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Taking the Guesswork out of Mixed-Use Building Requirements

Design Strategies and Fire Separation Details for Light-Frame Wood Buildings

1. Introduction

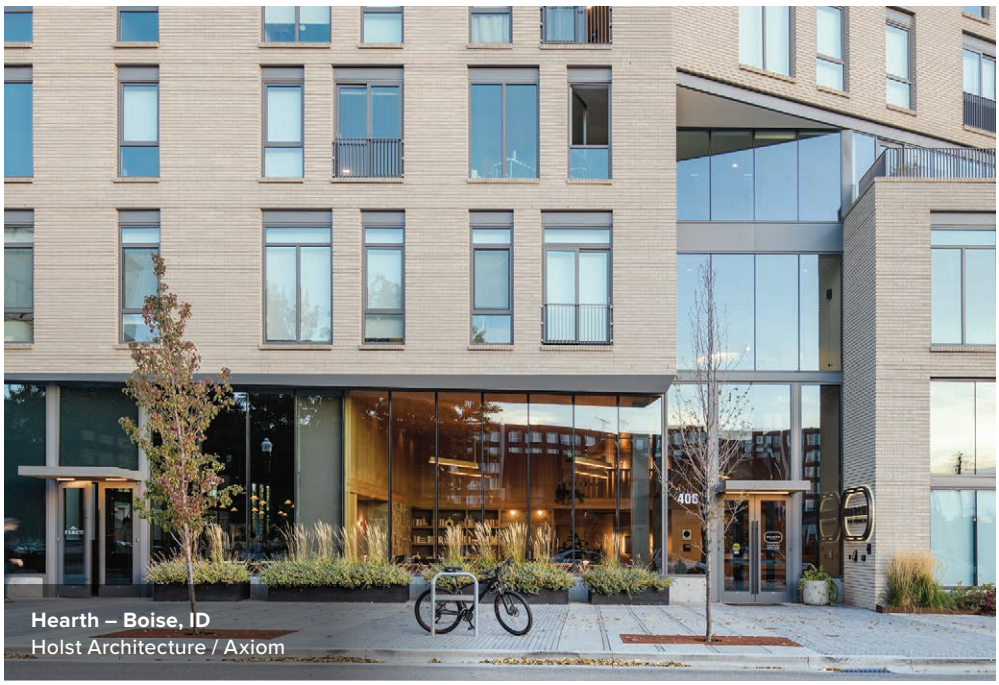
Mixed-use buildings, which combine multiple occupancies in a single structure, are common, but determining how to apply their unique set of code requirements can be complex. To simplify code analysis, this paper provides logical steps for key elements of design—such as determining allowable building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

Mixed-use buildings come in many shapes, sizes and configurations. In this paper, "mixed-use" 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 each other; a mid-rise building with ground-floor parking and multiple stories of residential apartments above; and a high-rise building with combinations of offices, retail space, residential units, and parking.

Before beginning a mixed-use analysis, it is important to understand the fire and life safety principles that guide design in accordance with the International Building Code (IBC). Allowable building sizes (heights and areas) and fire-resistance rating (FRR) requirements are based in part on the occupancy and construction type of the building. For foundational information about construction types, allowable building sizes, and FRRs, see *Designing with Wood Under the IBC: Construction Types, Building Size, and Fire Resistance*. Unless noted otherwise, references in this paper are to the 2024 IBC.

2. Mixed-Use Buildings

The IBC requires each portion of a building to be classified as an occupancy based on its primary purpose or use. The simplest way to analyze a mixed-use project is as a single-occupancy building. This can be accomplished through code provisions such as those allowing incidental uses or small assembly spaces. When a building contains multiple occupancies, the code provides several options for analyzing it as mixed-use, as discussed in Section 3.



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Eight-story development includes residential and live/work units, a fitness center, co-working and conference rooms, retail space, and parking

Contents

2.1 Incidental Uses

Incidental uses (IBC Section 509) are ancillary functions associated with a given occupancy that generally pose a greater level of risk and are limited to uses listed in IBC Table 509.1. 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 509.1 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. However, the protection requirements are not applicable to incidental uses that are located within and serve a dwelling unit. Incidental uses are not required to also comply with the accessory use provisions of Section 508.2.*

Examples of incidental uses from Table 509.1 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—i.e., it does not need to be treated as a separate occupancy. However, the area of each incidental use

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 whether 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 whether 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 509.1 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 509.1 requires that both of these incidental use types be separated from the main portion of the building with 1-hour fire-resistance-rated construction unless equipped with automatic sprinklers. This project has an NFPA 13 sprinkler system, so the 1-hour separation is not required. Both 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 area 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.

space cannot exceed 10% of the area of the story on which it is located. Note: Some local building codes revise this section to limit the *aggregate* area of incidental uses to 10% or less, so it is important to check for modifications in applicable codes.

Incidental uses must be separated from adjoining spaces with fire-resistance-rated construction or equipped with an automatic sprinkler system (or sometimes both) as required in Table 509.1. Where an FRR is required, walls must be designed as fire barriers (Section 707) and floors and roofs must be designed as horizontal assemblies (Section 711). When Table 509.1 allows the use of sprinklers in lieu of fire-resistance-rated assemblies, 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.

2.2 Accessory Occupancies

Addressed in IBC Section 508.2, accessory occupancies are rooms or spaces that 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. Code commentary to that section 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 purpose and function of an accessory occupancy must be secondary to the structure's main reason for being occupied. 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.

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 whether 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 Section 3, *Mixed-Use Analysis*. Finally, 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 an F-1 occupancy exceeds 12,000 SF, or in certain types of factories that produce or contain large amounts of materials with a high fire risk. Other than ambulatory care facilities and laboratories involving lithium-ion or lithium metal batteries, 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 paper 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 whether sprinkler protection is required.*

Examples include a lunchroom in a retail store or a 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 (e.g., egress, sprinkler requirements, interior finishes, and structural loading) for that occupancy classification. 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.

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.

Except in a few situations, Section 508.2.4 does not require separation between accessory occupancies and the main occupancy. However, it may be required by other provisions of the code. 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 necessary to separate the accessory occupancy from the main occupancy to remain under the threshold. For more on this, see Section 4, *Sprinkler Thresholds and Fire Areas*.

2.3 Live/Work Units

Section 508.5, provisions for live/work units, was added to the 2021 IBC to allow small businesses to operate within an R-2 dwelling unit. As long as the limits within this section are met, the entire live/work unit can be classified as R-2, and there is no separation required between the dwelling and business area within the live/work unit. To limit fire loads, storage areas are limited and hazardous uses are prohibited. Since the entire unit is classified as R-2, the entire building is required to be sprinklered in accordance with IBC Section 903.3.1.1 or 903.3.1.2 for NFPA 13 and 13R sprinkler systems, respectively.

To qualify as a live/work unit, there are limitations on size, location, and number of nonresidential workers/employees. The area of the live/work unit must be less than or equal to 3,000 SF and the nonresidential area must be less than or equal to 50 percent of the area of each live/work unit. The nonresidential area is limited to the first or main floor only, and no more than five employees are allowed to occupy the nonresidential area at any one time.

Egress and accessibility for the business area within the live/work unit are regulated based on the function of the area and not on the R-2 residential requirements. The business/work area on the first floor must be fully accessible. Egress and accessibility for the dwelling area shall conform with R-2 residential requirements. Floor openings for stairways and other vertical elements between levels of a live/work unit do not need to be enclosed.

2.4 Small Buildings and Tenant Spaces

IBC Section 303.1.1 states that a small building or tenant space used for assembly purposes with an occupant load of less than 50 persons shall be classified as a Group B occupancy. Examples of this include a small café or fast food establishment. While these buildings or spaces would ordinarily need to be classified as Assembly Group A, the benefit of classifying them as Group B is that larger heights and areas are generally allowed for Group B occupancies.

EXAMPLE 3:

Multi-Story Accessory Occupancies

PROJECT DETAILS:

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

ASSIGNMENT:

Determine whether 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, the accessory occupancy provisions of the code may be used. 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 is allowed 28,500 SF per story and 57,000 SF for the entire building, indicating that the proposed areas are acceptable. 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 Section 903.2.3 requires the use of sprinklers in Group E fire areas exceeding 12,000 SF, the building must also be sprinklered.

2.5 Small Assembly Spaces

IBC Section 303.1.2 addresses small assembly spaces, which are similar to accessory occupancies but with their own set of criteria. This section permits a small assembly space 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 it is less than 750 SF or has an occupant load of less than 50 persons. As with small tenant spaces, the benefit of classifying small assembly spaces as Group B is that larger heights and areas are generally allowed. The advantage 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 Section 508.2, small assembly spaces are not limited to 10% of the floor area either individually or combined.

Examples where 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 whether 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 Table 506.2, a non-sprinklered, Group B, Type V-B building can be 9,000 SF, which is greater than the proposed building area. Therefore, Type V-B can be used and no fire-resistance-rated separation is required between the conference room and adjoining office space.

2.6 Other Assembly Spaces

IBC Section 303.1.3 allows assembly areas associated with Group E occupancies to be considered part of the educational 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. However, the commentary to Section 303.1.3 clarifies that these assembly spaces must be solely used by students and staff. If they will be used for functions attended by others, they need to be classified as the appropriate Group A occupancy.

Places of religious worship are typically classified as Group A-3 occupancy. In these buildings, 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-3 occupancy.

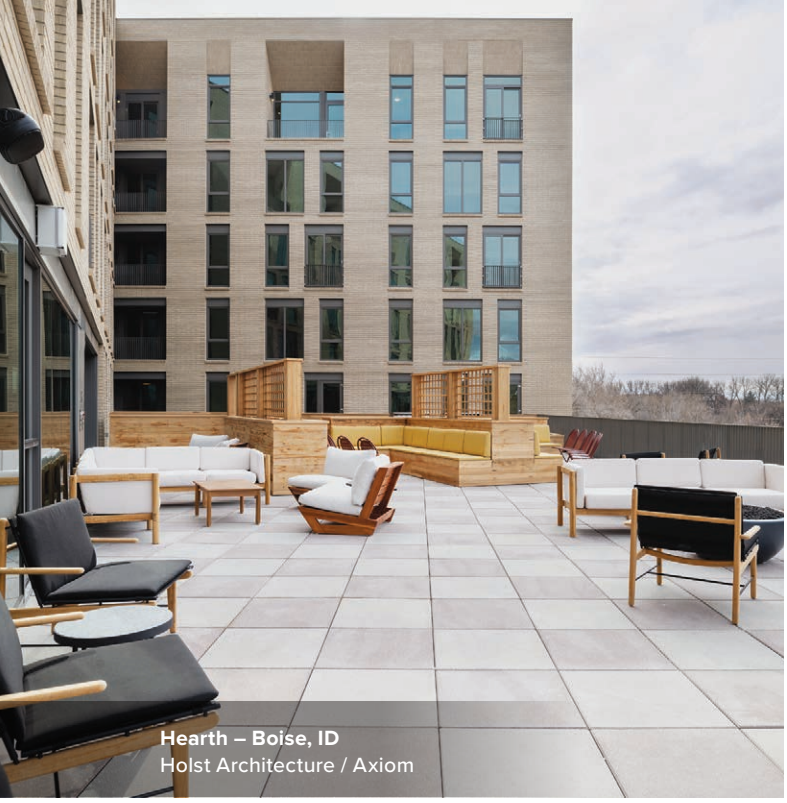
For both of the above conditions, it is important to note that, when a room or space might be used for multiple purposes, IBC Section 302 requires that the limitations of each use and associated occupancy be applied. For example, if the gym in the school building might be used for craft fairs or weekend 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.

2.7 Occupiable Roofs

Occupiable roofs, addressed in IBC Section 503.1.4, are becoming more common as outdoor amenity spaces, offering fresh air and views, and increasing overall marketability of the properties. In most instances, these roof decks are open air, without roof coverings, and have partial-height guards or parapet walls 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.

Section 503.1.4 clarifies that if the occupancy of the roof is also permitted for the story immediately below the roof, it does not need to be included in the building area regulated by Section 506 nor the building height and number of stories regulated by Section 504. 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.*



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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, occupiable roofs 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 on roofs. An automatic sprinkler system (either NFPA 13 or NFPA 13R where permitted) is required on all stories between the occupied roof and 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 occupiable 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, as well as buildings taller than 75 feet.

Further, Section 503.1.4 notes that any penthouses or other enclosed rooftop structures must comply with Section 1511. Per Section 1511.1.1, the aggregate area of rooftop penthouses and other enclosed rooftop structures cannot exceed one-third the area of the supporting roof. Beyond this limit, roof areas enclosed within rooftop structures or penthouses would be considered an additional story and would need to be included in building height and area calculations. More detail on this topic can be found in the WoodWorks article, *Occupiable Roof Decks and Allowable Building Size*.

2.8 Mezzanines and Equipment Platforms

Options for increasing the usable area within a building also include mezzanines and equipment platforms, addressed in IBC Section 505. Definitions for these spaces, allowable areas, and whether they count as additional stories are covered in the WoodWorks article, *Mixed-Use Code Strategies Part 1: Incidental Uses, Accessory Occupancies, and Small Spaces*.

3. Mixed-Use Building Analysis

The provisions discussed so far may reduce the number of distinct occupancies that need to be classified within a building or even allow the building to be classified as single occupancy. However, if the building still qualifies as mixed-use after applying these allowances, it must be analyzed accordingly—either as nonseparated or separated occupancies or by using fire walls, podiums, or other separation strategies.

3.1 Nonseparated Occupancies

Nonseparated occupancies, as defined in IBC Section 508.3, require no separation between different occupancies in the form of fire-resistance-rated floor or wall assemblies. The entire building must comply with the minimum construction type and fire protection requirements (IBC Chapter 9) applicable to its most restrictive occupancy.

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.

There are additional provisions addressing unique conditions for high-rise buildings (Section 508.3.1.1) and Group I-2, Condition 2 occupancies (Section 508.3.1.2), which are outside the scope of this paper. For more information, see the WoodWorks article, *Mixed-Use Code Strategies Part 2: Separated vs. Nonseparated Occupancies and Fire Areas*.

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 fire-resistance-rated 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 will be 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 1 shows allowable values for a sprinklered building with occupancies B and S-1 per IBC Tables 504.3, 504.4, and 506.2, assuming no opportunities for frontage area increase.

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. For Group B, Types V-A and III-B would also 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. Unless required by other sections of the code, a fire-resistance-rated fire barrier is not required to separate the two occupancy types within this building.

This example uses nonseparated occupancies for illustrative purposes. Example 7 provides a separated occupancy analysis, which is a more realistic approach for this specific building configuration.

Further, while this example follows the allowable heights and areas of Sections 504 and 506, warehouses often have clear space around them and can benefit from frontage increases or be classified as unlimited area buildings according to Section 507. For more on this topic, see the WoodWorks publication, *Wood in Industrial Buildings: Systems, Codes, and Design Opportunities*.

TABLE 1: 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

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Living quarters and apparatus bay are designed as distinct but attached masses; includes B, R-2, and S-1 occupancies, nonseparated

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; offices (B): 2,500 SF
- Second story: offices (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.

TABLE 2: 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

RESULTS:

The building will be sprinklered throughout since Section 903.2.8 requires the use of sprinklers throughout all buildings that contain a Group R fire area. Table 2 indicates the allowable height, number of stories, and floor area for a sprinklered building with occupancies R-2, B, and S-2, assuming no opportunities for frontage area increase.

The proposed floor area (12,000 SF per story; 36,000 SF total building), building height (38 feet), and number of stories (three) 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 more on this topic, see Section 8, *Mixed-Use Buildings with Parking*.

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 (at no cost) online and as an app for Android, iOS, and Windows. This tool is based on the IBC up to the 2021 edition and can accommodate multiple occupancies, assume separated occupancies, and perform frontage factor increases. It is especially useful for separated occupancy area calculations as these are often iterative. WoodWorks is also available for one-on-one project assistance, also at no cost, to guide designers through this process.

3.2 Separated Occupancies

Separated occupancy provisions outlined in IBC Section 508.4 require different occupancies to be separated using fire-resistance-rated walls (fire barriers in compliance with Section 707) and floor/ceiling assemblies (horizontal assemblies in compliance with Section 711). Table 508.4, replicated in Table 4 of this paper, provides the required hourly FRR for these separation assemblies. Note that the required hourly ratings 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 506.2.2). In specific instances where an NFPA 13R sprinkler is used, the limit of the sum of these story-specific ratios is 4.0. In addition to these total building ratio checks, no single story may have a sum of ratios greater than 1.0. Some local building codes modify these ratios, and this is another reason to confirm jurisdiction-specific requirements.

Table 508.4, footnote f, indicates that this table is not intended to be used for determining the FRR for assemblies separating fire areas; those requirements are found in Section 707.3.10, Table 707.3.10, and Section 901.7. They are discussed in Section 4 of this paper, *Sprinkler Thresholds and Fire Areas*.

Where separated occupancies are used, each separated space must comply with the code requirements for that occupancy. The fire protection and life safety provisions of Chapter 9 are determined based on the occupancies within a given fire area, and the threshold for providing sprinklers is often based on the size of the fire area. This is also discussed in Section 4.

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-resistance-rated separation for separated occupancies.

RESULTS:

From Example 5, the allowable sizes are shown in Table 3.

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

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. The actual area of Group S-1 occupancy, 41,000 SF, exceeds the allowable area of 36,000 SF; 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.

Again, while this example followed the allowable heights and areas of Sections 504 and 506, warehouses often have clear space around them and can benefit from frontage increases or be classified as unlimited area buildings according to Section 507. For more on this topic, see the WoodWorks publication, *Wood in Industrial Buildings: Systems, Codes, and Design Opportunities*.

TABLE 4: 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-I[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 Sections 406.3.2 and 406.6.4.

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.

3.3 Combination of Nonseparated and Separated Occupancies

Although less common, it is possible to design a building that includes both separated and nonseparated occupancies. This is recognized as an acceptable approach, as stated in IBC Section 508.1:

> *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, 508.4 or 508.5, 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 four options or 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 having 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 classified as nonseparated are checked for allowable height and area against the most limiting case 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 fire-resistance-rated fire barriers and/or horizontal assemblies, as specified in Table 508.4.

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
- Assume no opportunities for frontage area increase

ASSIGNMENT:

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

RESULTS:

The coffee bar/snack shop areas could be assumed to be A-2 occupancy. However, it might be advantageous to use the small assembly provisions of Section 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 building's main occupancy. 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.

Next, we'll determine the mix of occupancies in the rest of the building. While it is common to assume classrooms will be Group E educational occupancy, IBC Section 304 classifies educational occupancies for students above Grade 12 as Group B. The administration and office areas are also 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.

If the two coffee bars can be classified as Group B using Section 303.1.1 or 303.1.2, the building could be analyzed entirely as a Group B occupancy. Per IBC 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 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 5, Type V-A construction would be necessary for this building: Type V-B does not permit three stories for a Group A-2 occupancy nor is the allowable floor area of Type V-B adequate for A-2.

The benefit of the nonseparated option is that fire-resistance-rated separation between the coffee bars and other occupancies would not be required. However, a 1-hour FRR is required for nearly all structural systems and assemblies in Type V-A construction per IBC Table 601.

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

TABLE 5: 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

Actual area/allowable area ratio analysis for the first floor:

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 trade-off between Type V-B separated and Type V-A nonseparated is that Type V-B separated generally allows structural elements to be unrated, but does require the assemblies separating the coffee bars from adjacent occupancies to have a 1-hour FRR.

Keep in mind that, for buildings three stories and higher equipped throughout with an NFPA 13 sprinkler system, this sum of ratios for all stories cannot exceed 3.0, nor can any individual floor exceed 1.0. The verification for this is as follows:

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

The ratio for each of 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 fire-resistance-rated fire barriers would be required between the coffee areas and the rest of the building on the first level. A 1-hour FRR would also be required for the horizontal assembly between the coffee areas on the first level and the office and/or classroom spaces on the second level.

4. Sprinkler Thresholds and Fire Areas

Although other factors may influence whether a building will be sprinklered, such as insurance and property protection, the building code plays a role in the decision-making process.

IBC Section 903.2 identifies locations where an automatic sprinkler system is required. 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 (i.e., the level where people can exit and move away from the building). 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.
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 the A-2 occupancy.

An important distinction is that sprinkler thresholds given in Section 903.2 pertain to *fire areas*, which are different from the *allowable building areas* defined in Section 506 and previously discussed. By definition in Section 202, a fire area is enclosed by fire walls, fire barriers, exterior walls, or horizontal assemblies. Exterior areas within the horizontal projection of the roof or floor above are also included in the fire area.

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 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 FRR 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 6: 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: 7,000 SF per story; 21,000 SF total

ASSIGNMENT:

Determine whether sprinklers are required for the proposed retail building.

RESULTS:

IBC 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.

There are additional sprinkler requirements when a Group M occupancy includes high-piled storage or rack storage arrays (Section 903.2.7.1), the display and sale of upholstered furniture or mattresses (Section 903.2.7.2), and lithium-ion or lithium metal battery storage (Section 903.2.7.2).

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 to separate the building via horizontal floor/ceiling assemblies at the second and third stories, resulting in three fire areas, each 7,000 SF. Table 707.3.10 shows that the separations must have an FRR 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 one of the offices is now an employee lunchroom and categorized as occupancy Group A-2 rather than Group B. Determine whether the proposed non-sprinklered construction type is acceptable.

RESULTS:

As noted, warehouses can often be classified as unlimited area buildings according to IBC Section 507 or take advantage of frontage increases in Section 506.3. However, for this example, assume these provisions do not apply and use the allowable building areas of Section 506.2.

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 construction, 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 in Group F-1 occupancies when one of the following conditions exists:

1. The fire area exceeds 12,000 SF.
2. A fire area is located more than three stories above grade plane.
3. The combined area of all Group F-1 fire areas on all floors, including any mezzanines, exceeds 24,000 SF.
4. The space is used to manufacture lithium-ion or lithium metal batteries.
5. The space is used to manufacture vehicles, energy storage systems, or equipment containing lithium-ion or lithium metal batteries where the batteries are installed as part of the manufacturing process.

There are additional sprinkler requirements for the following F-1 use cases: woodworking operations (Section 903.2.4.1), the manufacture of distilled spirits (Section 903.2.4.2), and the manufacture of upholstered furniture or mattresses (Section 903.2.4.3). For this example, assume none of these special conditions apply.

Section 903.2.2 does not require the use of sprinklers in Group B buildings except in the case of ambulatory care facilities (Section 903.2.2.1) and laboratories used for the research and development of lithium-ion or lithium metal batteries. For this example, assume none of these special conditions apply.

As noted, Section 903.2.1.2 requires the use of an automatic sprinkler system in A-2 occupancies when one of the following conditions exists:

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

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 fire-resistance-rated separations.

RESULTS:

Table 7 indicates the allowable height, number of stories, and floor area for a building with occupancies A-2, B, and M, assuming no opportunities for frontage area increase.

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. Based on Table 7, Group A-2 is the most restrictive and Type III-A construction would be required 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 height of one story. Based on Table 7, 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 upper two stories is required to have a 1-hour FRR per Table 508.

Next, we'll confirm that an accessible roof deck with 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 in Table 504.4 for the story immediately below the roof. Because A-2 is permitted up to the second story for non-sprinklered, Type V-A buildings, and the second story is immediately below the third-story roof deck, this is acceptable. The accessible roof deck does not need to be included in the allowable area checks per Section 503.1.4.

Last, we need to confirm the sprinkler requirements in IBC 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 for a 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 7: 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

NS = Non-sprinklered
S1 = Single-story
SM = Multi-story

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 permitted through the use of sprinklers.

Based on Table 7, 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 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 non-sprinklered option, we'll confirm that an accessible roof deck is acceptable for Group A-2 occupancy. Because 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 complies with the provisions and the roof deck does not need to be included in the allowable area checks per Section 503.1.4.

As shown in this example, the benefit of using a combination of separated and nonseparated occupancies 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 a fire-resistance-rated 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 required to meet a 1-hour FRR. This is discussed further in Section 5, *Creating Separation in Mixed-Use Buildings*.

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

5. Creating Separation in Mixed-Use Buildings

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

5.1 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)
- FRR 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)
  - Separation of dwelling units (1-hour typically, with 1/2-hour allowed in Types II-B, III-B, and V-B construction)

Another notable requirement is discussed in Section 711.2.2, which says horizontal *"assemblies shall be continuous without vertical openings, except as permitted by this section and Section 712."* 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. Penetrations are addressed broadly in Section 712.1.4, which points to Section 714 for the protection of those penetrations. Section 714.5.2 Exception 7 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 wall board and the ceiling membrane is installed tight to the wall's double top plate.

Figure 1 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 horizontal assembly.

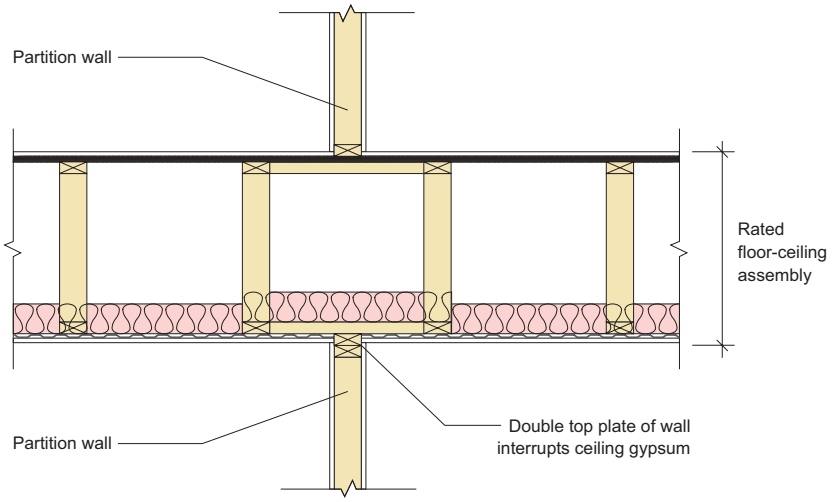


FIGURE 1: Sample partition wall-to-horizontal assembly depiction (section view)

5.2 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, the main difference being that horizontal assemblies are horizontal while fire barriers are vertical. Section 707 provides requirements related to 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)
- FRR 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)
  - 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, 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 a fire-resistance-rated 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 (Figure 2). 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 Light-Frame and Mass Timber Buildings*.

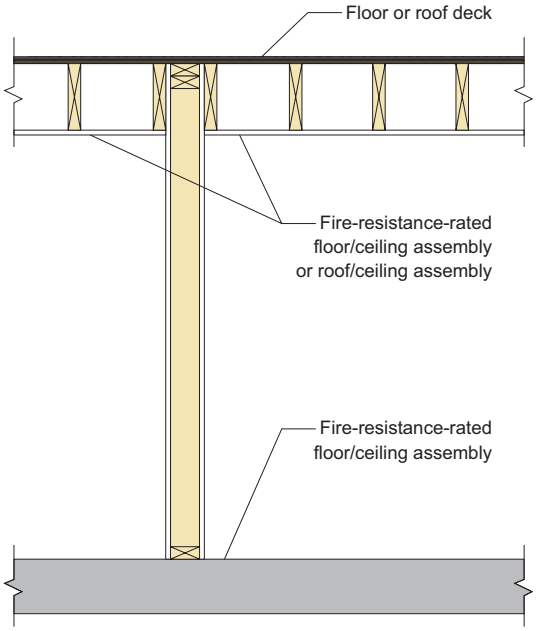


FIGURE 2: Sample fire barrier depiction (section view)
Source: IBC Commentary Figure 707.5 Continuity of Fire Barriers

5.3 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 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, replicated in Table 8 in this paper, 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 with noncombustible materials per Section 706.3. However, the exception to this section states that fire walls in Type V construction may be of combustible materials. See Figure 3 for an example of this approach.

Even when fire walls are required to be noncombustible, it is common to have adjacent wood bearing walls, not considered part of the wall assembly, but to help meet structural stability requirements for fire walls. See Figure 4 for an example of this approach.

TABLE 8: 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 FRR.

b. For Group H-1, H-2 or H-3 buildings, also see Sections 415.7 and 415.

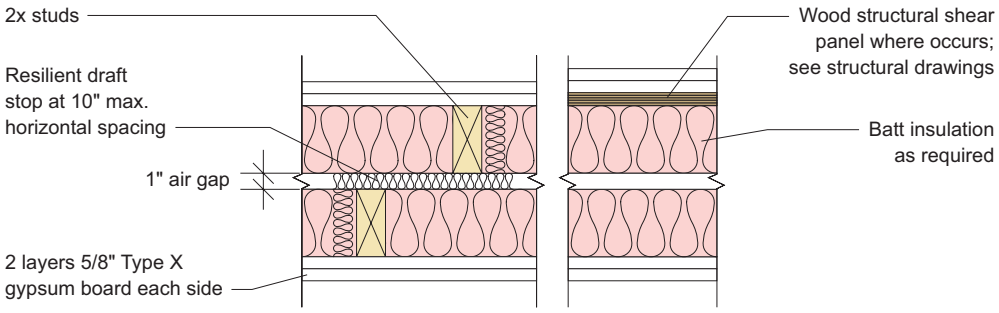


FIGURE 3: Sample 2-hour wood fire wall detail (plan view)

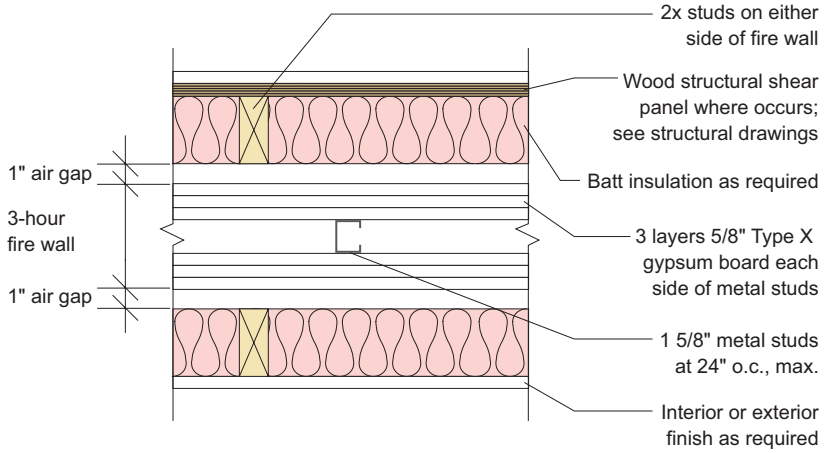
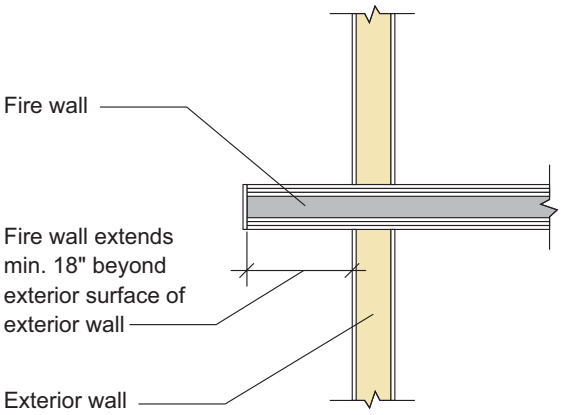


FIGURE 4: Sample 3-hour noncombustible fire wall flanked by wood stud walls detail (plan view)

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 (Figure 5). 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 (Figure 6).

Fire walls are required to have a higher level of structural stability than other types of walls; per Section 706.2, 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 Standard for High Challenge Fire Walls, Fire Walls, and Fire Barrier Walls are also permitted.

OPTION 1



OPTION 2

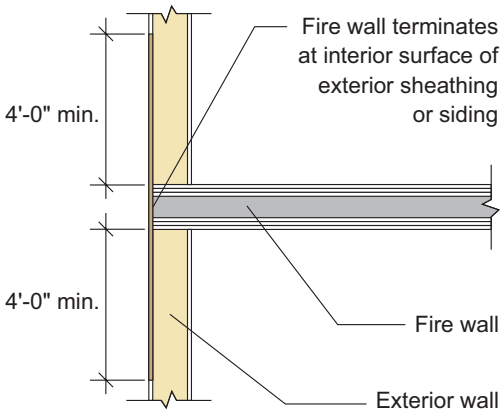
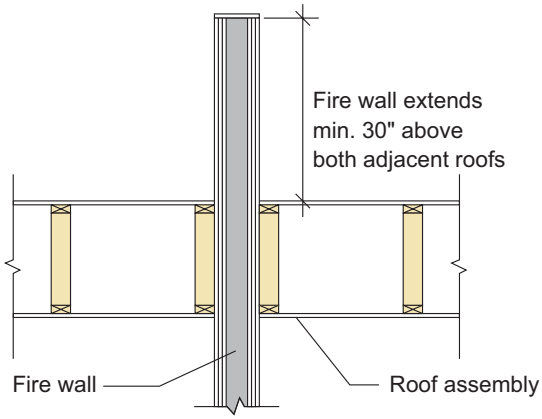


FIGURE 5: Two options for terminating a fire wall at an exterior wall (plan view)

Option 2 is allowed when <u>one</u> of the following conditions is met:

- Exterior wall rated for 1 hour min. 4 ft each side (opening protection required)
- Noncombustible sheathing/siding extends min. 4 ft each side
- Noncombustible exterior sheathing is used and building on each side of the fire wall is equipped throughout with NFPA 13 or NFPA 13R sprinkler system

OPTION 1



OPTION 2

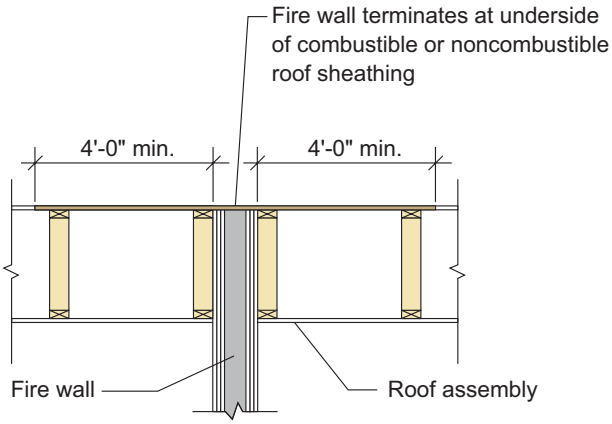


FIGURE 6: Two options for terminating a fire wall at a roof (section view)

Option 2 is permitted in Types II, IV, or V construction when <u>all</u> of the following conditions are met:

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

EXAMPLE 12:

Multi-Occupancy Sprinkler Threshold

PROJECT DETAILS:

- Single-story building; 39,500 SF total
- Apartments (R-2): 31,500 SF; 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 for code purposes means the Group B area does not need to be sprinklered. (Recall that all buildings containing a new Group R fire area require sprinklers throughout per Section 903.2.8.) Second, including a fire wall allows the construction type to be optimized. 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 without sprinklers (allows 9,000 SF). This would require a 2-hour fire wall, which could be framed with combustible 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. Because Section 903.2.2 does not require a sprinkler system for offices in occupancy Group B, the building could be non-sprinklered and use Type III-A, IV-C, or IV-HT construction. Alternatively, a fire wall could be used to separate the four-story portion from the five-story portion. The benefit of using a fire wall is that the four-story portion of the building could be Type V-A sprinklered, while the five-story portion would remain non-sprinklered, Type III-A, IV-C, or IV-HT. The fire wall separating the buildings is required to have a 3-hour FRR and to be framed with noncombustible materials.

6. 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 IBC 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 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 paper (e.g., Table 508.4).

7. Horizontal Building Separation

Horizontal building separation, often referred to as podium construction, is a provision in IBC Section 510.2 that allows an increase in building size. Separated by a 3-hour fire-resistance-rated 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 construction type.

For the buildings to be considered separate and distinct, they must meet the following requirements:

- They are separated with a horizontal assembly having a 3-hour FRR.
- The 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 have a minimum 2-hour FRR.
- The building below the podium may be any occupancy except Group H and the building above may be occupancy Group A, B, M, R, or S.

Although the number of stories of the upper building can be measured from the podium, the overall height (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.

The Distillery North – Boston, MA
ICON Architecture / Souza, True, and Partners

Trent Bell Photography

Light-frame wood residential units over a concrete podium that includes a café, commercial space, and parking

EXAMPLE 14:

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 light-frame wood construction in this mixed-use building.

RESULTS:

To use light-frame wood construction, this project must be Type III or V. IBC Table 504.4 shows that the highest story permitted for a Group R-2 occupancy is the fifth for Type III and fourth for Type V. However, this project has an R-2 occupancy on the sixth story. Using a podium at the first level will allow the upper five stories to be framed as Type III-A construction, maximizing the use of wood framing. The podium will be Type I-A construction with a 3-hour-rated slab at the transition to the wood structures above. 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 fire-resistance-rated walls would be required to separate the retail, restaurant, and storage 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.

8. Mixed-Use Building Buildings with Parking

In modern buildings, it is common to see parking (sometimes mixed with retail or restaurant space) on the first level, with four or more stories of light-frame wood residential units above. In this scenario, designers often assume the parking level is required to utilize the podium provision in Section 510.2 and be constructed in noncombustible materials. However, there are several opportunities to use alternate provisions and/or wood framing that can offer significant cost savings.

8.1 Code Requirements for Parking Structures

IBC 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 with 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 parking areas in a mixed-use building can be classified as private and Group U in certain circumstances, area limitations for private garages outlined in Section 406.3 make it more common to design them as public. The following information is based on public parking garages.

Section 406.5 provides requirements for open parking garages, including natural ventilation requirements in Section 406.5.2. With some exceptions, this section requires openings on 40% of the perimeter for a garage to qualify as open. Section 406.5.1 permits open parking garages to be of Types I, II, or IV construction.

Enclosed parking garages are covered in Section 406.6 and require both mechanical ventilation and NFPA 13 sprinklers in accordance with Section 903.2.10. There are no limitations on construction type for enclosed parking garages, indicating that Types III, IV, or V construction, all of which permit the use of wood, can be used.

8.2 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 provision 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.

Section 406.2.8 requires that parking garages be separated from other occupancies in accordance with 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 nonseparated or separated, or using the other unique occupancy designations discussed in this paper.

In a building with an NFPA 13 sprinkler system throughout, only a 1-hour FRR 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 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.

8.3 Parking Beneath Group R

The options in IBC Section 510.4 offer 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, thus 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 Type IV (open only) on the lowest level. The floor/ceiling assembly above the parking level is constructed of materials allowed for the type of construction being used for that parking level. This assembly is also 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 be of a different construction type. The overall height of the entire building (in feet), measured from grade plane, is limited to the more restrictive construction type.

The main benefit of Section 510.4 is that it provides an additional story without the more stringent requirements of Section 510.2 (i.e., the lowest level doesn't have to be Type I-A with a 3-hour-rated podium slab). Specifically, this provision allows the use of a heavy timber-framed parking level (if open) and, in most cases, only requires a 2-hour rating to separate the parking from adjacent residential units above.

8.4 Open Parking Garage Beneath Group A, B, I, M, or R

IBC Section 510.7 provides another option for using a mix of construction types in projects where parking garages are constructed below occupancy Group A, B, I, M, or R buildings. In contrast to the provisions of Section 510.4, this option applies to open parking garages but is not limited to one story. It 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 FRR 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 system with an open parking garage under a Group R occupancy would require a 1-hour FRR assembly.

EXAMPLE 15:

Mixed-Use with Parking and Occupiable Roof

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
- Occupiable 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 IBC Section 903.2.8. Per Section 503.1.4, the occupiable 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 as long as an occupant notification system is also provided. 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. The designer has several options for classifying this building.

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; Type III-B allows 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 second story would need a 1/2-hour FRR, 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-rated 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-rated 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 D: Use Section 510.4 with the lowest level being Type I-B with a 2-hour-rated assembly separating the garage from the residential stories, per Table 601, or Type IV with a 1-hour-rated assembly, per Table 508.4. Use Type V-A construction for the upper four stories.

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

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

Option G: While this paper focuses on the use of light-frame wood, another wood solution is to use Type IV-HT (mass timber) for the entire building with nonseparated occupancies. Group R-2 is the more restrictive of the two occupancies; Type IV-HT allows for 61,500 SF per story or 184,500 SF total with an 85-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. Alternatively Type IV-C could be used for the entire building, requiring a 2-hour rating separating the garage from the residential stories, per Table 601.

Conclusion

Although it can be challenging to navigate the building code when analyzing mixed-use buildings, there are 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-resistance-rated assemblies.

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Retail Village at Sycamore & Oak – Washington, DC
Adjaye Associates / Winstanley Architects & Planners / StructureCraft

Photo Dror Baldinger FAIA

Innovative project houses eateries, a fitness gym, performance space, and other occupancies

Pike Place Marketfront – Seattle, WA
The Miller Hull Partnership / Magnusson Klemencic Associates

Photos Lara Swimmer

Development mixes commercial spaces, offices, and senior/affordable housing

Mosaic Gardens at Westlake – Los Angeles, CA
Lahmon Architects / Labib Funk + Associates

Photo Benny Chan

Permanent supportive and traditional affordable housing in two light-frame wood structures over a shared podium; includes above and below ground parking

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