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Taking the Guesswork out of Mixed-Use Building Requirements

Mixed-Use Occupancy Design for Low- and Mid-Rise Wood Buildings

Mixed-use buildings, which combine multiple occupancies within a single structure, are common, but determining how to apply their unique set of code requirements can be a daunting task. To simplify code analysis, this document provides logical, code-compliant steps for key elements of design—such as determining allowable building size, fire separation needs, detailing requirements and the application of special provisions. With an emphasis on light wood-frame construction in Type III and V buildings, it also includes examples, calculations and sample details demonstrating how to navigate the various code requirements associated with mixed-use projects while maximizing building size and meeting fire and life safety requirements.

Mixed-use buildings come in many shapes, sizes and configurations. Although this term might have different meanings to different people, “mixed-use” in this document refers to a building with more than one occupancy group or more than one intended use. Examples include a low-rise commercial building with a shoe store, insurance agency, restaurant and warehouse storage space adjacent to one another; a mid-rise building with parking on the first story and multiple stories of residential apartments on the upper stories; and a high-rise building with combinations of office space, retail space, residential units and parking.

Fire and Life Safety – Building Size, Occupancy and Construction Types

The International Building Code¹ (IBC) is guided by the principle of designing for fire and life safety. Therefore, IBC limitations for building size are based on occupancy and construction

type as well as the presence or absence of active fire sprinkler systems. Unless noted otherwise, references in this document refer to the 2018 version of the IBC.

Occupancy considerations include the number and mobility of occupants, and the presence and amount of combustible and/or potentially hazardous material stored within the building. Construction type defines the extent to which combustible structural building materials are allowed. The combustibility of these materials, and the combustibility of the building’s contents as determined by occupancy, combine to determine the building’s total fuel load. Allowable building size is based on this fuel load as well as the hazard associated with the intended use of the building. For example, a building that is used to store a large volume of combustible contents or where indoor welding takes place poses a greater fire hazard than a typical office building.

Fire-resistance rating (FRR) requirements for different building elements are typically dictated by construction type or separation requirements and define the duration

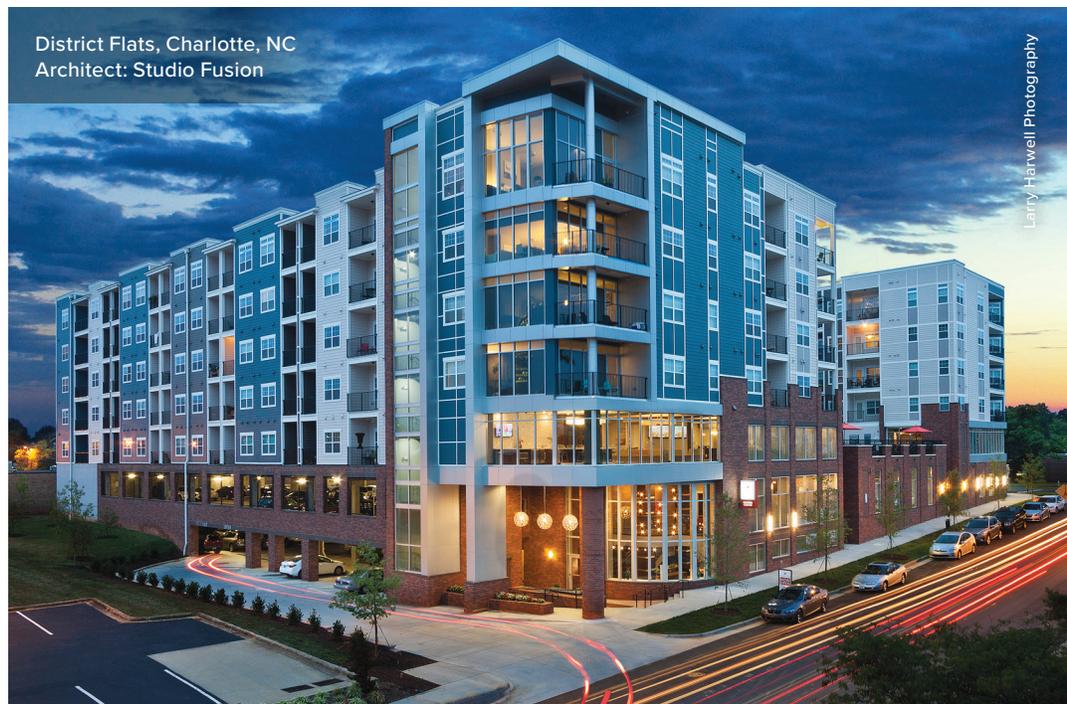


TABLE 1: Construction Types and Required FRRs

| Construction Type | I | II | III | IV | V |
|---------------------------------------|---|---|---|--|--------------------------------|
| Structural materials permitted | Noncombustible with exceptions for FRTW, heavy timber and light-frame | Noncombustible with exceptions for FRTW, heavy timber and light-frame | Interior: Any allowed by code Exterior walls: Noncombustible or FRTW | Interior: Exposed heavy timber per minimum sizes Exterior walls: Noncombustible or FRTW | Any allowed by code |
| Fire-resistance ratings (FRR) | 3 or 2 hrs for most components | 1 or 0 hrs for most components | 1 or 0 hrs for most components | Minimum heavy timber sizes for most components | 1 or 0 hrs for most components |

Source: IBC Section 602, Table 601, Table 602

FRTW = Fire retardant-treated wood

of time (in hours) that the structural systems must remain structurally sound and/or limit fire spread, providing the opportunity for occupants to safely exit the building and fire service personnel to enter during a fire event. Allowable building size, construction type, occupancy, FRR requirements and fire sprinkler requirements are all interconnected.

Given that the required size and occupancy configurations of a building are likely some of the first known input parameters for design, this information is often used to determine the allowable construction type(s) and required FRRs. Some designers think of building materials and building types in terms of traditional defaults. For example, it is often assumed that light wood-frame structures must be classified as Type V and steel or concrete structures as Type II. Although these generalizations do fit within the IBC requirements, relying on default assumptions can be unnecessary and limiting, and lead to sub-optimal design and cost outcomes.

Table 1 summarizes the five construction types and their required FRRs as defined in the IBC, along with examples of building materials that are permitted within each construction type.

Wood and Construction Types

Just as the use of a certain building material does not necessitate a particular construction type, a building with mixed occupancies also has alternatives. For example, a multi-story building with steel, concrete or masonry structural elements on the first story doesn't automatically have to be Type I or II construction, and wood framing can be used for some or all of the remaining building elements. The IBC states:

602.1.1 Minimum requirements. *A building or portion thereof shall not be required to conform to the details of a type of construction higher than that type which meets the minimum requirements based on occupancy even though*

TABLE 2: Construction Types That Permit Wood Framing Throughout

| Construction Type | III-A | III-B | IV | V-A | V-B |
|-------------------------------------|---|--|--|--|--|
| Exterior wall materials | FRTW | FRTW | FRTW or CLT | Any wood | Any wood |
| Exterior bearing wall rating | 2 hrs* | 2 hrs* | 2 hrs* | 1 hr* | 0 hrs* |
| Interior elements | Any wood | Any wood | Heavy/mass timber | Any wood | Any wood |
| Fire wall materials | Noncombustible | Noncombustible | Noncombustible | Any | Any |
| Building size | Usually second largest; typically same number of stories as IV but smaller area | Comparable to V-A; larger in some cases, smaller in others | Usually largest; typically same number of stories as III-A but larger area | Comparable to III-B; typically one or two stories less than III-A and IV | Smallest; typically one story less than V-A and 1/2 to 2/3 area of V-A |

*Minimum; higher FRR may be required by Table 602

Source: IBC Section 601, Table 601 and Section 706

CLT = Cross-laminated timber

certain features of such a building actually conform to a higher type of construction.

This section of the IBC permits some elements to be of a higher construction type without requiring that the entire building meet all the provisions of that type. For example, if a building's size and occupancy type permits the use of Type V-B construction, it could still be completely framed with noncombustible materials while being classified as Type V-B. Similarly, a Type III or V building could be framed with a combination of combustible and noncombustible materials, as permitted within the definitions of those construction types in IBC Chapter 6.

To achieve an optimized design, it is often advantageous to start the design process considering the least restrictive construction type—Type V-B—and increase from there if required. This design approach can provide the potential benefit of reducing project costs through the utilization of the most favorable construction type for the building under consideration.

Although there are several options for the use of wood framing in Types I and II, the IBC allows Types III, IV and V to be completely framed with wood. Table 2 summarizes the main differences between these construction types, as well as the wood systems permitted in each. These allowances are contained in IBC Section 602, Table 601 and Section 706.

Calculating Allowable Building Size

Chapter 5 of the IBC includes three tables that are used in determining a building's allowable size:

- Table 504.3 lists allowable building height in feet (measured as distance from grade plane to the average roof height of the highest roof surface).
- Table 504.4 lists allowable building height in number of stories above grade plane.
- Table 506.2 lists allowable area per story.

For multi-story buildings with one occupancy type, the total allowable building area is determined by the following formula:

$$A_a = [A_t + (NS \cdot I_f)] \cdot S_a \quad (\text{IBC Equation 5-2})$$

Where:

A_a = Allowable area – square feet (SF)

A_t = Tabular allowable area factor based on actual sprinkler conditions (NFPA 13, NFPA 13R, etc.) per Table 506.2

NS = Tabular allowable area factor per Table 506.2 for a non-sprinklered building, regardless of whether the building is sprinklered

I_f = Area increase factor due to frontage (percent) as calculated in Section 506.3

S_a = Actual number of building stories above grade plane, not to exceed three. For buildings with an NFPA 13R sprinkler system, S_a may be the actual number of building stories above grade plane, not to exceed four.

Note that buildings with three or more stories and equipped throughout with an NFPA 13 sprinkler system are still limited to a 3x floor area multiplier for total building area. For example, a multi-story Group R-2 building designed as Type V-A with an NFPA 13 sprinkler system would allow up to 36,000 SF on any given story. A four-story building with these conditions would be permitted to have a total building area of $36,000 \cdot 3 = 108,000$ SF. Note that these areas do not account for potential frontage increases.

Allowable Heights & Areas in the IBC

Starting with the 2015 IBC, the allowable heights and areas tables in Chapter 5 have been updated to show both the base tabular values and achievable values realized when taking advantage of height and area increases through the use of an automatic sprinkler system. "Base tabular values" are given in the tables as the "NS" or non-sprinklered condition. Note that, although NS values are provided for all occupancies as a baseline reference, some occupancies require the use of an automatic sprinkler system. The use of an NFPA 13 automatic sprinkler system allows an increase of 20 feet and one story above the base NS values. Additionally, a floor area increase of 300% is allowed for single-story buildings while an increase of 200% is allowed for multi-story buildings. Buildings equipped with an NFPA 13R sprinkler system may still achieve the height increases but are capped at four stories and 60 feet. No area increase is permitted with the use of an NFPA 13R sprinkler system. Although not discussed nor included in this document, area increases are possible for buildings with adequate frontage.

Mixed-Use Buildings

The simplest way to analyze a mixed-use building is as a single occupancy building. This can be accomplished either through code provisions such as incidental uses or small assembly spaces or by using nonseparated occupancies. Below is a list of codified methods of accommodating multiple occupancies in the same building, all of which are explained in further detail in subsequent sections of this document.

- Incidental uses – Section 509
- Accessory occupancies – Section 508.2
- Small assembly spaces – Section 303.1.2
- Other assembly spaces – Sections 303.1.3 and 303.1.4
- Occupied roof decks – Section 503.1.4
- Nonseparated occupancies – Section 508.3
- Separated occupancies – Section 508.4
- Separate buildings/fire walls – Section 503.1 and Section 706
- Special provisions including podiums and parking – Section 510

Incidental Uses (Section 509)

Incidental uses are ancillary functions associated with a given occupancy that generally pose a greater level of risk and are limited to the uses listed in Table 509. IBC Code Commentary to Section 509.1 states:

Incidental uses constitute special hazards or risks to life safety. Such uses or systems often pose risks that are not typically addressed by the provisions for the general occupancy groups under consideration. However, such uses and systems may functionally be an extension of the primary use. Only those uses and systems found in Table 509 are to be regulated as incidental uses. Incidental uses can be located within both single-occupancy and mixed-occupancy buildings. The concern is that those areas designated as incidental uses pose a risk to the remainder of the building, and as such, some degree of protection is required.

Examples of incidental uses from IBC Table 509 include laundry rooms over 100 SF and furnace rooms where any piece of equipment is over 400,000 Btu per hour input.

The benefit of classifying a room or space within a building as incidental use is that it can be considered the same occupancy as the main building or a portion thereof. It does not need to be treated as a separate occupancy. However, the area of each incidental use space cannot exceed 10% of the area of the story on which it is located. Incidental uses must be separated from adjoining spaces with fire resistance-rated construction or equipped with an automatic sprinkler system (or both in certain situations) as required in IBC Table 509. Construction requirements for separation include a fire barrier, horizontal assembly or both. When Table 509 allows the use of sprinklers in lieu of fire resistance-rated assemblies, IBC Section 509.4.2 requires that the incidental uses be separated from the remainder of the building with construction capable of resisting the passage of smoke. Examples of details that can be utilized to achieve this requirement can be found in Section 509.4.2.

EXAMPLE 1:

Incidental Uses

PROJECT DETAILS:

- Four-story apartment building; 18,000 SF per story (72,000 SF total)
- First story: 1,000-SF laundry room, 1,200-SF boiler room, 15,800 SF of apartments (R-2)
- Stories 2-4: 18,000 SF of apartments (R-2) on each story
- Type V-A construction with NFPA 13 sprinkler system throughout

ASSIGNMENT:

Determine if the proposed laundry and boiler rooms may be considered incidental uses and confirm that building areas are appropriate for the proposed construction type, occupancy and sprinkler system.

RESULTS:

The first step is to determine if the laundry room and boiler room can be classified as incidental uses in order to analyze the entire building as Group R-2 occupancy, eliminating the need for a mixed-use analysis.

IBC Table 509 lists laundry rooms over 100 SF and boiler rooms where the largest piece of equipment is over 15 psi and 10 horsepower as incidental uses. As noted, each incidental use must not exceed 10% of the area of the story on which it is located. The lowest story is 18,000 SF so each incidental use shall not exceed 1,800 SF. **Each room is below this value and can be classified as an incidental use.** IBC Table 509 requires that both of these types of incidental uses be separated from the main portion of the building with 1-hour FRR construction unless equipped with automatic sprinklers. This project has an NFPA 13 sprinkler system so the 1-hour separation is not required. Both of the incidental uses are required to be separated from the remainder of the building with construction capable of resisting the passage of smoke.

Next, IBC Table 506.2 is checked to verify that the proposed building size is appropriate for R-2 occupancy and Type V-A construction. For a Type V-A, multi-story building with an NFPA 13 sprinkler system, Group R-2 allows 36,000 SF per story and 108,000 SF for the entire building. Each story is only 18,000 SF and the total building area is 72,000 SF; therefore, **the proposed areas do allow for this project to be analyzed as single occupancy, Type V-A construction.**

Accessory Occupancies (Section 508.2)

Accessory occupancies are ancillary to the main occupancy and, when limited in area, are not considered to pose an increase in the hazard level of the building. IBC code commentary to Section 508.2 states:

Buildings often have rooms or spaces with an occupancy classification that is different from, but accessory to, the principal occupancy classification of the building. Where such accessory areas are limited in size, they will not ordinarily represent a significantly different life safety hazard. This principle does not apply where otherwise indicated in Section 508.2.4 for areas classified as Group H, I-1 or R.

The accessory occupancy must be ancillary to the principal purpose for which the structure is occupied. This means that the purpose and function of the area is subordinate and secondary to the structure's primary function. As such, the activities that occur in accessory use areas are necessary for the principal occupancy to properly function and would not otherwise reasonably exist apart from the principal occupancy.

Examples of accessory occupancies include a lunchroom in a business office or retail store or conference room in an office building.

Unlike incidental uses, an accessory occupancy is classified as the occupancy it aligns with most closely in IBC Chapter 3; it is not considered to be the same as the building's main occupancy. As such, it must conform to applicable code provisions such as egress, sprinkler requirements and structural loading for its occupancy classification.

In a building with accessory occupancies, the allowable height and floor area are based on the main occupancy. The *sum* of all accessory occupancies on a given story (if there are more than one) cannot exceed 10% of the area for that story. This is a distinction from incidental use areas, which are considered separately. Accessory occupancies also cannot exceed the tabular allowable floor area for non-sprinklered buildings, per IBC Table 506.2, based on the occupancy classification that most closely resembles the accessory occupancy.



No separation is required between accessory occupancies and the main occupancy per IBC 508.2.4, except in a few situations. However, other provisions of the code may require separation. For example, if an accessory occupancy requires automatic sprinkler protection when its fire area exceeds a certain threshold, fire barriers and horizontal assemblies might be required to separate the accessory occupancy from the main occupancy to remain under the threshold. For more on this, see the section, *Sprinkler Thresholds and Fire Areas*.

EXAMPLE 2:

Single-Story Accessory Occupancies

PROJECT DETAILS:

- Single-story warehouse; 10,800 SF total
- Factory (F-1): 9,600 SF; two offices (B): one is 400 SF, the other is 800 SF
- Type V-A construction, non-sprinklered*

ASSIGNMENT:

Determine if the proposed offices in a warehouse may be considered accessory occupancies and confirm that the overall project areas are appropriate for the proposed construction type, occupancy and absence of sprinkler system.

RESULTS:

The two offices meet the definition of accessory occupancies. The first check is to see if the accessory occupancies are under the 10% floor area limit. The total area of the story is 10,800 SF, so the sum of all accessory occupancy space on this story is limited to 1,080 SF. The total proposed accessory occupancy space is 1,200 SF, which exceeds this limit. Therefore, **this building needs to be analyzed as a mixed-use building**.

Next, IBC Table 506.2 is checked to verify that the proposed building area is acceptable, given the construction type and occupancies. For a Type V-A, non-sprinklered, single-story building, Group F-1 allows 14,000 SF and Group B allows 18,000 SF, indicating that **the proposed areas are acceptable**. For more detail on determining the allowable area of a mixed-use building, see the section, *Mixed-Use Analysis*. Next, the sprinkler provisions in IBC Chapter 9 are checked to see if the building is permitted to be non-sprinklered. IBC Section 903.2.4 requires the use of an automatic sprinkler system when the fire area of F-1 occupancies exceeds 12,000 SF. Other than ambulatory care facilities, IBC Section 903.2 does not require the use of sprinklers in Group B buildings. Therefore, **the building does not need to be sprinklered**.

* The examples in this document do not take into account the impact of egress requirements on the need for an automatic sprinkler system. The specifics of each project will determine if sprinkler protection is required.

EXAMPLE 3:

Multi-Story Accessory Occupancies

PROJECT DETAILS:

- Two-story elementary school building; 26,000 SF per story (52,000 SF total)
- First story: classrooms (E): 23,500 SF; offices (B): 2,500 SF
- Second story: classrooms (E): 24,500 SF; offices (B): 1,500 SF
- Type V-B construction with NFPA 13 sprinkler system throughout

ASSIGNMENT:

Determine if the proposed offices in a school may be considered accessory occupancies and confirm that overall project areas are appropriate for the proposed construction type, occupancy and sprinkler system.

RESULTS:

The two school offices meet the definition of accessory occupancies. The first check is to see if the accessory occupancies are under the 10% floor area limit. Each story is 26,000 SF, so the sum of all accessory space on each story is limited to 2,600 SF. Since the sum of accessory occupancies on each story does not exceed this, **it is acceptable to utilize the accessory occupancy provisions of the code.** No separation is required between the offices and classroom areas. Note that, if the entire 4,000 SF of office space was included on a single story, it would exceed the 2,600 SF limit and the project would need to be treated as a mixed-use building.

Next, IBC Table 506.2 is checked to verify that the proposed building area is acceptable given the construction type and occupancies. For a Type V-B, multi-story building with an NFPA 13 sprinkler system, Group E allows 28,500 SF per story and 57,000 SF for the entire building, indicating that **the proposed areas are acceptable.** IBC Table 504.4 allows two stories for Group E, sprinklered, Type V-B buildings, further indicating that **the proposed two-story building is acceptable.** Finally, the allowable floor area of Group B (offices) in non-sprinklered applications for Type V-B construction is 9,000 SF and the maximum office space on any given story is 2,500 SF, so the **floor space is also acceptable.** Since IBC Section 903.2.2 requires the use of sprinklers in Group E fire areas exceeding 12,000 SF, **the building must also be sprinklered.**

Small Assembly Spaces (Section 303.1.2)

IBC Section 303.1.2 is a potentially beneficial code provision similar to accessory occupancies but with its own set of criteria applicable to small assembly spaces. This section permits small assembly spaces accessory to another occupancy to be classified as something other than a Group A occupancy (either Group B or the same as the main occupancy of the building) if they are less than 750 SF or have an occupant load of less than 50 persons. The benefit of classifying small assembly spaces as Group B is that larger heights and areas are generally allowed for Group B than Group A. The benefit of classifying a small assembly space the same as the building's main occupancy is that a mixed-use analysis is not required.

Unlike the accessory occupancy provisions in IBC 508.2, small assembly spaces (individually or combined) are not limited to 10% of the floor area.

Examples of building configurations when this provision could be used include a conference room in an office building and café in a retail building.

EXAMPLE 4:

Small Assembly Space

PROJECT DETAILS:

- Single-story office building; 8,800 SF total
- Offices (B): 8,200 SF; conference room (A-3): 600 SF
- Type V-B construction, non-sprinklered

ASSIGNMENT:

Determine if the proposed conference room may be considered a small assembly space in accordance with Section 303.1.2.

RESULTS:

In this example, the conference room is accessory to the main function of the building. Therefore, it could be checked using the accessory provisions of Section 508.2. However, the simpler design route is to **use the small assembly space provisions since the area of the conference room is less than 750 SF.** The conference room can be classified as Group B occupancy, meaning the entire building is Group B. **No mixed-use building analysis is necessary.** Per IBC Table 506.2, a non-sprinklered, Group B, Type V-B construction building can be 9,000 SF, which is greater than the proposed building area. Therefore, Type V-B can be used and no FRR separation is required between the conference room and adjoining office space.

Other Assembly Spaces (Sections 303.1.3 & 303.1.4)

IBC Section 303.1.3 allows assembly areas associated with Group E occupancies to be considered part of the same occupancy. Common examples include gyms and cafeterias in school buildings. For these conditions, the assembly areas could be classified as Group E rather than Group A, matching the occupancy of the remainder of the building and not requiring a mixed-use analysis.

Places of religious worship are typically classified as Group A-3 occupancy. In these buildings, IBC Section 303.1.4 allows for accessory educational rooms and auditoriums with an occupant load of less than 100 to be considered part of the same Group A occupancy.

For both of the above conditions, it is important to note that, when a room or space might be used for multiple purposes, IBC Section 302 requires that the limitations of each use and associated occupancy be applied. For example, if the gym in the school building might be used for craft fairs or weekend farmers markets, the uses would go beyond those associated with the Group E occupancy, meaning the provisions of 303.1.3 would not be permitted and the gym would need to be classified as Group A.

Occupied Roof Decks (Section 503.1.4)

Occupied roof decks are becoming more common in multi-family and commercial buildings as designers and owners seek to increase the marketability of their rental spaces with more amenities. In most instances, these roof decks are open air, without roof coverings, and have partial-height guards or wall parapets around their perimeter. Designers often wonder if a roof deck of this kind needs to be included when calculating required construction type, building area and number of stories. Language was added to the 2018 IBC stating that a roof occupied in full or in part with the same occupancy as the story immediately below does not need to be included in the building area regulated by Section 506. Further, if the building is fully equipped with an NFPA 13 or NFPA 13R sprinkler system and an occupant notification system in accordance with section 907.5, the roof occupancy is not restricted to the occupancy of the story below. The commentary clarifies:

The code defines a story as “that portion of a building included between the upper surface of a floor and upper surface of the floor or roof next above.” An uncovered roof deck is clearly not a story, because there is no floor or roof above.

This section also exempts the area of an occupied roof from being part of the area of the building. Building area is also a function of story. No story, no building area.

Although uncovered and not considered a separate story for the purpose of building area and high-rise provisions, occupied roof decks do have associated fire and life safety requirements. IBC Section 1006.3 lists egress requirements and Section 903.2.1.6 lists sprinkler requirements for assembly occupancies. An automatic sprinkler system (either NFPA 13 or NFPA 13R, where permitted) is required on all stories between the occupied roof and the level of exit discharge when one of the following conditions exist:

- Group A-2 occupied roofs with an occupant load greater than 100
- Other Group A occupancies with an occupant load greater than 300

Roof Decks with Roof Coverings

Sometimes an occupied roof deck will be enclosed with full-height walls and/or a roof covering. This is addressed in Section 503.1.4.1, which states that elements or structures enclosing the occupied roof space shall not extend more than 48 inches above the surface of the occupied roof. Exceptions are made for penthouses, towers, domes, spires and cupolas.

In most instances, an occupied roof deck with a roof covering or walls that are taller than 48 inches is considered a separate story and must be included in building area calculations. If considered a mezzanine or accessory occupancy (Sections 505.2 and 508.2), it may be possible to exclude the occupied roof deck (and its enclosing elements) as a separate story when determining the construction type. The mezzanine provision would only apply if the roof deck space is open to the story below and only accessible as part of a private suite. If the roof deck is publicly accessible and considered an assembly occupancy, the accessory provisions can be applied to these common spaces, provided they are no more than 10% of the floor area below.

Mixed-Use Building Analysis

If none of the previously discussed provisions can be applied, the multi-occupancy building must be analyzed as a mixed-use structure using nonseparated or separated occupancies, or the use of building separations via fire walls, podiums or other special provisions must be employed.

Nonseparated Occupancies (Section 508.3)

Nonseparated occupancies, as defined in IBC Section 508.3, require no separation between different occupancies in the form of FRR floor or wall assemblies.

There are a few exceptions to this in Section 508.3.3, which states that separation is required between certain hazardous occupancies and other occupancies, between adjacent dwelling and sleeping units of residential occupancies (I-1, R-1, R-2 and R-3), and between dwelling and sleeping units of residential occupancies and other adjacent occupancies.

If the provisions for nonseparated occupancies are utilized, the total allowable building size (area, height and number of stories) is governed by the most restrictive occupancy that exists in the mixed-use building. This design route will generally result in smaller allowable building sizes than those permitted when using separated occupancies. However, it does have the benefit of potentially requiring fewer or no FRR assemblies separating occupancies.

EXAMPLE 5:

Nonseparated, Single-Story Mixed-Use Building

PROJECT DETAILS:

- Single-story warehouse and office building; 71,200 SF total
- Warehouse storage (S-1): 41,200 SF; regional dispatch office (B): 30,000 SF
- NFPA 13 sprinkler system
- 22 feet from grade plane to mean roof height

ASSIGNMENT:

Determine the most appropriate construction type for this mixed-use building with nonseparated occupancies.

RESULTS:

The building is sprinklered throughout since IBC Section 903.2.9 requires the use of sprinklers in Group S-1 fire areas exceeding 12,000 SF. When using nonseparated occupancies, the building size is limited by that of the most restrictive occupancy. Table 3 shows allowable values for a sprinklered building with occupancies B and S-1 per IBC Tables 504.3, 504.4 and 506.2.

Group S-1 is the more restrictive occupancy; in all cases, the allowable building size is less than or equal to that of Group B. With a proposed building area of 71,200 SF for Group S-1, **the lowest viable construction type is Type III-A construction**. Note that, for Group B, Types V-A and III-B construction would have been allowed for the proposed building area. However, because the occupancies are nonseparated, the entire building must conform to the more restrictive requirements of Group S-1. If there is an opportunity to use a frontage area increase on the building, it could be possible to use Type III-B construction. Unless required by other sections of the code, no FRR fire barrier is required to separate the two occupancy types within this building.

TABLE 3: Allowable Single-Story Building Area/Height/Stories

| | III-A | III-B | V-A | V-B |
|------------------|---------------|--------------|--------------|--------------|
| Group B | 114k SF/85'/6 | 76k SF/75'/4 | 72k SF/70'/4 | 36k SF/60'/3 |
| Group S-1 | 104k SF/85'/4 | 70k SF/75'/3 | 56k SF/70'/4 | 36k SF/60'/2 |

Source: IBC Tables 504.3, 504.4 and 506.2

EXAMPLE 6:

Nonseparated, Multi-Story Mixed-Use Building

PROJECT DETAILS:

- Three-story urban infill project; 12,000 SF per story (36,000 SF total)
- First story: enclosed parking (S-2): 9,500 SF; insurance agency (B): 1,200 SF; print shop (B): 1,300 SF
- Second story: martial arts studio (B): 2,400 SF; apartments (R-2): 9,600 SF
- Third story: apartments (R-2): 12,000 SF
- NFPA 13 sprinkler system
- 38 feet from grade plane to mean roof height

ASSIGNMENT:

Determine the most appropriate construction type for this multi-story building with nonseparated occupancies.

RESULTS:

The building is sprinklered throughout since Section 903.2.8 requires the use of sprinklers throughout all buildings that contain a Group R fire area. Table 4 indicates the allowable height, number of stories and floor area for a sprinklered building with occupancies R-2, B and S-2.

The proposed floor area (12,000 SF per story, 36,000 SF for total building), building height (38 feet) and number of stories (3) are all less than or equal to the most restrictive of the three occupancies present in this building for Type V-B construction. Therefore, **Type V-B is the most favorable option for this nonseparated occupancies analysis.** Although no FRR construction is required between each occupancy per Section 508.3.3, the R-2 areas must be separated from each other and from adjacent Group B and S-2 occupancies with 1/2-hour-rated construction per Sections 420.2, 420.3, 708.3 and 711.2.4.3. For further discussion on incorporating parking in mixed-use buildings, see the section, *Mixed-Use Buildings with Parking*.

TABLE 4: Allowable Multi-Story Building Floor Area/Height/Stories

| | V-A | V-B |
|------------------|-------------|---------------|
| Group R-2 | 36k SF/70'4 | 21k SF/60'3 |
| Group B | 54k SF/70'4 | 27k SF/60'3 |
| Group S-2 | 63k SF/70'5 | 40.5k SF/60'3 |

Source: IBC Tables 504.3, 504.4, and 506.2

Tools to Simplify Mixed-Occupancy Calculations

WoodWorks has several resources to assist designers with allowable building size and height analyses for mixed-use buildings. A [heights and areas calculator app](#),² jointly produced by WoodWorks and the American Wood Council, is available free for Windows, iOS and Android. A portion of a 2018 webinar presented by WoodWorks, [Choosing Construction Type Just Got Easier: Design Tools to Simplify IBC Chapter 5](#),³ discusses the tool and its functionality. This tool can accommodate multiple occupancies, assume separated occupancies and perform frontage factor increases. It is especially useful for separated occupancies area calculations as these are often iterative. WoodWorks is also available for one-on-one project assistance to help guide the designer through this process.

Separated Occupancies (Section 508.4)

Separated occupancy provisions, as outlined in Section 508.4 and shown in Table 6, require different occupancies to be separated using FRR walls (fire barriers in compliance with Section 707) and FRR floor/ceiling assemblies (horizontal assemblies in compliance with Section 711). Table 508.4 provides the required hourly FRR for these separation assemblies. Note that the required hourly ratings of these separation assemblies are usually less if the building is equipped throughout with an NFPA 13 sprinkler system.

IBC Table 508.4 groups certain occupancies together, such as A and E or B, F-1, M and S-1. These grouped occupancies are considered to have equivalent hazard levels with respect to fire safety. Therefore, if a building contains multiple occupancies within the same grouping, no separation is required between them and the area calculation benefits of separated occupancies can still be used. This is noted in Table 508.4 where “N” (no separation requirement) is shown.

When using separated occupancies, the allowable height and stories of the building are determined by limiting the height and number of stories of each separated occupancy to their applicable limits for the given construction type and occupancy group. This check is occupancy dependent, based on the highest point of

the building for each individual occupancy as measured from grade plane. For example, a two-story building with Group M on the first story and Group B on the second story would be checked against allowable height limits for Group M occupancies in Tables 504.3 and 504.4 as if it were a one-story building, and against Group B occupancies as if it were a two-story building.

The allowable area for each story is calculated by limiting the sum of the ratios of the actual area of each separated occupancy divided by its allowable area (Table 506.2 with area increase provisions, if applicable) to 1.0 (Section 508.4.2). For multi-story buildings, total building allowable area is calculated by limiting the sum of these story-specific ratios to 2.0 for a two-story building and 3.0 for a three-story or taller building (Section 506.2.4). In addition to these total building ratio checks, no single story may have a sum of ratios greater than 1.0.

EXAMPLE 7:

Separated, Single-Story Building

PROJECT DETAILS:

- Single-story warehouse and office building, 71,200 SF total
- Warehouse storage (S-1): 41,200 SF; regional dispatch office (B): 30,000 SF
- NFPA 13 sprinkler system
- 22 feet from grade plane to mean roof height
- Assume no opportunities for frontage area increase

ASSIGNMENT:

Using the same project details as the warehouse in Example 5, determine the most appropriate construction type and required fire-rated separation for separated occupancies.

RESULTS:

From Example 5, the allowable sizes are shown in Table 5.

TABLE 5: Allowable Single-Story Building Area/Height/Stories

| | III-A | III-B | V-A | V-B |
|------------------|---------------|--------------|--------------|--------------|
| Group B | 114k SF/85'6" | 76k SF/75'4" | 72k SF/70'4" | 36k SF/60'3" |
| Group S-1 | 104k SF/85'4" | 70k SF/75'3" | 56k SF/70'4" | 36k SF/60'2" |

Using a separated occupancy analysis, the actual area of each occupancy is divided by the allowable area. This ratio is calculated for both occupancies; the sum of the ratios for these two occupancies cannot exceed 1.0.

First let's check Type V-B. Actual area/allowable area ratio analysis:

Group B: 30,000 SF/36,000 SF = 0.83

Group S-1: 41,200 SF/36,000 SF = 1.14

Sum of ratios = 0.83 + 1.14 = 1.97 which is greater than 1.0; Type V-B is not allowed.

Let's check Type V-A:

Group B: 30,000 SF/72,000 SF = 0.42

Group S-1: 41,200 SF/56,000 SF = 0.74

Sum of ratios = 0.42 + 0.74 = 1.16 which is greater than 1.0; Type V-A is not allowed.

Let's check Type III-B:

Group B: 30,000 SF/76,000 SF = 0.4

Group S-1: 41,200 SF/70,000 SF = 0.59

Sum of ratios = 0.4 + 0.59 = 0.99 which is less than 1.0; Type III-B is allowed.

Based on the above calculations, **this project will be Type III-B construction if using separated occupancies.** Recall that it was Type III-A when using nonseparated occupancies. Finally, we will determine the hourly rating requirement for the fire barrier separating the different occupancies. As seen in IBC Table 508.4, **this combination of occupancies does not require fire barrier separation** as all are considered to have equivalent fire safety hazard levels.

TABLE 6: IBC Table 508.4 – Required Separation of Occupancies (Hours)^f

| Occupancy | A,E | | I-1 ^a , I-3, I-4 | | I-2 | | R ^a | | F-2, S-2 ^b , U | | B ^e , F-1, M, S-1 | | H-1 | | H-2 | | H-3, H-4 | | H-5 | |
|-----------------------------------|-----|----|-----------------------------|----|-----|----|----------------|----|---------------------------|----------------|------------------------------|----|-----|----|-----|----|----------------|----|-----|----|
| | S | NS | S | NS | S | NS | S | NS | S | NS | S | NS | S | NS | S | NS | S | NS | S | NS |
| A, E | N | N | 1 | 2 | 2 | NP | 1 | 2 | N | 1 | 1 | 2 | NP | NP | 3 | 4 | 2 | 3 | 2 | NP |
| I-1^a, I-3, I-4 | – | – | N | N | 2 | NP | 1 | NP | 1 | 2 | 1 | 2 | NP | NP | 3 | NP | 2 | NP | 2 | NP |
| I-2 | – | – | – | – | N | N | 2 | NP | 2 | NP | 2 | NP | NP | NP | 3 | NP | 2 | NP | 2 | NP |
| R^a | – | – | – | – | – | – | N | N | 1 ^c | 2 ^c | 1 | 2 | NP | NP | 3 | NP | 2 | NP | 2 | NP |
| F-2, S-2^b, U | – | – | – | – | – | – | – | – | N | N | 1 | 2 | NP | NP | 3 | 4 | 2 | 3 | 2 | NP |
| B^e, F-1, M, S-1 | – | – | – | – | – | – | – | – | – | – | N | N | NP | NP | 2 | 3 | 1 | 2 | 1 | NP |
| H-1 | – | – | – | – | – | – | – | – | – | – | – | – | N | NP | NP | NP | NP | NP | NP | NP |
| H-2 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | N | NP | 1 | NP | 1 | NP |
| H-3, H-4 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | 1 ^d | NP | 1 | NP |
| H-5 | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | – | N | NP |

S = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1.

NS = Buildings not equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1.

N = No separation requirement.

NP = Not permitted.

a. See Section 420.

b. The required separation from areas used only for private or pleasure vehicles shall be reduced by 1 hour but not to less than 1 hour.

c. See Section 406.3.2.

d. Separation is not required between occupancies of the same classification.

e. See Section 422.2 for ambulatory care facilities.

f. Occupancy separations that serve to define fire area limits established in Chapter 9 for requiring fire protection systems shall also comply with Section 707.3.10 and Table 707.3.10 in accordance with Section 901.7.

EXAMPLE 8:

Separated vs. Nonseparated Multi-Story Building

PROJECT DETAILS:

- Three-story college campus building; 20,400 SF per story (61,200 SF total)
- First story: two 800-SF coffee bars/snack shops; classrooms: 13,700 SF; administration: 1,700 SF; offices: 3,400 SF
- Stories 2-3: classrooms: 14,500 SF; offices: 5,900 SF
- NFPA 13 sprinkler system
- 48 feet from grade plane to mean roof height

ASSIGNMENT:

Explore different methods of analyzing this mixed-use building to determine construction type and fire-rated separations.

RESULTS:

The coffee bar/snack shop areas could be assumed to be A-2 occupancy. However, it might also be possible to use the small assembly provisions of IBC 303.1.2; although the area of each coffee bar exceeds 750 SF, if the occupant load is less than 50, the coffee bar areas could be classified as Group B or as part of the main occupancy of the building. Alternatively, the coffee bar areas may be considered accessory to the main function of the building, as their combined area of 1,600 SF does not exceed 10% of the area of the first story.

The next item to determine is what mix of occupancies exist in the rest of the building. While some may think classrooms are automatically classified as Group E educational occupancy, IBC Section 304 states that educational occupancies for students above Grade 12 are classified as Group B. The administration and office areas are all classified as Group B. As such, it is possible that this entire building, which initially might have appeared to contain three different occupancies, could be simplified to a single-occupancy building.

If the two coffee bars can be classified as Group B using Section 303.1.2, then the building could be analyzed entirely as a Group B occupancy. Per Table 504.4, a fully-sprinklered, three-story, Group B building may be Type V-B; Table 504.3 allows a maximum height of 60 feet; Table 506.2 allows 27,000 SF per story. Therefore, if the entire building could be analyzed as Group B, it could be constructed as Type V-B construction with sprinklers throughout.

If the two coffee bars have occupant loads of 50 or more and are not considered to be accessory occupancies, they would be classified as Group A-2 and a mixed-use analysis would be required.

Recall that, if the building uses nonseparated occupancies, the overall building size is limited by that of the most restrictive occupancy. Per Table 7, Type V-A would be necessary for this building; three stories is not permitted in Type V-B for Group A-2 occupancy nor is the allowable floor area of V-B for A-2 adequate.

The benefit of the nonseparated option is that no FRR separation between the coffee bars and other occupancies would be required. However, 1-hour FRR protection would be required for nearly all structural systems and assemblies in Type V-A, per IBC Table 601.

Alternatively, it is also possible to investigate a separated occupancies approach, allowing Type V-B construction.

TABLE 7: Allowable Multi-Story Building Floor Area/Height/Stories

| | V-A | V-B |
|------------------|----------------|--------------|
| Group A-2 | 34.5k SF/70'/3 | 18k SF/60'/2 |
| Group B | 54k SF/70'/4 | 27k SF/60'/3 |

Source: IBC Tables 504.3, 504.4 and 506.2

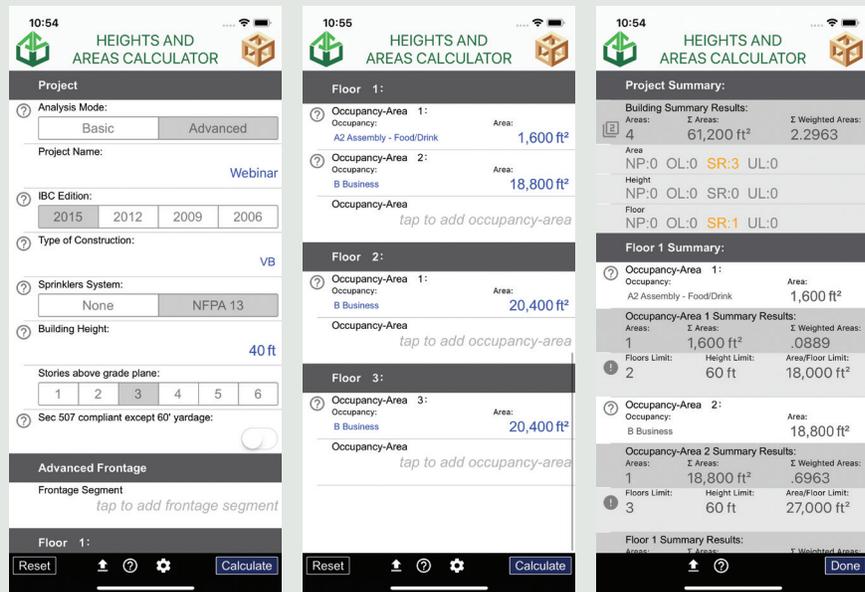


FIGURE 1: Verification of Example 8 in the heights and areas calculator
Source: WoodWorks, AWC

Actual area/allowable area ratio analysis:

Group A-2: 1,600 SF/18,000 SF = 0.09

Group B: 18,800 SF/27,000 SF = 0.70

Sum of ratios = 0.09 + 0.70 = 0.79 which is less than 1.0;

Type V-B is allowed.

The tradeoff between Type V-B separated and Type V-A nonseparated is that Type V-B separated allows structural elements to generally be unrated, but does require the assemblies separating the coffee bars from adjacent occupancies to have a 1-hour FRR. The WoodWorks/AWC heights and areas calculator app was used to verify the Type V-B separated option and the results are shown in Figure 1.

In the calculator output shown in Figure 1, note the sum of the weighted areas = 2.2963. Keep in mind that, for buildings three stories and higher equipped throughout with an NFPA 13 sprinkler system, this sum cannot exceed 3.0, nor can it exceed 1.0 for any given story. These results can be verified using the allowable floor areas for Type V-B occupancy of:

Group A-2: 18,000 SF

Group B: 27,000 SF

The sum of ratios for the first level = 0.79 (previously calculated)

The sum of ratios for the second and third levels =
 $20,400/27,000 = 0.76$

The sum of ratios for the entire building =
 $0.79 + 0.76 + 0.76 = 2.30$.

As noted, if using this separated occupancies option, 1-hour FRR fire barriers would be required between the coffee areas and the rest of the building on the first level. A 1-hour FRR horizontal assembly would also be required between the coffee areas on the first level and the office and/or classroom spaces on the second level.

Combination of Nonseparated and Separated Occupancies

Although not as common, it is possible to utilize a design combination that consists of separated and nonseparated occupancies in a building. This is recognized as an acceptable approach, as stated in the last sentence of Section 508.1:

508.1 General. *Each portion of a building shall be individually classified in accordance with Section 302.1. Where a building contains more than one occupancy group, the building or portion thereof shall comply with the applicable provisions of Section 508.2, 508.3 or 508.4, or a combination of these sections.*

Additionally, the code commentary provides the following discussion and examples:

The final sentence of this section reemphasizes the choice for the designer to use just the provisions of one of the three parts, or options, and not to use the other options. But the code also allows a mixture of the options in different portions of a building. For example, a building could be designed to comply with only Section 508.3 for nonseparated mixed occupancies and not comply with any of the provisions of either Section 508.2 or 508.4. A different example could be to use the provisions of Section 508.3 on the first story of a building which perhaps had three or four different occupancies, but then separate the upper stories of the building from the first story and treat the upper stories under Section 508.4 for separated occupancies.

When using this combination method, the areas that are classified as nonseparated would be checked for allowable height and area against the most limiting case of all of the occupancies in that portion of the building. These nonseparated portions would then need to be separated from the portions of the building being analyzed as separated occupancies using FRR fire barriers and/or horizontal assemblies, as specified in Table 508.4.

Sprinkler Thresholds and Fire Areas

Although there may be other factors that go into the decision of whether or not a building will be sprinklered, such as insurance and property protection, the building code also plays a role in the decision-making process. IBC Chapter 9 provides provisions that “specify where fire protection systems are required and shall apply to the design, installation and operation of fire protection systems” (Section 901.1).

Section 903.2 specifies provisions related to the requirements of an automatic sprinkler system in a building or portion of a building. These provisions are based on the occupancy and, in most cases, also consider the fire area, occupant load and elevation of the area under consideration relative to the level of exit discharge. For example, a Group A-2 occupancy requires the use of an automatic sprinkler system when one of the following conditions exists:

1. The fire area exceeds 5,000 SF (464.5 m²).
2. The fire area has an occupant load of 100 or more.
3. The fire area is located on a story other than a level of exit discharge serving such occupancies.

An important consideration in the sprinkler thresholds given in Section 903.2 is that the areas presented are *fire areas*. By definition in Section 202, a fire area is enclosed by fire walls, fire barriers, exterior walls and horizontal assemblies. To stay below the fire area thresholds, the floor area could be divided into multiple fire areas using fire barriers and/or horizontal assemblies. In a mixed-occupancy building containing nonseparated occupancies, individual occupancies would not typically be separated from one another using fire walls, fire barriers or horizontal assemblies. In this case, the fire area of one occupancy would include its own floor area, as well as the floor areas of all other nonseparated occupancies in the building. One fire area can stretch across an entire story and even across multiple stories if no fire barriers, fire walls or horizontal assemblies are employed to compartmentalize different occupancy spaces.

If separating different occupancies for the sole purpose of compartmentalizing fire areas, the fire-resistance rating of fire barriers and/or horizontal assemblies is obtained from Table 707.3.10 for the most restrictive of the occupancies being separated. It is important to note the difference between Table 707.3.10 and Table 508.4. Table 508.4 is used for obtaining the FRR of assemblies when using a separated occupancies approach to meet the limitations of allowable building areas of Table 506.2. Table 707.3.10 is used when separating a building with single or multiple occupancies into separate fire areas to meet the allowable fire area limits of Section 903.2.

TABLE 8: FRR Requirements for Fire Barrier Assemblies or Horizontal Assemblies Between Fire Areas

| Occupancy Group | Fire-Resistance Rating (hours) |
|--------------------------------------|--------------------------------|
| H-1, H-2 | 4 |
| F-1, H-3, S-1 | 3 |
| A, B, E, F-2, H-4, H-5, I, M, R, S-2 | 2 |
| U | 1 |

Source: IBC Table 707.3.10

EXAMPLE 9:

Single-Occupancy Sprinkler Threshold

PROJECT DETAILS:

- Three-story retail (M) building: 10,000 SF per story (30,000 SF total)

ASSIGNMENT:

Determine if sprinklers are required for the proposed retail building.

RESULTS:

Section 903.2.7 requires the use of an automatic sprinkler system when one of the following conditions exists:

1. A Group M fire area exceeds 12,000 SF.
2. A Group M fire area is located more than three stories above grade plane.
3. The combined area of all Group M fire areas on all stories, including any mezzanines, exceeds 24,000 SF.
4. A Group M occupancy used for the display and sale of upholstered furniture or mattresses exceeds 5,000 SF.

If the owner of this building desires to avoid the use of sprinklers, the building would need to be split into fire areas not exceeding 12,000 SF. One option would be separate the building via horizontal floor/ceiling assemblies at the second and third stories, resulting in three fire areas, each 10,000 SF. Table 707.3.10 shows that the separations must have a fire-resistance rating of 2 hours. Alternatively, 2-hour-rated fire barriers could be installed on some or all levels such that no combined fire area exceeds 12,000 SF. Under these conditions, **sprinklers would not be required for this project.**

EXAMPLE 10:

Multi-Occupancy Sprinkler Threshold

PROJECT DETAILS:

- Single-story warehouse; 10,800 SF total
- Factory (F-1): 9,600 SF; one office (B): 400 SF; one employee lunchroom (A-2): 800 SF
- Type V-A construction, non-sprinklered

ASSIGNMENT:

This is the same building as Example 2 except that one of the offices is now an employee lunchroom and categorized as occupancy Group A-2 rather than Group B. Determine if the proposed non-sprinklered construction type is acceptable.

RESULTS:

First, Table 506.2 is checked to verify that the proposed building falls within the allowable building size and construction type. For non-sprinklered Type V-A, Group F-1 allows 14,000 SF, Group B allows 18,000 SF, and Group A-2 allows 11,500 SF. The allowable areas for each occupancy type are not exceeded; therefore, **the building is permitted to be nonseparated Type V-A construction.**

Next, the sprinkler provisions in Chapter 9 are checked to see if the building is permitted to be non-sprinklered. Section 903.2.4 requires the use of an automatic sprinkler system when the fire area of an F-1 occupancy exceeds 12,000 SF. Other than ambulatory care facilities, Section 903.2 does not require the use of sprinklers in Group B buildings. Section 903.2.1.2 requires the use of an automatic sprinkler system when the fire area of A-2 occupancies exceeds 5,000 SF. If the A-2 occupancy is not bounded by fire walls or fire barriers, its fire area will include the entire 10,800 SF area of the building, exceeding the 5,000 SF limit. To limit the fire area of the A-2 occupancy, a fire barrier or fire wall could be provided. The fire barrier would require a 3-hour FRR per IBC Table 707.3.10. With this fire barrier, **it would not be necessary to sprinkler the building.** Alternatively, the building could be sprinklered, Type V-B, nonseparated.

EXAMPLE 11:

Separated vs. Nonseparated Multi-Story Building

PROJECT DETAILS:

- Three-story mixed-use building
- First story: restaurant (A-2): 2,000 SF; retail (M): 7,000 SF
- Second story: offices (B): 9,000 SF
- Third story: offices (B): 4,000 SF; roof deck patio (A-2): 2,500 SF

ASSIGNMENT:

Explore different methods of analyzing this mixed-use building to determine construction type, sprinkler requirements and FRR separations.

RESULTS:

Table 9 indicates the allowable height, number of stories and floor area for a building with occupancies A-2, B and M.

Non-Sprinklered Building Option:

If we consider the entire building to have nonseparated occupancies, the building size is limited to the most restrictive of all occupancies. By inspection of Table 9, Group A-2 is the most restrictive and would result in Type III-A construction to achieve a three-story height.

However, we can move to a less stringent construction type by using a combination of separated and nonseparated occupancies. If the first story is separated from the rest of the building, A-2 and M are still considered together as nonseparated occupancies with an area of 9,000 SF and a height of one story. Based on Table 9, Type V-A is now acceptable; Group A-2 governs with allowable areas and heights of 11,500 SF, 50 feet and two stories. The upper two stories of Group B, separated from the first story, may also be Type V-A construction with allowable areas and heights of 18,000 SF per story, 50 feet and three stories. Note that Type V-B non-sprinklered is still not viable due to the story limit on Group B and area limit on Group A-2. The separation between the first story and the upper two stories is required to have a 1-hour FRR per Table 508.4.

Next, we'll confirm that an accessible roof deck of Group A-2 occupancy is acceptable. As noted, Section 503.1.4 allows roof decks of any occupancy provided the occupancy of the roof deck is an occupancy permitted by Table 504.4 for the story immediately below the roof. Because A-2 is permitted up to the second story for non-sprinklered, V-A buildings, and the second story is immediately below the third-story roof deck, this is acceptable. The accessible roof deck patio does not need to be included in the allowable area checks per Section 503.1.4.

Last, we need to confirm the sprinkler requirements of Chapter 9. Sprinklers are required in Group A-2 occupancies when the fire area exceeds 5,000 SF (Section 903.2.1.2) and in Group M occupancies when the fire area exceeds 12,000 SF (Section 903.2.7). Group B occupancies do not require sprinklers for offices. Although the first story was analyzed as nonseparated, its 9,000 SF area exceeds the allowable fire area of non-sprinklered A-2 occupancy. In order to permit non-sprinklered construction, a fire barrier is required to separate the A-2 and M occupancies on the first story. Additionally, a horizontal assembly is required at the second story to separate the A-2 and M areas on the first story from the Group B areas on the second and third stories. Although Table 508.4 stipulates that the horizontal separation is required to have a 1-hour FRR, both the fire barrier wall and horizontal floor assembly need 2-hour FRRs to meet fire area thresholds per Table 707.3.10.

Non-sprinklered building option: Type V-A; 2-hour fire barrier between A-2 and M on the first level; 2-hour horizontal assembly at the second story

TABLE 9: Allowable Floor Area/Height/Stories

| | | III-A | III-B | V-A | V-B |
|------------------|-----------|----------------|----------------|----------------|--------------|
| Group A-2 | NS | 14k SF/65'/3 | 9.5k SF/55'/2 | 11.5k SF/50'/2 | 6k SF/40'/1 |
| | S1 | 56k SF/85'/4 | 38k SF/75'/3 | 46k SF/70'/3 | 24k SF/60'/2 |
| | SM | 42k SF/85'/4 | 28.5k SF/75'/3 | 34.5k SF/70'/3 | 18k SF/60'/2 |
| Group B | NS | 28.5k SF/65'/5 | 19k SF/55'/3 | 18k SF/50'/3 | 9k SF/40'/2 |
| | SM | 5.5k SF/85'/6 | 57k SF/75'/4 | 54k SF/70'/4 | 27k SF/60'/3 |
| Group M | NS | 18.5k SF/65'/4 | 12.5k SF/55'/2 | 14k SF/50'/3 | 9k SF/40'/1 |
| | S1 | 74k SF/85'/5 | 50k SF/75'/3 | 56k SF/70'/4 | 36k SF/60'/2 |
| | SM | 55.5k SF/85'/5 | 37.5k SF/75'/3 | 42k SF/70'/4 | 27k SF/60'/2 |

Source: IBC Tables 504.3, 504.4 and 506.2

Sprinklered Building Option:

First, we find that the 2-hour separations at the fire barrier wall and horizontal floor assembly are not necessary since fire area thresholds are no longer a concern.

Next, we will consider the increased allowable heights and areas provided by using sprinklers.

Based on Table 9, Type V-B construction can now be used as follows:

At the first level, A-2 and M are still nonseparated occupancies with an area of 9,000 SF and a height of one story. Group A-2 controls, with a single-story allowable area of 24,000 SF. The upper two stories of Group B, separated from the first story, may also be Type V-B construction with allowable areas and heights of 27,000 SF per story, 60 feet and three stories. Again, the separation between the first story and upper two stories is required to have a 1-hour FRR, per Table 508.4. Note that Type V-B construction would not be allowed if the entire building was nonseparated since the two-story limit on Group A-2 would then apply to the entire building.

Similar to the the non-sprinklered option, we'll confirm that an accessible roof deck of Group A-2 occupancy is acceptable. Due to the fact that Group A-2 is permitted up to the second story for sprinklered, Type V-B construction, and the second story is immediately below the roof deck, this is in compliance with the provisions and the roof top patio does not need to be included in the allowable area checks per Section 503.1.4.

The benefit of using a combination of separated and nonseparated occupancies, as shown in this example, is that it can result in a more economical construction type without providing unnecessary separations. It is not necessary to analyze the whole building as separated occupancies given that the first level (Groups A-2 and M) is acceptable when considered as nonseparated occupancies, eliminating the need for an FRR wall assembly. However, due to the number of stories, the entire building could not be considered as nonseparated occupancies under Type V-B construction. It should also be noted that all elements supporting the 1-hour FRR horizontal assembly at the second story are also required to meet a 1-hour FRR. This will be discussed in greater detail in the following section.

Sprinklered building option: Type V-B; no fire-rated wall assemblies; 1-hour FRR horizontal assembly at the second story; NFPA 13 sprinklers throughout

Creating Separation in Mixed-Use Buildings

When buildings require separation, either due to mixed occupancies, sprinkler area thresholds or other requirements, floor and roof systems are usually required to be constructed as horizontal assemblies, while walls are usually required to be constructed as fire barriers, as defined in Section 202. While the FRR requirements of these assemblies can vary depending on the function of the system, certain detailing and continuity aspects apply universally. Below is a summary of the IBC requirements for horizontal assemblies and fire barriers, along with practical design detailing options that meet the requirements.

Horizontal Assemblies

Section 202 defines a horizontal assembly as “a fire resistance-rated floor or roof assembly of materials designed to restrict the spread of fire in which continuity is maintained.” This indicates that horizontal assemblies are, by definition, fire resistance-rated and therefore, not every floor or roof assembly qualifies as a horizontal assembly. Section 711.2 provides requirements related to horizontal assemblies, including, but not limited to:

- Materials permitted by the type of construction;
- Supporting construction, required to have an FRR at least equal to that of the horizontal assembly (with several exceptions);
- Fire-resistance rating requirements; variable depending on the function of the horizontal assembly:
 - Separation of mixed occupancies (Table 508.4);
 - Separation of fire areas (Table 707.3.10); and
 - Separation of dwelling units, 1-hour except can be 1/2-hour in Types II-B, III-B and V-B construction

Another notable requirement is discussed in Section 711.2.2, which states that horizontal “assemblies shall be continuous without vertical openings, except as allowed in the code.” It is common practice to interrupt the ceiling gypsum at the head of partition wall locations. This interruption of gypsum at the intersection of the top of a partition wall and underside of the floor is considered a membrane penetration and is addressed in Section 714.5.2, Exception 7. This exception allows the ceiling gypsum to be interrupted by the double top plates of a light-frame wall, as long as the stud wall is sheathed with Type X gypsum wallboard and the ceiling membrane is installed tight to the wall's double top plate.

Figure 2 is an example of how Exception 7 in Section 714.5.2 can be implemented at the intersection of a head of partition wall and a horizontal assembly.

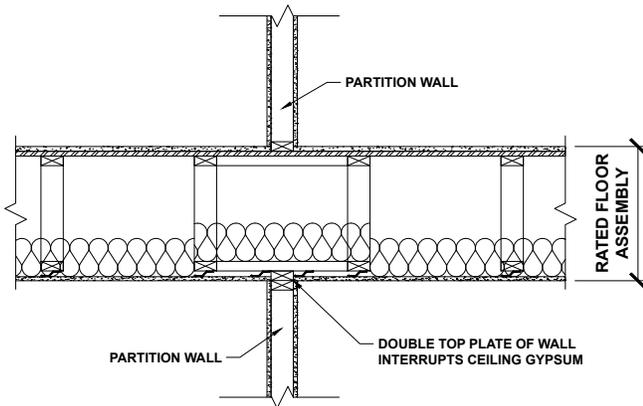


FIGURE 2: Sample partition wall-to-horizontal assembly depiction (section view)

Fire Barriers

IBC Section 202 defines a fire barrier as “a fire resistance-rated wall assembly of materials designed to restrict the spread of fire in which continuity is maintained.” Note the similarity in this definition to that of horizontal assemblies. The two are analogous to each other, the main difference being that horizontal assemblies are horizontal while fire barriers are vertical. Section 707 provides requirements related fire barriers, including, but not limited to:

- Materials permitted by the type of construction;
- Supporting construction, required to have an FRR at least equal to that of the fire barrier (with several exceptions);
- Fire resistance-rating requirements; variable depending on the function of the fire barrier:
 - Separation of mixed occupancies (Table 508.4);
 - Separation of fire areas, (Table 707.3.10); and
- Shaft enclosures (Section 713.4)

One often misunderstood point is that, depending on the wall assembly and application, an FRR wall might be required to provide confinement of fire or structural support (or both) during a fire event. Fire barriers are only one type of wall assembly. Requirements for fire barriers often differ from those for exterior walls, fire walls and fire partitions—specifically requirements relating to continuity, structural support and stability, and penetrations.

Another notable requirement is in Section 707.5, which states the continuity requirements for fire barriers. It requires that fire barriers “extend from the top of the foundation or floor/ceiling assembly below to the underside of the floor or roof sheathing, slab or deck above and shall be securely attached thereto. Such fire barriers shall be continuous through concealed space, such as the space above a suspended ceiling.” This is one of the main distinctions between a fire barrier and fire partition. A fire partition (e.g., a corridor wall) is permitted to terminate at the underside of an FRR floor/ceiling or roof/ceiling horizontal assembly, while a fire barrier is required to extend up to the underside of the floor/roof sheathing.

This continuity condition for a fire barrier is visually depicted in the IBC commentary, illustrating a simplistic situation where the wall is oriented parallel to the floor framing above (see Figure 3). However, in platform-frame construction, it is common that these walls directly support perpendicular framing elements. It is important to understand that continuity of the fire barrier assembly can still be maintained in these scenarios. For more information on this condition, see the WoodWorks publication *Shaft Wall Solutions for Wood-Frame Buildings*.⁴

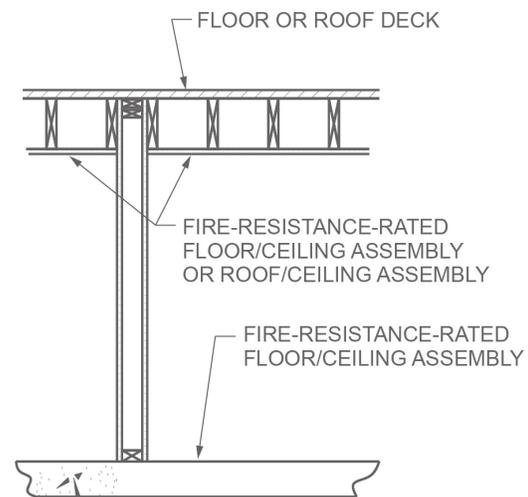


FIGURE 3: Sample fire barrier depiction (section view)
Source: IBC Commentary Figure 707.5

Fire Walls

Fire walls are used to separate buildings for the purposes of heights and areas and construction type requirements; their use allows the design of buildings with a larger footprint and/or different construction types. Fire walls create separate “buildings” on each side of the wall and all code provisions are applied to each building independently. Of all the fire resistance-rated wall types, fire walls carry the strictest requirements in terms of hourly ratings, allowable materials, structural stability, and horizontal and vertical continuity. Fire wall rating requirements are found in Table 706.4, as shown in Table 10, and are a function of the occupancy group(s). Recognition of footnote a in Table 706.4 is important, as it allows a reduction of required FRR from 3 hours to 2 hours when Type II or V construction is being used.

Fire walls are typically required to be framed of noncombustible materials, per Section 706.3. However, the exception to this section states that in Type V construction, fire walls may be of combustible materials. Although a fire wall in a construction type such as III would be required to be noncombustible, it is common to have adjacent wood-frame bearing walls, not considered as part of the fire wall assembly, but used to help meet the code’s structural stability requirements for fire walls. For example details that utilize this approach, see Figures 4 and 5.

TABLE 10: Fire Wall Fire-Resistance Ratings

| Group | Fire-Resistance Rating (hours) |
|-------------------------------------|--------------------------------|
| A, B, E, H-4, I, R-1, R-2, U | 3 ^a |
| F-1, H-3 ^b , H-5, M, S-1 | 3 |
| H-1, H-2 | 4 ^b |
| F-2, S-2, R-3, R-4 | 2 |

Source: IBC Table 706.4

- a. In Type II or V construction, walls shall be permitted to have a 2-hour fire-resistance rating.
- b. For Group H-1, H-2 or H-3 buildings, also see Sections 415.7 and 415.8.

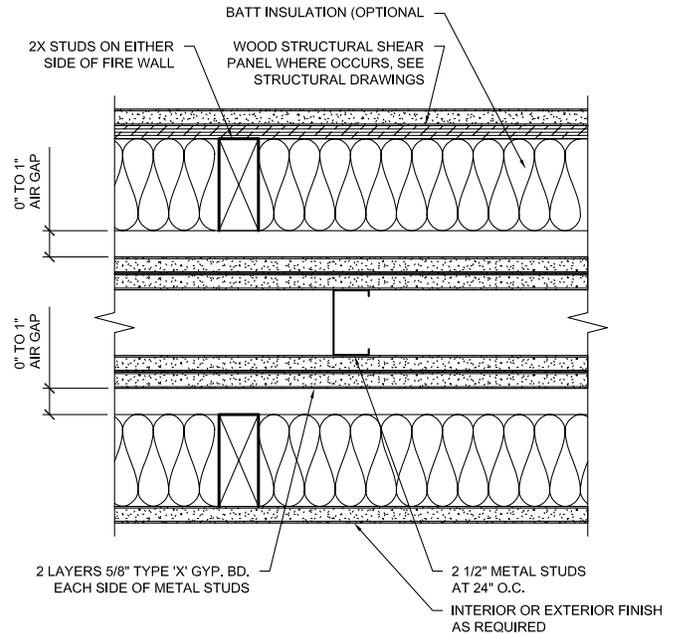


FIGURE 4: Sample 2-hour noncombustible fire wall flanked by wood stud walls detail (plan view)

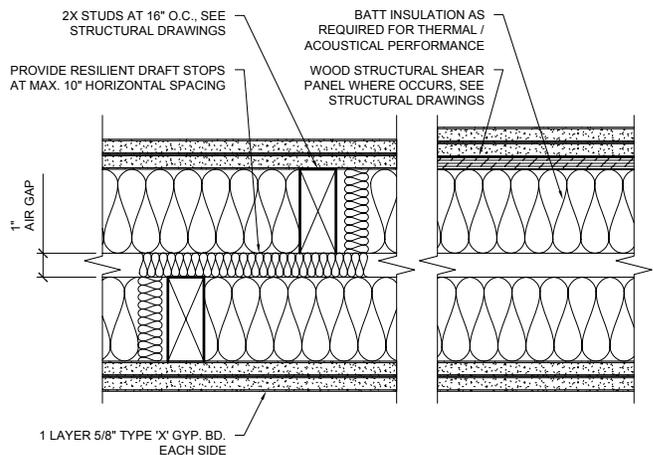
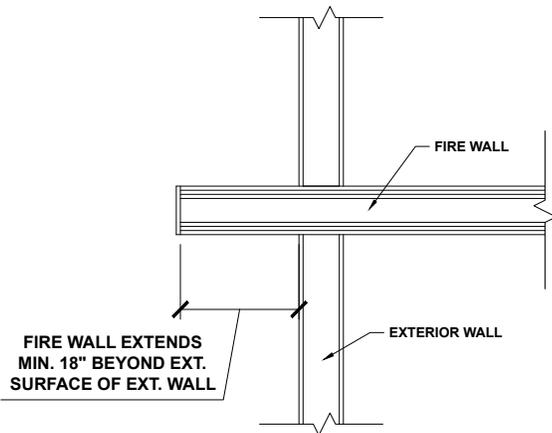


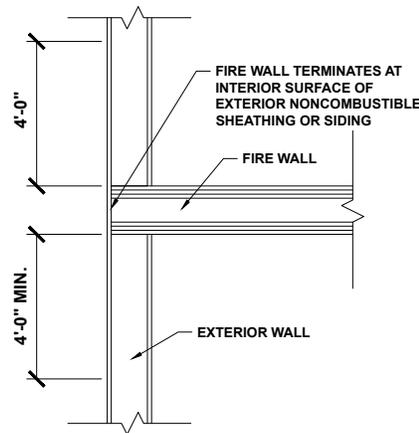
FIGURE 5: Sample 2-hour wood fire wall detail (plan view)

Fire walls are also required to meet certain horizontal and vertical continuity provisions. At fire wall to exterior wall conditions, the fire wall must extend beyond the face of the exterior wall or meet one of the exceptions noted in Section 706.5 (see Figure 6 for examples). Similarly, at fire wall to roof conditions, the fire wall must extend above the plane of the roof or meet one of the exceptions noted in Section 706.6 (see Figure 7 for examples).

OPTION 1



OPTION 2

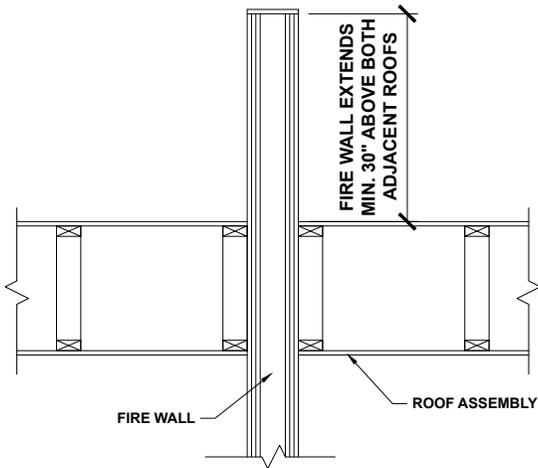


OPTIONS:

1. Exterior wall rated for 1 hour min. 4ft each side (opening protection required)
2. Noncombustible sheathing/siding extends min. 4ft each side
3. Building on each side of the firewall is equipped throughout with an NFPA or NFPA 13 sprinkler system

FIGURE 6: Two options for terminating a fire wall at an exterior wall (plan view)

OPTION 1



OPTION 2

IN CONSTRUCTION TYPES III, IV OR V

- No openings in roof within 4ft of fire wall
- Min. class B roof covering
- Roof sheathing/deck min. 4ft each side of fire wall is FRT or underside of sheathing is covered with 5/8" type X gypsum

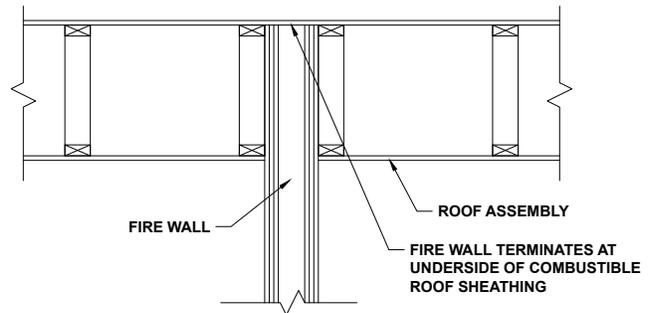


FIGURE 7: Two options for terminating a fire wall at the roof (section view)

Fire walls are required to have a higher level of structural stability than other types of walls; they must allow collapse of the structure on either side without causing the wall to collapse under fire conditions. Fire walls constructed to the provisions of NFPA 221 are also permitted.

EXAMPLE 12:

Multi-Occupancy Sprinkler Threshold

PROJECT DETAILS:

- Single-story building; 39,500 SF total
- Apartments (R-2): 31,500 SF; professional offices (B): 8,000 SF

ASSIGNMENT:

Explore the benefits of using a fire wall in the proposed mixed-use building.

RESULTS:

The benefits of using a fire wall in this building are twofold. First, separating the Group R-2 and B occupancies with a fire wall and creating two separate buildings means the Group B area does not need to be sprinklered. Recall that all buildings that contain a new Group R fire area require the use of sprinklers throughout (Section 903.2.8). Second, the inclusion of a fire wall allows for optimization of construction types. The Group R-2 area will be sprinklered and, if using an NFPA 13 system, Type V-A construction can be used. (Type V-B only allows 28,000 SF; Type V-A allows 48,000 SF.) The Group B area could use Type V-B construction even if not sprinklered (allows 9,000 SF). A 2-hour fire wall would be required for this example; this fire wall could be framed with combustible materials.

EXAMPLE 14:

Fire Wall Multi-Story Building

PROJECT DETAILS:

- Five-story hotel (R-1): 63,000 SF per story (315,000 SF total)

ASSIGNMENT:

Explore how a fire wall can be used to achieve a more economical construction type.

RESULTS:

Due to the total area of this building, it may initially appear to require Type I construction. However, Type I is not economical for a five-story hotel. One alternative is to use a fire wall to split the building into separate buildings. Type III-A construction allows up to 72,000 SF per story and 216,000 SF for an entire building. If a fire wall is placed at or near the middle of this building, it will divide the building into two separate buildings, each approximately 158,000 SF, allowing this project to be wood-framed, Type III-A, sprinklered. Note that the fire wall itself would require a 3-hour FRR and be framed of noncombustible materials.

EXAMPLE 13:

Fire Wall in a Multi-Story Stepped Building

PROJECT DETAILS:

- Four- and five-story building (portion of building is four stories and portion is five stories)
- Stories 1-4: offices (B): 18,000 SF per story
- Fifth story: offices (B): 8,000 SF

ASSIGNMENT:

Explore options for analyzing the proposed mixed-use building with and without a fire wall.

RESULTS:

Two main options exist for this building. Although Section 903.2 doesn't require it, the building could be sprinklered throughout and use Type III-A or IV construction. Alternatively, the building could remain non-sprinklered and a fire wall could be used to separate the fourth-story portion from the fifth-story portion. The benefit of using a fire wall is that the fourth-story portion of the building could be Type V-A while the fifth-story portion would be Type III-A or IV. The fire wall separating the buildings is required to have a 3-hour FRR and to be framed with noncombustible materials.

Unique Separation Requirements

Under certain circumstances, requirements for separation between occupancies or areas of the same occupancy are contained in other sections of the code. Many of these requirements exist in Chapter 4. A common example is that assemblies separating dwelling units or a dwelling unit from another occupancy require a minimum 1-hour FRR for all construction types except Types II-B, III-B and V-B, where a 1/2-hour rating is adequate. Note that these requirements are listed as footnotes in some of the tables referenced in this document (e.g., footnotes in Table 508.4).

Horizontal Building Separation (Section 510.2)

Horizontal building separation, often referred to as podium or pedestal style construction, is a provision contained in Section 510.2 that allows an increase in building height in terms of stories from grade. Separated by a 3-hour FRR horizontal assembly, these podium-style buildings are treated in the code as two separate structures built one on top of the other for the purpose of determining area limitations, continuity of fire walls, allowable number of stories, and type of construction.

EXAMPLE 15:

Podium Building

PROJECT DETAILS:

- Six-story building; 31,700 SF per story (190,200 SF total)
- First story: retail (M): 24,000 SF; restaurant (A-2): 6,500 SF; storage (S-2): 1,200 SF
- Stories 2-6: apartments (R-2): 31,700 SF per story

ASSIGNMENT:

Explore how using a podium design can maximize efficiencies of wood-frame construction in this mixed-use building.

RESULTS:

To use light-frame wood construction, this project must be Types III or V. Table 504.4 shows that the highest story on which R-2 is allowed is the fifth story for Type III and fourth story for Type V. However, this project has a Group R-2 occupancy on the sixth story. Using a podium at the first story will allow the upper five stories to be framed as Type III-A construction, maximizing the use of wood framing. The podium level will be Type I-A construction with a 3-hour rating at the podium level. Since occupancy groups A-2, M and S-2 are all allowed unlimited areas in Type I-A construction, the lowest level could be analyzed as nonseparated occupancies and no FRR walls would be required to separate these areas. The total building height from grade plane would also need to be limited to 85 feet, per the allowances of Type III-A construction.

For the buildings to be considered as separate and distinct, several requirements must be met, including:

- Buildings are separated with a horizontal assembly having an FRR of 3-hours
- Building below the horizontal assembly is of Type I-A construction and equipped with an NFPA 13 sprinkler system
- Shaft, stairway, ramp and escalator enclosures through the horizontal assembly shall have not less than a 2-hour FRR
- Building below the podium may be any occupancy except Group H and the building above may be occupancy Groups A, B, M, R or S

Although the number of stories of the upper building can be measured from the podium, the overall height of the two buildings together, in feet, is measured from grade plane and is limited by the provisions of Chapter 5 for the more restrictive of the two buildings. The IBC does not limit the number of podium stories.

Mixed-Use Buildings with Parking

Accommodating a combination of parking and other occupancies in a building such as residences and retail/restaurants is a common design practice. In multi-story, multi-family wood-frame construction, a common configuration is parking (sometimes mixed with other commercial space) on the first level, with three or more stories of wood-frame residential on top. Many designers assume that the parking level is required to be noncombustible and utilize the podium provision described above; however, there are several opportunities for alternate provisions and/or wood framing that can offer significant cost savings.

Code Requirements for Parking Structures

Section 311.3 states that parking garages, open or enclosed, are classified as Group S-2 occupancy, while Section 312.1 states that private garages are classified as Group U. As such, there are two factors to consider when designing buildings that have parking areas:

- Whether the parking is private or public, and
- Whether the parking is open or enclosed

Section 202 defines a private garage as *“a building or portion of a building in which motor vehicles used by the owner or tenants of the building or buildings on the premises are stored or kept, without provisions for repairing or servicing such vehicles for profit.”* Although there are circumstances where the parking areas of a mixed-use building can be classified as private and Group U, due to the area limitations on private garages outlined in 406.3, it is more common to design the garages as public. The following information is based on public parking garages.

Section 406 provides several provisions specific to motor vehicle-related occupancies. Section 406.5 provides requirements for open parking garages. The natural ventilation requirements for a garage to qualify as open are discussed in Section 406.5.2 and generally require openings on at least 40% of the garage's perimeter, with some exceptions specified. Section 406.5.1 permits open parking garages to be of Types I, II or IV construction.

Enclosed parking garages are covered by Section 406.6 and require both mechanical ventilation and NFPA 13 sprinklers, per Section 903.2.10. There are no limitations on construction type for enclosed parking garages, indicating that wood-frame parking garages of Types III, IV or V construction can be used.

Occupancy Separation Option

Occupancy separation is a cost-effective design option frequently overlooked when a parking garage is classified as enclosed. This design route utilizes a single construction type for the entire building (i.e., the Type I-A podium of Section 510.2 is not necessary). As noted, when the parking garage is classified as enclosed, any construction type can be utilized and there is no requirement for noncombustible materials in the parking areas. As mentioned previously, there is no code requirement to use Types I or II simply due to the presence of noncombustible materials.

Section 406.2.8 requires that parking garages be separated from other occupancies, per Section 508.1. In addition, open parking garages are subject to the requirements of Sections 402.4.2.3 for malls, 406.5.11, 510.3, 510.4 and 510.7. Under Section 508.1, mixed-occupancy buildings can be classified as either nonseparated or separated using the design methods discussed previously in this document.

In a building that has an NFPA 13 sprinkler system throughout, only a 1-hour rating is required when separating parking from occupancies such as Group B, M and R, per Table 508.4. This indicates that a mixed-use

building consisting of an enclosed parking area and other occupancies could be completely framed with wood if allowable building size calculations permit the use of Types III, IV or V construction. Even if other materials are used in

EXAMPLE 16:

Mixed-Use with Parking and Occupied Roof Deck

PROJECT DETAILS:

- Five-story mixed-use building; 21,000 SF per story (105,000 SF total)
- First story: parking (S-2) 21,000 SF
- Stories 2-5: apartments (R-2) 21,000 SF per level;
- Occupied roof deck
- 68 feet from grade plane to mean roof height

ASSIGNMENT:

Determine the most efficient construction type for this mixed-use building.

RESULTS:

Since this building contains new Group R fire areas, it will have an NFPA 13 sprinkler system in accordance with Section 903.2.8. Per Section 503.1.4, the occupied roof deck is not considered an additional story. According to Exception 1, given that the building is fully sprinklered, the occupancy of the roof is not limited to that of the story immediately below. This building can be analyzed as five stories above grade plane.

The first item to determine is whether the parking garage on the first level is open parking or enclosed. If enclosed, it can be any construction type. If open, the construction type for the first level is restricted to Types I, II, or IV per Section 406.5.1. Several options for classifying this building are listed below.

If the first level is enclosed parking:

Option A: Use Type III-B construction for the entire building with nonseparated occupancies. Group R-2 is the more restrictive of the two occupancies present; Type III-B allows for 48,000 SF per story or 144,000 SF total with a 75-foot and five-story height limit. The floor assembly between the garage and the second story would need a 1/2-hour rating, per Section 711.2.4.3.

Option B: Use Section 510.4 with the lowest level being Type I-B construction and a 2-hour assembly separating the garage from the residential stories (see Table 601 for FRR requirements for Type I-B buildings). Use Type V-A construction for the upper four stories.

Option C: Use Section 510.2 with the lowest level being Type I-A construction and a 3-hour podium separating the garage from the residential stories. Use Type V-A construction for the upper four stories.

If the first level is open parking:

Option A: Use Section 510.4 with the lowest level being Type I-B with a 2-hour assembly separating the garage from the residential stories, per Table 601, or Type IV with a 1-hour assembly, per Table 508.4. Use Type V-A construction for the upper four stories.

Option B: Use Section 510.7 with the lowest level being Type II-B or IV construction and a 1-hour assembly separating the garage from the residential stories (see Table 508.4). Use Type III-B construction for the upper four stories.

Option C: Use Section 510.2 with the lowest level being Type I-A construction and a 3-hour podium separating the garage from the residential stories. Use Type V-A construction for the upper four stories.

the building (perhaps as columns, beams or walls on lower levels), there is economic value in using Section 602.1.1 to classify the entire building as the lowest construction type allowed.

Parking Beneath Group R (Section 510.4)

Utilizing the options presented in Section 510.4 offers the ability to capitalize on an increased number of stories, similar to the horizontal separation provision of Section 510.2, by stacking a Group R building on top of a single-story Group S-2 parking garage, gaining an additional story. This provision is more limited in its application but has the benefit of less restrictive FRRs and construction types on the lowest level. Specifically, this provision allows the use of Type I (open or enclosed parking) or IV (open only) on the lowest level. The floor/ceiling assembly above the parking level is constructed of materials allowed per the type of construction used for that parking level. In addition, the floor/ceiling assembly above the parking level is required to be rated per Table 508.4 or Table 601 (for floor members and primary structural frame members), whichever is greater. The portion of the structure above the parking level is considered a separate building and can therefore be of a different construction type. The overall height of the building, in feet, measured from grade plane, is limited to the more restrictive construction type.

The main benefit of utilizing Section 510.4 is that it provides the benefit of an additional story while not requiring the full podium provision limitations of Section 510.2 (i.e., the lowest level doesn't have to be Type I-A with a 3-hour podium slab). Specifically, this provision allows the use of a heavy timber-framed parking level (if open) and only requires a 1-hour rating (if the parking level is Type IV) or 2-hour rating (if the parking level is Type I) to separate the parking from adjacent residential units above.

Open Parking Garage Beneath Group A, B, I, M or R (Section 510.7)

Section 510.7 provides another option for using a mix of construction types in projects where parking garages are constructed below occupancy Groups A, B, I, M or R buildings. In contrast to the provisions of Section 510.4, this option is limited to open parking garages, but is not limited to one story. This option requires that the overall height of the building, in both feet and stories, be measured from grade plane. Construction Types I, II or IV can be used for the parking level(s) and any construction type can be used for the levels above, provided overall building height and area limits are met.

The fire-resistance rating of the assembly separating the parking from the occupancies above must meet the requirements of Table 508.4. For example, a building equipped throughout with an NFPA 13 sprinkler with an open parking garage under a Group R occupancy would require a 1-hour FRR assembly.

Conclusion

Although navigating the building code can seem like a daunting task when analyzing mixed-use buildings, there are often methods of simplifying these analyses. By taking advantage of specific code provisions, designers have opportunities to utilize a more economical construction type and optimize the number and locations of required fire-rated assemblies.

For more information, WoodWorks offers free one-on-one technical assistance as well as a wide range of online resources (www.woodworks.org). For assistance with a commercial or multi-family project, email help@woodworks.org or visit <http://www.woodworks.org/project-assistance>.

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² American Wood Council, WoodWorks. Heights and Areas Calculator. www.awc.org/codes-standards/calculators-software/heights-areas

³ American Wood Council. (2018.) Choosing Construction Type Just Got Easier: Design Tools to Simplify IBC Chapter 5. <https://www.youtube.com/watch?v=w67F48rQI5E>

⁴ WoodWorks. (2021.) Shaft Wall Solutions for Wood Frame Buildings. www.woodworks.org/wp-content/uploads/wood_solution_paper-Shaft-Wall-Solutions-for-Wood-Frame-Buildings-WoodWorks.pdf

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