freeze/thaw damage. So now the question is, 'Can we design water-shedding details that help us step back from the edge?'"

Terry Brennan described a building in Utica, New York, that had problems after it was insulated. "It showed signs of failure after 3 or 4 inches of foam was sprayed on the inside of the 3-wythe brick wall," Brennan told me. "The building had a bunch of stupid detailing: some projections like gargoyles, as well as a cast-concrete projecting shelf. The rain landing on the coping directed all of the water to the outboard edge, which ends at a mortar joint. The walls were wet. That's stupid. However, the building didn't fail until it got spray-foamed, because it was able to dry out. But once it was insulated, the building had bad freeze/thaw damage in just two years. It failed

News

because it's located in a cold climate and the building had really stupid detailing."

Deal with the rain

The moral of the story is: If you aren't willing to manage bulk water issues, don't bother to insulate your brick building. "You need to deal with the rain," says Brennan. "You need to do everything you can to keep the rain off the wall. If there are ledges, you want copper flashing to shed it off the ledge — flashing with a projecting drip-edge."

Building scientist Joseph Lstiburek agrees. "You can insulate walls to a great extent if water isn't concentrated on the surfaces," says Lstiburek. "So the first thing that you do before you do any insulation is you install your drip edges, you deal with your flashings, you deal with the rain shedding things that will basically kick the water off of the surface."

Assess the bricks

Bricks vary. Lstiburek says, "Some brick is really bad, some brick is pretty bad, some brick is pretty good, and some brick is great."

At the Building Science Corporation, John Straube and Chris Schumacher have been researching which types of tests are most useful. They have developed a testing protocol to determine the thermal conductivity and freeze resistance of bricks. "We now have a test method that allows us to look at the load and the response of the materials," says Chris Schumacher. "There is a critical degree of saturation at which freeze/thaw damage occurs. You can test the brick to quantify the point at which the material fails. You want to establish a limit for moisture content during freeze/thaw."

Don't assume that all of the bricks in your building are identical. "The best bricks were often used on the exterior," notes Straube. "If I take a brick sample from the exterior, it may be different from the brick sample from the interior."

Although it's a good idea to test bricks from all of the wythes in the wall, the inner wythe is often the most crucial one to test. "After you insulate, the biggest change is in the interior side of the masonry," says Straube. "The outer wythe has always been cold in winter, but now the inner wythe might for the first time flirt with 32 degrees or lower in some climates."

Hygrothermal modeling

Once your bricks are tested, you'll have a good idea of their vulnerability to freeze/thaw damage. You'll also have some values that can be plugged into a hygrothermal modeling program like WUFI.

However, few energy consultants are WUFI experts. Users of WUFI must be careful of the "garbage in, garbage out" problem. When it comes to WUFI, remember: don't try this at home. "WUFI modeling can guide decision making," says Straube. "But WUFI modeling requires knowledge, comparison to measured data, and real experience."

Climate matters

WUFI modeling uses climatic data to model moisture and thermal flows through building assemblies. In general, brick walls in cold climates are more susceptible to freeze/thaw problems than brick walls in warm climates.

"It's rare that we have to worry about freeze/thaw problems in places like New Jersey and New York City," says Lstiburek. "I don't think we have much to worry about in Boston. But I'd be real nervous in Burlington, Vermont, and I'm real nervous in Ottawa, and I'm kind of semi-nervous in Toronto. ... When we start getting into, say, Portland, Maine, I'm going to say you probably shouldn't insulate more than R-10."

One more worry: embedded beams and joists

The exterior walls of many old multi-wythe brick builders are used to support beams and joists. If the building is insulated on the interior, the ends of these embedded beams get colder — and therefore wetter. Moreover, less energy is available to help them dry out.

"Embedded wood timbers can rot," says Straube. "Wood and steel are both moisture-sensitive. If steel corrodes, it expands — and that is a problem. There are a number of techniques to address embedded beams. You can inject the wood with borate salts to preserve the wood. You can insert metal wedges to conduct heat to the end of the beam. You can install hot water pipes to heat the end of the beam. Finally, there's the practical Yankee solution: you build a load-bearing wood wall to support the beam, and then you fire up your chainsaw and cut off the end of the beam."

Almost all of the solutions to the embedded beam problem have drawbacks except the chainsaw solution.

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What type of insulation? And how thick?

Most people assume that you need thicker insulation in a cold climate than a warm climate. While that makes sense for wood-framed buildings, it isn't necessarily true for an old brick building. In general, brick buildings in cold climates get less insulation than buildings in warm climates. (Thinner insulation allows more escaping heat, keeping the bricks a little warmer and safer. Moreover, in some cases, thin insulation can allow some drying to the interior.)

"So the question is, 'Well, how much insulation can I add before I get into trouble?'" says Lstiburek. "You're going to hate this answer or love this answer — depending on whether you're a client or a consultant. The consultant's answer is, 'It depends.'"

Clearly, fiberglass batts should never be used to insulate the interior of a brick wall. (Since fiberglass batts are permeable to vapor and air, they permit interior moisture to condense on the cold bricks. That's bad.) Most experts agree that the best insulation for the interior of an old brick building is closed-cell spray foam. In most cases, the foam is sprayed directly against the interior side of the brick. To determine how thick you can go, you'll need to talk to your consultant. "We take samples of brick and send them to John Straube for the hot and cold soak test," says Brennan. "Then he does WUFI modeling. We generally end up installing about 3 inches of closed-cell foam."

If the building is vulnerable, don't insulate the walls

In some cases, your consultant may advise you that it's best to leave your walls uninsulated.

"Sometimes you just don't insulate the walls," says Straube. "Even if the walls are left uninsulated, you can often reduce heating demand by 50% by addressing air sealing, the basement, the roof, and the windows."

Can I use cellulose?

Some energy experts have insulated old brick buildings on the interior with cellulose. One of the pioneers of this technique is Chris Benedict, a New York City architect.

Benedict described her technique in an article published in the March/April 2010 issue of *Home Energy* magazine. "In 1998 I started specifying a wall assembly for masonry buildings comprised of 2 5/8-inch metal studs at 16 inches on center, front face of the studs 4 inches or 5 inches (depending on the construction budget) out from the interior face of the existing masonry wall, covered in 5/8-inch gypsum board," Benedict wrote. "The gypsum board was carefully sealed with caulk to the subfloor at the base of the wall, brought up between the wood joists to the underside of the subfloor above, and sealed. Dry cellulose insulation was then blown into the 4-inch or 5-inch cavity at 3 1/2 lb. per cubic foot density, giving a true R-14 or R-17.5. For the vapor barrier I used flat wall paint, nothing else! All holes in the ADA were sealed. ... to date I have yet to see a masonry building destroyed by insulating it."

Like other experts interviewed for this story, Benedict emphasizes water management. "As part of the scope of my work I make sure that the wall is pointed and in good repair," she wrote. "The building is thoroughly assessed for any damage to bricks and mortar inside and out. ... If a building is showing any problems with liquid water management, these problems must be resolved prior to insulating."

I asked John Straube how he felt about Benedict's technique. "I have qualms," he told me. "But if the air sealing is done right, I don't think there is a problem. First you have to walk around the building and see if it leaks. Then you ask, can I get it airtight? You need to install a fluid-applied membrane that is vapor-permeable but airtight on the interior surface of the bricks."

Straube prefers closed-cell spray foam. "One thing about spray foam: it does a really good job or air-tightening, as well as some water tightening," he says.

More maintenance

According to Bill Rose, a research architect at the Building Research Council at the University of Illinois, anyone who insulates the interior of an old brick building should plan to inspect the exterior on a regular schedule.

Rose imagined a conversation with a building owner. "People say, 'We have a mandate to put insulation on our walls. How much damage will happen to this building if we insulate at the interior?' I say, 'If you do that, during winter the exterior materials will be wetter than they used to be.' So then I'm asked, 'What is the range of damage?' And I say, 'Everything falls into the maintenance range. You'll need to increase the maintenance budget.' There is uncertainty, but I'm happy to go forward if we include the concept of increased maintenance. That's how we address worry problems. We have to have more eyes on what happens."

Can I go forward without a consultant?

If you own a building with low risk factors, you may decide to go ahead without hiring a consultant.

An example of a building with low risk factors would be a building in Philadelphia with no signs of exterior water damage, without any deteriorating bricks, and with flashings that do a good job of keeping rainwater off the building.

Last week's blog: **"Utility-Scale Wind Turbines."**

TAGS: **BRICK, FREEZE THAW, FREEZE/THAW, INSULATION RETROFIT**

Image Credits:

John Straube
Terry Brennan
Building Science Corporation

18
COMMENTS

1. SAT, 08/13/2011 - 01:48

EDITED SAT, 08/13/2011 - 14:59.

Foam Injection
by Kevin Dickson, MSME

Helpful? 0 Sign in to vote

Denver's most respected home energy upgrading contractor has been injecting foam into brick walls for years. In a double wythe wall, you can sneak in an inch of foam for an R value of 6+.

Dennis Brachfeld of AAS reports no moisture problems (Denver is relatively dry) and much increased comfort. It's a very expensive procedure, even without building a new interior wall, so they rarely do an entire home, just the most uncomforable rooms.

In my own testing, I found that the "blue can" Great Stuff (low expansion) fills the wythe cavity much better than the cheaper, standard "red can" stuff.

Note: foam injection may cause worse problems even than insulation on the inner wall. That's because it plugs the cavity behind the exterior bricks. This cavity is traditionally relied on to help drain and dry the brick. So stay away from this method if you have rain in the day with freezing at night.

2. SAT, 08/13/2011 - 14:34

fiberglass
by james brown

Helpful? 0 Sign in to vote

"Clearly, fiberglass batts should never be used to insulate the interior of a brick wall."

is fiberglass so bad? Even when used with a good vapour check on the interior? It will allow the wall to dry to the inside, will closed-cell spray foam allow this?

3.
SAT, 08/13/2011 - 15:30

Response to James
by Martin Holladay, GBA Advisor

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James,
Q. "Is fiberglass so bad?"

A. Yes. It is almost impossible to make drywall so airtight that interior air will never contact the bricks and lead to condensation.

Q. "Even when used with a good vapour check on the interior?"

A. The problem has more to do with air leakage and air convection than vapor diffusion.

Q. "It will allow the wall to dry to the inside."

A. Precisely my point -- you don't want to allow vapor diffusion to occur between the warm, interior air and the cold bricks -- a vapor-open assembly is counterproductive.

Q. "Will closed-cell spray foam allow this?"

A. No, and that's a good thing.

4.
SAT, 08/13/2011 - 16:26

EDITED SAT, 08/13/2011 - 16:28.

fiberglass again
by james brown

Helpful? 0 Sign in to vote

I ask because you don't advocate interior polyethylene barriers because that stops the wall drying to the inside, but you are advocating closed-cell foam which will also stop the wall drying to the inside. Am I misunderstanding something? I don't want to install the wrong material in my renovation. No one over here (UK) uses spray foam on bricks, most use closed-cell foam boards.

Also perhaps cellulose has worked (as mentioned in the article) as it has vapour resistivity between mineral wool and closed cell foam. (I'm using figures for resitivity from the following document http://www.viking-house.ie /download.html , pg 3 and 4). However, the cellulose manufacturer does not recommend cellulose on solid masonry walls.

By the way you might be interested in some of the projects on that site (eg the solar slab).

5.
SUN, 08/14/2011 - 04:10

Response to James Brown
by Martin Holladay, GBA Advisor

Helpful? 0 Sign in to vote

James,
You're right -- I don't advise the use of interior poly in most climates. However, interior poly makes sense in much of Canada and Alaska -- at least on the interior of wood-framed buildings.

Load-bearing brick walls differ in many ways from wood-framed buildings, however, as I try to make clear in the article. I don't think you should use any rules of thumb from wood-framed construction when insulating an existing building with load-bearing brick walls. In case you are wondering, I don't advocate the use of interior poly when insulating brick walls.

Rigid foam boards can be used to insulate the interior of a brick wall, as long as the seams between the sheets are carefully sealed with caulk, canned foam, or tape. All of the other advice in the article above would still need to be followed: deal with the rain, assess the bricks, consider the climate, and don't install too much insulation.

Cellulose insulation differs in two important ways from fiberglass batts: dense-packed cellulose does a much better job of limiting air infiltration than batts, and cellulose is hygroscopic. If you were to use fiberglass batts to insulate a cold brick wall, condensation could run down the brick wall and pool on the floor. If you install cellulose -- still an experimental method, and probably risky in cold climates -- the cellulose is able to absorb and store a certain amount of moisture that might otherwise condense against the cold bricks. If the wall assembly allows drying to occur at a faster rate than

moisture accumulation -- something that can be determined by WUFI -- such walls can succeed. Perhaps.

6. SUN, 08/14/2011 - 05:16
EDITED MON, 08/15/2011 - 02:47.

fiberglass
by james brown

thanks Martin. I've got a better grip on the issues now.

Helpful? 0 Sign in to vote

7. MON, 08/15/2011 - 02:55

cellulose
by james brown

I know cellulose is best applied damp with a blower machine but these can't be rented in the UK. Is it feasible to mix the cellulose with say, a paddle mixer in a big bucket, adding water and then apply it by hand, a bit like rendering/harling/plastering? This would be for filling the gaps between studs before drywalling over.

Helpful? 0 Sign in to vote

8. MON, 08/15/2011 - 03:35
EDITED TUE, 08/16/2011 - 02:32.

Response to James Brown
by Martin Holladay, GBA Advisor

James,
I don't recommend your suggested technique, for a variety of reasons. The technique introduces too much water; you won't be able to fill all the gaps; and the density of the installed insulation will be too low.

Helpful? 0 Sign in to vote

Insulating the interior of a brick wall is tricky. You want a carefully air-sealed assembly. If you want to insulate with cellulose -- I method I don't recommend -- then I suggest you take John Straube's advice: "You need to install a fluid-applied membrane that is vapor-permeable but airtight on the interior surface of the bricks." This is not a method that is appropriate for do-it-yourselfers who spread gobs of insulation with their hands.

My advice is to hire an insulation contractor experienced at insulating brick walls.

9. MON, 08/15/2011 - 14:29

Extending existing buildings
by Buildingwell .org

This article brings up a number of good points about insulating brick buildings to help extend their lifetimes. While it's true that the preferred method would be to insulate the exterior, there are a number of reasons that may be impossible - many times related to historic reasons such as for credit, zoning or funding. Insulating the interior as you've stated really comes down to "it depends" which is probably the best way to put it. A professional can be most helpful in determine whether the interior insulation is really the best thing for the brick building and if so, to what extent. In the end, the deciding factor should be the cost and life-cycle assessment for your options.

Helpful? 0 Sign in to vote

10. MON, 08/15/2011 - 14:53

insulating brick house from outside with foam
by Robert Haverlock

As I understand it, your saying insulate from the inside, but not outside. I witnessed a foam company insulate from the outside by drilling holes in the gaps 16in on center, Does this, or could this not also fill up any rain plaine designed into the home? And I have not read in this blog anything about rain plaines being involved? Here in Seattle Washington.

Helpful? 0 Sign in to vote