The Code Corner

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Exterior Walls

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In 1943, American psychologist Abraham Maslow proposed his "Hierarchy of Needs" motivational model. At the base of the five-stage model are the biological and physiological needs, or, in other terms, the basic life needs; and found within that first stage is the need for shelter. Growing from that basic need came man-made structures for sleeping and eating, and eventually, for work and play. The elemental feature of these structures is the physical separation between interior and exterior space, commonly referred to as the building enclosure, which typically includes the roof and exterior walls. Over time, exterior walls (and in some cases, roofs) have expanded from their basic purpose of separating interior from exterior to providing a medium for architectural expression by incorporating unique shapes, fenestration, and a variety of materials.

However, an exterior wall's purpose goes well beyond the fundamental need described above. As a barrier against the elements of weather, exterior walls need to endure what Mother Nature can inflict upon them, such as water, wind, and earthquakes. With the increase of sustainability in building design, energy efficiency has elevated to an almost equal footing with architectural aesthetics--in some cases, aesthetics have taken a position behind energy efficiency in wall system design. And lastly, fire-resistance cannot be ignored if exterior walls are located in close proximity to other structures or property lines. All of these characteristics of exterior walls are directly affected to some degree by the provisions of the building code.

Weather Protection

Chapter 14 of the 2006 *International Building Code* (IBC) addresses the performance of weather-resistant envelopes. Much of the content of this chapter is on the installation of materials as "exterior wall coverings," such as veneers (wood, masonry, stone, metal and glass), fiber cement siding, vinyl siding, doors, windows, and metal composite materials. Additionally, Table 1405.2 specifies minimum thicknesses for weather covering materials. For example, natural stone veneer requires a 2-inch minimum thickness of material. But underlying the requirements for each of these wall coverings is the all important need to keep water out.

In Section 1403.2, the IBC emphasizes this minimum performance requirement by stating that exterior walls "shall be designed and constructed in such a manner as to prevent the accumulation of water within the wall assembly…and a means for draining water that enters the assembly to the exterior." The only exceptions to this requirement are assemblies that have been tested in accordance with ASTM E 331, *Test Method for Water Penetration of Exterior Windows, Skylights, Doors and Curtain Walls by Uniform Static Air Pressure Difference*, and concrete and masonry walls designed in accordance with their respective chapters in the IBC.

The only problem with this, especially for masonry, is that those chapters do not address any type of flashing. The *IBC Commentary* states that the water resistive barrier and means of drainage can be omitted from masonry and concrete walls because "the penetration of moisture behind the exterior wall finish is not detrimental to concrete and masonry substrates." Fortunately, architects and contractors are keenly aware that moisture, although not detrimental to those materials themselves, can create other problems such as mold. Therefore, flashing and drainage are still essential elements of these wall types, even though they are not explicitly required in the building code. An important note is that these exceptions do not apply to masonry veneers unless the veneer is over a concrete or masonry wall designed as stated above.

For veneers, a water-resistive barrier is required between the veneer and the substrate, such as studs or sheathing. Section 1404.2 establishes one layer of No. 15 felt complying with ASTM D 226 for Type 1 felt as an acceptable water-resistive barrier. The Section also allows "other approved materials," so the designer can utilize many of the other materials that are on the market for such an application. To be considered "approved," the International Code Council Evaluation Service (ICC-ES) has prepared AC38, *Acceptance Criteria for Water-Resistive Barriers*, that is utilized by the service to evaluate products submitted for an Evaluation Service Report (ESR). The criteria permits products complying with UBC Standard 14-1 (Fed. Spec. UU-B-790a) for paper-based barriers and ASTM D 226 for felt-based barriers. Polymeric-based barriers, such as Tyvek and other comparable products, are evaluated based on tensile strength (ASTM D 828 or D 882), water resistance (ASTM D 779), water-vapor transmission (ASTM E 96), and cracking at freezing temperatures.

Fire Resistance

For fire resistance, Chapter 14 redirects the user to Chapter 7, "Fire-Resistance-Rated Construction," in which Section 704 specifically addresses the fire-resistance requirements of exterior walls. However, this Section does not determine the conditions under which an exterior wall is required to be protected; that is determined in Chapter 6, "Types of Construction."

Tables 601 and 602 determine the fire-resistance rating for exterior walls based on construction type, occupancy, and fire separation distance[*]. These ratings vary from no rating at all to 3 hours. However, there is a slight difference between the fire-resistance rating for exterior walls and other types of fire-resistance-rated walls, such as fire barriers and fire walls. Exterior walls are only required to have a rating based on exposure from the inside, with one exception: exterior walls that are 5 feet or less from the property line are required to have a fire-resistance rating for exposure from both sides.

For fire-resistance-rated (and even non-fire-resistance-rated) exterior walls, openings, including both windows and doors, are required to be protected in accordance with Section 704.8. Fortunately, this Section does not necessarily require all openings to be protected; a mix of both protected and unprotected openings may be permitted. Table 704.8 sets the allowable percentages of protected and unprotected openings based on fire separation distance for each story. Yet, if a mix of protected and unprotected openings is considered, the allowable opening areas cannot be based solely on the percentages in the Table; the sum of the ratios for actual areas to allowable areas cannot exceed one.

For example, the exterior wall of a story for a building is 1,000 s.f. The fire separation distance is between 10 and 15 feet. According to Table 704.8, the building can have 15% unprotected openings or 45% protected openings; but how much area of each is allowable? That can only be determined by using the actual areas in the design. For our example, the design includes an 8 foot by 6 foot specialty window that has no fire-resistance rating. The rest of the openings, which are protected, have a total area of 360 s.f. Is the design in compliance?

[*] Fire separation distance is defined in Section 702 as "the distance measured from the building face to one of the following: 1. The closest interior lot line; 2. To the centerline of a street, an alley or public way; or 3. To an imaginary line between two buildings on the same property."

The answer is "no." The unprotected opening is 48 s.f.; divide that by 150 s.f. (15% of 1,000 s.f.) to get a ratio of 0.32. Next, divide the actual area of protected openings, 360 s.f., by 450 s.f (45% of 1,000 s.f.) to get a ratio of 0.8. Add the two ratios together and you get a total of 1.12, which is greater than 1, therefore the design is unacceptable. To be in compliance with the code, the area of protected openings will have to be 306 s.f. or less.

If you are still scratching your head about non-fire-resistance-rated openings having to comply with Table 704.8, do not fret…read the fine print in footnote "i," which is applicable to unprotected openings having a fire separation distance greater than 5 feet. This footnote allows unprotected openings to be unlimited if exterior walls (bearing and nonbearing) and the exterior structural frame are not required to be fire-resistance-rated per Tables 601 and 602.

The last area to cover regarding fire-resistance of exterior walls is the provision in the code that permits wall assemblies that do not comply with the unexposed surface temperature rise requirements of ASTM E 119, *Test Methods for Fire Tests of Building Construction and Materials*. Since thermal exposure to adjacent properties and buildings are a concern during a structure fire, an exterior wall that doesn't reduce the temperature on the unexposed surface as required by ASTM E 119, must be taken into consideration. Section 704.7 allows wall assemblies that have exceeded the 250 deg. F (121 deg. C) limitation by applying a portion of the wall area to the opening area. To determine that area, Figure 704.7 is used to find the equivalent opening factor. To use the Figure, two items are required: the required hourly rating and the average unexposed surface temperature of the wall assembly that has been determined through testing at the required rating.

To illustrate how this is applied, let us assume a building has an exterior wall with an area of 500 s.f. The wall is between 15 and 20 feet from the nearest property line and is required to have a 1-hour fire-resistance rating. Within that wall are 190 s.f. of protected openings. The assembly used has an average unexposed surface temperature of 1,200 deg. F. determined through testing in accordance of ASTM E 119. Using Figure 704.7, the equivalent opening factor is 0.35. The wall area (500 s.f.) is multiplied by the factor (0.35) to obtain an equivalent area of 175 s.f. This is added to the area of actual protected openings to achieve the full equivalent area of 365 s.f. If no unprotected openings are in the wall assembly, then according to Table 704.8, 75% of the wall area may have protected openings, which equates to 375 s.f. Therefore, since the equivalent area (365 s.f.) is less than 375 s.f., then the wall assembly is acceptable.

Energy Efficiency

Chapter 13 of the IBC addresses energy efficiency; however, when reviewing that chapter you will find little in the way of requirements. What you will find is a reference to the *International Energy Conservation Code* (IECC). The IECC establishes requirements for two building types: residential and commercial. However, this article will only address the commercial requirements located in Chapter 5. Additionally, for commercial buildings, the IECC gives the designer two options: comply with the requirements of the IECC or ASHRAE/IESNA Standard 90.1, *Energy Standard for Buildings Except for Low-Rise Residential Buildings*; but, for brevity, this article will focus only on the IECC requirements.

Section 502 addresses the building envelope, and Section 502.2.3 specifically addresses above-grade walls. The provisions of this Section require a minimum thermal resistance (R-value) in accordance with Table 502.2(1). To use this Table, the climate zone in which the project is located must be determined. The climate zone can be determined in Chapter 3 using either the map in Figure 301.1 or the listing by state, county, and territory in Table 301.1. For example, Maricopa County in Arizona is Zone 2.

Returning to Table 502.2(1) and using climate zone 2, there is no required R-value for mass walls*, but metal, metal-framed, and wood-framed buildings must have an R-value of 13. Opaque swinging doors must have a maximum U-value (thermal transmittance, which is 1/R) of 0.70, whereas opaque roll-up or sliding doors must have a maximum U-value of 1.45.

Building fenestration, which includes windows and doors (except opaque doors), must comply with the provisions of Section 502.3. This Section establishes the maximum area of vertical fenestration (40% of above-grade wall area) and skylights (3% of gross roof area). Additionally, Table 502.3 establishes the minimum U-value and solar heat gain coefficient (SHGC) based on climate zone and window projection factor (PF). The PF is calculated by dividing the horizontal distance of the furthest edge of a shading device from the vertical surface of glazing by the vertical distance of the underside of a shading device to the bottom of glazing.

Other mandatory requirements of the IECC include air leakage of windows, doors, storefront, curtain walls, penetrations, and other exterior openings. Also, if exterior walls are framed, and the cavities are not vented to allow moisture to escape, a vapor retarder having a permeance rating of 1 perm or less is required. All of these additional provisions are contingent upon the climate zone in which the project is located or other exceptions.

The Future

Our shelters have matured from simple structures to the advanced and complex systems of interconnected components and materials found in today's buildings. However, this process of improvement will continue long into the future. But this constant development is not limited to physical building elements; it also applies to the research and learning processes connected with environmental, life safety and fire science issues that also affect the products we develop and the codes we write. As we develop new building components and materials, the building code will continue to evolve to address these new technologies--and the problems that may follow (exterior insulation and finishing systems and the subsequent mold epidemic come to mind).

To comment on this article, suggest other topics, or submit a question regarding codes, contact the author at ron@specsandcodes.com.

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* Walls weighing at least 35 psf of wall surface area or 25 psf of wall surface area if the material weight is not more than 120 pcf.