Clarifying Curtain Wall Firestop Standards

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Curtain wall design has been common in commercial construction for more than 30 years, but there have been no firm standards or testing procedures for fire protection of exterior curtain walls and floor-to-wall perimeter voids. The model codes include only cursory mention of this building issue, and thus architects, designers, contractors and code officials have often adopted untested and uncertain solutions. In more recent years, effective products have been developed and tested for curtain wall fire protection in accordance with ASTM E119, but no systems have been formally acknowledged in the applicable codes.

A curtain wall building is a multi-story structure having exterior walls that are not part of the load bearing structure. Because floor slabs are supported by interior beams and columns, there is a perimeter void or gap typically ranging from one to eight inches between each floor slab and the exterior curtain wall. Perimeter voids are generally hidden from view after construction, and once installed, these construction gaps are never inspected or reevaluated unless renovations are made. They must be sealed to prevent spread of flames, smoke and toxic gases in the event of a fire.

Each of the three U.S. model building codes address the issue of perimeter voids to some extent. Table 1 summarizes ICBO, BOCA and SBCCI standards. ICBO specifies, in broad terms, a UBC standard test to evaluate materials for use in protecting perimeter voids. ICBO and SBCCI require that the material be "approved" while BOCA does not. All of the codes require that the perimeter void system be an extension of the rated floor assembly without regard to the rating of the exterior, curtain wall system.

1997 ICBO – 709.3.2.2

Interior. When fire-resistive floor or floor-ceiling assemblies are required, voids created at the intersection of the exterior wall assemblies and such floor assemblies shall be sealed with an approved material. Such material shall be securely installed and capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste when subjected to UBC Standard 7-1 (ASTM E119) time-temperature fire conditions under a minimum positive pressure differential of 0.01 inch of water column (2.5 Pa) for the time period at least equal to the fire resistance rating of the floor assembly.

1996 BOCA – 713.2

Continuity: All floor/ceiling and roof/ceiling assemblies shall be continuous without openings or penetrations except as permitted by this section. Floor assemblies which are required to be fire resistance rated shall extend to and be tight against the exterior walls, or other provisions shall be made for maintaining the fire resistance rating of the assembly at such locations.

1997 SBCCI – 705.3.1.5

Any openings between the edge of a floor deck and an exterior wall shall be sealed using an approved material or assembly of materials designed and tested for this purpose. The material shall remain in place, sealing the opening, for a time period at least equal to the required fire resistance rating of the floor deck.

2000 ICC – 712.4

Exterior curtain wall/ floor intersection. Where fire resistance rated floor or floor-ceiling assemblies are required, voids created at the intersection of the exterior curtain wall assemblies and such floor assemblies shall be sealed with an approved material. Such material shall be securely installed and capable of preventing the passage of flame and hot gases sufficient to ignite cotton waste where subjected to ASTM E 119 time-temperature fire conditions under a minimum positive pressure differential of 0.01 inch of water column (2.5 Pa) for the time period at least equal to the fire resistance rating of the floor assembly.

***Table 1** – Current model code content related to perimeter gap and curtain wall fire protection.*

Perimeter voids have traditionally been sealed using mineral wool cut to the required depth and width, and placed in the construction gap – either friction fit or held in place with support clips.

In the early 1970s, the industry began to recognize the fact that fires in buildings with curtain wall construction were reaching through windows and traveling from floor to floor. Major fires in the U.S. and Mexico prompted suppliers, code officials and the model code groups to seek passive systems that could contain a fire at the building's perimeter, and various insulating materials were developed in an attempt to solve this challenge.

Outside walls may be constructed using one of several materials including glass, light gage metals and gypsum wallboard. The concrete slab or concrete block test may accurately simulate some rated walls, but non-rated wall system performance will vary significantly under test conditions.

It was suggested for a time that conventional glass fiber wall insulation could protect curtain walls and prevent the spread of fire up the outside of a building. However, as Table 2 shows, construction materials such as glass fiber insulation melt or burn at levels far below the potential temperature of a structure fire. Flames inside a building can melt aluminum and copper, and cause steel studs and panels to buckle, and the loss of these structural elements allows fire to escape quickly up the outside walls.

As with all firestop issues, the intent is to confine a fire in the room of origin and prevent propagation through the floor, ceiling, or walls. With ineffective curtain wall and perimeter void fire protection, fire can spread through the space between floors and walls (the safing gap), through the window head transom and the cavity of the curtain wall, and through broken glass or melted aluminum spandrel panels (Figure 1 – see last page).

A basic fire test under ASTM E 119 conditions assumes that the fire will expose only the underside of the floor slab, the underside of the joint system and the upper interior surface of the curtain wall below the slab to the threat of fire. In fact, the exterior face of the curtain wall system may also be exposed due to flames passing through window openings below the spandrel area.

During the last 10-15 years there have been significant advances in fire testing of building components. Newer standard tests have been or are being developed for various building components above and beyond evaluating the fire resistance of floors and walls.

Construction Material	Melting Point
Solder	360 °F
Cellulose (flash point)	450 °F
Zinc	790 °F
Glass fiber insulation	1050 °F
Aluminum	1220 °F
Plate glass	1510 °F
Copper	1980 °F

Table 2 *– Typical curtain wall materials are vulnerable to the heat of a structural fire, and in the absence of effective insulation, this can lead to rapid flame propagation from floor-to-floor.*

ASTM is currently processing a standard to address this issue. It is described as proposed ASTM "Standard Test Method For Determining the Fire-Endurance of Perimeter Fire Barrier Systems using the Intermediate Scale, Multi-Story Test Apparatus." The proposed ASTM standard recognizes that perimeter voids, created at the intersection of the exterior wall assembly and fire resistive floors must be tested to ensure that they are as capable of containing the spread of fire, as are the assemblies into which they are installed. The test allows for dynamic or static testing. Dynamic testing includes cycling the joint system from its maximum to its minimum width to simulate movement of the joint over time.

In the proposed ASTM method, temperatures are measured on the unexposed surfaces of the joint system, and limits on temperature rise are incorporated into the test criteria. These measurements address the concern that in many cases, a combustible material may be next to or on top of the joint, and a temperature limit would assist in reducing the possibility of the combustible material being ignited via heat transmission through the joint. The proposed standard requires that the systems exhibit neither flames nor gases hot enough to ignite cotton waste on the unexposed side.

This proposed new ASTM test standard for qualifying the performance of curtain wall firestopping is nearing final approval by a task group of ASTM E05 subcommittee 11, and is expected to be implemented during 2001. As previously mentioned, this standard to be known as *ASTM STANDARD TEST METHOD FOR DETERMINING THE FIRE ENDURANCE OF PERIMETER FIRE BARRIER SYSTEMS USING THE INTERMEDIATE SCALE, MULTI-STORY TEST APPARATUS*, will clarify performance expectations and

Interval (minutes)	Average Room Temp
0 - 5	1151 °F
5 - 10	1346 °F
10 - 15	1482 °F
15 - 20	1600 °F
20 - 25	1597 °F
25 - 30	1648 °F

***Table 3** – OPL test conditions (ASTM E 119) for curtain wall fire protection testing.*

confirm the performance of tested and rated assemblies for perimeter fire protection systems in multi-story curtain wall buildings. It will represent a compilation and expansion of the test standards currently covered by BOCA, ICBO, SBCCI, NFPA Code #101 as well as the new International Code, ICC.

The proposed standard also accommodates movement between structural components that might be caused by wind, environmental conditions, concrete slab loads or seismic activity – without losing fire protection effectiveness.

Traditional Curtain Wall and Perimeter Gap Firestopping

A very common perimeter void seal consists of a mineral wool or ceramic fiber blanket placed in the perimeter void, either friction fit or held in place by mechanical fasteners, with glass fiber installed against an unrated curtain wall. This firestop approach offers uncertain results because it does not ensure an effective life safety system against the containment of fire, smoke or toxic gases.

An Effective Curtain Wall Fire Containment Approach

Two industry participants, 3M Fire Protection Products and Thermafiber LLC, recently formed an alliance to develop tested fire-stopping systems for curtain wall fire containment in multi-level commercial buildings. The cooperatively developed system (Figure 2) consists of Thermafiber® brand Firespan® and safing insulations plus 3M Fire Barrier Spray, a flexible, water-based coating that provides an effective firestop and smoke seal for perimeter voids and accommodates dynamic movement between the curtain wall and the floor. Thermafiber mineral wool insulation resists temperatures beyond 2000 °F, and can protect underlying curtain wall structures and stop the progression of fire through the three paths of fire propagation shown earlier in Figure 1. Curtain wall and perimeter void fire stopping systems developed by 3M and Thermafiber were tested at the Omega Point Laboratory (OPL) in San Antonio, TX, following the draft standard under development by ASTM E05 Subcommittee 11.

The Test Arrangement

The OPL curtain wall test setup consisted of a mockup two-story structure with concrete test rooms. Propane gas diffusion burners mounted at two locations were used to create fire conditions, with standard ASTM E119 time-temperature test conditions (Table 3). One tested curtain wall system consisted of 4-inch thick Thermafiber® Firespan SS foil-faced insulation mounted between metal studs. The perimeter void was insulated with 10.75-inch Thermafiber safing compressed to fit the 8-inch gap, and coated on the top surface with a 1/8" coating of 3M Fire Barrier Spray, overlapping one-half inch onto the concrete floor and curtain wall assembly (Figure 2). This flexible, water-based elastomer spray dried to a minimum 1/16-inch thick seal to accommodate movement, and prevent the passage of hot gases and smoke. The 3M Fire Barrier Spray has been fire-tested and evaluated under the pass/fail criteria of ASTM E 119, at maximum extended joint width, and cycled 500 times at a minimum of 10 cycles per minute.

Results

The Omega Point Laboratory test report[1] concluded, "The test specimen as described did not allow flames to penetrate through the curtain wall and smoke seal system to the second floor at any time during the test period". The data should prove useful in the completion of the draft ASTM standard for curtain wall and perimeter void fire protection standards, which will be a valuable tool for both specifying architects and code officials as they work to maximize the safety of curtain wall structures through nationally-recognized construction and inspection standards.

[1] Omega Point Laboratories Project No. 9006-103759, February 25, 1999

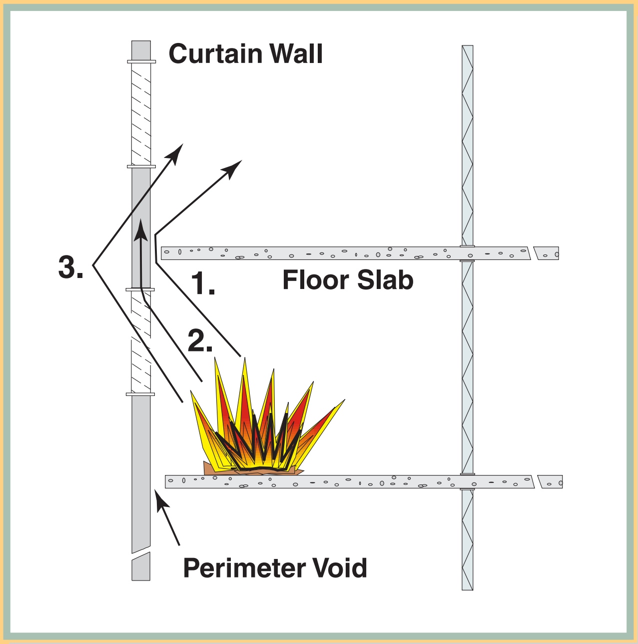

Figure 1 – In unprotected construction, a curtain wall fire can propagate through the safing gap (1); through the window head transom and curtain wall cavity (2); and through broken windows or melted aluminum spandrel panels in the curtain wall above (3).

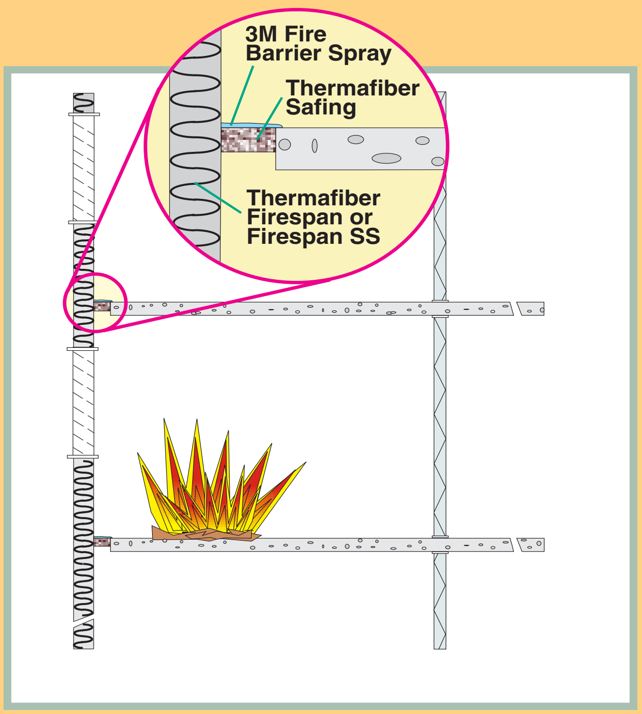

Figure 2 – Effective curtain wall and perimeter void firestopping measures combine high quality Thermafiber insulation and 3M Fire Barrier Spray to protect both exterior curtain walls and the floor-to-wall gap.

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