Flood Resistant Construction Using Closed-Cell SPF

The 2017 U.S. hurricane season, the worst in more than a decade, has taken its toll on millions living in the southeastern US. It is not only the destructive winds, but the flooding caused by rain and storm surge that has damaged tens of thousands of homes. While these recent events are well documented, floods can occur in all regions of the US, and a significant number of homes may be vulnerable to flooding. Floodwater damage is very different from rainwater or domestic water supply leaks. Floods are typically categorized as by: coastal floods from storm surge, river floods (fluvial) and surface floods from high rain levels (pluvial). Each category of flood water brings with it potentially dangerous corrosive materials and/or bio-hazards including sewage, fuel oils, chemicals from the lawn and street and possibly other hazardous materials from miles away.

There are several resources on the following pages to help homeowners address the immediate impact after a flood event[i],[ii]. Once the cleanup is completed, the question becomes how to re-build. If a home has experienced a flood, it is likely that it will experience another. Rebuilding a flooded home to accommodate a future flood is not only a good idea, it may be a requirement for certain flood insurance programs.

IMPORTANT RESOURCES

The U.S. Federal Emergency Management Agency (FEMA) has published a document entitled *Flood Damage-Resistant Material Requirements for Buildings Located in Special Flood Hazard Areas* in accordance with the National Flood Insurance Program[iii]. This comprehensive document details construction materials and practices for new homes in special flood areas and establishes requirements for certain homes to be covered by the National Flood Insurance Program. It is also an excellent resource for selecting materials for flood resistance, even if the home is not part this insurance program, as it lowers the cost of rebuilding and may lower the cost of insurance premiums for the homeowner.

Table 2 of the FEMA document is important, as it clearly states that any fibrous insulation or open-cell foam insulation is not an acceptable material. Only closed-cell foams such as XPS, PIR and closed-cell SPF are acceptable...basically insulations that do not absorb or retain significant amounts of water. Closed cell spray foam is arguably the best choice because there are no seams or layers to trap the floodwater and hold bio-hazardous debris in the assembly.

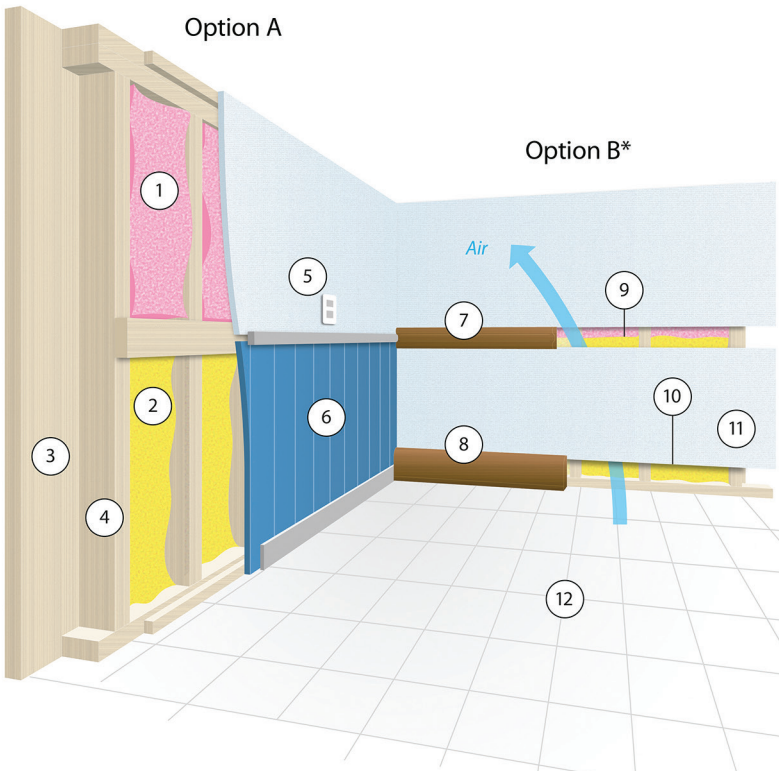
After Hurricane Katrina, new flood-resistant construction techniques have been implemented in New Orleans and the surrounding areas. The LSU AgCenter publishes a document called *Wet Floodproofing*[iv]. The concept is to allow floodwaters to enter a home to minimize water pressure on walls, and use materials and construction techniques that facilitate cleanup and drying. This approach is like designs proposed by Building Science Corporation[v]. **Figure 1** illustrates how closed-cell foam can be used as a cavity insulation in any part of the structure, especially assemblies expected to be below the flood line. It also shows removable wainscot on the left, and removable chair-rail and baseboard with gaps in the gypsum board; both construction techniques facilitate drying after a flood.

As the floodwaters recede the primary objective of the homeowner, building owner or restoration contractor is to dry the structure and contents as rapidly as possible to reduce the potential for mold growth and further degradation of the structure. Remove saturated furniture, carpet, rugs and drapes, then dehumidify as rapidly as possible. If electricity is not yet restored, this can be a challenge and if the flood was caused by a tropical storm, the humidity outside might remain too high to be of much use in drying with ventilation. Mold grows best in hot and humid conditions so cooling and dehumidifying as rapidly as possible is critically important.

Considerations for Closed-Cell Foam Installation

In many cases, contractors will be under pressure from the homeowner or building owner to rebuild quickly. While that is well understood, it is important for contractors to do the job correctly.

FIGURE 1. Wet floodproofed walls and floors



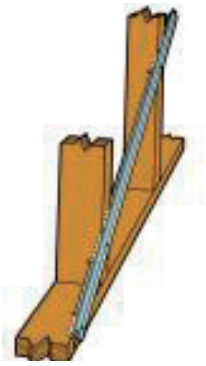
1. Batt, loose-fill or open-cell SPF insulation
2. Closed-cell (2pcf) SPF insulation
3. Wood or foam-board sheathing
4. Preservative-treated lumber
5. Elevated outlets
6. Removable or hinged wainscot panels (ideally water resistant)
7. Chair rail molding over gap to prevent wicking
8. Extra-wide, snap-on base board
9. Gap in wall board
10. Gypsum board ends
11. Ideally paperless gypsum board or water-resistant cladding
12. Water-resistant flooring with waterproof adhesive and/or mortar on concrete slab or pressure-treated sub floor

Depending on maximum expected flood level, upper gap may be placed at top plate and covered with removable crown molding

Courtesy of LSI AgCenter/FEMA

STEP 1: The first step is to remove all wet and water damaged materials from the structure. For walls and ceilings, this includes drywall, fibrous or open-cell SPF insulations, and certain wood sheathings. OSB and fiberboard sheathings will most likely be damaged. Removal of structural sheathings could result in structural failure of the building, so always consult a structural engineer before removing any sheathing or walls from a building. Removing structural sheathing may require carefully sequenced placement of cross-bracing on the remaining framing, such as a cut-in T-rail added to the framing, as shown in **Figure 2**.

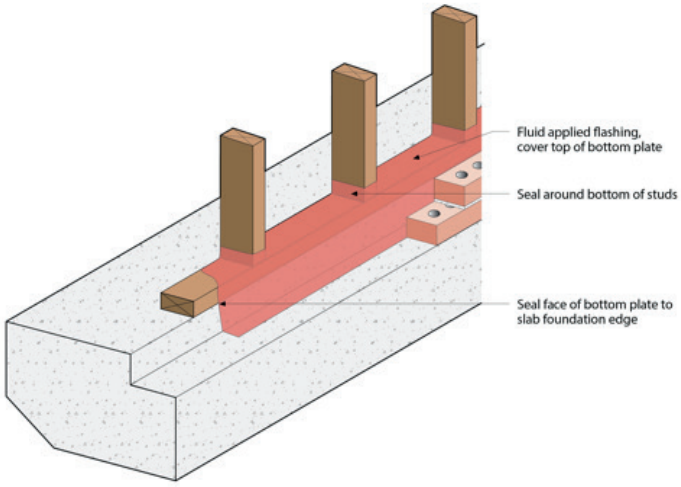
FIGURE 2. Example of a galvanized steel T-rail cross-brace.



All damaged flooring, underlayment and subflooring should be removed and replaced. Unless installed over concrete, vinyl flooring and other moisture impermeable flooring products should be removed and replaced with alternate materials.

STEP 2: The next step is to ensure all remaining substrate surfaces are clean, dry and clear of debris. A clean, dry surface is important for SPF adhesion, and good adhesion is critical for a continuous, air-tight and water-resistant assembly. Floodwaters can carry a significant number of contaminants, such as sewage, sludge and oils. Detergents and mold treatment chemicals used during cleanup may also affect adhesion. It is critical to be sure these residues are removed from all substrates. It is also important to be sure that all substrates are dry, below the moisture content limits provided in the manufacturers installation instructions. Dehumidifiers, fans and heaters may be used to accelerate drying. Joe Lstiburek suggests the use of a liquid applied flashing over the toe plate area[vi], as shown in **Figure 3**. This coating helps protect the framing elements from future flooding by promoting proper drainage.

FIGURE 3. Liquid-applied flashing over bottom (toe) plate.



Courtesy of Building Science Corporation

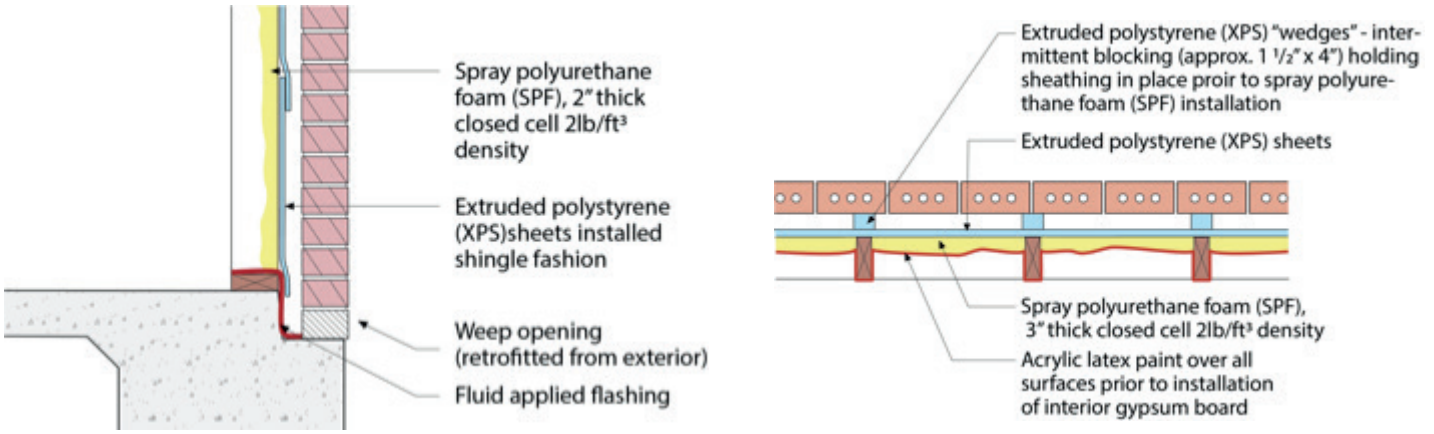
Walls with Brick Facades

Existing frame walls with brick facades can present challenges. Usually framed walls with brick facades will have wood or fiberboard sheathing. If this is damaged by water and removed using proper shear strength remediation, the question becomes can SPF be directly applied to the clean, dried brick. A minimum air gap of 1" is recommended behind the brick according to the Brick Industry Association[vii]. Such a gap is critical in forming a drainage plane for older brick that absorbs water[viii] and for painted brick or flood-resistant construction that needs to rapidly dry after a wetting event or flood.

A drainage plane in an existing brick façade can be created using several techniques. One method is to install thin sheets of closed-cell foam board (XPS) between the framing and brick, and use XPS blocks to wedge the board against the framing, as shown in **Figure 4**. Alternately, one can use a 3D rainscreen (drainage mat) in each cavity, with the filter side towards the interior, as shown in **Figure 5**. A third method uses a water-resistant membrane (**Figure 6**) or breathable underlayment product installed between the brick and framing. Brick ties may need to be removed to install and position XPS or certain membranes. In this case, there are fastening systems available to pin the brick to the framing from the outside[ix].

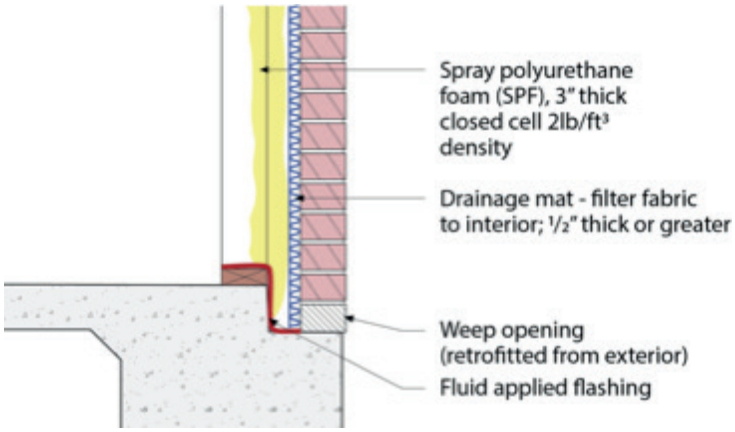
Closed-cell SPF can then be applied in a picture-frame technique[x] to seal and secure it to the studs and brick ties first, and then directly to the membrane to fill the cavity. Excess mortar behind the façade, combined with a thin fabric should provide the air-gap needed for drying. This membrane should extend all the way from the top of façade to the weep holes at the bottom of the brick façade to facilitate drying behind the brick.

FIGURE 4. Use of XPS Foam Board between framing and brick façade to create a drainage plane



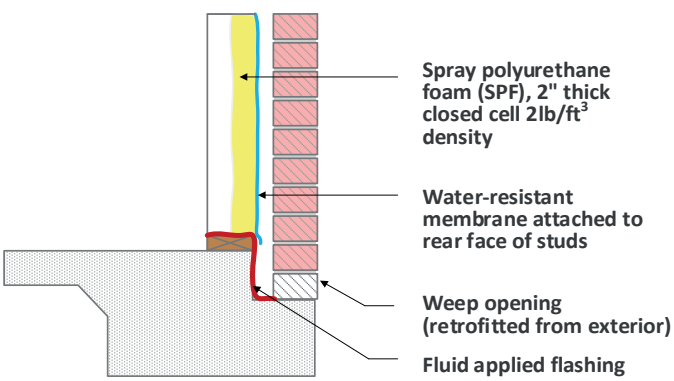
Courtesy of Building Science Corporation

FIGURE 5. Use of a drainage mat (3D rainscreen) to create a drainage plane



Courtesy of Building Science Corporation

FIGURE 6. Use of a membrane material to create a drainage plane.



Courtesy of H.C. Fennell Consulting, LLC

STEP 3: The next step is to apply the closed-cell SPF. During installation, perform regular qualitative adhesion checks for all substrate materials. When installing any closed-cell SPF in cavities, use a picture framing technique to avoid shrinkage and delamination. Follow all manufacturer's instructions regarding maximum pass thickness.

STEP 4: The final step is to install a code-compliant 15-minute thermal barrier over all SPF when the foam is exposed to an interior occupied space. ½" thick gypsum board meets the model building code prescriptive requirements for a thermal barrier. Alternative thermal barrier coatings or coverings may be used with proper fire testing. See SPFA-126 "Thermal and Ignition Barriers"[xi]. A spray applied semi-permeable acrylic paint can be applied on the surface of the closed-cell SPF to provide a more durable surface for pressure washing if the drywall is removed after a future flood event.

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