

Openings – Part 2

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In Part 1, the importance of protecting openings was addressed with a focus on interior windows and doors. But opening protection is not limited to interior construction; openings in exterior walls are also subject to protection.

Openings in Exterior Walls

Protection requirements for openings located in exterior walls are determined in a manner completely different than that for interior openings. One of the most notable differences is that just because an exterior wall is required to be of fire-resistive construction does not mean that openings in that same wall are required to be protected.

Fire-resistive requirements for exterior walls are determined in Chapter 6 of the *International Building Code (IBC)*¹. Table 601 sets the fire-resistive construction for exterior bearing and nonbearing walls based on construction type. For nonbearing walls, Table 601 references Table 602, which determines the fire-resistance rating based on three factors: fire separation distance, type of construction, and occupancy group. The fire-resistance rating for exterior bearing walls will vary from 1 hour for Type VB construction to 3 hours for Type IA construction, but according to footnote “F” of Table 601, the fire-resistance rating cannot be less than that required by Table 602. Therefore, if Table 601 indicates that the rating for the exterior bearing wall is 1 hour and Table 602 requires the same wall to be 2 hours, Table 602 governs, and the wall must be of 2-hour fire-resistive construction.

That explains the requirements for exterior walls, but establishes no criteria for openings. To determine the fire-resistive requirements for openings, Section 705 must be consulted. Unlike interior fire-resistance-rated assemblies, where all openings are required to be protected based on the fire-resistance rating of the wall assembly, openings in exterior walls may be unprotected, protected, or a combination of both. The allowable area of each is determined by the percentages indicated in Table 705.8, based on fire separation distance and sprinkler protection; however, the sprinkler protection only impacts allowable area of unprotected openings.

The percentages provided in Table 705.8 are the maximum areas permitted for openings per story. For example, if a fire-resistance-rated exterior wall is located 12 feet from the lot line, and the building is two stories in height, then 45% of the wall area of each story is permitted to have protected openings, or unprotected openings if the building is sprinklered throughout; or, if the building is not sprinklered throughout, then 15% of the wall area at each story is permitted to have unprotected openings.

To better explain how Table 705.8 is applied, consider the building elevation in Figure 1. Each story is 10 feet in height; the parapet cannot be included in the second story exterior wall area since the IBC definition of “story” is the measurement from the floor to the next floor or roof above, so the measurement must be to the roof line and not to the top of the wall. Therefore, the area of wall for each story is 750 ft.². For this example, the building is nonsprinklered and the wall has a fire separation distance of 18 feet.

¹ References to the IBC in this article are for the 2009 Edition.

To determine if the openings in this building elevation require protection or not, the first step is to determine the actual area of openings per floor. The first story has a total opening area of 366 ft.² (81 ft.² × 4) + 42 ft.²; the second story has 105 ft.² of openings (21 ft.² × 5).

The next step is to determine the percentage of openings per story. The percentage of openings in the first floor wall area is 49% (366 ft.² ÷ 750 ft.²). The second story has 14% of its wall area as openings (105 ft.² ÷ 750 ft.²). With these percentages, we can determine whether or not the openings require protection.

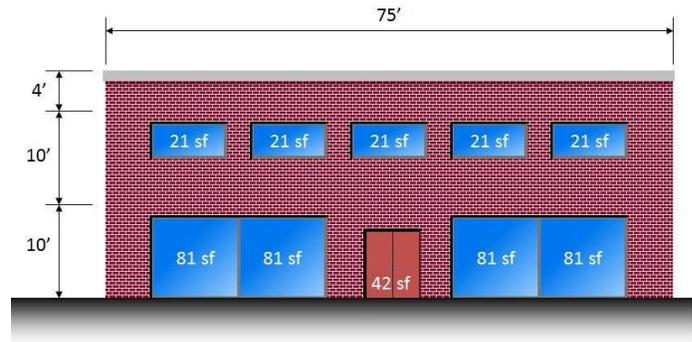


Figure 1 - Building Elevation.

As previously mentioned, the fire separation distance for the wall is 18 feet. Looking at Table 705.8, each story is permitted to have protected openings in 75% of the wall area or 25% unprotected openings, since the building is nonsprinklered. The percentage of actual openings at the second floor is 14%, which is less than 25%; therefore, all the windows in this story may be unprotected. However, the first story has openings which cover 49% of the wall, which exceeds the allowable 25%, but does not exceed the 75% allowable area for protected openings. Thus, the first floor must have protected opening.

If unprotected openings are desired, then the building must be sprinklered, since 75% of the wall area is permitted to have unprotected openings if the building is sprinklered throughout. But if sprinklering the building is not an option, and the project cannot afford the cost of protected openings, then there are only two alternatives available: 1) reduce the area of openings so that the percentage is equal to or less than the allowable area for unprotected openings, or 2) provide a mix of protected and unprotected openings to reduce the area of protected openings required. The first one is easy, but may not achieve the desired result. The second one requires some manipulation to achieve compliance.

Therefore, in the example, the door will be considered unprotected and the storefront glazing is protected. If a combination of protected and unprotected openings are used, then the sum of the ratios of actual to allowable areas cannot exceed 1, which is provided by Equation 7-2 in the IBC: $(A_p/a_p) + (A_u/a_u) \leq 1$, where A_p is actual area of protected openings, a_p is allowable area of protected openings, A_u is actual area of unprotected openings, and a_u is allowable area of unprotected openings. The allowable area for protected openings (a_p) would be 75% of the wall area for the story, or 562.5 ft.², and the allowable area for unprotected openings (a_u) would be 25% or, 187.5 ft.². Since the actual area of the door is 42 ft.² (A_u) and the actual area of the storefront glazing is 324 ft.² (A_p), the equation would be set up as follows:

$$(A_p/a_p) + (A_u/a_u) = (324 \text{ ft.}^2/562.5 \text{ ft.}^2) + (42 \text{ ft.}^2/187.5 \text{ ft.}^2) = 0.576 + 0.224 = 0.8 \leq 1$$

The discussion thus far has only mentioned openings as either protected or unprotected, with no mention of the requirements for a protected opening in the discussion of fire-resistance ratings. For openings in exterior walls, the fire-resistance ratings are provided in Table 715.4. For walls with a 1-hour fire-resistance rating, openings are required to have a ¾-hour or greater rating. For exterior walls with a 2- or 3-hour fire-resistance rating, the openings must have a 1½-hour or greater rating. If our example building is of Type VA construction with a Group B occupancy, and the wall is nonbearing, then the fire-

resistance rating of the wall would be 1-hour per Tables 601 and 602. Therefore, the openings in the wall would need to have a ¾-hour rating.

Walls Not Parallel With Lot Lines

Determining protected openings is easy when the exterior walls are parallel with the lot line; however, not all buildings are constructed square with their lots nor are all lot shapes rectilinear. So when a building has an exterior wall that is not parallel with the adjacent lot line, the determination of protected openings gets a little more complicated. The easy approach is to use the fire separation distance between the exterior wall and the lot line at the closest point and apply that percentage to the entire length of the exterior wall. However, that can be a somewhat overly restrictive.

Even though the IBC does not address nonparallel exterior walls and lot lines, the following method uses the IBC principles of exterior wall opening protection in a segmental application over the entire length of the wall (See Figure 2).

The method requires establishing lines parallel to the wall in question at distances equal to the ranges used in Table 705.8. The reason the lines are parallel to the wall is that fire separation distance is measured perpendicular to the wall and not the lot line per IBC definition. At the point where each distance line intersects the lot line, establish another line perpendicular to the distance line back to the building's wall. These lines create the zones of fire separation distance along the length of the exterior wall.

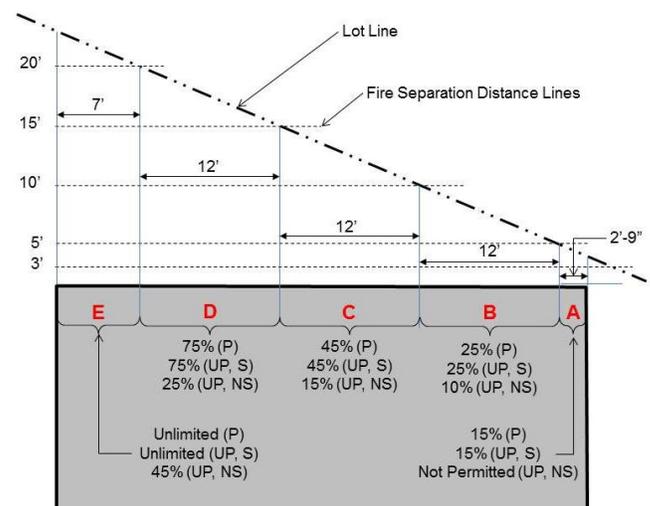


Figure 2 - Opening protection for angled lot lines.
(P) Protected; (UP,S) Unprotected, Sprinklered;
(UP, NS) Unprotected, Nonsprinklered.

For each zone, determine the length and identify the permitted allowable opening percentage. The percentage is then applicable to each zone based on the area for that zone (length of zone × story height). Using the example in Figure 2, if the building had a story height of 13 feet and it was nonsprinklered, the permitted unprotected opening areas would be as follows:

- Zone A: No openings permitted
- Zone B: 15.6 ft.² (12 ft. × 13 ft. × 10%)
- Zone C: 23.4 ft.² (12 ft. × 13 ft. × 15%)
- Zone D: 39 ft.² (12 ft. × 13 ft. × 25%)
- Zone E: 40.95 ft.² (7 ft. × 13 ft. × 45%)

The same process is used for each zone for protected openings, or for unprotected openings if a sprinkler system is installed throughout. For a combination of protected and unprotected openings, the same process described earlier for mixed openings is used, but is applied to each zone separately.

Exterior Opening Exceptions

There are several exceptions to the requirements for openings in exterior walls. In Section 705.8.1 there are two exceptions. The first exception applies to openings in the first story for all occupancy groups except Group H and has two conditions, of which only one or the other needs to be met. The first condition allows unlimited unprotected openings when the exterior wall faces a street and has a fire separation distance greater than 15 feet. The second condition allows unlimited unprotected openings when the exterior wall faces an occupied space that is at least 30 ft. wide and is accessed by a street using a fire lane. This condition may seem odd, since Table 705.8 allows unlimited unprotected openings when the fire separation distance is 30 ft. or greater. However, this condition permits the open space to be one that is not on the building's lot, as long as the space is dedicated for public use or is an open space between buildings on the same lot².

The second exception to Section 705.8.1 allows unlimited unprotected openings when the exterior bearing and nonbearing walls, as well as the exterior primary structural frame, are not required to be fire-resistance rated. Therefore, this exception would only apply to Types VB, IIIB, and IIB; and if a sprinkler system is used to substitute for 1-hour construction, the exception would also apply to Types VA, IIIA, and IIA.

Although not technically considered exceptions, the footnotes of Table 705.8 also provide some alternatives to the general requirements for exterior wall opening protection. Footnote “d” allows 25% of the wall area to have protected and unprotected openings in a Group R-3 building when the fire separation distance is 3 feet to less than 5 feet; footnote “e” does not permit openings for Groups H-2 and H-3 when the fire separation distance is less than 15 feet; footnote “f” allows unlimited protected and unprotected openings for Group R-3 when the fire separation distance is 5 feet or greater; and the area of openings in an open parking structure is not limited when the fire separation distance is 10 feet or greater.

Vertical Separation of Openings

Openings in exterior walls may need to be vertically separated in accordance with Section 705.8.5. If openings in adjacent stories are within 5 feet of each other (See Figure 3) and the window in the story below is unprotected, then the openings must be separated by a 3-foot, 1-hour fire-resistant-rated spandrel or a 30-inch, 1-hour fire-resistant-rated horizontal flame barrier (See Figure 4). As always, there are exceptions to the requirements.

The exceptions exclude buildings under certain conditions from complying with the vertical separation requirements. The first exception is for buildings that have three or fewer stories above grade plane. The second applies to any building that is sprinklered throughout with either an NFPA 13 or NFPA 13R system. The final exception applies to all open parking garages.

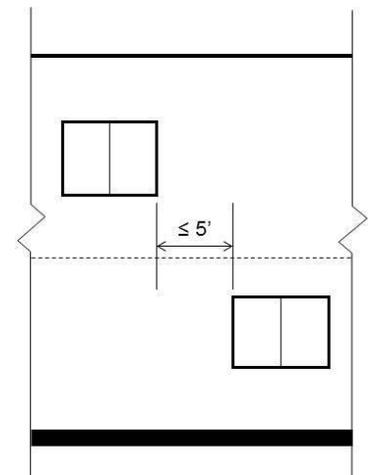


Figure 3 - Horizontal distance that requires compliance with vertical separation requirements.

² Typically, fire separation distance between buildings on the same lot is measured between the face of the wall and an imaginary line between the buildings.

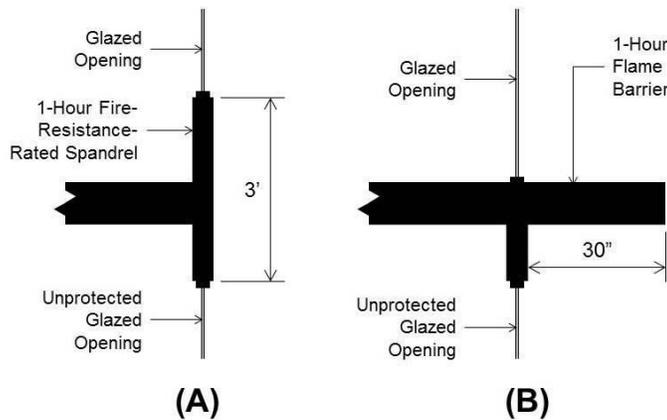


Figure 4 - Vertical separation of openings in exterior walls. (A) Provides separation by use of vertical, fire-resistance-rated spandrel. (B) Provides separation by use of horizontal, fire-resistance-rated flame barrier.

with a fire rating determined by one of the three standards, and 4) alternative methods allowed by Section 104.11. The first method allows selecting openings that have been tested and listed in various sources such as UL and FM Global. The second requires using a calculated method that has been approved by the building official; this may require consulting a specialist, which is also likely for the third method. The fourth method allows the use of the alternative materials, design and methods section of the IBC, which may require a research report, testing, or both.

Windows that are not Openings

Even though this two-part article series is titled “Openings,” it would not be complete without a discussion on windows that are not considered openings, but are in fact considered fire-resistance-rated walls. Section 715.2 states that glazing tested in accordance with ASTM E 119, *Test Methods for Fire Tests of Building Construction and Materials*, or UL 263, *Standard for Fire Test of Building Construction and Materials*, are not subject to the requirements of Section 715 for opening protectives.

A few manufacturers provide products that have been tested using these two standards and are thus not openings, but more like “fire-rated transparent walls,” since they have been tested using the same standards as required for fire-resistance-rated wall assemblies, such as fire walls and fire barriers. Although not currently addressed in the IBC, glazing that has been tested and has passed the requirements of ASTM E 119 or UL 263, including the prevention of radiant heat, are given the “W” mark for “Walls” in lieu of the “D” and “OH” marks mentioned in Part 1 of this article³. Therefore, they can be included in exterior and interior locations where fire-resistance-rated assemblies are required and not be limited to the size and area restrictions for openings. Fire-rated transparent walls may have unlimited area as long as each lite of glazing, bounded by the frame, does not exceed the maximum tested area.

Another difference between glazed openings and fire-rated transparent walls is the required fire-resistance rating. As mentioned earlier in this article series, the fire-resistance ratings for openings are, in

Alternate Methods for Determining Fire Ratings of Openings

As mentioned in Part 1 of this article, one of the standards for fire-resistance-rated doors is NFPA 252. For fire-resistance-rated windows, the acceptable standards include NFPA 257 and UL 9. For alternative methods of determining fire-resistance ratings of openings, the IBC identifies four methods or procedures in Section 715.3. However, whichever method or procedure is selected, it must be based on one of those three standards.

The four methods and procedures listed in the IBC include 1) designs documented in approved sources, 2) calculations performed in an approved manner, 3) engineering analysis based on comparison to openings

³ The “W” mark has been approved for the 2012 Edition of the IBC.

most cases, lower than the fire-resistance rating of the walls in which the openings are installed. However, fire-rated transparent walls, when installed in place of typical fire-resistance-rated wall assemblies, must have a fire-rating that is equal to or greater than the required rating for the wall assembly. For example, if the required rating for a fire barrier used as an occupancy separation is 2-hours, then the rating for the fire-rated transparent wall must also be 2 hours or greater.

While many fire-rated glazing systems are manufactured using ceramic, wired, or specialty tempered glass, fire-rated transparent walls utilize tempered glazing that is laminated with an intumescent interlayer. When a fire reaches a temperature to shatter the tempered glass on the fire side, the intumescent layer will create a char that will insulate the opposite side from radiant heat transfer.

There are a couple of things to keep in mind when considering the use of fire-rated transparent walls. The first thing to consider is the cost; fire-rated transparent walls are not inexpensive. The second is possible resistance from the local building department to accept these systems as anything but openings. This resistance is usually derived from the misconception that “if you can see through it, then it’s an opening.” Even though this perception is contrary to the IBC, building departments are made up of people, and it may take some effort on the part of the design team to convince the local building department that these systems are in compliance with the code.

Coordination with Other Requirements

The placement of openings in fire-resistive assemblies must be carefully considered to ensure that maximum allowable areas are not exceeded; but coordination with other sections of the IBC is just as important. Fire-resistance-rated doors must also conform to the means of egress requirements of Chapter 10, and fire-resistance-rated windows need to comply with the safety glazing requirements of Chapter 24 when located in one or more of the hazardous locations listed. Additionally, exterior fire-resistance-rated openings are subject to the structural load requirements of Chapters 16 and 24, as well as the energy requirements of the *International Energy Conservation Code*, if adopted.

Protected openings are essential in order to make buildings functional when fire-resistive construction is required by the building code. Otherwise, to move from one fire area⁴ to the next would require exiting and reentering the building. Just installing a door or window in these assemblies is not enough; the fire-resistive performance of the wall assembly must not be significantly compromised. Therefore, opening protection is required to maintain that minimum fire-resistive performance.

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⁴ A “fire area” is defined in the IBC, in part, as “The aggregate floor area enclosed and bounded by fire walls, fire barriers, exterior walls or horizontal assemblies of a building.”