THE USE OF SPRAY POLYURETHANE FOAM IN MASONRY CAVITY WALL CONSTRUCTION

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Introduction

Spray polyurethane foam (SPF) insulation is commonly used as a construction material because it performs several functions simultaneously. In the case of masonry cavity wall construction, SPF provides insulation, dampproofing, and air infiltration control. Because one material accomplishes all of these tasks, the cost of SPF is competitive with conventional insulation and dampproofing systems.

Masonry cavity walls consist of two wythes of masonry with an air space between them. (A "wythe" is defined as a vertical wall of masonry units one-unit thick.) Most commonly, the inner wythe is constructed of concrete masonry units (CMU), while the outer wythe is constructed of decorative clay brick. The two wythes are usually tied together with galvanized steel anchors spaced approximately two feet on center. The air space – typically 2 to 4 inches in width – allows for the installation of insulation and dampproofing. The outer wythe acts as a rain shield; the inner (insulated) wythe provides thermal mass. The CMU inner wythe may or may not be load bearing.

With conventional construction techniques, liquid-applied dampproofing is installed on the outside CMU surface. Prior to installing the face brick, board stock insulation – usually expanded or extruded polystyrene – is friction fitted onto the CMU wall surface and held in place by the metal anchors.

An alternative technique of dampproofing and insulating the inner CMU wythe is to use SPF. There are open-cell and closed-cell SPF systems available on the market today. For use in masonry cavity walls, only closed-cell SPF exhibiting physical properties listed below should be specified:

Dampproofing

SPF has been used for decades as a roofing membrane. Its use as a dampproofing material is less known.

SPF is closed-cell and does not readily absorb liquid water. To verify its resistance to moisture penetration, 1/2-inch thick samples (triplicate) were tested using a Suter Hydrostatic Pressure Tester in accordance with AATCC[1] Test Method 127 *Water Resistance: Hydrostatic Pressure Test*. In this particular test, a hydrostatic head of 55 cm (22 in) was maintained for five hours, after which the head pressure was raised at a constant rate of 1 cm/sec (0.4 in/sec) until failure or maximum hydrostatic head pressure was reached (failure is indicated by the appearance of three water droplets on the bottom surface of the specimen). All three samples tested reached the maximum hydrostatic pressure of 184.9 cm (72.8 in) without failure.

Figure 1: SPF application to CMU wythe.

Figure 2: Conventional dampproofing and insulation.

PROPERTY	TEST METHOD	VALUE	UNITS
Density	ASTM D 1622	2.0 min	lb/ft^3
Compressive Strength	ASTM D 1621	20 min	lb/in^2
Closed Cell Content	ASTM D 2856	90 % min	
R-Value per inch	ASTM C 518, C 236 or C 177	6.5 min	°F• ft^2• hr/BTU
Hydrostatic Pressure Resistance	AATCC 127	No Failure @ 184.9 cm	
Flame Spread	ASTM E 84	75 max	
Smoke Developed	ASTM E 84	450 max	

Table 1

Although the sample thickness was only 1/2 inch, SPF in a masonry cavity wall application would be applied in thicknesses of one inch or more.

Assembly	Air Leakage at 1.57 psf (cfm/ft^2)	Air Leakage at 6.24 psf (cfm/ft^2)
CMU + 1" SPF	0.00	0.00
Gypsum Board + 1" SPF	0.00	0.01

Table 2

Insulation

As an insulation material, SPF offers several advantages in masonry cavity wall applications:

- Low labor requirements for installation
- Seamless
- Conforms to unusual shapes and configurations
- High R-value (6.5 - 7.0 per inch)
- Fills construction gaps

Generally, the thickness of the SPF application will be determined by the specified R-value. Since the R-value per unit thickness of SPF is greater than most board insulations, the insulation thickness can be reduced.

Figure 3: SPF readily fills construction voids.

For example, to achieve an R-10, a 1.5-inch thickness of SPF will provide sufficient R-value to replace 2-inch thick polystyrene board.

Because SPF is spray applied and expands in place, the insulation forms an intimate fit to masonry anchors and wall protrusions. Gaps and seams are eliminated, thereby increasing the effectiveness of the insulation. Additionally, construction voids, commonly left at structural steel to masonry joints at building corners, can be completely filled with spray foam.

Air Barrier

In addition to providing dampproofing and insulation, SPF offers additional benefits as an air barrier. SPF wall assemblies were tested in accordance with ASTM E 283 ("Standard Test Method for Determining the Rate of Air Leakage Through Exterior Windows, Curtain Walls, and Doors Under Specified Pressure Differences Across the Specimen"). The first assembly consisted of CMU blocks with 0.375-in. mortar joints and a one-inch thickness of SPF. The second assembly consisted of exterior drywall sprayed with a one-inch thickness of SPF. ASTM E 283 allows an infiltration rate of 0.06 cfm/ft^2 at a pressure differential of 1.57 psf. (During the test procedure, no leakage was detected at 1.57 psf, so the pressure was increased to 6.24 psf.) Test results of the two assemblies are shown in *Table 2*.

Figure 4: SPF application at the roof-wall juncture. The spray pattern can be seen at the lower right corner of this photo.

Details

Certain construction joints and transition areas are impossible to insulate, air seal, and dampproof with any material other than SPF. Fascias, entryway overheads, eave overhangs, and other features can be designed independently of the building envelope.

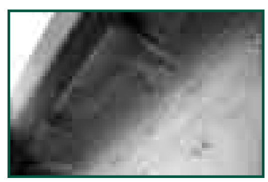

Figure 5: Note the tight seal developed around the roof trusses and the roof-wall juncture.

Hogan (1996) emphasized the need for air sealing the roof-to-wall juncture. SPF conforms to difficult shapes such as fluted metal roof decking and is an ideal material to accomplish this seal. If the roof trusses extend through the CMU wall, these penetrations can be sealed as well. This creates a continuous and seamless barrier from the roofline to the wall surface along the entire outside perimeter. Thermal, moisture, and air leakage at these tricky architectural features can be totally eliminated.

SPF nicely bridges structural steel column to masonry joints. However, building movement and settlement may crack the SPF at these joints. To avoid potential problems, a self-adhering membrane or tape may be applied across the joint prior to applying SPF.

Alternatively, redundancy could be provided using conventional joint materials (e.g., backer rod and sealant).

At through-wall flashings, SPF is applied down the CMU wall and tied onto the upper lip of the flashing. The SPF application is continued below the through-wall flashing and down onto the footer as appropriate *(see Figure 6)*. SPF forms a tight seal to the flashing system (above and below); weep vents in the outer wythe permit the escape of water that may have penetrated the brick facing.

Thermal Barriers and Code Requirements

Building codes require that foam plastic insulations (including SPF) be separated from building interiors by a thermal barrier. The intent of a thermal barrier is to slow the temperature rise of the foam plastic insulation in the event of a fire. The most commonly used thermal barrier material in use is 1/2-inch gypsum wallboard.

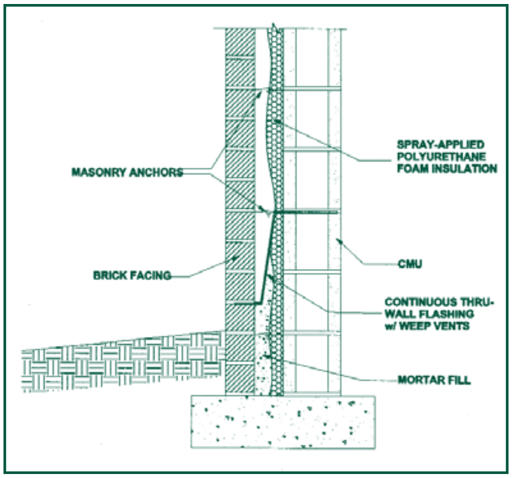

Figure 6: Detail of through-wall flashing and footer.

An exception to the thermal barrier requirement is "in a masonry or concrete wall, floor, or roof system where the foam plastic insulation is covered on each face by a minimum of 1 inch (25 mm) thickness of masonry or concrete" (Code 2003). Therefore, in general, masonry cavity walls do not require thermal barriers. At certain wall joints and construction details, however, masonry may not form a continuous layer between the SPF and the interior (for example, the roof-to-wall juncture). These details may require the addition of a thermal barrier.

Roofing grade SPF should not be used in masonry cavity wall construction because the smoke-developed indices are too high. The 2003 International Building Code requires foam plastic insulation to have a flame spread index of not more than 75 and a smoke-developed index of not more than 450 when tested in accordance with ASTM E 84. However, an exception within the code does not limit the smoke-developed index of roofing-applied foam plastic insulations. Most SPF formulated for roofing applications has smoke-developed indices that exceed 450.

UV Stability

Ultraviolet light will gradually degrade SPF. Once the exterior brick wythe is installed, the SPF is no longer exposed to sunlight, but during construction, SPF may be exposed for days or months. Within hours of its application, SPF will begin to darken. SPF sprayed a few days later will be markedly different in color. In four to six months, the foam skin will begin to deteriorate and a "dusty" surface will develop. (This, of course, depends on the degree of exposure to sunlight.)

If left exposed indefinitely, the dusting SPF surface will wash off, and eventually the thickness of the SPF will begin to diminish. Field studies suggest that the SPF may be left exposed for up to six months without deleterious effects. If the construction schedule suggests that the SPF will be left exposed for longer than six months, the foam may be thinly coated with an acrylic coating or the specified foam thickness can be increased by 1/4 inch.

Figure 7: Effects of UV exposure. Lighter SPF was applied several days after the darker SPF.

Economics

Although SPF insulation is more expensive than insulation boards at equal R-value, economics favor SPF in masonry cavity wall construction. Conventional liquid-applied dampproofing, insulation boards, and air barrier membranes require two or three separate application steps. Because SPF accomplishes all three functions with one material, only one application step is needed. The result is less labor, and often, less material cost.

Summary

SPF's unique characteristics as a closed-cell, spray-applied, fully-adhered foam plastic insulation make it particularly suited to masonry cavity wall construction. It combines the features of high R-value, efficient insulation while providing air sealing and dampproofing. The result is an economical, high performance building envelope assembly. ■

REFERENCES

Code 2003. *2003 International Building Code.* Section 2603.4.1.1.

Hogan, Lyle. "Designing Roofs To Avoid Air Invasion and Positive Pressure from Within," *Interface,* May, 1996, p. 14.

1. American Association of Textile Chemists and Colorists.

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