HUNTSMAN
BUILDING SOLUTIONS

Spray Foam & Resiliency

BES-103 - DESIGN NOTE

Resiliency

This Design Note reviews Huntsman Building Solutions' (HBS) closed-cell spray polyurethane foam (ccSPF) and how it can be used in the design of resilient construction. There are sections discussing how ccSPF is resistant to flood water damage and mold and mildew growth, acts as a Radon abatement material, provides increased racking strength to a structure, can limit the risks of wind-uplift on a roof structure, and when used as an exterior continuous insulation, is resistant to wind loads, and air and water infiltration.

Closed-Cell Spray Foam

Closed-cell spray polyurethane foam (ccSPF) has been long used as a versatile insulation product with its ability to provide 3 functions in 1 product. Insulation, Air Barrier, and Vapor Retarder. HBS ccSPF insulation has also shown an ability to increase the efficacy of a building to resist the effects of severe weather events. Multiple case studies and research programs have showcased ccSPF's ability to withstand flooding, storm surge and high winds.

Flood Resistance

Flooding can be one of the most costly weather events to a home/building owner. Provisions are in place to help limit the damage potential of flooding, but the best way to lessen these effects is to use flood resistant materials.

The Federal Emergency Management Agency (FEMA) has developed a Technical Bulletin: Flood Damage-Resistant Materials Requirements for Buildings Located in Special Flood Hazard Areas in Accordance with the National Flood Insurance Program, which provides guidance for protecting buildings that are constructed in special flood hazard areas. This document provides a rating system for building materials from 1-5. 1 being the least resistant to water damage, and 5 being Highly Resistant to floodwater damage. ccSPF qualifies as a Class 5 building material and is considered highly resistant to floodwater, damage caused by moving water, and can be successfully cleaned after a flood event.

Sections R322.1.8 and Section 1403.6 in the IRC and IBC respectively, require building materials used for flooring, interior/exterior walls, and wall coverings in flood prone areas to be rated as Class 4 or Class 5 according to FEMA TB-2. This allows ccSPF to be used in the construction of homes and buildings in flood prone areas.

Case Study

In 2017 a case study was performed on a flooded basement in Montreal, which had 4' of standing water, for a period of 5 days. The basement wall assembly consisted of an 8" foundation wall, 2"x4" wood stud wall spaced 1" from foundation wall, 2-½" ccSPF in the stud cavity, and ½" gypsum. After the flood water was mitigated, the gypsum wallboard was removed, basement walls were washed, and the remainder of the basement cleaned out. Dehumidifiers and industrial fans were then put in place for 5 days to allow the basement to dry out.

After the 5-day drying period, sections of the ccSPF were cut out to be lab tested. Results confirmed the ccSPF's physical properties were still intact, including acceptable moisture content levels. The wood studs were also measured for moisture content, throughout the basement, to measure the level of drying that had occurred. The exposed portions of studs, and the entire stud depth above the level of standing water, were shown to have acceptable moisture content levels after this 5-day drying period. Sections of the studs that were imbedded in the ccSPF still had elevated levels, which required additional drying time. Based on the ratio of dry to wet wood, this would dry out quickly. Following the additional drying period, new gypsum can be installed, and the walls will perform just as well as it did prior to the flood event.

Mold Resistance

Aside from the water damage that may be caused by flooding, the growth of mold and mildew can become a pestering issue. Mold and mildew can result in musty odors and severe health concerns if left untreated in your home/building. ccSPF has been tested in accordance with ASTM C1338: Standard Test Method for Determining Fungi Resistance of Insulation Materials and Facings and shown to support no fungal growth. In addition to being impermeable to mold growth, HBS ccSPF is UL GreenGuard Gold certified for low chemical emissions. The combination of these tests show additional benefits ccSPF can contribute to the air quality of your home/building.

Radon Abatement

Radon is a noxious gas that travels through soil and can infiltrate into a building, typically through cracks in the foundation floors and/or walls, and cause serious health concerns for its occupants. Starting in 2015, the International Residential Code (IRC) introduced measures that should be taken to protect your building from Radon infiltration. ccSPF is one of the few materials that has been tested and approved as a soil-gas-retarder and can be used as a Radon abatement material.

ccSPF is applied directly on top of the gas-permeable layer (typically directly to the ground), prior to casting the foundation slab, or placing the floor assembly. This provides a gas-impermeable layer that will bridge any cracks that may form in the slab or floor assembly over the lifespan of the building. Due to its ability to seal around penetrations, and being installed without joints, ccSPF makes this a seamless install, without the need for additional transition products. Additionally, when ccSPF is used in this application, it can simultaneously act as the required basement wall/slab insulation as well as the exterior foundation dampproofing.

Racking Strength

Walls are typically the main structural components in a wood-framed building. They must be designed to withstand the vertical loads (weight of structure, occupants and furnishings, standing water/snow, etc..) and lateral loads (wind and earthquake). The shear forces exerted from lateral loads can cause racking of your structure. Racking is the term used when your structure “tilts” or is forced out of plumb. While buildings that are designed and built to the specifications of the building code should resist racking, a severe event can cause excessive movement and even permanent damage, such as cracking in wall finishes.

Testing programs have shown that adding ccSPF to a typical 2”x4” wood-framed stud wall can increase the racking strength of the assembly by as much as 200% and decrease the deflection by as much as 75%. Figure 1 is taken from a test program conducted by the National Association of Home Builders (NAHB) and shows the difference between wall assemblies that were built with and without ccSPF.

The 8’x8’ test walls were constructed using nominal 2”x4” wood studs, spaced 16” o.c., with either vinyl siding over 15-lb. felt paper or textured plywood siding, and interior ½” gypsum. The stud cavities without spray foam were left empty. The stud cavities with spray foam were filled with ccSPF (1.5 lb./ft3 density).

These studies demonstrated how walls filled with ccSPF are better suited to handle the peak loads associated with severe weather events and add peace of mind to the building owner.

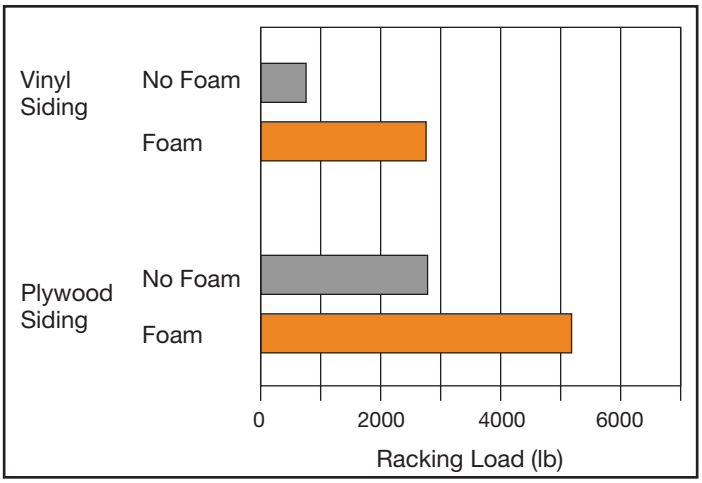
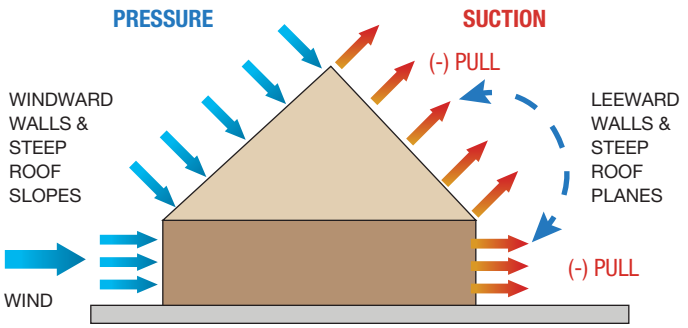


Figure 1

Wind Uplift

Wind forces can be catastrophic, causing widespread damage to buildings during extreme weather events. Wind uplift occurs when the air pressure below the roof deck is greater than the air pressure above the roof deck. This causes an upward pressure on the roof deck and its supporting members.

When air moves across a building it creates positive pressure on the windward sides of the building, and negative pressure (suction) on the leeward sides. See Figure 2. Positive pressure can build inside the building as air enters through doors, windows, and other openings. If the combination of the positive pressure inside the building and the negative pressure on the exterior side of the roof become great enough, structural failures and even a complete roof blow-off can occur.



Pressure vs. Suction

Source: American Society of Civil Engineers, 1990

Figure 2

The use of ccSPF to create an unvented attic assembly (see BES-101 Benefits of Unvented Attics) can help reduce the stresses of wind uplift on a building in two separate ways. First, creating an unvented attic assembly seals off all openings and penetrations in the attic space. This allows less air leakage into a building, reducing the opportunity for positive pressure to build within the structure. Although the negative pressures on the exterior side of the roof remain unchanged, the effective pressure on a roof structure is reduced due to the lower positive pressure exerted from the interior. Second, ccSPF acts as an "adhesive" by connecting joints between sheathing panels and by strengthening the connections between the roof sheathing and the structure. A study was conducted by SPFA to determine the strength ccSPF can add to a roof system. A baseline, standard construction without ccSPF, was compared to two separate ccSPF applications. When used as a fillet adhesive (only used at joints and connections) and when used as a full cavity insulation. The results can be seen in Figure 3.

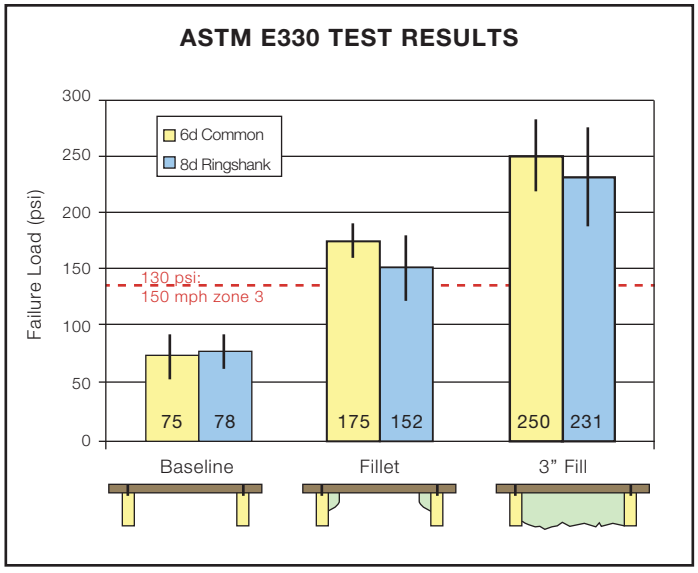


Figure 3

The use of ccSPF used in a fillet application improved the uplift resistance by approximately 2x, and by approximately 3x when used as a full-cavity insulation, depending on the size of nails used. This shows the drastic difference ccSPF can make on the strength of your roof system.

The Federal Emergency Management Agency (FEMA) has also created FEMA P-804: Wind Retrofit Guide for Residential Buildings. This document was designed to showcase different ways a home can be retrofit to increase its resiliency against severe weather. One section includes applying "SPF adhesive" to joints in the sheathing panels and at all intersections with the roof structure. The same application described in the SPFA study as a fillet application. This is another example where ccSPF is used to improve the resiliency of your building.

Air and Water Infiltration

One of the most efficient ways to insulate your building is using continuous insulation on the exterior side of your wall. This is most effective due to the elimination of thermal bridging that occurs at wall studs when insulating in the wall cavity. ccSPF can be used as an exterior continuous insulation, while also being able to resist air and water infiltration through the wall assembly.

The Air Barrier Association of America (ABAA) has a listing service which evaluates various assemblies in accordance with ASTM E2357: Standard Test Method for Determining Air Leakage of Air Barrier Assemblies and certifies that the products tested can be used in an Air Barrier Assembly. Multiple ccSPF products have been tested and approved by ABAA as an Air Barrier Assembly, when applied to the exterior side of a base wall assembly. This allows ccSPF to be used as an exterior continuous insulation without the need for additional full-surface air and vapor barriers.

In Canada, the Canadian Construction Materials Centre (CCMC) has also reviewed and accepted HBS ccSPF as an Air Barrier System. Testing was conducted in accordance with CAN/ULC S742: Standard for Air Barrier Assemblies – Specification and ccSPF, applied on an exterior wall surface, passed the required air leakage testing, as well as a maximum wind loading pressure of 3,820 Pa (~80 psf). Based on the wind load requirements in Canada, this pressure rating would allow spray foam to be used as an air barrier system in every Canadian city and on buildings up to approximately 90 stories in height, depending on the specific wind speed requirements.

Along with its ability to resist air infiltration, ccSPF has also been tested to show it can resist water penetration through an exterior wall assembly. Successful testing has been conducted in accordance with ASTM E331: Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference & AC71: Acceptance Criteria for Foam Plastic Sheathing Panels used as Water-Resistive Barriers. These 2 test methods allow the use of ccSPF behind all exterior wall claddings while providing a weather-resistant exterior wall envelope.

Exposed Product

When ccSPF is used as an exterior continuous insulation, it is common for the product to be left exposed up to 3 months during typical construction sequencing. In extreme situations it can even take 6+ months for the exterior façade to be completely installed and cover up the ccSPF. Even though ccSPF is not UV stable, it has shown an ability to maintain its performance characteristics even when left exposed for extended periods of time.

HBS has conducted a program to confirm this performance by leaving 2 mock-up walls outside for a 12-month period. Two separate 8' x 8' wall assemblies were constructed with typical window openings, penetrations, and transitions. One assembly had a nominal 1" and the other a nominal 4" of ccSPF applied to exterior sheathing. Both walls were placed outside for a period 12 months, receiving exposure to UV, wind, rain, snow, and freeze/thaw cycles. The walls were then tested in accordance with ASTM E331: Standard Test Method for Water Penetration of Exterior Windows, Skylights, Doors, and Curtain Walls by Uniform Static Air Pressure Difference and showed no signs of water leakage after the test period. The ccSPF maintained its ability to resist water penetration and air leakage after this extended exposure.

It is expected that ccSPF will reduce in thickness during its UV exposure. UV exposure causes the surface to become friable, and eventually will wear away. It can be estimated that a thickness reduction of approximately 1/16" will occur after 12 months of exposure. Because the core material remains intact and protected, confirmed by the exposure study, the performance of the system remains. Only a reduction in R-value will occur proportionately to the reduction in thickness. If desired, this loss in thickness can be regained by applying a new layer of ccSPF.

Using ccSPF as an exterior continuous insulation allows you to maintain flexibility with construction sequencing and timing, while still ensuring the overall building performance once the project has completed.

Summary

Constructing resilient buildings is becoming ever more prevalent, and ccSPF is poised to help. Whether it's rain/flood waters, high winds, or prolonged UV exposure, ccSPF has shown an ability to perform well in these severe weather events. Using ccSPF in your building can help resist long-term damage to your structure, without sacrificing its performance characteristics. This is a perfect product to use in both new construction and retrofit projects.

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