Applying the Building Code: Step-by-Step Guidance for Design and Building Professionals

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Based on the 2015 *International Codes®*

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In memory of Ralph W. Liebing, RA, CPCA, CBO, CSI, CDT (1936–2014).
A former Hamilton County, Ohio, building commissioner and a prolific writer, Ralph encouraged me to write and advised me at the beginning. Unfortunately, he was not able to see the final result.

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PREFACE

ABOUT THIS BOOK

Building codes are complex documents and they get more complex every time they are revised. However, the methods used to educate design professionals on the proper application of the building code have largely focused on explaining the code on a requirement-by-requirement basis—devoid of any explanation on how or when the code requirements are applied within the context of the building design process. This book fills that void by explaining the building code using a straightforward step-by-step method that conforms to the standard design phases that design professionals have used for decades.

The American Institute of Architects (AIA; www.aia.org) has established five phases of basic services that are described in its Document B101-2007, *Standard Form of Agreement Between Owner and Architect*, which consist of the following:

- Schematic design phase
- Design development phase
- Construction documents phase
- Bidding or negotiation phase
- Construction phase

The first three phases make up the design phases of a project, which involves the architect taking the owner's requirements (i.e., program) and transforming them into a set of drawings and specifications that eventually form the basis of a construction contract between the owner and contractor. This book offers a step-by-step process for applying the building code based on the three design phases of an architect's basic services.

HOW TO USE THIS BOOK

This book is not intended to be used in lieu of the building code, since the building code provides more requirements than what could be adequately discussed in this book. The book intentionally does not replicate requirements in the code but directs the user to the specific location where the information can be found. Therefore, to properly use this book, a copy of the building code must be available.

The steps within each design phase are placed in a logical order based on the availability of project information, some of which is provided by previous steps. However, not all steps must follow the sequence exactly as presented in this book—slight alterations can be made to adjust for project-specific situations. Additionally, one step does not need to be completed before the next step can begin. Many of the steps can be accomplished concurrently.

The steps are placed in the latest possible phase they can be accomplished with minimal risk to the project. If a step is accomplished in a later phase, there is a possibility that portions of the design may need to be revised, costing time and money. For example, waiting until the construction documents phase to calculate *occupant load* may require redesign of the egress system (e.g., adding doors, widening *stairways* and *corridors*) or restroom facilities (e.g., adding plumbing fixtures) and could have a domino effect by impacting other elements of the building design. Similarly, accomplishing a step earlier in the process may affect time and money by performing unnecessary work that may need to be abandoned or revised significantly. However, there are some steps that may be accomplished earlier with little to no risk to the project.

Design professionals are frequently retained to provide predesign services that may include site selection and programming. While performing these predesign services, the design professional has access to some basic project information and can accomplish some of the early steps indicated for the schematic design phase. For example, Steps 1 through 8 could be completed using data the design professional generated for the programming statement—information most design professionals get at the schematic design phase if they are hired only to perform basic services.

As previously mentioned, the step-by-step process is structured around the traditional design services provided by design professionals under common owner–architect agreements, such as those published by the AIA and ConsensusDocs (www.consensusdocs.org). However, with the various delivery methods in use today, the design professional may be bound under a variety of contractual arrangements that use alternate phasing. For example, if the design–build delivery method is used, then *preliminary design* and *final design* phases may be used in lieu of the three design phases previously mentioned. The same applies to contracts utilizing documents published by the Engineering Joint Contract Documents Committee (EJCDC; www.ejcdc.org). These documents may be used when an engineering firm is the prime design professional to the owner and the architect is a consultant to the engineering firm.

Even though the design phases used on a project may be different from those presented in this book, the step-by-step process can easily be adjusted to accommodate any type of delivery method. Regardless of the delivery method used, the steps and the order in which they are discussed should remain relatively unaltered—it is mostly a matter of where to stop at each phase. For example, if the design period is split into preliminary and final design phases, Steps 1 through 18 can be accomplished during preliminary design and the remaining steps accomplished during final design.

REFERENCES

Since referencing the contents within the various codes covered by this book, as well as content in other areas of this book, can be very confusing, all references made will conform to the following conventions:

- For referenced sections, tables, equations, and appendices from the various codes and standards covered, each reference will begin with the code's or standard's acronym followed by the type of item referenced (i.e., Section, Table, Equation, or Appendix) and the number. For example, "IBC

Section 104" refers to Section 104 of the *International Building Code*. See Part I "Code Basics" for acronyms used for the various codes and standards.

- For references to other areas within this book that are a part of the step-by-step process, the reference will be preceded by the word "Step" followed by the specific number reference. For example, "Step 7.3" refers to the "Determining Allowable Area" section of Step 7.
- For references to other areas within this book that are not part of the step-by-step process, the reference will identify the part number (i.e., I, V, or VI) followed by the title of the specific area within the Part. For example, Part VI "The Building Official" refers to the section titled "The Building Official" located in Part VI.
- References to an appendix that is not preceded by an acronym refer to the appendix within this book.

TERMINOLOGY

Identification of building code terminology used in this book is similar to that used in the IBC with some exceptions. The descriptions below explain how terminology is used in this book:

Term Format	Explanation
IBC term	Terms used within the IBC will be italicized as indicated. Use the IBC to obtain the definition. Example: *Fire areas* are used in determining sprinkler requirements.
Other code term (Code)	Terms used in other codes referenced by the IBC are also italicized but will be followed by the acronym for the code in which the term is defined. Since many terms are defined in multiple ICC codes, if a term is provided in the IBC, then it will be considered an IBC term unless specifically identified with another code. Example: When the existing occupancy group is changed, it is considered a *change of occupancy (IEBC)*.
Noncode term	Terms defined by sources other than a code will be bold and italicized. The definitions for these terms are provided in this book.

EXAMPLE PROJECT

To assist in illustrating the application of the step-by-step process, an example project is used throughout all steps provided. The project is a mixed-use residential building that incorporates apartments, parking, amenity, and commercial uses.

Although individual examples are used throughout the book to explain specific applications of code requirements, the use of a single example project for all steps will explain how the level of information available at that phase of design can be used when applying the building code. Additionally, the example project will also show how information collected and decisions made during previous steps are used for subsequent steps.

A copy of the programming statement for the example project is located in Appendix A.

Acknowledgments

First and foremost I want to thank my wife, Susan, and my daughters, Sarah, Rebecca, and Whitney for their encouragement and endurance through this challenging but rewarding experience of writing my first book—I love you all. To my parents, Al and Bonnie, thank you for the love and support that only a mom and dad can give.

Thank you to Richard Baxter, CSI, past president of the Salt Lake City CSI chapter, who graciously invited me to be the keynote speaker at the chapter's annual Education Symposium by asking me to speak on a topic something like a "step-by-step code analysis." From that simple request and ensuing presentation grew the idea for this book.

I also want to thank the readers of my *Code Corner* articles for their thirst of building code knowledge and the many unsolicited positive comments I have received. It gave me the confidence as a writer to accomplish this enormous undertaking.

To my students and fellow faculty, past and present, at Taliesin, the Frank Lloyd Wright School of Architecture, I want to thank you for your support of building code education and giving me the opportunity to preach what I practice.

Thank you to the many folks at Wiley for their patience and understanding while working with this novice book author. Your efforts and support are greatly appreciated.

Finally, I want to acknowledge my extended family, friends, clients, and CSI colleagues for their shared enthusiasm throughout this experience.

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PART I

Code Basics

The *International Building Code*® (IBC), like the history of model building codes before it, does not intend that a building be designed in a particular manner or style or that it must use certain materials. The IBC establishes minimum requirements for the protection of public health, safety, and welfare, but within those requirements is great flexibility for the design professional. Some code requirements offer only one method for compliance, but many have options or alternatives for the design professional to consider. It is the design professional's responsibility to consider these code options and alternatives and compare them to the owner's program requirements and budget, as well as the design professional's own design vision for the building, to decide which option provides the most value for the building's owner.

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Building Code Organization

The first part of understanding the building code is to become familiar with its organizational structure and basic content. In the early 1990s, prior to the publication of the first IBC, the three model code development organizations, with the assistance of the Council of American Building Officials (CABO), were members of the Board for the Coordination of Model Codes (BCMC), which standardized the chapter arrangement of the three model codes published at the time. This chapter arrangement, with slight modifications (mainly title revisions), continues to this day in the IBC. The 35 chapters in the IBC consist of the following:

- Chapter 1, Scope and Administration
- Chapter 2, Definitions
- Chapter 3, Use and Occupancy Classification
- Chapter 4, Special Detailed Requirements Based on Use and Occupancy
- Chapter 5, General Building Heights and Areas
- Chapter 6, Types of Construction
- Chapter 7, Fire and Smoke Protection Features
- Chapter 8, Interior Finishes
- Chapter 9, Fire Protection Systems
- Chapter 10, Means of Egress
- Chapter 11, Accessibility
- Chapter 12, Interior Environment
- Chapter 13, Energy Efficiency
- Chapter 14, Exterior Walls
- Chapter 15, Roof Assemblies and Rooftop Structures
- Chapter 16, Structural Design
- Chapter 17, Structural Tests and Special Inspections
- Chapter 18, Soils and Foundations

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- Chapter 19, Concrete
- Chapter 20, Aluminum
- Chapter 21, Masonry
- Chapter 22, Steel
- Chapter 23, Wood
- Chapter 24, Glass and Glazing
- Chapter 25, Gypsum Board and Plaster
- Chapter 26, Plastic
- Chapter 27, Electrical
- Chapter 28, Mechanical Systems
- Chapter 29, Plumbing Systems
- Chapter 30, Elevators and Conveying Systems
- Chapter 31, Special Construction
- Chapter 32, Encroachments into the Public Right-of-Way
- Chapter 33, Safeguards During Construction
- Chapter 34, (Reserved)—Previously "Existing Structures"; now covered in the *International Existing Building Code®* (IEBC) only
- Chapter 35, Referenced Standards

Understanding the chapter arrangement is a beginning, but you also need to understand what is covered in each of the chapters. Knowing this fundamental information will allow you to quickly find the information you are seeking. For example, if you want to know the requirements for doors, knowing that doors are a part of the *means of egress* system will lead you to Chapter 10. The index can also be used to quickly find the location of information. With the availability of codes in multiple electronic formats, the content of codes can be searched quickly and more thoroughly.

For brief explanations on the content of each chapter, refer to the section titled "Effective Use of the International Building Code" located near the front of each IBC edition.

The second part of understanding the building code is to **not try to memorize it**. Although one is bound to involuntarily memorize code content due to frequent use, reliance on memory when applying the building code to a project could potentially lead to errors. There are several reasons for this, and the first and foremost reason is that the building code is revised every three years. What may have been required in one edition may not be required in another edition or it may have been significantly revised to include exceptions and/or special conditions and requirements.

Even though the *International Codes®* are revised consistently every three years, the jurisdictions that adopt them do not do so consistently. Design professionals who provide services covering several jurisdictions may encounter various editions of the codes. Additionally, jurisdictions will amend the codes they adopt to reflect local practice, conditions, or experience. Therefore, relying on memorization when working on projects in multiple jurisdictions could prove detrimental.

OTHER CODES AND REGULATIONS

Although the building code is the preeminent type of code adopted by jurisdictions, there are other codes that are applicable to a project that are typically required by the building code by reference. The International Code Council (ICC) publishes a series of complementary codes that are referenced by the IBC. These include the following:

- *International Fuel Gas Code® (IFGC)*
  This code covers fixed fuel-gas piping systems and appliances.

- *International Mechanical Code® (IMC)*
  This code covers mechanical systems, such as heating, ventilating, and air conditioning systems (HVAC); fireplaces and solid fuel-burning equipment; solar systems; and fuel-oil piping and storage.
- *International Plumbing Code® (IPC)*
  This code covers plumbing fixtures; piping for supply, waste, and vents; storm drainage; special piping and storage for medical gases; and subsurface landscape irrigation systems. Some content, especially in regard to plumbing fixtures, is replicated in the IBC.
- *International Private Sewage Disposal Code® (IPSDC)*
  This code covers septic tank and leach fields and other similar systems installed where a public sewer system is not available.
- *International Property Maintenance Code® (IPMC)*
  This code covers existing buildings in regard to their maintenance and sanitary conditions to ensure that the public health, safety, and welfare are sustained.
- *International Fire Code® (IFC)*
  This code covers the protection of structures and property from fire or explosion. Content includes requirements for sprinkler, smoke control, and alarm systems for new and existing buildings; fire department access; hazardous material storage and usage; and special uses and occupancies. Some content, such as sprinkler, smoke control, and alarm requirements, are replicated in the IBC.
- *International Energy Conservation Code® (IECC)*
  This code covers the effective use of energy over the lifecycle of a building. It provides requirements for *commercial buildings (IECC)* and *residential buildings (IECC)*. A *residential building* is considered one- or two-family *dwellings*, *townhouses*, and Group R-2, R-3, and R-4 buildings that are less than four *stories* above the *grade plane*. A *commercial building* is considered anything that is not defined as a *residential building*. If a building includes both residential and commercial occupancies, then, per IECC Sections C101.4.1 and R101.4.1, the commercial and residential occupancies will be considered separately when applying the requirements of the IECC.
- *International Existing Building Code® (IEBC)*
  This code covers the alteration, addition, movement, and repair of existing structures. The code also provides similar requirements for historic buildings. The IBC previously had requirements for existing structures, but this has been removed and now all content for existing buildings is incorporated in the IEBC.
- *International Residential Code® (IRC)*
  This code covers one- and two-family *dwelling*s and *townhouses* not more than three *stories* above the *grade plane*. This is a self-contained code with all requirements for electrical, mechanical, plumbing, and fuel-gas systems. It also replicates IECC requirements for energy conservation. The IRC may be used for *live/work units* within *townhouses* and for owner-occupied lodging (i.e., bed and breakfast lodging) for five or fewer guests.
- *International Wildland-Urban Interface Code® (IWUIC)*
  This code covers additional requirements for structures built within a defined geographical area that abuts natural areas, such as forests, where there exists a high level of vegetative fuels.

The ICC also publishes other codes that are not referenced by the IBC but are coordinated with the other codes and may reference one of the codes listed above. These other ICC codes include the following:

- *International Green Construction Code® (IgCC)*
- *International Code Council Performance Code® (ICCPC)*
- *International Swimming Pool and Spa Code® (ISPSC)*
- *International Zoning Code® (IZC)*

Besides ICC, other organizations develop codes that either are referenced in the ICC codes or are frequently adopted in lieu of some of the ICC codes. These include the following:

National Fire Protection Association (NFPA; www.nfpa.org)

- NFPA 1, *Fire Code*
- NFPA 54, *National Fuel Gas Code*
- NFPA 70, *National Electrical Code® (NEC)*—Since the ICC does not publish an electrical code, the IBC references the NEC.
- NFPA 72, *National Fire Alarm and Signaling Code*—This code is also referenced by the IBC.
- NFPA 101, *Life Safety Code®*
- NFPA 900, *Building Energy Code*
- NFPA 5000, *Building Construction and Safety Code®*

International Association of Plumbing and Mechanical Officials (IAPMO; www.iapmo.org)

- *Uniform Plumbing Code® (UPC)*
- *Uniform Mechanical Code® (UMC)*
- *Uniform Swimming Pool, Spa and Hot Tub Code® (USPSHTC)*
- *Uniform Solar Energy Hydronic Code® (USEHC)*

In addition to codes, there are other regulations that have an impact on a project. These include zoning, environmental, occupational safety, and accessibility regulations.

Zoning ordinances restrict how the land within a particular area of the jurisdiction may be used, including the building use, building size, *lot* coverage, setbacks, and number of parking spaces. Some of the zoning restrictions may contradict what the building code may permit. For example, zoning ordinances typically restrict *building height*, which may be less than what the building code allows. Therefore, the requirements of both the building code and zoning ordinance need to be evaluated, with the most restrictive establishing the requirements.

Environmental regulations are typically enforced by an agency other than the building department. City or county health departments and the Environmental Protection Agency (EPA) establish requirements for air quality. Many city, county, and state health agencies establish health regulations that affect several building types, including restaurants, schools, and hospitals.

THINGS TO LOOK OUT FOR

When reviewing the code, be sure to read applicable exceptions and footnotes for tables. Exceptions are clearly identified as such and typically modify the application of a code provision preceding the exception or exceptions. Exceptions usually exclude the previous provision under specific conditions stated in the exceptions, but they may also provide compliance alternates or provide additional requirements under certain conditions. Footnotes are used in most tables and usually provide clarification or additional information; but, like exceptions, they may also modify a table's contents for specific conditions. Since they may alter the application of the building code, it is important to understand the content of related exceptions and table footnotes so that you do not unnecessarily provide more than what is required for a specific project.

KNOW THE DEFINITIONS

Building codes could not be properly utilized unless one knows the meanings of the special terms used within them. In most cases, the terms used by building codes carry the same meanings found in a common dictionary. In fact, up until the publication of the IBC, the *Uniform Building Code* (UBC) established Webster's *Third New International Dictionary of the English Language* (editions varied depending on the code publication date) as the only source of meanings for words or terms not defined in the building code itself. The IBC has dropped the Webster's dictionary in favor of a broad statement that accepts the "ordinarily accepted meanings" for terms not defined in the code.

The purpose of having special definitions for terms that may be found in a common dictionary is that those common definitions are typically too broad for a legally based document such as the building code. Take the term *accessible* for example. According to one dictionary, *accessible* means, "Easily approached, entered, or obtainable." But in the context of the building code, one could ask to whom does this apply? Prior to the Americans with Disabilities Act (ADA), a lot of people would have considered their buildings to be *accessible* to the public. But, with the passing of the ADA, the term *accessible* took on a new meaning that most dictionaries still do not include. Therefore, the building code has to define it as "A *site*, *building*, *facility* or portion thereof, that complies with Chapter 11." The scope of Chapter 11, which is titled "Accessibility," is to "control the design and construction of facilities for accessibility to physically disabled persons." Therefore, *accessible* under the building code applies to "physically disabled persons." A meaning that could not be legally obtained from the definition found in a common dictionary.

When using the building code, you need to be aware of the fact that certain terms carry very specific meanings. When you come across a term in the building code for which you know the "ordinarily accepted meaning," you should check IBC Chapter 2 to make sure that the building code has not narrowed that definition to a more specific application. To make it easier to identify them, the 2009 IBC and later editions print all defined terms in italics within the code content.

Types of Fire-Resistive Assemblies and Construction

Fire resistance is a passive fire protection measure designed to prevent or slow the spread of fire by using materials and assemblies tested for their fire-resistive properties. The requirements for fire-resistive assemblies and construction are located in IBC Chapter 7.

The *fire-resistance* property of an assembly is based on time, usually in either minutes or hours. The most common method for testing assemblies to determine their endurance is ASTM E 119. Similar test methods are available from NFPA 251 and UL 263. The ASTM International (ASTM) and Underwriters Laboratories (UL) methods are specifically referenced in the IBC. UL provides a listing of tested assemblies that is available on its "Fire Resistance Wizard" website.

In addition to tested assemblies, the IBC allows the use of GA-600, which provides a listing of historically tested generic and proprietary assemblies; however, only those assemblies listed as "GENERIC" are accepted. Assemblies listed as "PROPRIETARY" are not acceptable under the IBC as prescriptive assemblies, but they may be *approved* for use by the *building official*.

If a tested assembly is not available or neither UL nor Gypsum Association (GA) listings have an assembly that suits the needs of the project, *fire resistance* may be determined based on the prescriptive systems provided in IBC Section 721 or they may be calculated per IBC Section 722. If using the calculated method, the *construction documents* should indicate the calculations used to determine the indicated *fire-resistance rating*.

The IBC identifies five types of fire-resistive assemblies and three types of fire-resistive construction. Where a *fire-resistance rating* is required by the building code and is identified by one of the five fire-resistive assemblies, the construction, extent, openings, and penetrations must conform to the requirements of that assembly as described in the specific section of Chapter 7. Where a *fire-resistance-rated* wall is required but no assembly is indicated, such as in IBC Tables 601 and 602, the wall must comply with the material and construction requirements of the tested assembly, but openings may or may not be required and protection of penetrations is not required.

This section provides a general overview of the types of fire-resistive assemblies and construction used in the IBC. A detailed discussion regarding the application of the different types is located in Step 15. The types of fire-resistive assemblies and construction consist of the following:

Fire-Resistive Assemblies

- Fire walls
- Fire barriers
- Fire partitions
- Smoke barriers
- Horizontal assemblies

Fire-Resistive Construction

- Exterior walls
- Interior bearing walls
- Structural frame

FIRE WALLS (IBC SECTION 706)

Fire walls are used to divide a large, single building on the same *lot* into two or more buildings or to serve as a shared wall between two buildings on different *lots*; in the latter case, the *fire wall* is referred to as a "party wall." *Fire walls* have minimum *fire-resistance ratings* of 2 to 4 hours based on the occupancy group or groups they are separating. (See discussion on occupancy groups in Step 3.) Openings in *fire walls* are required to be protected; however, openings in party walls are not permitted.

Although the role of a *fire wall* in a building's passive fire protection system may sound simple in concept, it is the understanding of *fire wall* design that seems to elude to many design professionals. One of the more confusing design features of a *fire wall* is the requirement for structural stability—the *fire wall* must remain in place if the building on either side of the *fire wall* collapses. To maintain the required structural stability, *fire walls* are often independent of a building's structural system, thus allowing the structural frame of a building to fail and not bring down the *fire wall* along with it.

Since a *fire wall* provides a complete separation of a building, it is required to extend from *exterior wall* to *exterior wall* and from the foundation to a point that is 30 inches above the adjacent roof surfaces, unless one of the exceptions applies. Additionally, as a wall, the *fire wall* must be vertical without any horizontal offsets.

FIRE BARRIERS (IBC SECTION 707)

Fire barriers are used for *shaft enclosures*, *exit* enclosures (i.e., *exit stairways*, *horizontal exits*, and *exit passageways*), incidental use separation, occupancy group separation, *control area* separation, *fire area* separation, and *atrium* separation. *Fire barriers* have *fire-resistance ratings* of 1 to 4 hours, depending on the specific purpose they serve. If a *fire barrier* serves more than one purpose with different *fire-resistance ratings*, the most restrictive rating must be used. Openings in *fire barriers* are required to be protected.

The continuity of a *fire barrier* shall extend from the top of the floor/ceiling assembly to the underside of the sheathing, slab, or deck of the floor or roof above. *Fire barriers* are required to be continuous through concealed spaces, such as soffits. The supporting construction of a *fire barrier* must have a *fire-resistance rating* equal to the *fire barrier*.

FIRE PARTITIONS (IBC SECTION 708)

Fire partitions are wall assemblies that provide minimal passive protection and are used to separate the following areas:

- *Dwelling units* in the same building
- *Sleeping units* in the same building
- Tenant spaces in covered *malls*
- *Corridor* walls
- Elevator lobbies

Fire partitions have a *fire-resistance rating* of 1 hour; however, where permitted, *corridor* walls and some *dwelling unit* separations are allowed to have a $^1/_2$-hour rating. Openings in *fire partitions* are required to be protected.

SMOKE BARRIERS (IBC SECTION 709)

Smoke barriers are used in various locations as stipulated by the code in order to prevent the movement of smoke from one compartment to another. *Smoke barriers* can be vertical or horizontal and only require a 1-hour *fire-resistance rating*. Openings in *smoke barriers* are required to be protected and resist the passage of smoke.

A similar assembly is the *smoke partition*, which is not required to have any *fire-resistance rating*. Openings in *smoke partitions* are not required to be protected from fire, but they are required to resist the passage of smoke.

The continuity of a *smoke barrier*, like the *fire barrier*, shall extend from the top of the floor/ceiling assembly to the underside of the sheathing, slab, or deck of the floor or roof above. However, unlike *fire barriers*, *smoke barriers* shall extend from outside wall to outside wall, except when used for elevator lobby and *area of refuge* separation. *Smoke barriers* are required to be continuous through concealed spaces, such as soffits. The supporting construction of a *smoke barrier* must have a *fire-resistance rating* equal to the *smoke barrier*.

Horizontal *smoke barriers* are new in the 2015 IBC and some gaps in the requirements exist. For example, the IBC is silent on the continuity of a horizontal *smoke barrier*. Since it is required to have a *fire-resistance rating*, the horizontal *smoke barrier* will be treated as a *horizontal assembly*; however, the smoke leakage requirements will likely be enforced only to the extent that the smoke protection is required.

HORIZONTAL ASSEMBLIES (IBC SECTION 711)

Horizontal assemblies apply to floor and roof construction. The *fire-resistance rating* is based on construction type and ranges from 0 to 2 hours. However, a *horizontal assembly* may have a *fire-resistance rating* of 1 to 4 hours when required to separate spaces as required for *fire barriers*, *smoke barriers*, and *fire partitions*. When a *fire-resistance rating* is required for a *horizontal assembly*, the supporting construction must have an equal or greater rating. For example, if a floor system is required to have a 1-hour rating, then the bearing walls and/or columns that support the floor system are also required to have at least a 1-hour rating.

EXTERIOR WALLS

An *exterior wall* is a wall that encloses a building by separating interior space from the exterior. The interior space may be conditioned (cooled and/or heated) or unconditioned space. The *fire-resistance rating* of an *exterior wall* depends on its construction type (see the discussion on construction types in Step 4), its occupancy group or groups, and its *fire separation distance* (see Step 16 for a discussion on *fire separation distance*).

IBC Table 601 establishes the minimum required *fire-resistance rating* of exterior bearing walls. As mentioned earlier, *fire-resistance-rated horizontal assemblies* are required to be supported by construction having an equal or greater *fire-resistance rating*. Therefore, exterior bearing walls within a construction type will not have a rating less than the rating for *horizontal assemblies* (i.e., floor and roof construction) also within that construction type. IBC Table 602 may modify this *fire resistance* based on the occupancy group and *fire separation distance*; however, the *fire-resistance rating* cannot be less than what is required by IBC Table 601. IBC Table 602 also establishes the minimum *fire-resistance rating* for exterior nonbearing walls. *Fire-resistance ratings* will vary from 0 to 3 hours.

INTERIOR BEARING WALLS

Interior bearing walls may be required to have a *fire-resistance rating* based on construction type per IBC Table 601. Similar to exterior bearing walls, interior bearing walls within a construction type will not have a rating less than the rating for *horizontal assemblies* also within that construction type. *Fire-resistance ratings* will vary from 0 to 3 hours. Openings in *fire-resistance-rated* interior bearing walls are not required to be protected.

STRUCTURAL FRAME

IBC Table 601 identifies the required *fire resistance* for a building's structural frame based on the building's construction type. If the structural frame is required to have a *fire-resistance rating*, the structural members must be individually protected, even if they are to be concealed within another *fire-resistance-rated* assembly. IBC Section 704 provides the requirements for protection of structural members.

Types of Automatic Fire-Extinguishing Systems and Standpipes

In the IBC, there are two ways that fire sprinklers may be required in a building: through either a direct requirement or an indirect requirement. A direct requirement is one that the design professional has little to no control over, such as one based on an occupancy group. On the other hand, an indirect requirement is one that the design professional does have control over, such as using a sprinkler system to increase the allowable *building height* and *area* or as a reduction or elimination of another requirement (commonly referred to as a "sprinkler trade-off"), such as exterior opening protection.

Some requirements or trade-offs are based on a specific type of sprinkler system. Therefore, it is incumbent upon design professionals to understand the differences between the types of sprinkler systems permitted so they can make a proper selection if a sprinkler system is to be installed, since the type installed could have an impact on the project cost. There are three types of sprinkler systems identified in the IBC and they are based on the standards of the NFPA:

- NFPA 13, *Standard for the Installation of Sprinkler Systems*
- NFPA 13R, *Standard for the Installation of Sprinkler Systems in Residential Occupancies Up to and Including Four Stories in Height*
- NFPA 13D, *Standard for the Installation of Sprinkler Systems in One- and Two-Family Dwellings and Manufactured Homes*

These NFPA standards provide the technical requirements for installation of each type of sprinkler system but do not establish scope. In other words, they describe how each type of sprinkler system is to be installed, but not when a sprinkler system is required—that is left to the building code.

IBC Section 903.3.1 identifies these systems and the applications in which they can be used. Throughout the IBC where references to sprinkler systems are made, the references are to the IBC sections and not the NFPA standards. For example, when the IBC requires a sprinkler system "throughout in accordance with Section 903.3.1.1," it is requiring a system installed per NFPA 13.

Something to keep in mind is that whether a sprinkler system is installed or not, the project may still require a standpipe system. A standpipe is a vertical water piping system to which firefighter hoses can be connected. They serve a purpose similar to fire hydrants except they are located inside a building. There are three *classes of standpipe systems*:

- **Class I**—This class is intended to be used by the fire department and provides 2.5-inch hose connections and valves.
- **Class II**—This class is intended to be used by the occupants of the building and provides 1.5-inch hose connections and valves.
- **Class III**—This class is a combination of Class I and II standpipes and provides both 2.5- and 1.5-inch nose connections and valves.

If a standpipe system is required, then it might be worth the added cost to install a sprinkler system, since much of a sprinkler system's cost is in the fire line to the building and the fire riser, which is similar to a standpipe and can serve both purposes. Below are some conditions in which a standpipe system is required:

- Provide a Class III standpipe when the floor level of the highest floor is more than 30 feet above the lowest level of fire department access or when the floor level of the lowest level is more than 30 feet below the highest level of fire department access. Take note that the measurement is not from the *grade plane*. A Class I standpipe is permitted if a NFPA 13 or NFPA 13R system is installed.
- Provide a Class I standpipe when a sprinkler system is not installed in a Group A building and the *occupant load* exceeds 1,000.
- Provide a Class I standpipe in covered and open *mall* buildings.
- Provide a Class III standpipe for *stages* with an area greater than 1,000 sq. ft. If a NFPA 13 system is installed, then a Class II standpipe system may be installed or the fire riser is installed with a 1.5-inch hose connection per NFPA 13.

NFPA 13 (IBC SECTION 903.3.1.1)

A sprinkler system installed per the NFPA 13 standard is considered a full commercial system. Whether required by a direct or indirect requirement, the NFPA 13 system is always permitted. According to the NFPA, the concept behind the NFPA 13 sprinkler system is property protection and life safety. Because of its property protection aspect, the intent of a NFPA 13 system is to stop a fire no matter where it occurs, including concealed spaces, such as *attics* and soffits.

Of the three sprinkler systems used by the IBC, the NFPA 13 system is considered the most expensive type of system.

NFPA 13R (IBC SECTION 903.3.1.2)

NFPA 13R is the standard for what can be considered a commercial residential sprinkler system for multifamily residential buildings and was created to bridge the gap between the NFPA 13 and 13D systems. This system is only permitted in residential occupancies in buildings four *stories* or less in height, such as apartments, condominiums, hotels, and motels. Unlike the NFPA 13 sprinkler system, the concept behind the NFPA 13R sprinkler system, according to the NFPA, is life safety with property protection a secondary concern. Therefore, the sprinkler system is only required in *occupiable spaces* of the building and not in concealed spaces, such as *attics* and closets. There are other technical differences between the NFPA 13 and 13R systems, such as lower water discharge demands that permit the use of smaller piping and combining the demand for a domestic and fire sprinkler in a single service main.

The NFPA 13R system is more conservative than a NFPA 13D system; therefore, its installation cost will be higher than a NFPA 13D system, but not as high as a NFPA 13 system.

NFPA 13D (IBC SECTION 903.3.1.3)

The NFPA 13D standard is, as its title implies, applicable to sprinkler systems installed in one- and two-family residences and manufactured homes. The IBC permits a NFPA 13D sprinkler system in detached or fire-wall-separated one- and two-family homes, congregate housing, and *townhouses*. According to the NFPA, the only purpose of a NFPA 13D sprinkler system is life safety, and, similar to the NFPA 13R sprinkler system, it is only required in *occupiable spaces* of the structure.

Of the three sprinkler systems used by the IBC, the NFPA 13D system is considered the least expensive type of system.

Alternative Materials/Methods and Modifications

Most of the provisions contained in building codes are "prescriptive," or explicitly spelled out as to what is required in order to be *approved*. But in this day and age of new technologies, creative use of materials, and the development of new materials, it is very difficult to publish a prescriptive building code that addresses every conceivable material and method possible. Understanding this, the building code has established the section titled "Alternative Materials, Design and Methods of Construction and Equipment" (IBC Section 104.11).

The *building official*, in accordance with the building code, is the only authority permitted to approve alternative materials or methods. Building codes do not provide specific criteria that must be followed in order to get an alternative material or method *approved*; that responsibility lies with the jurisdiction. Most jurisdictions will have in place a policy or procedure for submitting and evaluating alternative materials and methods. In order to approve the alternative material or method, the *building official* may require reports, tests, or both. These reports and tests can be very expensive to accomplish. Some manufacturers will have this done as part of their product development, knowing that their product does not meet the present prescriptive requirements of the code.

Another substitution for the prescriptive requirements of the building code is the modification. A modification is permitted if compliance with the strict letter of the code is deemed impractical. Like the alternative material and method provision, only the *building official* can approve a modification. In order to be *approved*, the modification cannot reduce the "health, accessibility, life and fire safety, and structural requirements" and the modification conforms to the "intent and purpose" of the code as stated in IBC Section 104.1.

Applying the Building Code: Step-by-Step Guidance for Design and Building Professionals. Ronald L. Geren, FCSI, AIA

STEP 1

Determine Applicable Building Code

STEP OVERVIEW

Since its introduction in 2000, there have been six editions of the *International Codes*. Each edition set is published every three years. Jurisdictions across the country and internationally have adopted some of the codes within ICC's family of codes, but because of the number of available editions, no single edition year is adopted uniformly across all jurisdictions. Therefore, it is incumbent upon the design professional to know which codes are specifically adopted by the authority having jurisdiction (AHJ).

1.1 IDENTIFYING THE AUTHORITY HAVING JURISDICTION

Before determining the applicable code the design professional must first determine what organization or organizations have jurisdictional authority for building code enforcement. Trying to identify all of the authorities having jurisdiction (AHJs) for a project could prove daunting. There is no single source to go to that lists every conceivable AHJ applicable to a particular project type and location. A good way to find out who the AHJs are on a project is to ask the city or county, members on the design team (including consultants), the owner (this may not be their first project in this location), and colleagues who have worked on similar projects in the same area.

When starting a project, investigate all the possible ties that the building will have with the community. To begin, list all possible aspects of the project that could be regulated by others (i.e., food service, educational occupancy, utilities, elevators, etc.) and then contact the organizations that might be the AHJs for those areas. If they are not the ones, they may point you in the proper direction. A project start-up checklist may facilitate this process, especially if it is updated regularly.

See Part VI "Authority Having Jurisdiction" for a broader discussion on AHJs.

Applying the Building Code: Step-by-Step Guidance for Design and Building Professionals. Ronald L. Geren, FCSI, AIA

1.2 ADOPTED CODES AND AMENDMENTS

Once the AHJ has been determined, the design professional should obtain a list of adopted codes. Most jurisdictions have an official website, which may include a list of the applicable codes. Otherwise, a call to the jurisdiction's building department will likely provide the list.

Many AHJs do not adopt codes without some level of modification called "amendments." Statutory AHJs—especially states, counties, and local jurisdictions—will adopt codes by ordinance through their individual legislative processes, thus giving the code the status of law. Each code published by the ICC includes within its preface a sample copy of an ordinance that may be used. Typically within the adoption ordinance is a list of amendments that revise the code to reflect the jurisdiction's policies, experience, environmental conditions, or other factors deemed significant to the jurisdiction. The design professional must acquire a copy of the AHJ's amendments to ensure proper compliance with the adopted codes.

Many of the *International Codes* include appendices located just before the index of each applicable code. Appendices are not mandatory unless specifically adopted by the jurisdiction. If the adopting ordinance does not identify an appendix or it states that a specific appendix is not adopted, then the requirements of that appendix is not applicable in the jurisdiction.

Design professionals can obtain a copy of the adopting ordinance from the jurisdiction. Many jurisdictions will provide access to their ordinances on their official websites; others may link to a third-party online source such as Municode (www.municode.com). Some jurisdictions will publish their amendments in separate documents that are easier to navigate and read. Furthermore, many states and local jurisdictions, under contract with the ICC, will have the codes they have adopted published with their amendments. Most of these custom codes are available for purchase through various online book retailers or the ICC. The ICC also provides many of these codes as free resources on its website.

1.3 CODE ALTERNATES

The IBC identifies two codes that are alternatives to the IBC to the extent they are referenced: The IEBC and the IRC. The use of the IEBC is discussed in Part V. The IRC is required for detached one- and two-family *dwelling units* and *townhouses* with multiple *dwelling units* (may exceed two) but not more than three *stories* in height. Each *dwelling unit* must have a separate *means of egress*. The IRC identifies other *structures* that typically are constructed per the IBC but may be constructed under the IRC. These include *live/work units* and *lodging houses* with five or fewer *guest rooms*.

EXAMPLE PROJECT—STEP 1

The building code applicable to the example project used throughout this step-by-step process will be the 2015 IBC and the other 2015 code editions referenced by the IBC. It is assumed that there are no local amendments.

PART II

Schematic Design

The schematic design phase includes the evaluation of the owner's program, review of the owner's budget, and discussion of alternative approaches to the design per American Institute of Architects (AIA) Document B101-2007, *Standard Form of Agreement Between Owner and Architect*. Following those preliminary actions, the design professional then proceeds with the preparation of schematic design documents that convey the design intent to the owner. Schematic design documents typically include site plans, floor plans, elevations, and sections.

The application of the building code at this phase of a project, especially at the beginning, can be a bit overwhelming, since very little information is available to the designer. The key to proper application of the building code during this phase of a project's design is to focus on the broad scope requirements of the code (e.g., height, area, construction type, and *occupant load*) and leave the detailed requirements (e.g., firestopping, finishes, and roof and wall assemblies) for the later phases. The broader requirements have the most impact on the design and should be evaluated early. Time spent on detailed requirements may be wasted, since a project experiences significant changes from one phase to the next.

Applying the Building Code: Step-by-Step Guidance for Design and Building Professionals. Ronald L. Geren, FCSI, AIA

STEP 2

Obtain Essential Building Data

STEP OVERVIEW

In order to apply the building code properly, the design professional needs to know the basic characteristics of the proposed project. However, at this early stage of the project, a design has not been developed. Therefore, the only source available to the design professional that can provide this information is the owner's program. The information that should be collected includes the following:

Total *building area*
Number of *stories*
Building area per *story*
Building height in feet
Type of sprinkler system, if any
Proposed construction materials
Climate zone (IECC)
Flood hazard area

2.1 TOTAL BUILDING AREA

As the definition of *building area* states, the measurement of a building's floor area is taken within the *exterior walls* and excludes the area occupied by the *exterior walls* (Figure 2.1-1). However, at this stage of design when *exterior walls* are not well defined , it is better to work with a total *building area* slightly larger than what may eventually be designed.

Also excluded from the *building area* are vent *shafts* and *courts*. A *court* is defined by the IBC; however, a vent *shaft* is not. *Courts* are spaces surrounded on three or more sides by building walls or other devices

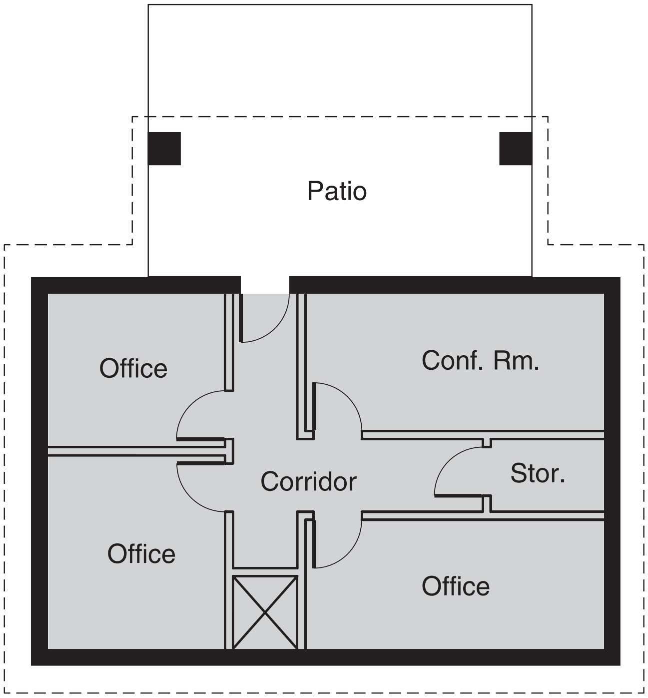

FIGURE 2.1-1. Shaded portion indicates floor area that is included in the determination of *building area*.

and are open to the sky. Similarly, vent *shafts* are considered to be those areas surrounded by building walls and open to the sky for ventilation purposes and are not usually accessible by the occupants, unlike *courts*, which can be occupied. Not included in the definition, but excluded per IBC Section 505.2, are *mezzanines*. The floor areas of *mezzanines* complying with the requirements of IBC Section 505 are not to contribute to the *building area*.

The total area of the building can be determined by extracting area requirements from the owner's program. If the program does not stipulate a maximum area for the entire building, then the sum of all program spaces can be used to determine the total area. There may be cases where circulation and other ancillary spaces are not included in the list of program spaces; therefore, the sum of program areas may need to be supplemented to ensure that the proposed area used when applying the building code is as close as possible to the final design *building area*.

If some programmed spaces are identified to be located in one or more *basement* levels, then those areas need not be included in the total *building area* for building code purposes per IBC Section 506.1.3, provided that the total area of the *basements* does not exceed the area allowed for a single *story*.

Another situation to keep in mind is covered exterior areas. Per the IBC definition, exterior areas that are covered by the extension of the roof or floor above are to be included in the total *building area* (Figures 2.1-2 and 2.1-3). Generally, the area under overhangs and attached *awnings* and *canopies* are not included in the *building area*.

2.2 NUMBER OF STORIES

The number of *stories* may be predetermined by the owner's program or it may be dictated by necessity. If the property area is less than the total *building area*, then multiple *stories* will be necessary. Even if the

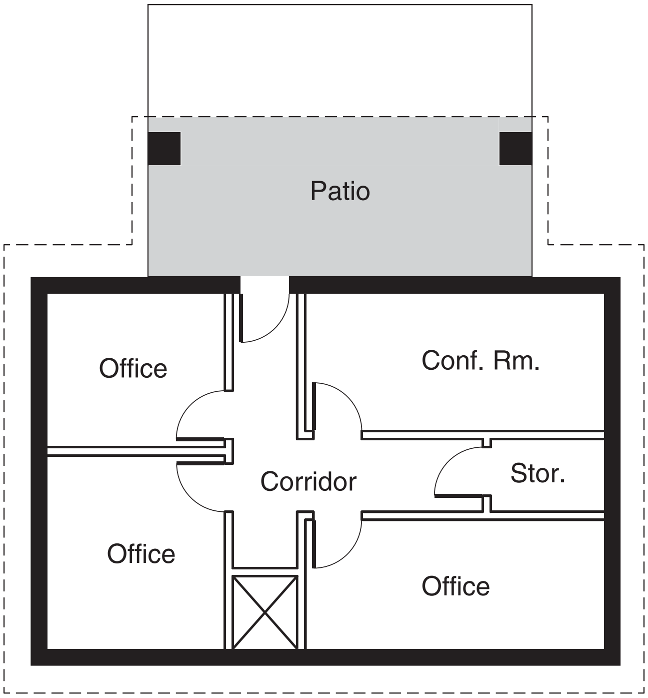

FIGURE 2.1-2. The shaded area indicates the area that is included in the determination of *building area* because the roof extends over the patio.

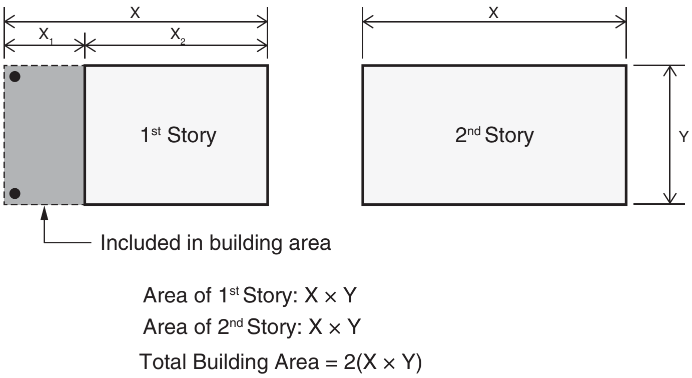

FIGURE 2.1-3. The shaded area indicates the area that is included in the determination of *building area* because the 2nd story extends beyond the area of the 1st story.

owner's program provides the number of *stories*, it may prove beneficial to go through the following process to verify that the programmed number of *stories* is feasible.

Besides the building code regulating height, zoning ordinances also regulate height. Zoning ordinances should be checked for maximum height requirements, minimum setbacks, and maximum *lot* coverage. Maximum height requirements in the zoning ordinance, like the building code, are stated both in number of *stories* and in feet. Therefore, the programmed height should be checked with the zoning ordinance for the applicable zone to ensure that neither the number of *stories* nor the height in feet exceeds the maximum. If the maximum *lot* coverage (usually provided as a percentage) results in an area that is less than the total *building area* or if the minimum setbacks leave an area that is less than the building area, then multiple *stories* will be necessary.

2.2.1 GRADE PLANE

Height limitations in both the building code and the zoning ordinance are based on the number of *stories* above a stipulated plane called a *grade plane*. A zoning ordinance may use the building code's definition for *grade plane* or provide its own. Therefore, both the building code and the zoning ordinance should be checked.

The points of elevation used for determining the average plane are measured horizontally from a building's *exterior walls* to a point 6 feet away. If the *lot line* is less than 6 feet from the building's *exterior wall*, then the elevation is taken at the *lot line* (Figure 2.2.1-1). There is no limitation on the number of elevation points to include in determining the *grade plane*, but those at each corner of a building are typically used. (Figure 2.2.1-2).

If the building has a planned *basement* and will be constructed on a sloped *site*, the determination of a *grade plane* is important. A *basement* under these conditions may, in fact, be considered a *story above grade plane* and must be included in the number of *stories* for height. There are two conditions that may make a *basement* a *story above grade plane* (Figure 2.2.1-3):

- The finished floor surface of the floor next above is 6 feet or more above the *grade plane*.
- The finished floor surface of the floor next above is more than 12 feet or more above the finished grade at any point.

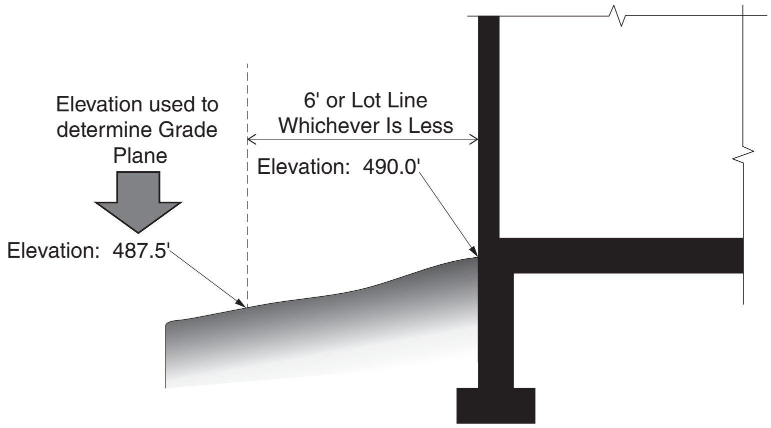

FIGURE 2.2.1-1. Establishing points to determine *grade plane*.

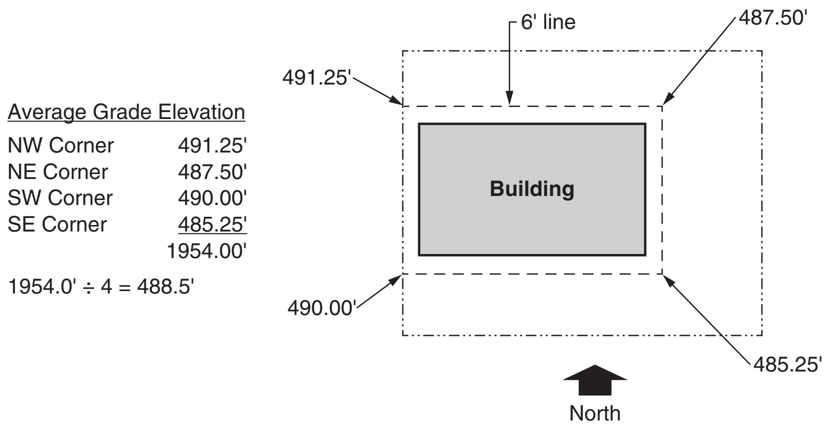

FIGURE 2.2.1-2. Determining *grade plane* elevation. The *grade plane* for this building is 488.5 ft.

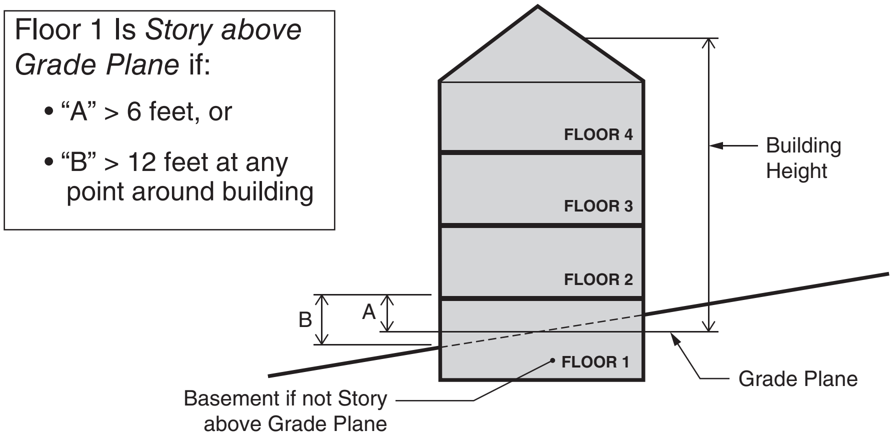

FIGURE 2.2.1-3. Determining a *story above grade plane*.

2.2.2 MEZZANINES

A *mezzanine* is essentially a small elevated floor area within another space, and if the *mezzanine* complies with IBC Section 505, it is not considered a *story*. To be considered a *mezzanine*, the clear height above and below the *mezzanine* must be 7 feet or more. The area of a *mezzanine* cannot exceed one-third of the floor area of the space in which it is located. More than one *mezzanine* may be located within a space provided the sum of areas for all *mezzanines* does not exceed the one-third limitation.

2.3 BUILDING AREA PER STORY

As total *building area* is regulated by the building code, so is the floor area per *story*. Based on the total *building area* and the number of *stories*, the probable, or average, floor area per *story* can be derived. Using the owner's program, it may be easy to determine which of the programmed spaces are required on different levels, thereby allowing a more definitive floor area per *story*.

2.4 BUILDING HEIGHT IN FEET

Although an accurate height in feet is difficult, if not impossible, to determine early in the schematic design phase, it is important to obtain a general idea of what the *building height* in feet will likely be. It is important to point out that the measurement is to the average roof surface and not the highest point of the roof (Figures 2.4-1 and 2.4-2). Since the measurement is to the highest roof surface, parapets are not included in the measurement.

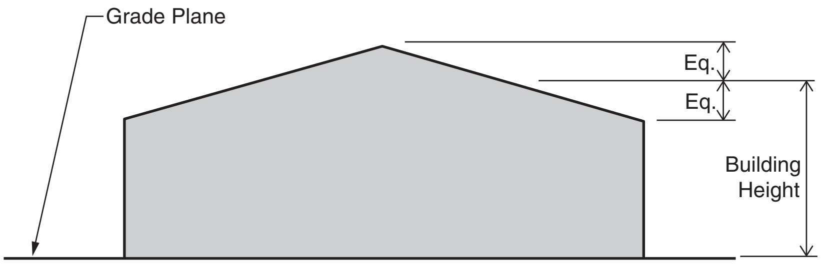

FIGURE 2.4-1. *Building height* for a building with a steep-sloped roof.

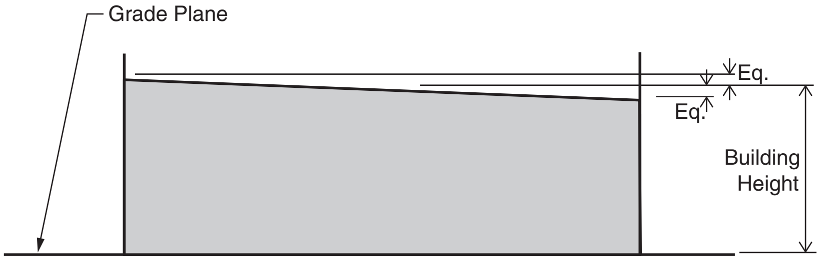

FIGURE 2.4-2. *Building height* for a building with a low-sloped roof, with or without parapets.

2.5 TYPE OF SPRINKLER SYSTEM

A sprinkler system may be mandatory by ordinance separate from the building code, by the owner, by the owner's insurance company, or by some other requirement not related to the building code. It is important to know this early on so that any sprinkler trade-offs can be considered when applying the building code.

The building code also identifies certain types of buildings and occupancies that require a sprinkler system, which could be determined at this phase of design. These include, but are not limited to, residential occupancies, high-hazard occupancies, institutional *facilities* (e.g., *hospitals*, detention *facilities*, prisons, day cares, etc.), *high-rise buildings*, and *mall* buildings. IBC Section 903.2 identifies where sprinkler systems are required.

Many of the fire sprinkler requirements are based on the concept of a *fire area*. Noticeably missing from the definition of a *fire area* are *fire partitions* and *smoke barriers*; therefore, those assemblies cannot be considered when determining the extent of a *fire area* (Figure 2.5-1). There are two things that should be considered when working with *fire areas*:

- For a *fire area* that extends through multiple *stories* (fire area "C" in Figure 2.5-1), the floor area includes the sum of all applicable floor areas on all *stories* included within the *fire area*.
- If a *fire area* contains multiple occupancy groups, the *fire area* is considered a *fire area* for each occupancy group. For example, assume fire area "C" in Figure 2.5-1 has Group M and Group A-3 occupancies on the first story and a Group S-1 occupancy on the second story. For determination of sprinkler requirements, fire area "C" needs to be evaluated as a Group A-3 *fire area* per IBC Section 903.2.1.3, as a Group M *fire area* per IBC Section 903.2.7, and as a Group S-1 *fire area* per IBC Section 903.2.9.

When determining fire sprinkler requirements, *fire areas* can be applied to provide the designer with a couple of options. If the floor area within a *fire area* exceeds the area threshold established in IBC Section 903.2 for the particular occupancy group, then a sprinkler system is required. However, to avoid installing a sprinkler system, the designer can create smaller *fire areas* that are below the threshold by adding fire-resistive assemblies (Figure 2.5-2). See Part I for a discussion on the types of sprinkler systems approved for use by the IBC.

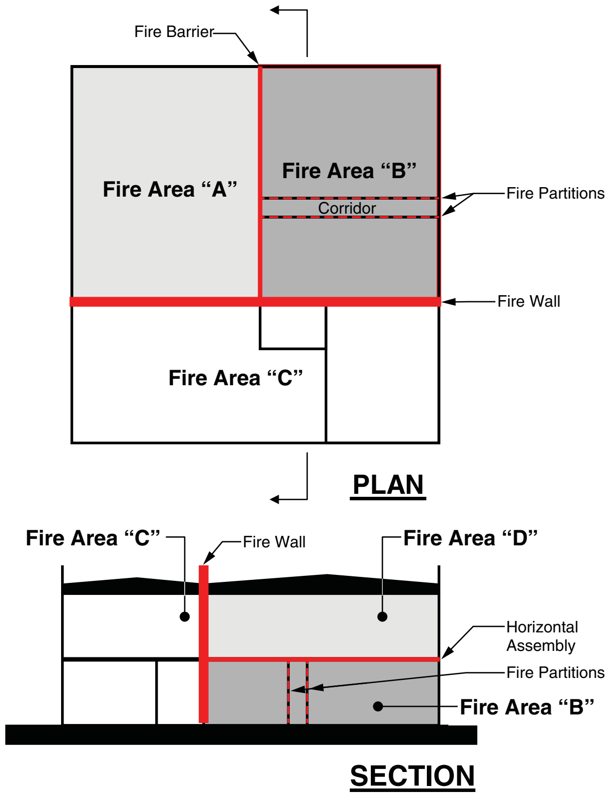

FIGURE 2.5-1. *Fire area* examples.

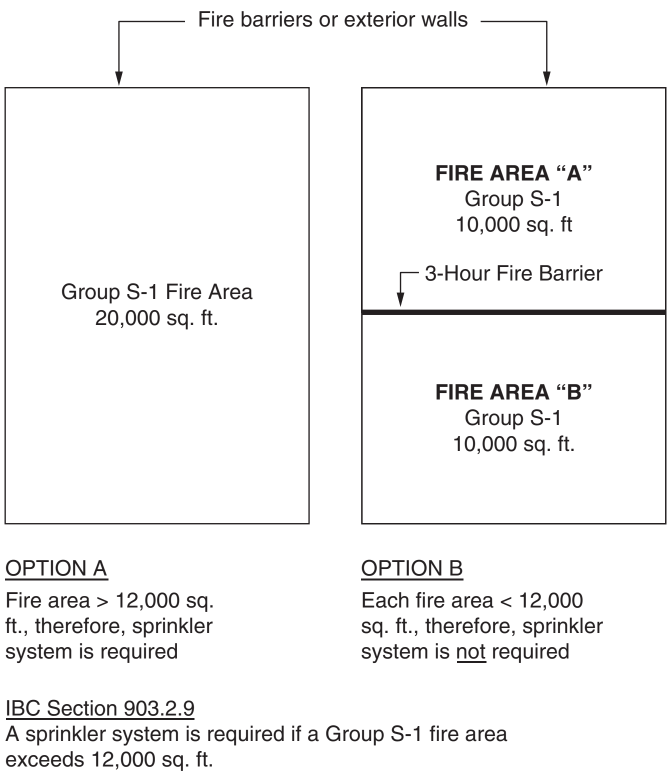

FIGURE 2.5-2. *Fire area* application options.

2.6 PROPOSED CONSTRUCTION MATERIALS

The materials to be considered for this step are the primary structural materials and not *interior finishes*, *exterior wall coverings*, and roofing systems. The selection of materials is prefatory to the determination of construction type in Step 4, which is predicated on the primary structural materials selected.

This is only a preliminary selection, and the materials may change as the design progresses and as cost estimates as prepared.

2.7 CLIMATE ZONE

The *climate zone (IECC)* of the project is based on the geographical location of the project. The *climate zone* will determine the minimum energy performance of the building envelope. The *climate zone* is determined by referring to IECC Figure C301.1 or Table C301.1 for commercial projects or IECC Figure R301.1 or Table R301.1 for residential projects. There really is no difference between the two figures and tables, but they are provided separately to have completely identifiable requirements for each application. The tables identify the *climate zone* for each county within each state, the District of Columbia, and U.S. territories. A jurisdiction may require a *climate zone* other than the one indicated for that jurisdiction's location, so local amendments should be reviewed.

2.8 FLOOD HAZARD AREA

The project site may be located within a *flood hazard area*, or, more appropriately, a *special flood hazard area, or SFHA*. A *flood hazard area* is either an area considered to be within the 100-year floodplain, which is defined by the IBC as a *base flood*, or an area designated by the jurisdiction. *SFHAs* are based on specific zones identified on the reference flood maps. Thus, all *SFHAs* are *flood hazard areas*, but not all *flood hazard areas* are *SFHAs*. The *base flood elevation, or BFE* is the water surface elevation associated with the 100-year flood.

NOTE:

A 100-year flood is not a flood that occurs every 100 years. In fact, it indicates the probability of a flood reaching or exceeding a certain elevation within any year. For the 100-year flood, there is a 1% chance that the *BFE* will be equaled or exceeded in any year. To calculate the percentage, take 100 and divide by the flood year, and that will give you the percentage of probability (100/100 yr. = 1%; 100/50 yr. = 2%; 100/10 yr. = 10%, etc.).

SFHAs are annotated in a series of maps referred to as *Flood Insurance Rate Maps, or FIRMs*. They are prepared by the Federal Emergency Management Agency (FEMA; www.fema.gov) and are available for viewing on its website just by entering a street address. If the property is located in a shaded area that is annotated with either an "A" or "V" designation, then the property is within the 100-year floodplain. Both of these designations have variations (i.e., AE, AO, VE, VO), which are explained in the map's legend. "A" zones apply to either inland or coastal regions, while "V" zones apply only to coastal regions subject to high-velocity wave actions.

Depending on the zone, *FIRMs* may indicate the *BFE* for a flood hazard area. However, the IBC uses the term *design flood elevation, or DFE*. The *DFE* may or may not equal the *BFE*, but it will never be lower than the *BFE*. A *DFE* set at a higher elevation may be established by a jurisdiction based on actual flood elevations experienced by the jurisdiction which are not reflected in the most current *FIRMs* available.

The information can be easily obtained via FEMA's website; however, an alternative is to ask the project's civil engineering or geotechnical consultant. They can determine if the project site is within a *SFHA* or not and, if it is, what the *DFE* will be so that the design properly incorporates that information early on in the design process.

EXAMPLE PROJECT—STEP 2

The example project will be a privatized student housing facility with community spaces on the first story and student apartments on the stories above. A single parking level is located in the basement. An outdoor pool and deck area is also provided for the residents. The full program for the example project is located in Appendix A.

- Total Building Area: 60,000 sq. ft. (not including basement)
- Number of Stories: 4 stories
- Building Area per Story:
  - Basement: 15,000 sq. ft. (Minimum, Parking)
  - 1st Story: 15,000 sq. ft. (Total)

Breakdown of 1st-Story Floor Area	
4,500 sq. ft.	(Dining Hall with Kitchen)
500 sq. ft.	(Public Restrooms)
950 sq. ft.	(Convenience Shop)
700 sq. ft.	(2 Study Rooms @ 350 sq. ft. ea.)
800 sq. ft.	(Lounge)
800 sq. ft.	(Covered Outdoor Patio)
700 sq. ft.	(Management Office)
1,100 sq. ft.	(Manager's Apartment)
600 sq. ft.	(Exercise Room)
1,100 sq. ft.	(Mechanical Room)
250 sq. ft.	(Trash Room)
300 sq. ft.	(Mail Room)
2,700 sq. ft.	(Circulation/Structure)

  - 2nd Story: 15,000 sq. ft. (Total)

Breakdown of 2nd-Story Floor Area	
6,000 sq. ft.	(8 Two-Bedroom Apartments @ 750 sq. ft. ea.)
4,000 sq. ft.	(4 Three-Bedroom Apartments @ 1,000 sq. ft. ea.)
2,500 sq. ft.	(2 Four-Bedroom Apartments @ 1,250 sq. ft. ea.)
2,500 sq. ft.	(Circulation/Structure)

  - 3rd Story: 15,000 sq. ft. (Same as 2nd Story)
  - 4th Story: 15,000 sq. ft. (Same as 2nd Story)
- Building Height in Feet: 42 feet—This is based on a 12-foot floor-to-floor height for the first story and 10-foot floor-to-floor heights for the other stories.

- Sprinkler System: NFPA 13R—This standard allows this system to be installed throughout residential buildings even if the building includes accessory or incidental spaces that are not strictly residential in nature.
- Proposed Construction Materials: Wood frame—Although wood frame construction is limited to supporting two floors and a roof (i.e., three stories) per IBC Section 2304.3.3, it can be used in buildings more than three stories if an analysis will show that shrinkage would not have an adverse effect on the building's mechanical, electrical, or plumbing systems.
- Climate Zone: 4A—The climate zone will be based on a Midwest U.S. location.
- Special Flood Hazard Area: No—The project is assumed to not be located within a 100-year floodplain.

STEP 3

Determine Occupancy Group or Groups

STEP OVERVIEW

The IBC requires that a building or portion thereof be classified based on its planned use called an "occupancy group." IBC Chapter 3 identifies 10 major occupancy groups with some of those divided into smaller subgroups. Although some buildings may be classified into one occupancy group, most buildings are likely to be considered mixed-occupancy buildings, which means more than one occupancy group can be applied to the building.

The occupancy groups in the IBC consist of the following:

Assembly: Groups A-1, A-2, A-3, A-4, and A-5
Business: Group B
Educational: Group E
Factory and Industrial: Groups F-1 and F-2
High Hazard: Groups H-1, H-2, H-3, H-4, and H-5
Institutional: Groups I-1, I-2, I-3, and I-4
Mercantile: Group M
Residential: Groups R-1, R-2, R-3, and R-4
Storage: Groups S-1 and S-2
Utility and Miscellaneous: Group U

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3.1 INTRODUCTION TO OCCUPANCY GROUPS

The occupancy classification of a building plays a significant role in the application of the building code on a project, especially in the determination of allowable height and area. Many requirements are based on the occupancy group or groups identified within a building. Therefore, each space within the proposed project needs to be classified by the design professional. At this phase of a project's design, the assignment of occupancy groups to the spaces can be quickly accomplished based on the descriptions of spaces in the owner's program.

If the use of a room or space is not specifically provided in the building code, then it should be classified in the occupancy group that most closely resembles the actual use according to fire safety and relative hazards. Additionally, if a room or space will be occupied for different purposes at different times, the room or space shall comply with all requirements for each applicable occupancy group.

3.2 ASSEMBLY GROUP A (IBC SECTION 303)

Assembly occupancies include those buildings or spaces used for the gathering of persons for "civic, social or religious functions" and for purposes such as "recreation, food or drink consumption or awaiting transportation." If a building or tenant space is used for any of those purposes but has an *occupant load* of less than 50, then the IBC requires that the space be classified as a Group B occupancy. Similarly, if a space within a building is used for assembly purposes and has an *occupant load* less than 50 or has a floor area that is less than 750 sq. ft., it can be classified either as a Group B occupancy or as part of the occupancy in which it is located. For those spaces that are for assembly purposes, a quick *occupant load* calculation can be completed using the proposed floor areas for those spaces. See Step 8 for a discussion on calculating *occupant loads*.

Assembly spaces associated with Group E occupancies are not considered separate occupancies and shall be considered a part of the Group E occupancy. Conversely, educational spaces associated with a religious assembly, such as a church or temple, can be classified as a part of the religious assembly (Group A-3) and not as a separate occupancy, such as a Group E occupancy, if the *occupant load* of the space is less than 100.

The following are the subgroups within the assembly occupancy classification:

Group A-1: Assembly uses where motion pictures and the performing arts are viewed by occupants in fixed seating.

Group A-2: Assembly uses where food and drink are consumed. This includes commercial kitchens that are associated with food establishments, such as restaurants and cafeterias.

Group A-3: Assembly uses for worship, recreation, or amusement and for assembly spaces that cannot be classified in any other Group A occupancy.

Group A-4: Assembly uses for the viewing of indoor sports and activities that include spectator seating.

Group A-5: Assembly spaces for the viewing of outdoor sports and activities.

3.3 BUSINESS GROUP B (IBC SECTION 304)

Business occupancies include those buildings or spaces used for offices, professional services, education above the 12th grade, laboratories, and other transaction-based business uses. The Group B occupancy has no subgroups.

3.4 EDUCATIONAL GROUP E (IBC SECTION 305)

Educational occupancies include those buildings or spaces used for the education of six or more persons up to and including the 12th grade. See the discussion on Group A occupancies for the exception applicable to places of worship.

This group also includes day care *facilities* that supervise, educate, or provide personal service for more than five children over 2 $^{1}/_{2}$ years old for less than 24 hours per day. This occupancy group does not apply to places of worship or occupancies that provide day care services for five or fewer children. For the latter, the day care space is considered part of the main occupancy.

The Group E occupancy has no subgroups.

3.5 FACTORY GROUP F (IBC SECTION 306)

Factory occupancies include those buildings and spaces used for the assembly, manufacture, or fabrication of products and materials. The occupancy group is also applicable to uses where items are disassembled, repaired, processed, or packaged. The Group F occupancy is applied when neither the Group H nor the Group S occupancy is applicable.

The following are the subgroups within the factory occupancy classification:

GROUP F-1: Factory uses where the operations are of a moderate hazard and cannot be classified as a Group F-2 occupancy. The IBC provides some very specific examples.

GROUP F-2: Factory uses where the operations are of a low hazard. This includes operations involving items of noncombustible or very low combustible materials. The IBC provides some very specific examples.

3.6 HIGH-HAZARD GROUP H (IBC SECTION 307)

High-hazard occupancies include those buildings and spaces used to manufacture, process, generate, or store materials that pose a *physical hazard* or *health hazard*. However, not all buildings or spaces that involve *hazardous materials* need to be classified as a Group H occupancy. If the *hazardous materials* can be stored and used in quantities that do not exceed those allowed in IBC Tables 307.1(1) and 307.1(2) per *control area*, then the building can be classified using one of the other occupancy groups as applicable.

IBC Section 414.2 establishes the construction criteria for *control areas*, which consist of *fire barriers* per IBC Section 707 and *horizontal assemblies* per IBC Section 711. The *fire-resistance rating* for the *fire barriers* and *horizontal assemblies* are dependent upon the height of the *control area* in *stories* above the *grade plane* per IBC Table 414.2.2. Any *control area* on the fourth *story* or higher requires a 2-hour rating, and anything below, including up to two *stories* below the *grade plane*, requires a 1-hour rating. *Control areas* are not permitted any lower than two *stories* below the *grade plane*. If a building has no identified *control areas* or no fire-resistive construction required by other provisions of the IBC complying with the requirements for *control areas*, then the entire building would be considered a single *control area*.

If the expected quantities of *hazardous materials* will exceed the maximums listed in IBC Tables 307.1(1) and 307.1(2), then the design professional can take one or more of the following actions:

- Add additional *control areas*. However, the number of *control areas* is limited to four on the first *story*. Additionally, per IBC Table 414.2.2, the number of *control areas* permitted per *story* decreases and the maximum quantities per *control area* are reduced if the *control areas* are located on upper level *stories* and on *stories* below the *grade plane*.

- Add a sprinkler system. The footnotes in the tables allow the quantities to be increased 100% if a sprinkler system is installed per NFPA 13. If the action below is also taken, then the increases are accumulative; thus, the quantities can be 400% of the maximums indicated in the tables.
- Store the *hazardous materials* in *approved* cabinets, containers, or storage cans. The footnotes in the tables allow the quantities to be increased 100% if the storage vessels comply with the IFC or are listed with an *approved* organization. If the action above is also taken, then the increases are accumulative; thus, the quantities can be 400% of the maximums indicated in the tables.
- Classify the use as a Group H occupancy. This should be the last resort if none of the other options will work.

High-hazard occupancies are complex uses and can challenge design professionals if they are not experienced in designing buildings containing *hazardous materials*. Nevertheless, the use of *hazardous materials* is very common; they are used in medical clinics and *hospitals*, manufacturing plants, research laboratories, aircraft and vehicle maintenance shops, and many other uses—many of which do not require a Group H classification. If *hazardous materials* are expected to be used on a project and the design professional does not have the experience designing for *hazardous material* uses, then hiring a consultant may be well worth the additional fee.

Detailed requirements for Group H occupancies are discussed in Step 6. The following are the subgroups within the high-hazard occupancy classification:

GROUP H-1: High-hazard uses containing materials with a *detonation* potential.
GROUP H-2: High-hazard uses containing materials that have a *deflagration* potential or that create a hazard from accelerated burning.
GROUP H-3: High-hazard uses containing materials that are easily combustible or pose a *physical hazard*.
GROUP H-4: High-hazard uses containing materials that pose a *health hazard*.
GROUP H-5: High-hazard uses containing *hazardous production materials*, or *HPMs* used in semiconductor fabrication and research and development laboratories.

3.7 INSTITUTIONAL GROUP I (IBC SECTION 308)

Institutional occupancies include those buildings and spaces where people are cared for or live in a supervised environment, that have physical limitations due to age or health, are harbored for medical or other care treatment, or where people are detained for penal or correctional purposes in which liberties are restricted.

Detailed requirements for some Group I occupancies are discussed in Step 6. The following are the subgroups within the institutional occupancy classification:

GROUP I-1: Institutional uses where more than 16 persons reside on a 24-hour basis under a supervised environment and receive *custodial care*. These include, but are not limited to, assisted living *facilities*, *group homes*, and halfway houses. If there are 6 to 16 persons receiving care, the use shall be classified as a Group R-4 occupancy. If the number of persons is 5 or less, then the use shall be classified as a Group R-3. This occupancy group includes two conditions that must also be identified with the occupancy group:

CONDITION 1: All persons receiving care are capable of evacuating a building without assistance in response to an emergency situation.
CONDITION 2: One or many persons may be unable to evacuate a building without assistance in response to an emergency situation.

Group I-2: Institutional uses for *medical care* on a 24-hour basis for more than 5 persons. These include, but are not limited to, *hospitals* and *nursing homes*. This occupancy group includes two conditions that must also be identified with the occupancy group:

Condition 1: *Facilities* that provide nursing and *medical care*, but do not provide emergency care, surgery, obstetrics, and in-patient stabilization for psychiatric or detoxification (may or may not include *nursing homes* or *foster care facilities*).

Condition 2: *Facilities* that provide nursing and *medical care*, but could provide emergency care, surgery, obstetrics, and in-patient stabilization for psychiatric or detoxification (may or may not include *hospitals*).

Group I-3: Institutional uses for more than 5 persons who are under restraint or security. These include, but are not limited to, jails, prisons, and correctional centers. This occupancy group includes five conditions that must also be identified with the occupancy group:

Condition 1: Free movement is allowed between sleeping areas, other permitted areas, and the exterior without restraint. A Group I-3, Condition 1 *facility* may be classified as a Group R occupancy.

Condition 2: Free movement is allowed between sleeping areas and any *smoke compartment* to one or more other *smoke compartments*; however, egress to the exterior is not permitted due to locked *exits*.

Condition 3: Free movement is allowed within a single *smoke compartment* that includes *sleeping units* and activity spaces. Movement to another *smoke compartment* is restricted by remotely released egress doors.

Condition 4: Free movement is restricted from an occupied space. Movement from *sleeping units*, activity spaces, and other occupied areas within a *smoke compartment* or movement to another *smoke compartment* is restricted by remotely released egress doors.

Condition 5: Free movement from occupied spaces is completely restricted. Movement from *sleeping units*, activity spaces, and other occupied areas within a *smoke compartment* or movement to another *smoke compartment* is restricted by staff-controlled manually released egress doors.

Group I-4: Institutional uses for more than 5 persons who receive *custodial care* for less than 24 hours per day. These include adult and child day care *facilities*.

3.8 MERCANTILE GROUP M (IBC SECTION 309)

Mercantile occupancies include those buildings and spaces where merchandise is on display for sale and where goods, wares, or merchandise are stocked and accessible to the public. Stock rooms that are not accessible to the public shall be classified as a Group S occupancy.

The Group M occupancy has no subgroups.

3.9 RESIDENTIAL GROUP R (IBC SECTION 310)

Residential occupancies include those buildings and spaces used for sleeping purposes when not classified as a Group I occupancy. There are some terms used that help to distinguish the various subgroups within the Group R occupancy classification. These terms include *dwelling unit*, *sleeping unit*, and *transient*. Where the term "nontransient" is used in the IBC, it means the occupancy of a *dwelling unit* or *sleeping unit* is not *transient* or, in other words, is occupied longer than 30 days.

Detailed requirements for some Group R occupancies are covered in Step 6. The following are the subgroups within the residential occupancy classification:

Group R-1: Residential uses consisting of *sleeping units* where the occupants are *transient* in nature. These include, but are not limited to, motels and hotels and *congregate living facilities* and boarding houses with more than 10 occupants.

Group R-2: Residential uses consisting of *sleeping units* or more than two *dwelling units* where the occupants are nontransient. These include, but are not limited to, extended-stay motels and hotels, *congregate living facilities*, and boarding houses with more than 16 occupants, dormitories, fraternities and sororities, *live/work units*, and apartments/condominiums.

Group R-3: Residential uses where the occupants are primarily permanent and the use cannot be classified in Groups R-1, R-2, R-4, or I. This group applies to nontransient *congregate living facilities* and boarding houses with 16 or less occupants and to *transient congregate living facilities* and boarding houses with 10 or less occupants.

Care *facilities* with 5 or less persons receiving care may also be classified in this group or, if located in a single-family *dwelling*, may comply with the IRC provided a sprinkler system is installed per NFPA 13D or per IRC Section P2904.

Group R-4: Residential uses where less than 16 but more than 5 persons reside on a 24-hour basis under a supervised environment and receive *custodial care*. These include, but are not limited to, assisted living *facilities*, *group homes*, and halfway houses.

3.10 STORAGE GROUP S (IBC SECTION 311)

Storage occupancies include those buildings and spaces used for storage of products and materials not classified as a Group H occupancy.

The following are the subgroups within the storage occupancy classification:

Group S-1: Storage uses where the materials are of a moderate hazard and cannot be classified as a Group S-2 occupancy. The IBC provides some very specific examples.

Group S-2: Storage uses where the materials are of a low hazard. This includes storage of noncombustible products and materials on wood pallets or in cardboard boxes. Stored products may include small quantities of plastic materials, such as plastic wrapping, knobs, and handles. The IBC provides some very specific examples. Also included in this occupancy group are open and closed parking garages (see Step 6 for information on parking garages).

3.11 UTILITY AND MISCELLANEOUS GROUP U (IBC SECTION 312)

Utility and miscellaneous occupancies include those buildings that are not classified in any of the other occupancy groups. These are typically ancillary-type *structures* that have limited to no human occupancy and a low fire hazard. The IBC identifies some examples, including greenhouses, fences over 6 feet in height, and carports. Carports and *private garages* that exceed 1,000 sq. ft. in floor area (3,000 sq. ft. if no repair work or fuel dispensing is performed) or one *story* in height must be classified as Group S-2 parking garages. (See Step 6 for special requirements for *private garages* and carports.)

3.12 INCIDENTAL USES (IBC SECTION 509)

Incidental uses are described in IBC Section 509.1 as "ancillary functions associated with a given occupancy that generally pose a greater level of risk to that occupancy." The IBC limits incidental uses to those listed in IBC Table 509, which includes furnace and boiler rooms, laundry rooms, waste and linen rooms, and paint shops, for example. The table requires that incidental uses be separated from adjacent spaces with *fire-resistance-rated* construction, a sprinkler system, or both. The sprinkler system option, if permitted, is only required for the incidental use and not the entire building. A sprinkler system installed throughout the building will satisfy the sprinkler option.

Incidental uses are not separately classified but are included in the occupancy group in which they are located. However, the total area of all incidental uses cannot exceed 10% of the *story's* floor area in which the incidental uses are located. Otherwise, incidental uses are classified within the occupancy group that most closely resembles the use.

EXAMPLE PROJECT—STEP 3

The occupancy groups can be assigned to the example project using the project data collected in Step 2.

- Student Apartments: **Group R-2**
  Since students will occupy the apartments for longer than 30 days, the units are considered nontransient and classified as Group R-2. Additionally, even though the spaces are considered dwelling units by IBC definition, the fact they are used solely for housing students also makes this a dormitory. Both are classified as Group R-2 occupancies, but the dormitory distinction adds other requirements that will be apparent as the project develops.
- Dining Hall and Kitchen: **Group A-2**
  Based on the size of this space (4,500 sq. ft.), it is rather clear that it will have an occupant load of 50 or more, even if some of the area will be dedicated to the kitchen.
- Public Restrooms: **Group A-2**
  Restrooms can be difficult to classify especially in a mixed-occupancy building, since the restrooms may serve several occupancy groups. Usually they are classified in the occupancy group in which they are located as an incidental use. The public restrooms in this project will serve the dining hall, lounge, study rooms, covered outdoor patio, pool area, and exercise room. Since the dining hall may be used by nonresidents, public restrooms are required. Therefore, locating the restrooms near the dining hall would be prudent, thus making it easier to classify them as part of the Group A-2.
- Convenience Shop: **Group M**
  The convenience shop sells merchandise, so this space is easily classified as a Group M.
- Study Rooms: **Group B**
  Since the study rooms are less than 750 sq. ft., they are not classified as assembly occupancies. The IBC allows them to be classified either as a Group B occupancy or as accessory to another occupancy. Although these spaces are accessory to the Group R-2, they are classified as a Group B because when the number of exits are determined in Step 9, Group B allows a higher occupant load than Group R-2 before two exit doors are required.
- Lounge: **Group A-3**
  The lounge will be used for resident gatherings; therefore, it is an assembly use. Since the area exceeds 750 sq. ft. and the occupant load is 50 or greater (based on 15 sq. ft. per occupant per IBC Table 1004.1.2), the space must be classified as a Group A. Group A-3 is considered the most appropriate since none of the other Group A occupancies apply.
- Covered Outdoor Patio: **Group A-3**
  The covered outdoor patio is part of the building area (covered by the story above); therefore, it will need to be assigned an occupancy group classification in order to determine allowable

area. The patio is similar to the lounge, so it will be considered an assembly use. Since the area exceeds 750 sq. ft. and the occupant load is 50 or greater (based on 15 sq. ft. per occupant per IBC Table 1004.1.2), the space must be classified as a Group A. Group A-3 is considered the most appropriate since none of the other Group A occupancies apply.

- Management Office: **Group B**
  The management office is intended to be a space where the business side of the student housing facility is conducted. Therefore, it can be clearly classified as a Group B occupancy.
- Manager's Apartment: **Group R-2**
  The manager's apartment is not unlike the student apartments located on the stories above. Since this apartment is intended to be occupied by nontransient residents, the space is classified as a Group R-2 occupancy.
- Exercise Room: **Group B**
  The exercise room would be considered a recreational use and, thus, a Group A occupancy. However, both the size of the space (less than 750 sq. ft.) and the occupant load (less than 50, based on 50 sq. ft. per occupant per IBC Table 1004.1.2) allow the space to be classified as a Group B occupancy. It could be classified as a Group R-2—the main occupancy of the building—but, when the number of exits are determined in Step 9, Group B allows a higher occupant load than Group R-2 before two exit doors are required.
- Mail Room: **Group S-1**
  The mail room includes a storage room for securing packages, so it will be classified as a Group S-1.
- Trash Room: **Group R-2**
  The trash room complies with the requirements for incidental uses, since it is a waste collection room over 100 sq. ft. (per IBC Table 509). Since this space is primarily in support of the residential occupancy, the trash room can be classified as a Group R-2 occupancy. This space would normally be classified as a Group S-2 but will be included with Group S-1 for determining plumbing fixtures in Step 11.
- Mechanical Room: **Group R-2**
  The mechanical room can be classified as an incidental use, since the sum of the mechanical room and trash room floor areas (1,350 sq. ft.) does not exceed 10% of the first story (10% of 15,000 sq. ft. = 1,500 sq. ft.). Thus, it does not need to be classified as a Group S-2 but will be included with Group S-1 for determining plumbing fixtures in Step 11. The mechanical room will also function as a maintenance space with storage.
- Parking Garage: **Group S-2**
  Parking garages are explicitly identified as a Group S-2 occupancy.
- Circulation (1st Story): **Group A-2**
  Circulation is difficult to classify when more than one occupancy group is served by the circulation spaces. At this stage of design, floor plans are not generated yet; therefore, until more information becomes available, the circulation on this floor will be considered part of the Group A-2 occupancy (the largest occupancy on this floor).
- Circulation (2nd to 4th Stories): **Group R-2**
  Assigning an occupancy group to the circulation spaces on these floors is much easier, since these floors consist entirely of Group R-2 occupancies.

STEP 4

Determine Construction Type Based on Anticipated Materials

STEP OVERVIEW

Similar to the classification of occupancy groups, the IBC requires that a building be classified based on its fire-resistive characteristics called a construction type. In IBC Chapter 6, five major construction types are identified with some of those divided into smaller subtypes for a total of nine different construction types. The type of construction has a direct impact on the allowable area and height for a building among many other requirements. Table 4.1 lists the construction types indicated in the IBC.

4.1 INTRODUCTION TO CONSTRUCTION TYPES

The fire-resistive characteristics of a building are directly related to the materials used for a building's construction. The materials in this case are for a building's primary structural systems and not *interior finishes* or exterior roofing or wall coverings. Based on the materials, the construction types can be categorized as either combustible or noncombustible. Noncombustible materials are determined through testing per ASTM E 136. If the material is a composite material, then the structural base of the composite material is required to pass ASTM E 136 and surfacing is to have a maximum flame spread index of 50 per ASTM E 84. This allows materials such as gypsum board to be considered noncombustible even though it has a paper facing.

The fire-resistive characteristics for each occupancy group are indicated in IBC Table 601, which establishes minimum *fire-resistance ratings* for building elements, such as the structural frame, bearing walls,

TABLE 4.1. Construction Types

Type I	Type IA Type IB	Noncombustible
Type II	Type IIA Type IIB	
Type III	Type IIIA Type IIIB	Combustible
Type IV		
Type V	Type VA Type VB	

floor construction, and roof construction. The *fire-resistance ratings* are based on tests per ASTM E 119 or UL 263. As discussed in Part I "Code Basics," the *fire-resistance-rated* construction per IBC Table 601 are not assemblies, except for floor and roof construction, which are considered *horizontal assemblies*. Openings in *fire-resistance-rated* walls required by IBC Table 601 are not required to be protected unless another provision requires protection.

Only one construction type can apply to a building unless a *fire wall* is used to separate a building into multiple buildings or another provision allows multiple construction types in a single building. Furthermore, a building is only required to comply with the construction type for which it meets the minimum requirements based on occupancy. For example, if a building complies with the construction, area, and height requirements for a Group B, Type VB building but some elements of the building are designed to Type IIB construction, then the building is only required to be classified as a Type VB building—the building is not required to have the other elements revised to comply with Type IIB construction.

Other sections of the IBC may require specific construction types under special conditions. These are typically found in IBC Chapter 4 for special occupancies and uses and IBC Chapter 31 for special construction (see Step 6) as well as IBC Section 510 for special provisions (see Step 7).

4.2 TYPE I CONSTRUCTION

Type I construction consists of materials that are noncombustible. Construction materials used for this construction type typically consist of concrete, structural steel, metal stud framing with gypsum board, and masonry. Some combustible materials are permitted per IBC Section 603, including fire-retardant-treated wood for nonbearing interior partitions that require a *fire-resistance rating* of 2 hours or less and nonbearing *exterior walls* that do not require a *fire-resistance rating*.

The difference between Type IA and Type IB construction is the level of *fire resistance* required. Per IBC Table 601, Type IA construction requires a higher *fire-resistance rating* for the structural frame, bearing walls, and roof construction.

4.3 TYPE II CONSTRUCTION

Type II construction also consists of materials that are noncombustible and construction materials used are identical to those typically used for Type I construction. Similar to Type I construction, some combustible materials are permitted per IBC Section 603.

The difference between Type IIA and Type IIB construction is the level of *fire resistance* required. Per IBC Table 601, Type IIA construction requires a 1-hour *fire-resistance rating* for all building elements, except for nonbearing interior walls and partitions, whereas Type IIB does not require any *fire-resistance ratings* for any building element.

4.4 TYPE III CONSTRUCTION

Type III construction allows combustible construction in a building; however, *exterior walls* must be of noncombustible construction. Interior construction can be of any material that is permitted by the building code. Fire-retardant-treated wood is permitted in *exterior walls* that have a *fire-resistance rating* of 2 hours or less.

The difference between Type IIIA and Type IIIB construction is the level of *fire resistance* required. Per IBC Table 601, Type IIIA construction requires a 1-hour *fire-resistance rating* for all building elements, except for bearing *exterior walls*, which require a 2-hour rating. Type IIIB does not require any *fire-resistance ratings* for any building element, except that exterior bearing walls are still required to have a 2-hour rating.

4.5 TYPE IV CONSTRUCTION

Type IV construction allows solid or laminated heavy timber wood construction in a building; however, *exterior walls* must be of noncombustible construction. Fire-retardant-treated wood is permitted in *exterior walls* that have a *fire-resistance rating* of 2 hours or less. Heavy timber construction has a history of providing increased *fire resistance*, especially when compared to unprotected steel. To be considered heavy timber construction, the dimensions of solid sawn or glued-laminated members must comply with IBC Table 602.4.

The construction of floors and roofs cannot include concealed spaces. Therefore, the primary and secondary structural members supporting floor and roof decks must be exposed. Roof and floor decks are required to be tongue-and-groove planks with thicknesses of 2 and 3 inches, respectively. Interior partitions may be constructed of two layers of 1-inch boards, 4-inch-thick laminated materials, or 1-hour fire-resistive construction.

4.6 TYPE V CONSTRUCTION

Type V construction allows the use of any material permitted by the building code. This is important to emphasize, because many design professionals associate Type V construction with *only* wood frame construction—any building that conforms to the requirements for Type V construction, even if constructed completely of noncombustible materials, may be classified as Type V construction. The difference between Type VA and Type VB construction is the level of *fire resistance* required. Per IBC Table 601, Type VA construction requires a 1-hour *fire-resistance rating* for all building elements, except for nonbearing interior walls and partitions, whereas Type VB does not require any *fire-resistance ratings* for any building element.

EXAMPLE PROJECT—STEP 4

From the data collected in Step 2, wood frame construction is desired, so the construction types that would be applicable are Types III, IV, and V. As mentioned previously, the construction type has an impact on the allowable area and height of a building; thus, a very quick review of IBC Tables 504.3 “Allowable Building Heights in Feet above Grade Plane,” 504.4 “Allowable Number of Stories above Grade Plane," and 506.2 "Allowable Area Factor in Square Feet" can probably eliminate some of the construction types.

The Group R-2 occupancy is located on the highest floor, so that should be used initially to see which construction types are permitted. Types IIIA, IIIB, and IV allow four stories, whereas Type VA allows three stories and Type VB two stories. Since the building will be sprinklered per NFPA 13R, the height of the building can be increased by one story per IBC Table 504.4 and up to 60 feet per IBC Table 504.3. Therefore, Type VA construction can be added to the list of acceptable construction types.

The owner's desire is to keep costs as low as possible, so Type III (A or B) construction would require costly masonry or concrete exterior walls to comply with the noncombustible requirement for exterior walls—even the permitted fire-retardant-treated wood option costs more than standard wood frame construction. Type IV construction also has higher construction costs than Type V construction.

Therefore, the best classification for this project is Type VA construction.

STEP 5

Determine How Mixed Uses and Occupancies Will Be Handled

STEP OVERVIEW

As mentioned in Step 3, most buildings will include two or more occupancy groups—rarely will a building consist of a single occupancy group. However, if that rare exception applies to a project, then this step is not applicable and may be skipped. The requirements for mixed uses and occupancies are located in IBC Chapter 5 because they have an impact on the allowable height and area of a building.

5.1 INTRODUCTION TO MIXED OCCUPANCIES

Allowable height and area are dependent upon the occupancy group (Step 3) and the construction type (Step 4), and once those are determined, the allowable height and area of a single-occupancy building can easily be calculated (Step 7). However, buildings with multiple occupancy groups will have multiple allowable heights and areas, which complicates the determination of a single height and area for a building. Therefore, the IBC has established some options for the design professional based on the separation of occupancies using *fire barriers*:

- Separated occupancies
- Nonseparated occupancies
- Accessory occupancies
- Combination of the three options above
- Incidental uses

Determining how to handle mixed occupancies is not as simple as it may appear. The decision will have a direct impact on allowable height and area. Consequently, the option used may need to be readdressed several times during the course of design to satisfy the owner's programming requirements, design revisions, or both.

5.2 SEPARATED OCCUPANCIES

The separated occupancies option, as the name implies, requires separation using *fire barriers* having the *fire-resistance ratings* indicated in IBC Table 508.4. The required *fire-resistance ratings* vary depending on whether or not a building is sprinklered throughout with a system per NFPA 13. The installation of the sprinkler system will reduce the required ratings by 1 hour; thus, a required 2-hour separation for a nonsprinklered building would be reduced to a 1-hour separation if a sprinkler system is installed. The use of a sprinkler system for the reduction of the occupancy separation *fire-resistance rating* does not prevent the use of the sprinkler system for height and area increases.

The height and area restrictions for each occupancy group are applied individually to each occupancy group. For example, assume a Type VA three-story office building (primarily a Group B occupancy) includes several large conference rooms (Group A-3 with 50 occupants or more) on the first story (Figure 5.2-1). If the spaces are separated per IBC Table 508.4, then the Group B occupancies can be located in buildings up to three *stories* in height per IBC Table 504.4 and limits Group A occupancies to two *stories*. Since the Group A-3 occupancies are on the first story and the Group B occupancies are not located more than three *stories* above the *grade plane*, then the building complies with each occupancy group based on height.

When compared to the nonseparated occupancies option, the separated occupancies option will allow a building with slightly larger floor areas. Therefore, if no separation is required between any of the occupancy groups in a building, the separated method could still be used. Allowable area for separated occupancies is based on the sum of ratios of actual floor areas to allowable floor areas. Since it is difficult to quickly gauge compliance with allowable area requirements, this option may have to be readdressed after completion of Step 7.

5.3 NONSEPARATED OCCUPANCIES

The nonseparated occupancies option allows all occupancies identified in a building per Step 3 to exist without separation by *fire barriers*. However, the allowable height and area of a building will be limited

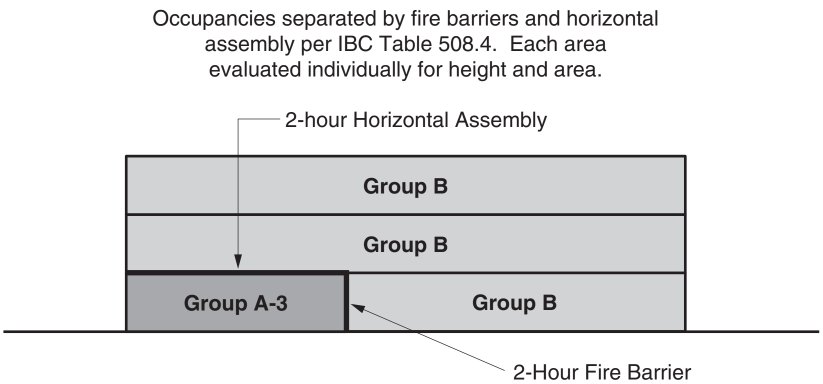

FIGURE 5.2-1. Separated occupancies.

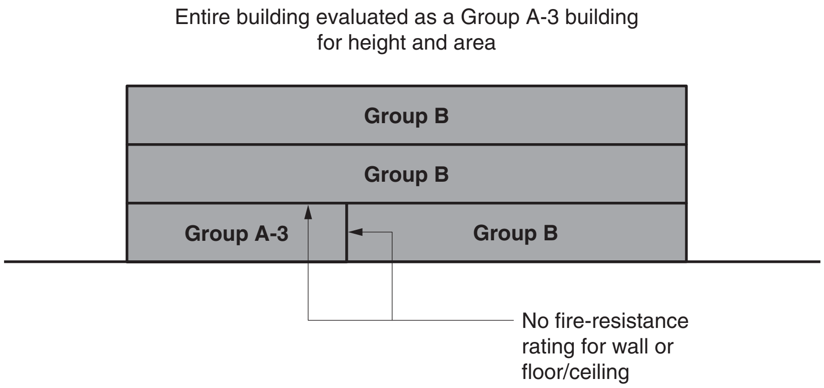

FIGURE 5.3-1. Nonseparated occupancies.

to the most restrictive occupancy group. Before considering this option, a quick review of the allowable heights and areas of each occupancy group based on the selected construction type (see Step 4) within a building would determine its feasibility.

Using the example building for the separated occupancies option (Figure 5.3-1), the nonseparated occupancies option would not be allowed, since the Group A-3 occupancy is limited to two *stories*—even though the Group A-3 occupancies are located only on the first story and Group B is allowed three *stories*. With the nonseparated occupancies option, the height and area requirements for the most restrictive occupancy (Group A-3 in this example) apply to the entire building.

If the allowable height complies with the most restrictive occupancy group, then a preliminary check on allowable area should be conducted to see if there is a significant difference between the actual *story* floor area and the allowable floor area per *story* for the most restrictive occupancy group.

5.4 ACCESSORY OCCUPANCIES

Accessory occupancies are required to be classified in accordance with IBC Chapter 3 but are not required to be separated from other occupancies. To qualify as an accessory occupancy, the occupancy must be ancillary to the main occupancy and cannot exceed the allowable area per IBC Table 506.2 without increases. The sum of all accessory occupancies cannot exceed 10% of the floor area of the *story* in which they are located (Figure 5.4-1). Additionally, an accessory occupancy cannot be located on a *story* higher than that indicated in IBC Table 504.4 without the increases.

5.5 COMBINATION OF OPTIONS

Any of the three options previously covered can be used in combination to suit the specific needs of a project. For example, assume a museum (Group A-3) includes management offices (Group B), a gift shop (Group M), and storage warehouse (Group S-1). Using the separated occupancies method, the Group A-3 exhibit area must be separated from the other occupancy groups (Figure 5.5-1); however, the owner wants the gift shop open to the exhibit area. To resolve this issue, the gift shop is still classified as a Group M but is considered a nonseparated occupancy and is included with the museum's Group A-3 occupancy (Figure 5.5-2).

Since any of the three options may be used in combination with each other, all three options can be used. Using the museum example, the owner also wants the office area to be nonseparated from the

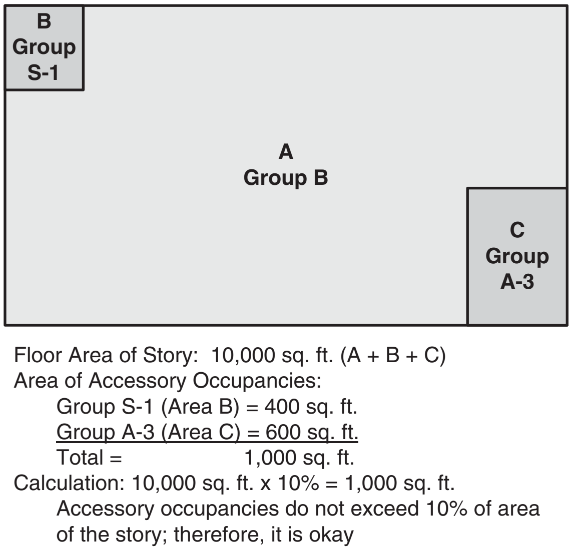

FIGURE 5.4-1. Accessory occupancies.

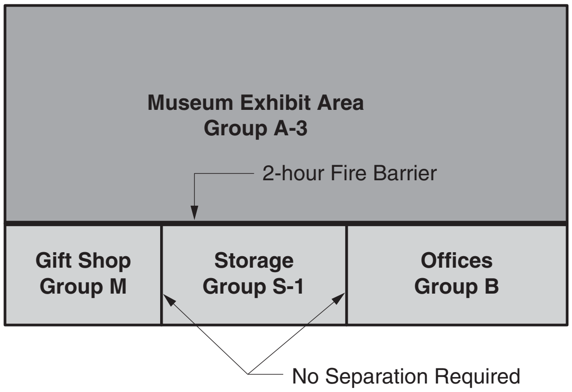

FIGURE 5.5-1. Mixed occupancies separated in accordance with IBC Section 508.4.

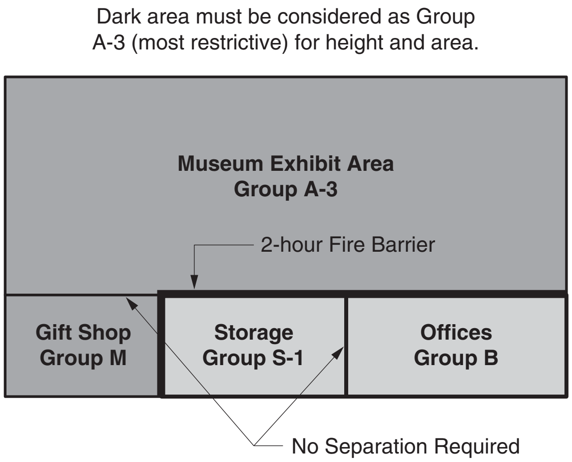

FIGURE 5.5-2. Combination of separated and nonseparated occupancies.

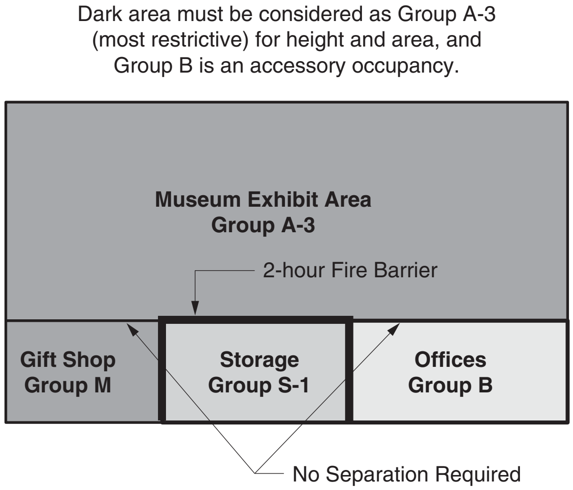

FIGURE 5.5-3. Combination of separated, nonseparated, and accessory occupancies.

exhibit area; however, it is determined that the sum of the floor areas for the exhibit area, gift shop, and offices will exceed the allowable area for Group A-3. Therefore, the offices may be considered an accessory occupancy if the floor area of the offices does not exceed 10% of the total floor area of the *story*. Assuming that the offices do not exceed the 10% limitation, the only space that will require separation is the Group S-1 storage (Figure 5.5-3).

5.6 DECIDING WHICH METHOD TO USE

Before making a decision, some things should be reviewed to see if there are some programming requirements or code issues that may guide the design professional in making a decision. In regard to the owner's program, it may require openness between some of the spaces, which may point toward nonseparated occupancies throughout the building. However, if openness is not an owner requisite, then separated occupancies may be utilized throughout or in portions of the building. A mix of the methods covered in this step is also an option, which allows some areas to be nonseparated where needed and separated where it can be easily achieved.

Of the methods allowed, the nonseparated method is the easiest, since it essentially regards the building as a single-occupancy building based on the most restrictive occupancy group in regard to area and height. A quick check can be conducted to see if the nonseparated method can be applied to the entire building just by looking at the allowable heights for each occupancy group.

For example, if a building is four *stories* in height and the most restrictive occupancy group in the building is allowed three *stories* per IBC Table 504.4, then, at a minimum, a combination of separated and nonseparated occupancies will be necessary. However, if the *building height* does not exceed the allowable height, then the area of the building can next be evaluated. Select the *story* in the building that has the largest floor area. If this area does not exceed the allowable area for the most restrictive occupancy per IBC Table 506.2, then the entire building can be considered a nonseparated building throughout. If the floor area of the *story* does exceed the allowable, then a combination of methods is required.

If the proposed building exceeds the allowable height, area, or both, then a sprinkler system may be considered if not already considered to provide greater height and area. If that provides sufficient height and area for nonseparated uses, then that method can be used throughout; otherwise, a combination of methods will be required.

This step only provides a preliminary determination for handling mixed occupancies and is used as a starting point when beginning Step 7. When Step 7 is addressed, this decision may be modified slightly based on the detailed analysis conducted during that step.

EXAMPLE PROJECT—STEP 5

The first action to take in completing this step is to determine the allowable heights and areas per IBC Tables 504.3, 504.4, and 506.2. The table below identifies the allowable height in stories and the allowable area per story for each occupancy group based on Type VA construction (per Step 4). The heights, where applicable, include the increase for the NFPA 13R sprinkler system (S13R); otherwise, the nonsprinklered (NS) heights must be used. Area increases are not permitted when using a NFPA 13R system, so the NS values must be used.

Comparison of Each Occupancy Group for Height and Area

	Group	Height	Area
Most Restrictive→	A-2	2 stories	11,500 sq. ft.
Most Restrictive→	A-3	2 stories	11,500 sq. ft.
	B	3 stories	18,000 sq. ft.
	M	3 stories	14,000 sq. ft.
	R-2	4 stories	12,000 sq. ft.
	S-1	3 stories	14,000 sq. ft.
	S-2	4 stories	21,000 sq. ft.

Since the building is planned to be four stories in height (per Step 2) and the Group A occupancies (both A-2 and A-3) are limited to two stories (the most restrictive occupancy groups), the nonseparated occupancies option cannot be the sole method used.

Therefore, the next action to take is to determine what the separation requirements are between each of the occupancy groups in the building. The table below outlines each of the occupancy groups in the example project and indicates the required fire-resistive rating for the other occupancies that may be adjacent to that occupancy. Since this building is planned to be sprinklered with a NFPA 13R system (per Step 2), the nonsprinklered (NS) ratings in IBC Table 508.4 must be used.

Comparison of Required Occupancy Separations per IBC Table 508.4

Group	2 Hours	1 Hour	No Separation
A-2	B, M, R-2, S-1	S-2	A-3
A-3	B, M, R-2, S-1	S-2	A-2
B	A-2, A-3, R-2, S-2	—	M, S-1
M	A-2, A-3, R-2, S-2	—	B, S-1
R-2	A-2, A-3, B, M, S-1,S-2	—	—
S-1	A-2, A-3, R-2, S-2	—	B, M
S-2	B, M, R-2, S-1	A-2, A-3	—

Per the owner's program, all of the Group A occupancy groups are located on the first story, so separating the first story from the other floors would be sufficient. The Group R-2 occupancy can be located on up to four stories. Since no other occupancy groups are located above the first story, occupancy separations are not required at the upper stories. Also, at this point, there is no need to consider the separation of any other occupancy groups on the first story.

As for the rest of the building, the handling of mixed occupancies for this project will be a combination of separated and nonseparated occupancies.

STEP 6

Determine Special Use and Occupancy if Applicable

STEP OVERVIEW

Although each building, or portion thereof, is classified into an occupancy group based on use of the building, this is generally considered a broad categorization. Some buildings have unique features that cannot be covered adequately through the occupancy classification. Therefore, individual requirements are established for special uses and occupancies in IBC Chapter 4 and special construction in IBC Chapter 31. The IBC identifies 21 special uses and occupancies that require additional consideration if included in a building project:

- Covered Mall and Open Mall Buildings
- High-Rise Buildings
- Atriums
- Underground Buildings
- Motor-Vehicle-Related Occupancies
- Group I-2
- Group I-3
- Motion Picture Projection Rooms
- Stages, Platforms, and Technical Production Areas
- Special Amusement Buildings
- Aircraft-Related Occupancies
- Combustible Storage
- Hazardous Materials
- Groups H-1, H-2, H-3, H-4, and H-5
- Application of Flammable Finishes
- Drying Rooms
- Organic Coatings
- Live/Work Units
- Groups I-1, R-1, R-2, R-3, and R-4
- Hydrogen Cut-Off Rooms
- Ambulatory Care Facilities
- Storm Shelters
- Children's Play Structures
- Hyperbaric Facilities
- Combustible Dusts, Grain Processing, and Storage

Applying the Building Code: Step-by-Step Guidance for Design and Building Professionals. Ronald L. Geren, FCSI, AIA

IBC Chapter 31 covers unique construction that cannot be addressed by other chapters of the code. Special construction considered at this phase of design includes membrane structures, pedestrian walkways, and tunnels. Other special construction addressed in IBC Chapter 31 is considered in Step 21 at design development.

This step does not take into consideration all of the requirements associated with special uses, occupancies, and construction. The purpose of this step is to identify those special uses, occupancies, and construction that are applicable and to incorporate the basic requirements at this phase that have a major impact on space planning, size limitations, classification of construction type, classification of occupancy group, and integration of special systems (i.e., smoke control, fire suppression, ventilation, etc.).

6.1 COVERED MALL AND OPEN MALL BUILDINGS (IBC SECTION 402)

The *covered mall building* definition in IBC Chapter 2 is actually a multipart definition that includes nested definitions for *mall*, *open mall*, and *open mall building*.

An *open mall* is essentially an uncovered *mall*, and an *open mall building* has an *open mall* that connects the tenants. When the IBC uses the term *covered mall building*, it also includes *open mall buildings*. For application of the building code, a perimeter line per IBC Section 402.1.2 must be established around *open malls* to define the extent of the *open mall building*—*anchor buildings* are not to be included within the perimeter line (Figure 6.1-1).

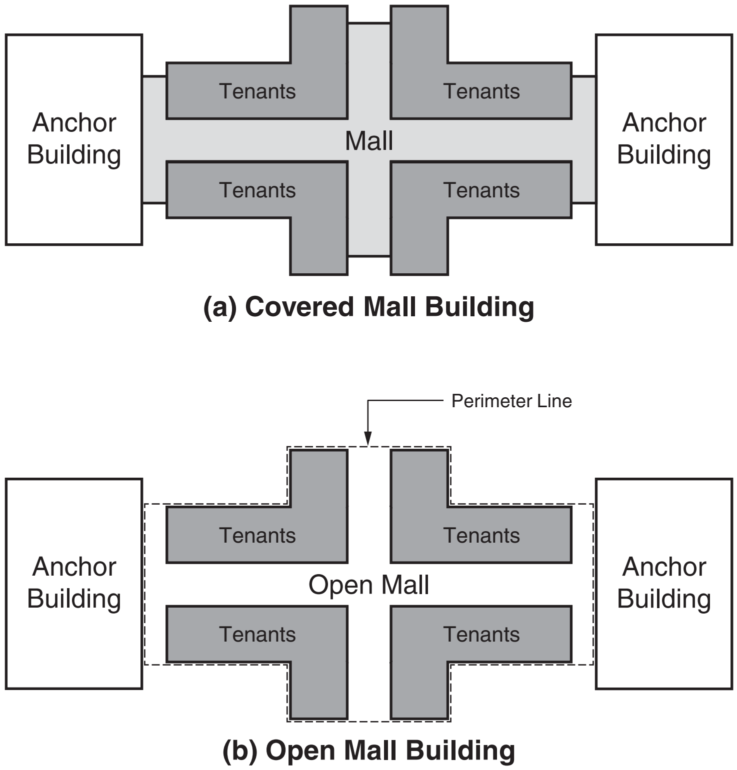

FIGURE 6.1-1. Components of a *mall* based on the IBC definitions. (a) A *covered mall building*, which includes the *mall* and tenant spaces. (b) An *open mall building*, which includes an *open mall* and tenant spaces, and the *open mall building* is defined by the perimeter line.

There are some significant design features for *mall* buildings that need to be addressed at this phase of the project. These include:

- A 60-foot open space around the perimeter of *covered mall buildings*, *anchor buildings*, and parking garages per IBC Section 402.1.1. There is an exception that allows the reduction of this open space to 40 feet provided specific conditions are met.
- Buildings are limited to three *stories* above the *grade plane* and no more than three floor levels at any point per IBC Section 402.1.
- The area of a Type I, II, III, or IV *covered mall building* is permitted to be of unlimited area provided the *anchor buildings* are not taller than three *stories* above the *grade plane* per IBC Section 402.4.1.
- *Fire walls* are required to separate *anchor buildings* from the covered *mall* per IBC Section 402.4.2.2. *Fire-resistance ratings* must comply with IBC Section 706. The rating is limited to 2 hours if the occupancy classification of the *anchor building* is the same as the *mall*.
- Protected openings are not required between *anchor buildings* and *malls* in Type IA, IB, IIA, or IIB buildings per IBC Section 402.4.2.2.1. However, this does not apply to Group R-1 *sleeping units* that open into the *mall*.
- A NFPA 13 sprinkler system is required throughout *covered* and *open mall buildings* and must be separate from the systems protecting tenant spaces and *anchor buildings* per IBC Section 402.5. Tenant space sprinkler systems cannot be a part of *anchor building* sprinkler systems. The data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time.
- A smoke control system is required in *covered mall buildings* with an *atrium* connecting three *stories* per IBC Section 402.7.2.
- Standby power to operate an *emergency voice/alarm communications* system is required for *covered mall buildings* greater than 50,000 sq. ft. in area and *open mall buildings* greater than 50,000 sq. ft. within the perimeter line.
- The aggregate clear egress width of *covered* and *open mall buildings* is 20 feet. No portion of the egress width can be less than 10 feet.

6.2 HIGH-RISE BUILDINGS (IBC SECTION 403)

Unlike the standard *building height* dimension regulated by the IBC, the height for determining a *high-rise building* is determined by two different points of measurement: (1) the lowest level of fire vehicle access and (2) the highest occupied floor (Figure 6.2-1). The following *structures* are excluded from the high-rise requirements:

- Air traffic control towers
- *Open parking garages*
- Buildings with a Group A-5 occupancy
- Special industrial occupancies per IBC Section 503.1.1
- Buildings with a Group H-1, H-2, or H-3 occupancy

Regarding the bottom point of measurement, if a building is constructed on a *site* that has varying grade levels around its perimeter, the measurement is not to be taken at the *grade plane* as defined by the IBC. Rather, the dimension is measured to the actual surface of the ground or pavement that is accessible by fire department vehicles. This measurement point can be above or below the *grade plane*.

For the upper measurement point, this is taken at the floor level and not the overall height of the building. For example, if a building has an overall height of 80 feet but the highest occupied floor is at 70 feet, it is not considered a *high-rise building*. However, if the building has an occupied roof (i.e., roof

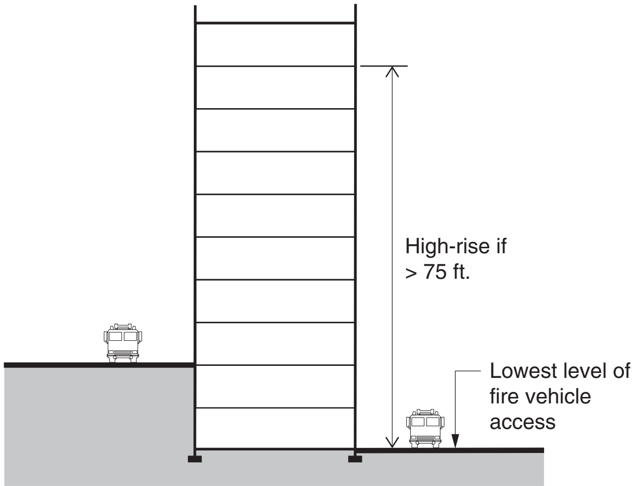

FIGURE 6.2-1. *High-rise building* determination.

decks, but excluding occupancy for maintenance purposes), some building officials would consider the roof as an "occupied floor," thereby making the roof and not the enclosed floor below the point of measurement.

A Type IA *high-rise building* that is not greater than 420 feet is permitted to be constructed using *fire-resistance ratings* equal to that of Type IB construction, except that the *fire-resistance rating* of columns supporting floors cannot be reduced. A Type IB *high-rise building*—except for Group F-1, M, and S-1 occupancies—is permitted to be constructed using the *fire-resistance ratings* of Type IIA construction. For either of these two reductions, the use of the *building height* and area limitations for the original construction type are permitted. For example, a Type IB, Group B *high-rise building* may reduce the *fire-resistance rating* of its building elements to that of Type IIA construction per IBC Table 601, but the height and area of the building is still limited to that of Type IB construction per IBC Chapter 5.

High-rise buildings also require some features that affect the design of the building at this phase of design:

- For buildings more than 420 feet in height, an additional *stairway* is required per IBC Section 403.5.2. A minimum of two *exits* are required for any *story* above the first *story* per IBC Section 1006.3; however, this requirement for *high-rise buildings* will require a third *stairway*. If three *exits* are required based on the *occupant load* calculated per Step 8, then a fourth *exit stairway* is required. There is an exception that eliminates the additional *stairway* and that is the provision of an occupant evacuation elevator installed per IBC Section 3008.
- *Stairways* serving *stories* located more than 75 feet above the lowest level of fire department vehicle access must be constructed as *smokeproof enclosures*. *Stairways* constructed as *smokeproof enclosures* must be accessed by either an exterior balcony or a ventilated vestibule per IBC Section 909.20.
- A minimum of two *exit stairways* are required by IBC Section 403.5.1 to be separated by a distance of 30 feet or one-fourth the overall diagonal dimension of the building, whichever is less, measured in a straight line between the nearest points of the two *stairways* (Figure 6.2-2).
- For buildings with an occupied floor more than 120 feet above the lowest level of fire department vehicle access, a minimum of two fire service access elevators per IBC Section 3007 are required by IBC Section 403.6.1.
- IBC Section 403.3 requires a system complying with NFPA 13, except for parking garages and telecommunications equipment buildings. For buildings over 420 feet in height, a second riser is

required for each sprinkler system zone. Furthermore, each riser must supply water to sprinklers on alternating floors. If a sprinkler system is required, then the data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time.

- A *fire command center* complying with IBC Section 911 is required in each *high-rise building* per IBC Section 403.4.6. The design professional can locate the *fire command center* where it best suits the project—typically near the main entrance—but the location must be *approved* by the fire chief. The size of the room must have a minimum area of 200 sq. ft. with a minimum dimension of 10 feet; therefore, a 20-foot by 10-foot room is the minimum room requirement.
- *Standby power systems* and *emergency power systems* (see Note below) are required per IBC Section 403.4.8 to support the loads indicated.

NOTE:

The main difference between a *standby power system* and an *emergency power system* is that the *emergency power system* requires its own distribution system (i.e., wiring, conduit, panels, etc.)—the *standby power system* can share the building's electrical distribution system.

- A method of smoke removal is required per IBC Section 403.4.7 for salvage and overhaul operations after a fire event. Smoke removal, as prescribed in this section, is not to be confused with smoke control, as prescribed in IBC Chapter 9. The methods include the following:
  - Operable windows providing 40 sq. ft. of open area per 50 feet of building perimeter. The openings are required to be spaced at no more than 50-foot intervals. For Group R-1 occupancies, each *sleeping unit* or suite can be provided with 2 sq. ft. of venting in lieu of the previous area requirement.
  - Fixed windows at the same size and intervals for operable windows. Fixed windows are to be designed so that they can be broken out or removed by firefighters.
  - Mechanical ventilation that provides one air change every 15 minutes for the involved area. Air cannot be recirculated to other portions of the building.
  - Any other method *approved* by the *building official* that will have a comparable performance to the prescriptive methods listed above.

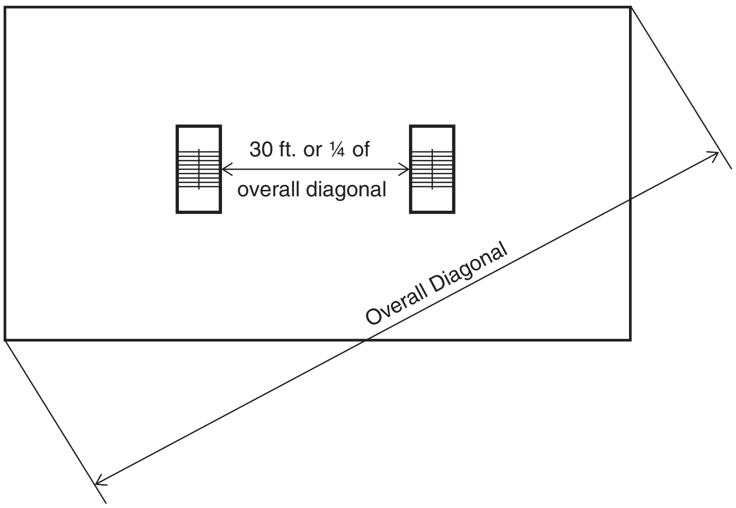

FIGURE 6.2-2. High-rise separation of *exits*.

6.3 ATRIUMS (IBC SECTION 404)

An *atrium* is defined in IBC Chapter 2 and is essentially an opening that connects two or more *stories* and is closed at the top and bottom. The definition specifically excludes enclosed *stairways*, hoistways for elevators and other vertical conveying systems, escalator openings, and *shafts* enclosing mechanical, electrical, plumbing, and other equipment. Also excluded is any space that is defined as a *mall*. The use of "*stories*" in the *atrium* definition does not include balconies and *mezzanines* in assembly groups.

There are two significant requirements that need to be considered at this phase of a project. The first is the requirement for a sprinkler system throughout the building. Any of the three sprinkler installation standards are acceptable as applicable to the occupancies and types of buildings; however, the *atrium* floor will be limited to "low fire hazard uses" unless the space is protected by a sprinkler system installed per NFPA 13. Spaces adjacent to or above the *atrium* are not required to be sprinklered if they are separated from the *atrium* by 2-hour *fire barriers*, *horizontal assemblies*, or both. If the ceiling of the *atrium* is higher than 55 feet above the *atrium* floor, then sprinkler protection at the *atrium* ceiling is not required. The data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time.

The second significant requirement is the installation of a mechanical (connected to a *standby power system*) or passive smoke control system per IBC Section 909. However, *atriums* that connect only two *stories* are not required to have the smoke control system. The volume of space required to be removed with the smoke control system is that volume enclosed by the required *fire barriers* and *horizontal assemblies* separating the *atrium* from adjacent spaces. Up to three *stories* are not required to be separated from the *atrium* provided the volume of the nonseparated adjacent spaces within those stories is included in the design of the smoke control system (Figure 6.3-1).

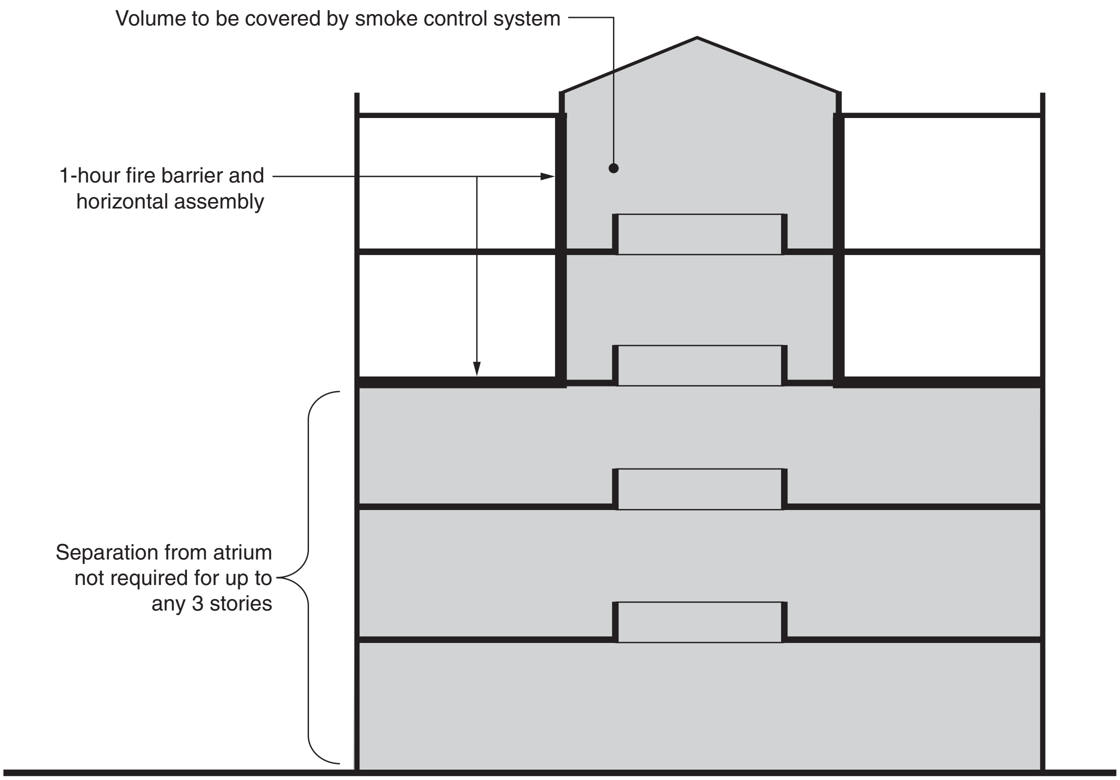

FIGURE 6.3-1. *Atriums.*

6.4 UNDERGROUND BUILDINGS (IBC SECTION 405)

There is no formal definition of an underground building in IBC Chapter 2, but it is described in IBC Section 405.1 as a building with floors intended for human occupancy located lower than 30 feet below the lowest finished floor where egress from the building occurs, called the *level of exit discharge* (Figure 6.4-1). Underground buildings pose a unique problem not encountered in buildings with floors elevated above the *grade plane*, and that is the inability to reach the below-grade floors from the building's exterior.

The IBC identifies specific uses that are exempted from the requirements for underground buildings. These include:

- One- and two-family *dwellings* sprinklered with a system complying with NFPA 13D.
- Parking garages protected with a sprinkler system installed per NFPA 13.
- Subways, railroads, or other transportation systems on a rail or other fixed guide *structure*.
- Grandstands, bleachers, stadiums, and arenas.
- A building where the lowest *story* is the only *story* and it meets the criteria for an underground building provided the *story* is not greater than 1,500 sq. ft. and the *occupant load* is less than 10.
- Mechanical spaces that are accessed by maintenance personnel on a limited basis.

Underground buildings are required to be of Type I construction for that portion below the lowest *level of exit discharge* per IBC Section 405.2. The portion of the building above the underground portion can be of any construction type permitted by the building code.

In accordance with IBC Section 405.4, if the lowest occupied floor level is more than 60 feet below the *level of exit discharge*, then the underground levels need to be divided into a minimum of two *smoke compartments*. The compartments shall extend up into the *level of exit discharge* serving the below-grade levels. Each compartment shall have direct access to an elevator. If an elevator will serve more than one compartment, then an elevator lobby is required.

Each floor level of an underground building is required to have at least two *exits* per IBC Section 405.7.1. If two *smoke compartments* are required as described above, then each compartment must have direct access to at least one *exit stairway* and a doorway into the adjacent *smoke compartment*. *Stairways* must be constructed as *smokeproof enclosures* per IBC Section 909.20 and be provided access balcony or through a ventilated vestibule.

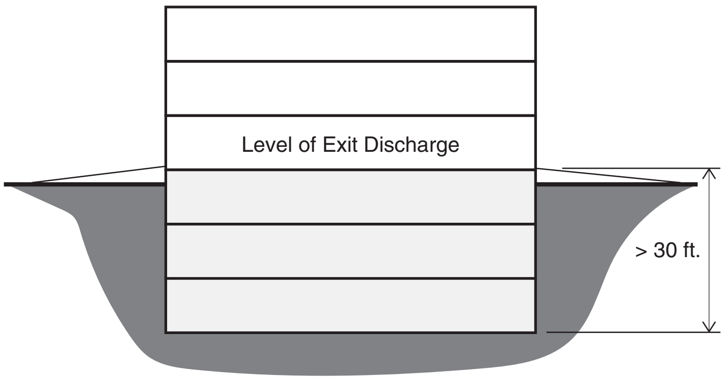

FIGURE 6.4-1. Underground building determination.

Other required systems within an underground building include the following:

- A smoke control system is required for underground buildings per IBC Section 405.5. If more than one *smoke compartment* is required, each compartment must have its own system.
- *Standby power* and *emergency power systems* are required per IBC Section 405.8 to support the loads indicated.
- A sprinkler system is required for all underground floor levels plus the *level of exit discharge*. The sprinkler system must be in accordance with NFPA 13. The data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time.
- A Class I automatic or manual wet standpipe is required per IBC Section 905.3.5.

6.5 MOTOR-VEHICLE-RELATED OCCUPANCIES (IBC SECTION 406)

Motor-vehicle-related occupancy requirements are found in IBC Section 406 and include the following types of occupancies:

- *Private garages* and carports
- Public parking garages
- Motor fuel-dispensing *facilities*
- Repair garages

6.5.1 PRIVATE GARAGES AND CARPORTS (IBC SECTION 406.3)

To be considered a carport, the space must be open on at least two sides; otherwise, it is considered a *private garage*. The floor of a carport or garage must have a drain or be sloped toward the main vehicle entry door.

Door openings are permitted between a garage and a *dwelling unit;* however, the door must be self-closing, of solid-core wood or hollow-metal construction, and have a *fire protection rating* of not less than 20 minutes. Door openings are not permitted between a garage and a room used for sleeping purposes.

6.5.2 PUBLIC PARKING GARAGES (IBC SECTION 406.4)

Public parking garages can be classified as either “open” or “enclosed.” Both types can either be part of a mixed-occupancy building or be a single-use *structure*. The requirements of IBC Chapter 5 for height and area apply; however, *open parking garages* have separate optional area and height provisions for single-use garages that permit larger *structures*.

The clear height of each floor, or “tier,” within a public parking garage is 7 feet; however, if *accessible* van parking spaces are provided, then the floor and route to the van parking spaces are required to have a clear height of 8 feet 2 inches per ICC/ANSI A117.1 Section 502.6.

Like *private garages*, public parking garages are not permitted to have door openings that lead directly to spaces used for sleeping purposes.

Parking garages associated with *covered mall buildings* may be considered as separate buildings (single-use *structures*) if they are separated by 2-hour *fire barriers* and *horizontal assemblies*.

6.5.2.1 Open Parking Garages (IBC Section 406.5)

Open parking garages are defined in IBC Chapter 2; however, the definition refers to this section for the specific requirements that determine an *open parking garage*. As stated in the term, an *open parking garage* is “open” to allow natural ventilation, but the size and extent of the openings are expressly described in this section.

To be considered an *open parking garage*, the openings must conform to two requirements stipulated in IBC Section 406.5.2:

- **Area of Openings:** The total sum of all *exterior wall* opening areas must be 20% or more of the total perimeter wall area of each tier.
- **Length of Openings:** The aggregate length of all openings must be 40% or more of the perimeter of the tier.

The openings complying with the above requirements must be uniformly distributed along two or more sides of the parking garage (Figure 6.5.2.1-1). When the openings are located on opposite sides of the parking garage, the 40% requirement for length is not applicable.

If any tiers of an *open parking garage* are located below grade, then additional requirements are applied to those openings located below grade. Vent wells are required at each opening on the outside of the parking garage wall. The horizontal clear space between the opening and the far vent well wall must be $1\frac{1}{2}$ times the depth of the opening. The dimensions of the clear space must be maintained from grade to the bottom of the lowest opening (Figure 6.5.2.1-2).

Open parking garages are required to be of Type I, II, or IV construction. Therefore, if the *open parking garage* is part of a mixed-occupancy building, then the rest of the building must have the same construction type as the parking garage. Alternatives to this requirement include separating the parking garage from the rest of the building with a *fire wall* or using one of the special provisions in IBC Section 510 (Sections 510.2, 510.3, 510.4, 510.7, or 510.8).

For single-use *open parking garages* (i.e., garages that are not part of a mixed-occupancy building), the area and height requirements do not need to comply with IBC Chapter 5; instead, IBC Section 406.5.4.1

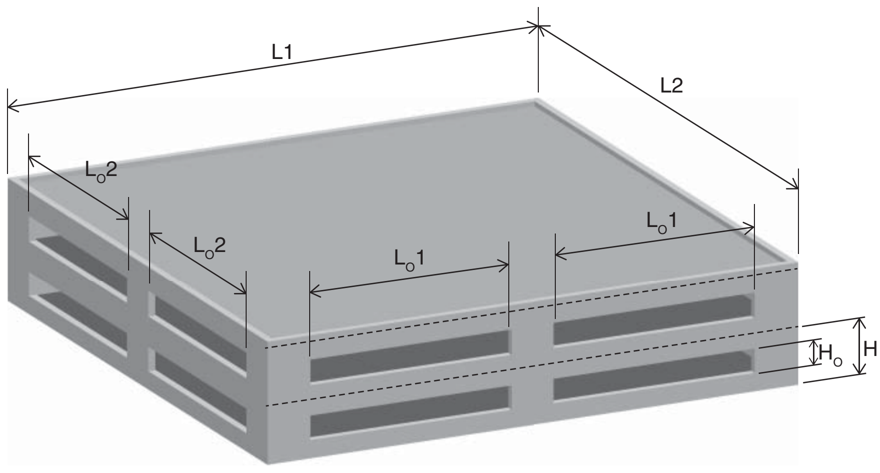

FIGURE 6.5.2.1-1. *Open parking garage* opening requirements.

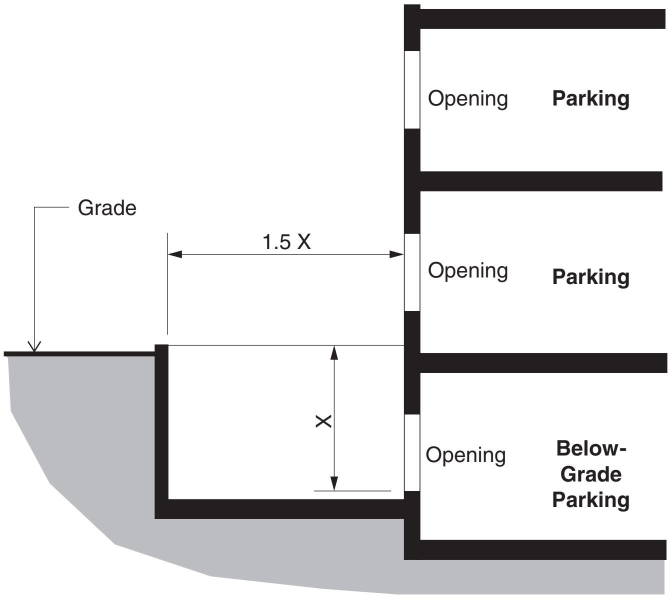

FIGURE 6.5.2.1-2. Openings below grade.

is used, which references IBC Table 406.5.4. This table establishes the allowable area per tier and the maximum number of tiers—height in feet is not restricted.

If below-grade enclosed parking garage levels are proposed with an *open parking garage*, then the entire parking garage must comply with one of two options:

- The parking garage is classified as a Group S-2 parking garage complying with IBC Table 503 with applicable increases.
- The parking garage is considered a single *structure* per IBC Section 406.5.4.1 but is allowed the enclosed levels in accordance with IBC Section 510.3. See Step 7.4 on special provisions.

For parking garages that have continually sloping floors, the number of tiers is determined by dividing the height by 9 feet 6 inches and rounding up to the next whole number. For allowable floor area compliance, the floor area of the horizontal projection taken at any cross section cannot exceed the allowable area.

Another distinction this table makes is the difference between a *ramp-access open parking garage* and a *mechanical-access open parking garage*. Each of these terms is defined in IBC Chapter 2. *Mechanical-access open parking garage*s employ the use of lifts, elevators, or other types of machines that move vehicles to and from their intended parking spaces—public access to the parking spaces is prohibited. Without an automatic sprinkler system installed, the *mechanical-access open parking garage* is limited to the same number of tiers as a *ramp-access open parking garage*. However, with an *automatic sprinkler system* installed, the number of tiers indicated in the table increases by as much as 50% for Construction Types I and II.

6.5.2.2 Enclosed Parking Garages (IBC Section 406.6)

Enclosed parking garages are not provided with a formal definition in the IBC. However, IBC Section 406.6.1 states that any parking garage or portion thereof that does not meet the opening requirements in IBC Section 406.5.2 for an *open parking garage* is considered an enclosed parking garage. Since this type of parking garage does not provide the natural ventilation that an *open parking garage* provides, a mechanical ventilation system per the IMC must be provided.

Sprinkler systems are also required in enclosed parking garages under certain conditions. Per IBC Section 903.2.10, if the parking garage has a *fire area* exceeding 12,000 sq. ft. or if the parking garage is located beneath other occupancy groups (except for Group R-3), then a sprinkler system is required throughout. If the parking garage will be used for storage of commercial trucks or buses, then a sprinkler system is required if the *fire area* exceeds 5,000 sq. ft. If a sprinkler system is required, then the data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time.

6.5.3 MOTOR FUEL-DISPENSING FACILITIES (IBC SECTION 406.7)

A motor-fuel-dispensing *facility* is building code language for “gas station” and is classified as a Group M occupancy. Although this section provides requirements for the common retail gas station, the requirements are also applicable to any *facility* that dispenses fuel for vehicles, including fuel-dispensing areas for organizational motor pools that are not accessed by the public. For schematic design, there are no requirements in the IBC that are of significance that need to be addressed. However, there are distance requirements in the *International Fire Code* (IFC) Chapters 23 and 57 that should be reviewed.

The *International Codes* do not reference liquid fuels (considered *flammable liquids*) by their common names but reference their classifications, which are used by the NFPA, U.S. Department of Transportation (USDOT), U.S. Environmental Protection Agency (EPA), and U.S. Occupational Safety and Health Administration (OSHA; www.osha.gov). The most common fuels used in dispensing systems and their respective classifications are provided in Table 6.5.3-1.

Underground tanks are required to have a 3-foot separation between any part of a tank and a building *basement*, cellar, or pit or between any part of the tank and a *lot line* per IFC Section 5704.2.11.1. Above-ground tanks, including those within vaults, must have the separation distances provided in IFC Table 2306.2.3. As for the dispensing devices, they are required to be located at the distances specified in IFC Section 2303.1.

Other fuels that can be dispensed are liquefied petroleum (LP) and compressed natural gas (CNG). Like liquid fuels described above, LP and CNG fuels also have separation requirements for dispensing locations established in IFC Chapter 23. For LP fuels, IFC Section 2307.4 requires a 25-foot separation from buildings, *lot lines*, and railroads and a 10-foot separation at streets, driveways, sidewalks, and similar thoroughfares. For buildings, the distance can be reduced to 10 feet if the *exterior walls* have a *fire-resistance rating* of 1 hour or greater. IFC Section 2308.3.1 covers CNG fuel-dispensing locations, which references IFC Section 2303.1, and provides some distances for unique conditions including transit rail and a “trolley bus line.”

6.5.4 REPAIR GARAGES (IBC SECTION 406.8)

Repair garages are classified as Group S-1 occupancies and are frequently collocated with motor fuel-dispensing *facilities* as a mixed occupancy. Repair garages can be used in mixed-occupancy buildings consisting of other occupancy groups as well. Although repair garages pose a higher hazard than parking garages, there are few requirements to be considered at the schematic design phase.

TABLE 6.5.3-1. Common Liquid Fuels Used in Dispensing Systems

Common Name	Class
Biodiesel	IIIB
Diesel	II
Gasoline	IB
Jet Fuel	II
Kerosene	IIIA

One of the more significant requirements that may apply to repair garages is the installation of a sprinkler system. IBC Section 903.2.9.1 provides four conditions when a sprinkler system is required throughout a building with a repair garage:

- When a repair garage is located in a *fire area* that exceeds 10,000 sq. ft. and the building has two or more *stories* above *grade plane* and includes *basements*.
- When a repair garage is located in a *fire area* that exceeds 12,000 sq. ft. and the building has no more than one *story above grade plane*.
- When a repair garage is located in a *basement*.
- When a repair garage is used to repair commercial trucks and buses located in a *fire area* that exceeds 5,000 sq. ft.

The other significant requirement is the installation of a mechanical ventilation system per the IMC. If the repair garage involves work on nonodorized fuels, then IBC Section 406.8.5 requires a gas detection system.

6.6 GROUP I-2 (IBC SECTION 407)

Since Group I-2 occupancies include buildings that provide *medical care* on a 24-hour basis, many occupants are in some capacity of not being able to care for their own safety; thus, these occupants rely on each facility's staff to help move them to safety in emergency situations. Additionally, the unique nature of buildings in this occupancy group requires special physical features not commonly found in other building types that would otherwise be prohibitive under the general requirements of the building. Because of this heightened risk to occupants and different functional requirements, the IBC provides special requirements for buildings in this occupancy group.

The majority of this section addresses *means of egress* with an emphasis on *corridors*. *Corridors* within this occupancy group perform other functions beyond circulation and egress; they also provide space for nursing stations, waiting areas, gift shops, and other similar spaces. IBC Section 407.2 allows these types of spaces within the *corridor* provided they are constructed as required for *corridors* and do not obstruct access to the *exits*. For space planning purposes at this phase, IBC Section 407.4.1 also requires that all habitable rooms (this is not to be confused with *habitable space*, as defined in IBC Chapter 2) have doorways that lead directly to a *corridor*.

One type of physical characteristic found in this occupancy group is the *care suite*. The IBC section referenced in the definition provides specific requirements for *care suites*, most of which address *means of egress* requirements that are addressed in Step 10. However, for this step, it should be noted that a *care suite* cannot exceed 5,000 sq. ft. if it includes rooms used for sleeping.

Since sprinkler systems are required in Group I-2 occupancies, the data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time. Even though a sprinkler system is required throughout per IBC Section 903.2.6, an automatic fire detection system is also required in these spaces.

6.7 GROUP I-3 (IBC SECTION 408)

Group I-3 occupancies include those *facilities* where the liberties of the occupants are significantly restricted, which include jails, prisons, and detention centers, among others. Like the special requirements for Group I-2, this section focuses on *means of egress*, fire and smoke separation, fire alarm and sprinkler systems, and some material requirements. Since most of the occupants within these building types have restricted movement through the *facilities*, there needs to be additional safeguards to protect the occupants while they are being relocated or evacuated under supervised and controlled conditions.

The *means of egress* requirements for Group I-3 are covered in Step 10 and fire and smoke assemblies are covered in Step 15. However, at this phase of design, it is important to know that a fire sprinkler system and a *fire alarm system* are required throughout buildings with a Group I-3 occupancy. The data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time.

6.8 MOTION PICTURE PROJECTION ROOMS (IBC SECTION 409)

Motion picture projection rooms have historically posed a unique hazard due to the heat from projection equipment upon the plastic-based film stock. In the early years of motion pictures, the celluloid film stock was cellulose nitrate, which was unstable, especially as it deteriorated. Cellulose nitrate is no longer produced and was replaced by cellulose acetate. Cellulose acetate was considered a "safety film," but it, too, had its disadvantages. Since the 1980s, the standard has moved to a polyester-based film. Whether cellulose acetate film or the more current polyester film is used, this section will apply to any professionally operated projection room. If by some chance cellulose nitrate film may be used, then the projection room must comply with NFPA 40.

This section requires that a projection room provide 80 sq. ft. for a single projection machine and 40 sq. ft. for each additional machine. Each piece of equipment shall be provided a minimum of 30 by 30 inches of clear working space on each side and at the rear. The clear spaces of adjacent machines may be shared. The minimum clear height of the projection room is 7 feet 6 inches.

Projection machines must be provided with ducts from the lamp directly to the exterior. The projection room itself is required to be supplied with air evenly throughout the space. For exhaust, the projection machine exhaust may be used or a separate system just for the projection room can be provided.

6.9 STAGES, PLATFORMS, AND TECHNICAL PRODUCTION AREAS (IBC SECTION 410)

Due to their similarities, the individual requirements for *stages* and *platforms* are both found in this single section of the IBC. Although providing similar functions, *stages* and *platforms* are clearly defined in order to highlight their differences. The significant difference between a *stage* and a *platform* is that *stages* have "overhead hanging curtains, drops, or scenery or *stage* effects other than lighting and sound," whereas these are absent from *platforms*. Overhead scenery and other combustibles increase the fire hazard; thus, *stages* are subject to more restrictive requirements. Another difference between the two is that a *platform* is considered a "raised area" by definition; however, the definition of a *stage* does not make this distinction. Therefore, a floor level performance area is a *stage*, provided all other characteristics conform to the definition.

Common to both *stages* and *platforms* are the technical production areas, which are superstructures located above them for access, supporting lighting, scenery, and other equipment. Called gridirons, pinrails, and catwalks, these elements are designed for human access in most cases, and are not to be considered as floors, *stories*, *mezzanines*, or levels.

6.9.1 STAGES (IBC SECTION 410.3)

A *stage* has unique characteristics that give it a higher risk for fire. As the definition indicates, *stages* utilize scenery drops, curtains, and other combustibles that are stored in an overhead space above the *stage* that is referred to in the industry as the "fly tower," "fly gallery," or "fly loft." This overhead space could be extremely high—at least 2 to 2 1/2 times the height of the proscenium, which is the opening between the *stage* and the seating area. The measurement between the lowest *stage* surface and the highest point of the roof or floor deck of the fly tower is considered the "*stage* height" and it has code compliance implications.

The size of the *stage* in terms of floor area also has code compliance implications. When the IBC refers to the floor area of a *stage*, it includes the entire performance area and any backstage and support areas not separated from the performance area by *fire-resistance-rated* construction. Therefore, this area can be much larger than just the visible performance area.

Stages are required to have an *automatic sprinkler system*. This is required whether or not the rest of the theater is required to be sprinklered per IBC Section 903.2.1.1. The only exception is for *stages* that have an area 1,000 sq. ft. or less or a height 50 feet or less and that do not have curtains, scenery, or other combustible hangings that are retracted vertically. If a sprinkler system is required, then the data collected in Step 2 should be revised to reflect a sprinkler system in the *stage* area (i.e., not throughout, unless it is decided to sprinkler the building throughout) if one was not selected at that time.

For *stage* areas greater than 1,000 sq. ft., a Class III wet standpipe must be provided on both sides of the *stage* per IBC Section 905.3.4. However, if a sprinkler system is installed in the building or area, then 1 1/2-inch hose connections must be installed per NFPA 13 or as required Class II or III standpipes.

6.9.2 PLATFORMS (IBC SECTION 410.4)

Platforms are generally used to raise the performance or speaker area to an elevation that allows better viewing by patrons but do not involve complex scenery or have curtains. The space beneath the *platform* may be used for storage but must comply with fire-resistive requirements.

6.10 SPECIAL AMUSEMENT BUILDINGS (IBC SECTION 411)

Special amusement buildings are those typically associated with rides and attractions commonly found at theme parks and fairgrounds. Chapter 2 contains a lengthy definition for a *special amusement building*, which emphasizes the unobvious *means of egress* systems that are inherent with these types of *structures*.

Amusement buildings are typically classified as Group A occupancies, but if the *occupant load* is less than 50, then the building can be classified as a Group B occupancy. This section does not apply to amusement buildings that do not have walls or roofs and are designed to prevent the accumulation of smoke.

An *automatic sprinkler system,* a *fire alarm system,* and an *emergency voice/alarm communications* system are required in *special amusement buildings*. The data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time.

6.11 AIRCRAFT-RELATED OCCUPANCIES (IBC SECTION 412)

As the title of this IBC section indicates, the provisions within affect those *facilities* that include occupancies associated with or directly involving aircraft operations. The occupancies include airport traffic control towers, aircraft hangars, *residential aircraft hangars*, aircraft paint hangars, aircraft manufacturing *facilities*, and *heliports* and *helistops*.

6.11.1 AIRPORT TRAFFIC CONTROL TOWERS (IBC SECTION 412.3)

As mentioned in the section on *high-rise buildings*, airport traffic control towers are exempt from the requirements of *high-rise buildings*. On the other hand, the height of airport traffic control towers still poses a greater risk to its occupants than most other buildings of lower height. Thus, the requirements in this section only apply to airport traffic control towers that do not exceed 1,500 sq. ft. per floor; otherwise, the airport traffic control tower must be regulated as a *high-rise building*. The spaces on any floor are limited to the control cab, mechanical and electrical equipment rooms, radar and electronics rooms, offices incidental to the operation of the airport traffic control tower, and lounges and sanitary facilities for employees.

If the project includes an airport traffic control tower, then the construction type determined in Step 4 may have to be modified. In accordance with IBC Table 412.3.1, the construction type will be dictated by tower height. If the construction type is determined to be different than what is planned, consider using a *fire wall* between the tower and the rest of the building.

Airport traffic control towers are required to have an automatic fire detection system as well as a *standby power system* for mechanical and electrical systems, elevator equipment, automatic fire detection system, and pressurization systems for *stairways*, if provided.

6.11.2 AIRCRAFT HANGARS (IBC SECTION 412.4)

Aircraft hangars are similar in character to parking garages in that they have very little fire load, since most materials within hangars are noncombustible. However, the presence of jet fuel increases the hazard requiring special consideration.

The IBC requires that any *basements* be separated from the hangar above with floor construction of Type IA construction. Since the floor, a *horizontal assembly*, is required to have a *fire-resistance rating* per Type IA construction, the *structure* supporting the floor must have an equal rating. The language of the section states that the floor assembly between the *basement* and hangar be Type IA construction but that does not mean the *basement* is classified as Type IA construction. Therefore, the construction type given to the rest of the hangar *structure* is also applied to the *basement* when determining allowable area and any other requirements based on construction type. In addition to the type of construction for the floor assembly above, *basements* are not permitted to have openings that communicate with the hangar and any access to the *basement* must be made from the exterior.

Aircraft hangars are required to be protected with a *fire protection system*; however, the types of systems required for hangars are much different than the typical sprinkler systems used for fire protection in other *facilities*. The type of system required is based on IBC Table 412.4.6, which uses the size and construction type of the hangar to determine which fire protection group per NFPA 409 will apply. NFPA 409 identifies four groups of aircraft hangars (I through IV), but the IBC only recognizes Groups I, II, and III. The types of *fire protection systems* include the following:

- Foam–water deluge system
- Combination of an automatic sprinkler system per NFPA 13 and a low-level, low-expansion foam system
- Combination of an automatic sprinkler system per NFPA 13 and a high-expansion foam system
- Closed-head foam–water sprinkler system

The first two types are permitted for Group I hangars and all four are permitted for Group II hangars. Group III hangars are permitted to be protected as allowed by the IBC, but if any of the hazardous operations listed in IBC Section 412.4.6.1 occur, then one of the four systems listed above must be installed.

If a sprinkler system is provided, then the data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time.

There is one exception to the *fire protections system* which does not eliminate the protection but allows a reduction in the type of protection. The exception applies to *fixed base operators* with Group II hangars used solely for storage of *transient aircraft*. Defined by the IBC, a *fixed base operator* essentially means a commercial company that has operating rights on an airport. The exception requires a fire suppression system but does not require the foam requirements.

6.11.3 RESIDENTIAL AIRCRAFT HANGARS (IBC SECTION 412.5)

Residential aircraft hangars do not have the same construction and fire protection requirements as for the hangars discussed above. *Residential aircraft hangars* must either be in a *structure* physically separated from a *dwelling unit* or be separated using a *fire barrier*. The hangar is also required to have a *smoke alarm* installed in the hangar that is interconnected with the residential *smoke alarm*.

In addition to the physical or *fire barrier* separation, all mechanical, electrical, and plumbing systems installed in the hangar cannot be connected with systems in the residential unit.

6.11.4 AIRCRAFT PAINT HANGARS (IBC SECTION 412.6)

The application of flammable paint finishes is something that is regulated in several areas of the IBC. Since aircraft are typically large, the *structures* used to paint them far exceed the size of a normal paint booth. Therefore, requirements specifically addressing aircraft painting *facilities* are necessary.

The determination of whether or not this section is applicable is not dependent on the physical size of the building or the size of the aircraft. It is actually dependent on the quantity of paint (a *flammable liquid*) used. If the quantity of paint exceeds that allowed in IBC Table 307.1(1) for a *control area* (see Step 3), then the requirements of this section will apply. In theory, the larger the plane, the greater the quantity of paint, so large aircraft will likely exceed the allowable quantity.

If a *structure* is determined to be an aircraft paint hangar subject to this section, then the hangar must be classified as a Group H-2 occupancy, and the building must be of either Type I or II construction. The hangar must also have a *fire protection system* per NFPA 409 (see Step 6.11.2 above for an explanation of hangar *fire protection systems*). If a sprinkler system is provided, then the data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time.

6.11.5 AIRCRAFT MANUFACTURING FACILITIES (IBC SECTION 412.7)

Aircraft manufacturing *facilities* require buildings with large interior spaces to accommodate the aircraft. Since these spaces need large floor areas but typically have a low fire load and *occupant load*, the travel distances to *exits* are extended (see Step 10). However, as a trade-off for the increased travel distance, these *facilities* are required to be of Type I or II construction.

6.11.6 HELIPORTS AND HELISTOPS (IBC SECTION 412.8)

Heliports and *helistops* are *facilities* in support of helicopter operations. *Heliports* are like airports in that they provide full service for helicopters; whereas a *helistop* is also a *heliport*, that does not include maintenance, repair, storage, and fueling.

The landing area for helicopters weighing less than 3,500 pounds must be at least 20 feet square and have an average width at roof level of 15 feet but with a width no less than 5 feet.

The IBC requires compliance with NFPA 418 for rooftop *heliports* and *helistops*. Roof construction must be of noncombustible materials. Two *means of egress* are required and shall not be located on the same side of the landing area per NFPA 418. The IBC permits *heliports* or *helistops* with a landing area less than 60 feet in length and less than 2,000 sq. ft. in area to utilize a fire escape, alternating tread device, or ladder to the floor below as one of the required *means of egress*.

A Class I or III standpipe is required at the roof and a foam *fire protection system* is required per IFC Section 2007.5.

6.12 COMBUSTIBLE STORAGE (IBC SECTION 413)

This section addresses the storage of combustible materials in a typical small commercial or residential setting and within what is considered a large commercial or industrial setting. For the large commercial or industrial setting, such as in many warehouses, effective use of space requires the placing of materials as high as possible; this is what is termed as *high-piled combustible storage*.

The small commercial or residential storage setting typically includes storing materials wherever there is room. This could be in *attics*, under the floor, or in other concealed spaces. These spaces must be protected by either fire-resistive construction or an *automatic sprinkler system*. The fire-resistive construction or sprinkler protection is not required for Group R and U occupancies.

6.13 HAZARDOUS MATERIALS (IBC SECTION 414)

Regardless of whether *hazardous materials* are located in Group H occupancies or other occupancy groups, the buildings and adjacent areas where they are located must comply with some minimum requirements. The IBC and IFC provide requirements for the storage, dispensing, and use of *hazardous materials* for interior and exterior conditions. The IFC has extensive requirements contained in 18 chapters located in Part V of the code. The IBC, however, provides two sections, Sections 414.5 and 414.6, that address the building requirements related to these conditions, most of which reference back to the IFC.

For indoor conditions, *explosion* control is required for some chemicals that have *explosive* characteristics, whether they are classified as *explosives* or not. IBC Table 414.5.1 lists the material categories that pose an *explosive* hazard. For each category, the table indicates whether a barricade or *explosion* venting/prevention system is required. If a chemical's *explosive* characteristic is based on *deflagration* (e.g., the *explosion* created by the ignition of natural gas due to a leak is *deflagration*), the requirement is to provide venting or another method that prevents the potential for an *explosion*. If mechanical ventilation is provided, an *emergency power system* or a *standby power system* is required unless one of the exceptions is applicable. *Explosions* created by *detonation* are managed through barricade construction that deflects, vents, or withstands the blast overpressure.

Spill control and secondary containment are required for indoor and outdoor storage of *hazardous materials*. The intent of spill control is to prevent the flow of hazardous liquids into adjacent areas. Spill control is required for liquids in individual containers of more than 55 gallons or when the aggregate stored capacity in multiple containers exceeds 1,000 gallons. IFC Section 5004.2.1 provides four methods of spill control. Secondary containment for hazardous liquids and solids is required when liquids require spill control and when solids are stored in individual containers with a capacity exceeding 550 pounds or the aggregate capacity of multiple containers exceeds 10,000 pounds. IFC Section 5004.2.2 provides some basic requirements for secondary containment and references, via IFC Table 5004.2.2, individual chapters for specific requirements based on material category.

Per the IBC, when weather protection for outdoor storage of *hazardous materials* complies with the requirements of IBC Section 414.6.1, the *structure* is still considered outdoor storage and does not need to meet the indoor storage requirements. Walls are permitted on one or more sides provided they do not cover more than 25% of the perimeter, and the overhead *structure* must be of noncombustible materials.

An emergency alarm is required in Group H occupancies where *hazardous materials* are stored and along routes where *hazardous materials* are transported through a building's *means of egress* system. The *emergency alarm system* must be on a *standby power system*.

Group M display and storage areas and Group S storage areas are given some relief in IBC Section 414.2.5. These occupancy groups are permitted quantities that exceed IBC Tables 307.1(1) and 307.1(2) without classifying the building or use as a Group H occupancy. There are three caveats to this provision:

1. Materials are displayed and stored in accordance with the IFC.
2. The quantities do not exceed those indicated in IBC Table 414.2.5(1) per *control area*.
3. The materials are nonflammable solids, nonflammable liquids, or noncombustible liquids.

Similar to the other tables that establish maximum quantities, IBC Table 414.2.5(1) also has an extensive list of footnotes, two of which are nearly identical to the footnotes in the other tables for increases due to sprinkler system installation (footnote "b") and storage in *approved* cabinets (footnote "c"). These, too, are accumulative; therefore, a total of four times the indicated quantities are permitted if both footnotes are applicable.

6.14 GROUPS H-1, H-2, H-3, H-4, AND H-5 (IBC SECTION 415)

IBC Section 415 includes special provisions for Group H occupancies; some are general in scope and others are applicable to a specific Group H occupancy. The general requirements include an automatic fire detection system (IBC Section 415.3) and a sprinkler system installed throughout (IBC Section 415.4).

Group H occupancies also have specific *fire separation distances* that must be met even if other provisions of the IBC allow a closer distance. Furthermore, the distances are measured from the walls enclosing the occupancy, whether they are interior or *exterior walls*, to the nearest *lot line*—even if that *lot line* is on a *public way* (i.e., cannot measure to the center of the *public way* as provided in the definition for *fire separation distance*) (Figure 6.14-1). The required *fire separation distances* per occupancy consist of the following:

- Group H-1: 75 feet, but not less than that required by IFC Chapter 56. Buildings used for fireworks manufacturing are required to comply with the distances in NFPA 1124.
- Group H-2: 30 feet when the area of the Group H-2 occupancy exceeds 1000 sq. ft. and is not required to be a detached building.
- Groups H-2 and H-3: 50 feet when a detached building is required.
- Groups H-2 and H-3 (containing materials with *explosive* characteristics): Per IFC Section 5601.8.

For buildings where *explosives* are manufactured or used and required separation is determined using the quantity distances in accordance with the IFC, the *fire separation distance* shall be the dimension measured between buildings and not to assumed *lot lines*, since quantity distances are much farther than normal *fire separation distances*.

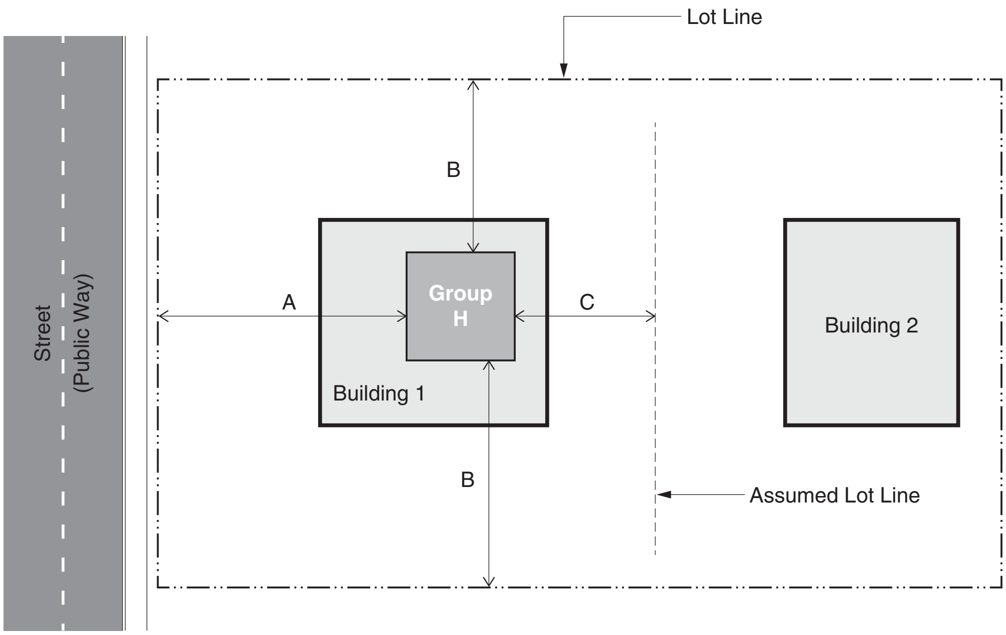

FIGURE 6.14-1. Measurement of *fire separation distances* for Group H occupancies. Distances are measured to *lot lines* (distance B) and assumed *lot lines* (distance C; except for manufacturing and use of *explosives* when quantity distances are used). Measurement is also to *lot lines* adjacent to *public ways* (distance A) and not to centerline.

Detached buildings for Groups H-1, H-2, and H-3 are required when the quantities exceed those indicated in IBC Table 415.6.2. If a detached building is required, wall and opening protection based on *fire separation distance* is not required. Specific requirements for each of the Group H occupancies are provided in IBC Sections 415.7 through 415.11 and are too numerous to discuss in detail.

Of all the high-hazard occupancy groups, Group H-5 has the longest list of special requirements (IBC Section 415.11). Since the response of building codes to industry changes is considered slow, the rapid rise of computer and other electronics has led to the increase of fabrication *facilities*, which were regulated inconsistently using provisions for occupancy groups in the codes used at that time. The process used for manufacturing in these fabrication *facilities* involve the use of *HPM*. As the definition states, the end product of the manufacturing process is not hazardous, just the materials used to make the end product.

The list of requirements for Group H-5, just in this section alone, is quite extensive. Therefore, the design professional involved in the semiconductor industry should become very familiar with these requirements. The requirements include special rooms for storage of *HPM*, *emergency alarm systems*, ventilation systems, gas detection systems, manual *fire alarm systems, emergency control stations*, and *emergency power systems*. These are in addition to the other systems required of all Group H occupancies previously mentioned.

6.15 APPLICATION OF FLAMMABLE FINISHES (IBC SECTION 416)

The hazard associated with the application of flammable finishes lies in the aerosolization of paint products. Although there is a level of hazard with paint products alone, the hazard increases when the paint is sprayed, creating an air–fuel mixture that can cause rapid *deflagration*. Therefore, special consideration is given to spaces that are used for this type of application.

Spray rooms, spray spaces, and spray booths will require ventilation systems that are designed in accordance with the IMC. Even though the principal concern of this section is with spray application of paints, some of the requirements are also applicable to other finish methods, including powder coating and dipping. For all finish application methods, an *automatic sprinkler system* or other *approved* fire-extinguishing system is required per IBC Chapter 9.

6.16 DRYING ROOMS (IBC SECTION 417)

In the manufacture of certain products, drying rooms or kilns are used to either cure a finish or adhesive or reduce moisture within a material. To induce the drying process, high temperatures are introduced into the drying rooms via steam or hot water piping, electrical resistance, or burning of fuel gas. Regardless of the heat source, there is the potential of igniting the materials subjected to the drying process. Therefore, drying rooms are required to be constructed of noncombustible materials, regardless of a building's construction type. If the materials used in a drying room are hazardous, then an *automatic sprinkler system* or other *approved* fire-extinguishing system is required per IBC Chapter 9.

6.17 ORGANIC COATINGS (IBC SECTION 418)

Users of the IBC may confuse this section with the IBC Chapter 4 section on flammable finishes previously discussed. Organic coatings are flammable finishes; however, this section is in regard to the manufacture of organic coatings and not the application.

Because of its *explosive* characteristics, this IBC section specifically mentions nitrocellulose. Nitrocellulose is used in many products, but since this section addresses coatings, only nitrocellulose used in the coatings industry is subject to its requirements. Nitrocellulose is used in some lacquer finishes, including nail polish and guitar finishes.

At this phase of a project, the only requirements of any significance include the following:

- The manufacture of organic coatings cannot be located in a building that includes other occupancies.
- The building cannot have pits or *basements*.
- Rooms used to store finished products that are flammable or combustible must be separated from the manufacturing area by fire-resistive construction.

6.18 LIVE/WORK UNITS (IBC SECTION 419)

Although the concept of *live/work units* has been around since long before the time of building codes, the idea slowly eroded away with the growth of large businesses and suburbanization. In order to revitalize urban districts, many jurisdictions have recognized and encouraged the live/work concept through zoning reforms.

If the nonresidential use (i.e., the "work" component of the *live/work unit*) does not exceed 10% of the *dwelling unit*, then the nonresidential use can be considered an accessory occupancy (see Step 5) and does not need to comply with the requirements of this section.

Live/work units are to be classified as Group R-2 occupancies with no requirement for fire-resistive separation between the residential and nonresidential uses. However, if the nonresidential use would otherwise be classified as a Group S or Group H occupancy, then the unit cannot be considered a *live/work unit* and will need to be considered a mixed-occupancy building.

As a *live/work unit*, there are some stipulated limitations in IBC Section 419.1.1 that will apply; otherwise, the unit will need to be considered a mixed-occupancy building. The limitations include the following:

- The *live/work unit* is limited to 3,000 sq. ft. in floor area.
- The nonresidential area cannot exceed 50% of the floor area of a *live/work unit*.
- The nonresidential use must be on the first floor or main floor of the *live/work unit*.
- If the resident hires workers or employees, not more than five can occupy the nonresidential area at any given time.

Since *live/work units* are residential occupancies, they are required to be sprinklered throughout. The data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time. Additionally, a monitored *fire alarm system* may be required if one of the following conditions exists per IBC Section 907.2.9:

- Any *live/work unit* is located more than two *stories* above the *lowest level of exit discharge*.
- Any *live/work unit* is located more than one *story* below the highest *level of exit discharge*.
- The building contains more than 16 *live/work units*.

6.19 GROUPS I-1, R-1, R-2, R-3, AND R-4 (IBC SECTION 420)

If the building includes any of these occupancy groups per Step 3, then the provisions within this IBC section are required in addition to other special requirements applied to these occupancy groups. Most of the special requirements in this section will be addressed in Step 15, but there are some requirements that essentially repeat others found in IBC Chapter 9.

IBC Section 420.5 requires that an automatic sprinkler system be installed throughout buildings with a Group R occupancy. Buildings with a Group I-1 *fire area* are also required to have an *automatic sprinkler system* throughout. If a sprinkler system is required, then the data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time. In addition to a sprinkler system, fire alarm and smoke detection systems are required in I-1, R-1, R-2, and R-4 per IBC Section 907.2.

Another requirement addressed in this section is the division of each *story* in Group I-1, Condition 2, occupancies into *smoke compartments*. The only areas that require the *smoke compartments* are *stories* used for patient care, treatment, or sleeping and other areas where the *occupant load* is 50 or greater. The *stories* must have a minimum of two *smoke compartments* each with an area not exceeding 22,500 sq. ft.; therefore, if the area of a single *story* is greater than 45,000 sq. ft., then three *smoke compartments* will be required.

6.20 HYDROGEN FUEL GAS ROOMS (IBC SECTION 421)

Hydrogen fuel is becoming more common and is frequently used in fuel cells to power electric motors and burned as a fuel for combustion engines. It is an environmentally friendly fuel, but, in the right mixture with air, the material can become volatile. For that reason, *facilities* that generate, store, distribute, or transport hydrogen fuel are subject to special requirements.

IBC Section 421 requires a ventilation and gas detection system in *hydrogen fuel gas rooms*. Hydrogen, being the smallest element, can escape through the walls of its containers and piping as well as through joints and other connections. Without the ventilation and gas detection systems, the leaking hydrogen will blend with the outside air to create that volatile mixture. The ventilation and gas detection systems are required to be connected to a *standby power system*.

6.21 AMBULATORY CARE FACILITIES (IBC SECTION 422)

Ambulatory care facilities were added to the IBC to accommodate the growing trend of smaller outpatient *facilities* that provide treatment or surgeries without having the need to stay in the *facilities* for 24 hours or more. This specialized use avoids having to comply with the extensive requirements for Group I but still addresses the unique nature of the use while classified as a Group B occupancy.

A sprinkler is required throughout the floor (not the entire building) if four or more care recipients are rendered *incapable of self-preservation* or if one or more care recipients are similarly incapable and they are located on floors other than the *level of exit discharge*. If the care is located on a level other than the *level of exit discharge*, then the floors below the care floor are required to be sprinklered, as well as any floors between the care floor and the *level of exit discharge*, including the *level of exit discharge*. If a sprinkler system is required, then the data collected in Step 2 should be revised to reflect a sprinkler system if one was not selected at that time.

In addition to a possible sprinkler system, a *fire alarm system* is required in all *ambulatory care facilities*.

Ambulatory care facilities are required to be separated into two or more *smoke compartments* if the care *facility* exceeds 10,000 sq. ft. on a single *story*. Each *smoke compartment* cannot be greater than 22,500 sq. ft.; therefore, if the *ambulatory care facility* on a single *story* is greater than 45,000 sq. ft., then three *smoke compartments* will be required.

6.22 STORM SHELTERS (IBC SECTION 423)

Requirements for *storm shelters* were added in the 2009 IBC and require compliance with ICC 500. IBC Section 423.1.1 stipulates that the requirements within the section apply to detached *structures* and safe rooms located within buildings for protection from high-wind storms, such as hurricanes and tornados. ICC 500 addresses the structural aspects of *storm shelters* as well as the minimum area per occupant, restroom *facilities*, and access.

There are two *facility* types where *storm shelters* are required to be provided in tornado regions:

- Critical emergency operation *facilities*, such as 9-1-1 call stations, emergency operation centers, and fire, rescue, ambulance, and police stations. The *storm shelter* is only required when the design wind speed for tornados is 250 MPH per the ICC 500 Figure 304.2(1).
- Group E occupancies where the *occupant load* is 50 or more and the design wind speed for tornados is 250 MPH per ICC 500 Figure 304.2(1). The *occupant load* of the shelter must be equal to or greater than the *occupant load* of the Group E occupancy. Day care *facilities* and Group E occupancies accessory to buildings for religious worship are exempted from the shelter requirement.

For both *facility* types, the shelter requirement does not apply if the building itself complies with the requirements of ICC 500.

6.23 CHILDREN'S PLAY STRUCTURES (IBC SECTION 424)

The requirements of this section only apply to play structures located within buildings of any occupancy group. Play structures that are 10 feet or less in height and 150 sq. ft. or less in area are exempted from the requirements of this section. Each play structure is limited to 300 sq. ft. in area. Much of the content within this section describes the types of combustible materials that are allowed in the construction of play structures.

In many cases, the owners of the buildings will purchase and install play structures independent of the construction contracts. However, the design professional should be aware of the owner's intent to provide play structures within the building because if the building is sprinklered the play structure will need to be provided with the same level of protection. Additionally, the design professional should be provided the size of the play structure, since a minimum separation of 5 feet is required between the play structure and building walls, partitions, and *means of egress* components. A minimum separation of 20 feet is required between individual play structures if more than one is provided within the same space.

6.24 HYPERBARIC FACILITIES (IBC SECTION 425)

Hyperbaric *facilities* include those that utilize oxygen at higher than normal pressures. Concentrated oxygen combusts rapidly; therefore, hyperbaric *facilities* must be protected from sources of fire. This section requires compliance with Chapter 20 of NFPA 99. The hyperbaric feature is actually a chamber located within a building. NFPA 99 identifies three classes of hyperbaric chambers:

- **Class A—**Multiple human occupancy
- **Class B—**Single human occupancy
- **Class C—**No human occupancy (animal only)

Some requirements addressed in NFPA 99 include the separation of Class A hyperbaric *facilities* from other portions of the building with 2-hour *fire barriers*. Class B and C chambers do not require separation. Class A chambers are also required to have a fixed deluge sprinkler system complying with the requirements of NFPA 99. The sprinkler system is not required throughout the building. Class B and C chambers are not required to have special fire protection, but, if part of a Group I occupancy or other occupancy requiring a sprinkler system, the hyperbaric *facility* will need to be sprinklered as required for the rest of the building.

6.25 COMBUSTIBLE DUSTS, GRAIN PROCESSING, AND STORAGE (IBC SECTION 426)

Spaces or *structures* where dusts are generated create a unique combustion hazard, especially when the dusts are suspended in the air for prolonged periods of time. At the right concentration, suspended dusts can be *explosive* and therefore require *explosion* control measures per the IFC and ventilation per the IMC. *Combustible dusts* can be generated within several types of functional areas, including wood shops, grinding areas, grain elevators, coal loading and storage (i.e., coal pockets per the IBC), and tire retreading (i.e., rebuilding per the IBC), some of which have specific requirements in this section.

IBC Section 426.1 requires compliance with the IFC and a number of NFPA standards that provide direction on specific applications:

- NFPA 61, *Standard for the Prevention of Fires and Dust Explosions in Agricultural and Food Processing Facilities*
- NFPA 85, *Boiler and Combustion Systems Hazards Code*
- NFPA 120, *Standard for Fire Prevention and Control in Coal Mines*
- NFPA 484, *Standard for Combustible Metals*

- NFPA 654, *Standard for the Prevention of Fire and Dust Explosions from the Manufacturing, Processing, and Handling of Combustible Particulate Solids*
- NFPA 655, *Standard for Prevention of Sulfur Fires and Explosions*
- NFPA 664, *Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities*

No specific references are provided for the IFC, but IFC Chapter 22 "Combustible Dust-Producing Operations" and, where an *explosion* hazard is present or potential, IFC Section 911 "Explosion Control" would be applicable for these types of *facilities*.

Grain elevators are permitted to have unlimited area and height if constructed of Type I or II construction. Type IV construction is allowed a maximum height of 65 feet, but in isolated areas this may be increased to 85 feet. Grain elevators cannot be located closer than 30 feet to an interior *lot line*, except along a railroad easement.

Grinding rooms that have *combustible dusts* that require it to be classified as a Group H-2 occupancy must be separated from other areas of the building with fire-resistive assemblies. For grinding areas not exceeding 3,000 sq. ft., 2-hour *fire barriers* and *horizontal assemblies* are required for the separation. For grinding areas over 3,000 sq. ft., the separations must have a 4-hour rating.

Coal pockets that are located less than 30 feet from interior *lot lines* or buildings on the same *lot* are required to be constructed of not less than Type IB construction. When they are located at more than 30 feet, the construction type shall not be less than Type IV when the height does not exceed 65 feet.

Tire rebuilding areas must also be separated from other parts of the building by 1-hour *fire barriers*. However, the separation is not required when one of the three exceptions are applicable. The three exceptions depend on the type of equipment that will be used, so the design professional should verify with the owner what equipment will be used before relying on any of the exceptions.

6.26 SPECIAL CONSTRUCTION

Special construction, covered in IBC Chapter 31, is uncommon building construction or building elements that have requirements that would not be easily prescribed in other areas of the IBC. Many of the structures and elements addressed in IBC Chapter 31 are of a minor nature and can be implemented at later phases of the project design, or they have no relevance to the focus of this book (e.g., temporary structures). However, there are two areas of special construction that should be addressed early in the design process.

6.26.1 MEMBRANE STRUCTURES (IBC SECTION 3102)

Membrane structures can come in many forms. The decision to use a membrane structure should come early in the design process, since their application is unique and may require consultants who specialize in this type of structure. The IBC identifies and defines seven different types of membrane structures. Regardless of the type of membrane structure considered, the requirements in IBC Section 3102 apply to all membrane structure types unless indicated otherwise.

Of key importance at this phase of design is the selection of a building construction type. As mentioned in Step 4, this is one of those areas where the construction type may need to be modified. If a membrane structure is used and the membrane fabric is noncombustible as determined per IBC Section 703.5, then the construction type will need to be of Type IIB construction per IBC Section 3102.3; otherwise, Type V construction must be used. Membrane structures supported by heavy timber frames are classified as Type IV construction.

The height and area of a membrane structure are also limited by this section. Per IBC Section 3102.5, membrane structures are limited to a maximum height of one story, unless they are used only as roofing on multistory buildings. The height in feet is limited by IBC Table 504.3, based on the construction type, and the allowable area is based on the requirements of IBC Section 506.

When a membrane structure is proposed to be a part of another structure with a different construction type, such as a *tensile membrane structure* over a courtyard of an office building, the requirements of IBC Section 3102.6 will need to be reviewed. The area of the membrane structure is included in the building area and the allowable area is based on the allowable area of the building. The membrane must be non-combustible, but IBC Section 3102.6.1.1 allows the use of a combustible membrane that has passed the tests for flame propagation per NFPA 701 in Type IIB, III, IV, and V construction as long as the membrane is located 20 feet or more above any occupiable floor area, including balconies and mezzanines.

For *air-inflated structures* or *air-supported structures*, if a structure has an area greater than 1,500 sq. ft., then an auxiliary inflation system will be required. The auxiliary inflation system is also required to be provided with a *standby power system*. Additionally, if these structures have an occupant load of 50 or more (see Step 8), then a secondary support system must be able to keep the membrane at least 20 feet above the floor or seating for roofs of Type I construction and 7 feet above the floor for other construction types and membrane uses. The secondary support for membranes over swimming pools is required regardless of occupant load.

6.26.2 PEDESTRIAN WALKWAYS AND TUNNELS (IBC SECTION 3104)

Pedestrian walkways and tunnels are structures that connect two or more buildings below grade, at grade, or above grade. When designed in accordance with IBC Section 3104, a pedestrian walkway or tunnel does not add to the building area for any buildings it connects, and the buildings it connects still remain as separate structures (unless considered together as a single building per IBC Section 503.1.2).

The minimum width of a pedestrian walkway or tunnel is 36 inches. If the pedestrian walkway or tunnel is used as a part of the *means of egress* system, then the width will need to be determined based on the occupant load proposed to use it per Step 19. The maximum width of a pedestrian walkway or tunnel is 30 feet.

EXAMPLE PROJECT—STEP 6

Of all the special uses and occupancies in the IBC, only two are applicable to the example project:

- **Parking Garage:** Since the parking garage is located in the basement, providing natural ventilation will be difficult in order to make this an open parking garage. Based on the limited area on the site, incorporating vent wells will not be practical. Therefore, the parking garage will be considered an enclosed parking garage per IBC Section 406.6.
- **Residential Group R-2:** Per IBC Section 420, the Group R-2 occupancy will require that the building be sprinklered throughout, and smoke alarms and a *fire alarm system* must also be provided.

STEP 7

Determine Allowable Area and Height

STEP OVERVIEW

The determination of allowable height and area depends on the two major classifications used in the IBC: construction type and occupancy group. As stated in Step 4, each building can only be classified as one construction type. However, each building can have more than one occupancy group as determined in Step 3. In Step 5, a decision was made on how mixed occupancies would be handled if more than one occupancy group exists in a building. These three steps must be completed before this step can proceed.

7.1 INTRODUCTION TO AREA AND HEIGHT REQUIREMENTS

In Step 5, a cursory evaluation regarding area and height was conducted in order to make a preliminary decision about how to handle mixed occupancies in a building. In Step 7, a complete analysis on *building area* and *building height* is conducted; in fact, it could be done concurrently with Step 5.

For those familiar with earlier editions of the IBC, the 2015 IBC introduces a new process for determining area and height, which could, initially, appear to be completely different from previous editions. However, the concepts remain the same and the main differences lie in the presentation of the requirements. Previously, the IBC provided one table for allowable area and height; any increases permitted for sprinkler systems and frontage were added to these allowable values. In the 2015 IBC, separate tables are provided for allowable area and height and include values for sprinklered and nonsprinklered buildings, thereby eliminating the need to perform calculations, except for the addition of frontage increases.

The IBC provides some general provisions that would modify the requirements covered within this step. IBC Section 503.1.1 allows special industrial buildings that require large areas and heights to exceed the limitations specified within IBC Chapter 5. The section offers some limited examples, but it would be wise

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to seek confirmation from the *building official* before proceeding in this direction to ensure the actual use will be accepted as a special industrial building.

Another general provision applies to buildings on the same *lot*. This may include the addition of new buildings on a *lot* with other existing buildings or two or more new buildings constructed on the same *lot*. Buildings on the same *lot* may be considered separate buildings or portions of the same building. If considered separate buildings, then an imaginary line (sometimes referred to as an "assumed *lot line*") would be placed between the buildings to determine *exterior wall* and opening protection (see Step 16.1). If considered portions of the same building, then the requirements for *exterior wall* and opening protection between the buildings would not apply, but the *building area* and *building height* would be limited to the building with the most restrictive requirements for height and area based on construction type and occupancy groups.

In order to perform this step completely, Steps 2, 3, 4, and 5 must be accomplished, at least preliminarily. The determination of area and height is predicated on the occupancies within the building and the construction type of the building. If multiple occupancies exist within the building, then the method used for handling mixed occupancies must also be decided.

Even though IBC Chapter 5 regulates *building area*, if the jurisdiction has adopted IFC Appendix B, then the allowable area may be even further restricted on the basis of available fire-flow at the project site. The area limitations in IFC Appendix B are based only on construction type with no reference to occupancy groups. Buildings that exceed the allowable areas of this appendix can be divided using *fire walls* with no openings to create smaller compliant areas.

7.2 DETERMINING ALLOWABLE HEIGHT (IBC SECTION 504)

Building height under the IBC is regulated in two ways: the maximum number of *stories* above the *grade plane* and the maximum height in feet from the *grade plane* to the median point of the highest roof (see Step 2). A building that exceeds the allowable height in feet but not in *stories* is still noncompliant with the IBC. The building is still noncompliant if the reverse is true (i.e., the building exceeds height in *stories* but not height in feet).

7.2.1 ALLOWABLE HEIGHT IN FEET

IBC Table 504.3 provides the allowable height in feet based on the construction type of the building and whether or not a sprinkler system is installed. The table lists the various occupancy groups vertically in the left column and the construction types across the top. The table is read by finding the applicable occupancy group on the left, then, based on the presence of a sprinkler system and type (NS for nonsprinklered, S for sprinklered per NFPA 13, or S13R for sprinklered per NFPA 13R), moving across the table in the applicable row to the column for the selected construction type. The intersection of the two provides the allowable height in feet. If UL is indicated, then the allowable height in feet is unlimited.

For the most part, if a building is sprinklered throughout, the allowable height is 20 feet more than the nonsprinklered height. There are a few exceptions to this rule. The first exception is for Group R buildings that are sprinklered using a NFPA 13R system, which limits them to a maximum of 60 feet in height regardless of construction type. The second exception is for certain Group I and H occupancies, which provide the same height for some or all construction types whether or not the building is sprinklered. Take note that these occupancy groups, as well as Group R, are required to have a sprinkler system; therefore, the heights for nonsprinklered buildings are only provided for evaluation of existing buildings per the IEBC and cannot be used for new buildings.

7.2.2 ALLOWABLE HEIGHT IN STORIES

Determining the allowable height in *stories* is very similar to the method used to determine height in feet; however, IBC Table 504.4 is used instead. The table is read by finding the occupancy group in the left column and moving across to the construction type using the applicable row based on the installation of a sprinkler system (NS for nonsprinklered, S for sprinklered per NFPA 13, or S13R for sprinklered per NFPA 13R). The intersection of the two provides the allowable height in *stories*. If UL is indicated, then the allowable height in *stories* is unlimited.

If a sprinkler system is installed throughout the building, an additional *story* is typically permitted. However, similar to the table for allowable height in feet, some occupancy groups have exceptions. For Group R occupancies that are protected with a NFPA 13R system, the height is limited to four *stories*. Additionally, Groups H, I, and R, which are required to have sprinkler systems installed, may have different allowable heights indicated for sprinklered and nonsprinklered buildings of which the latter is only used when evaluating existing buildings under the IEBC.

Floor levels complying with the requirements for *mezzanines* per IBC Section 505 (see Step 2) are not considered *stories*. Therefore, any conforming *mezzanines* in a building are not included when determining the number of *stories*.

7.2.3 ALLOWABLE HEIGHT FOR MIXED OCCUPANCIES

If a building contains multiple occupancy groups, then, per IBC Section 504.2, no occupancy group can be located at a height in feet or on a *story* greater than that allowed. The application of this requirement is dependent upon the method selected to handle mixed occupancies per Step 5.

For buildings using the nonseparated occupancies method, the height of the building is limited to the allowable height of the most restrictive occupancy group per IBC Section 508.3.2. To illustrate this application, consider a nonsprinklered Type VB building that includes nonseparated Group A-3 and B occupancies. Since the Group A-3 occupancy is the more restrictive of the two occupancy groups, the entire building will be limited to 40 feet per IBC Table 504.3 and one *story* in height per IBC Table 504.4.

For buildings using the separated occupancies method, the height of each occupancy group in the building is limited to the height indicated in the IBC tables per IBC Section 508.4.3. Using the example building in the previous paragraph, the Group A-3 occupancy is limited to 40 feet and one *story*, while the Group B occupancy is limited to 40 feet and two *stories*. Therefore, the entire building is permitted to be two *stories*, but the Group A-3 occupancy is limited to the first *story*.

7.3 DETERMINING ALLOWABLE AREA (IBC SECTION 506)

The allowable area for a *story* is determined per IBC Section 506.2 and is based on the areas provided in IBC Table 506.2, referred to as the "tabular allowable area," and requires that the occupancy groups be determined per Step 3 and construction type be selected per Step 4. Additionally, determining allowable area is also dependent on how mixed occupancies are proposed to be handled per Step 5. The allowable area of a *story* may be increased with the presence of a sprinkler system installed throughout and the size of the *yards* surrounding the perimeter of the building (i.e., frontage increase).

In regard to sprinkler systems, IBC Table 506.2 indicates four possible sprinkler system conditions: NS (nonsprinklered), S13R (sprinklered per NFPA 13R), S1 (single-story, sprinklered per NFPA 13), and SM (multistory, sprinklered per NFPA 13). Although NFPA 13R is included as a sprinkler condition in IBC Table 506.2, its use throughout a building does not permit an increase in the allowable area and is included in the table with an area equal to that for nonsprinklered buildings. To read IBC Table 506.2, start with the applicable occupancy group in the left column and move to the next column and select the row representing the building's sprinkler condition. Next, continue laterally to the column for the appropriate construction type and the value in that column is the allowable area.

The allowable areas assigned to each sprinkler system condition for each construction type in IBC Table 506.2 are based on multiples of the allowable area for nonsprinklered buildings of the same occupancy group and construction type. Multistory sprinklered buildings (SM) are allowed three times the area for a nonsprinklered building, while single-story sprinklered buildings (S1) have an allowable area that is four times the area for nonsprinklered buildings. Single-story sprinklered buildings are permitted more area per *story* than multistory buildings, since occupants can egress more efficiently horizontally rather than vertically down *stairways* or *ramps*.

7.3.1 CALCULATING FRONTAGE INCREASE

The allowable area determined in IBC Table 506.2 may be additionally increased if the perimeter of a building is provided with sufficient frontage, or open space, per IBC Section 506.3. In order to qualify for a frontage increase, more than 25% of a building's perimeter must be on a *public way* or have open space with a minimum width of 20 feet. Additionally, the open space must be on the same *lot* as the building or dedicated for public use and must be accessible by a street or fire lane (Figure 7.3.1-1).

To calculate the increase permitted, use IBC Equation 5-5:

$$I_f = [F/P - 0.25]W/30$$

where:

I_f = Frontage increase factor
F = Building perimeter that fronts a *public way* or open space with the minimum width (feet)
P = Full perimeter of the building (feet)
W = Width of *public way* or open space (feet)

The value of P is the complete perimeter of the building. If a building is divided by *fire walls*, then the value of P for each separated building will include the exteriors walls associated with the building plus the length of the *fire wall* or *walls* (Figure 7.3.1-2).

The value of F is determined by identifying the actual perimeter of a building that has a *public way* or open space with the minimum distance of 20 feet. If a *public way* or open space does not have a width of

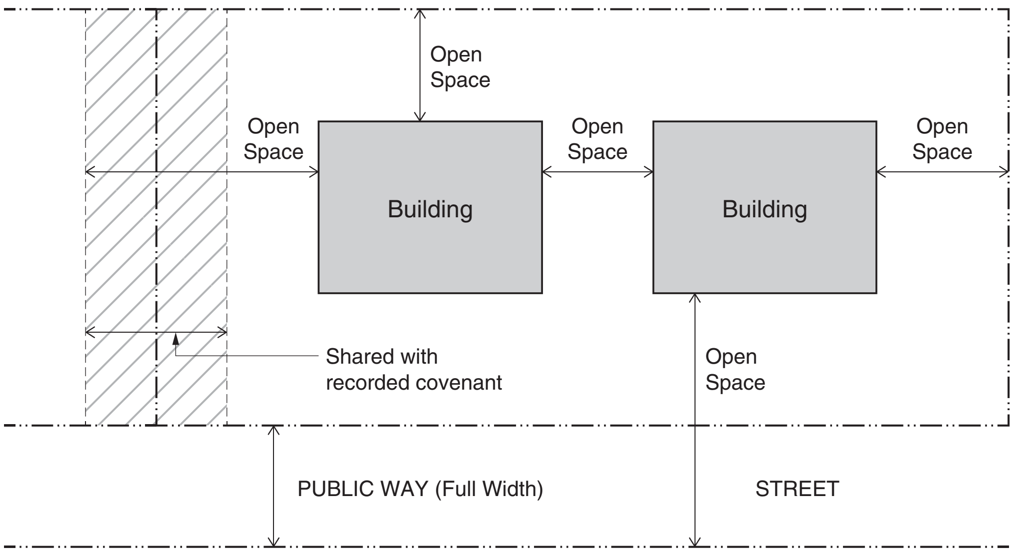
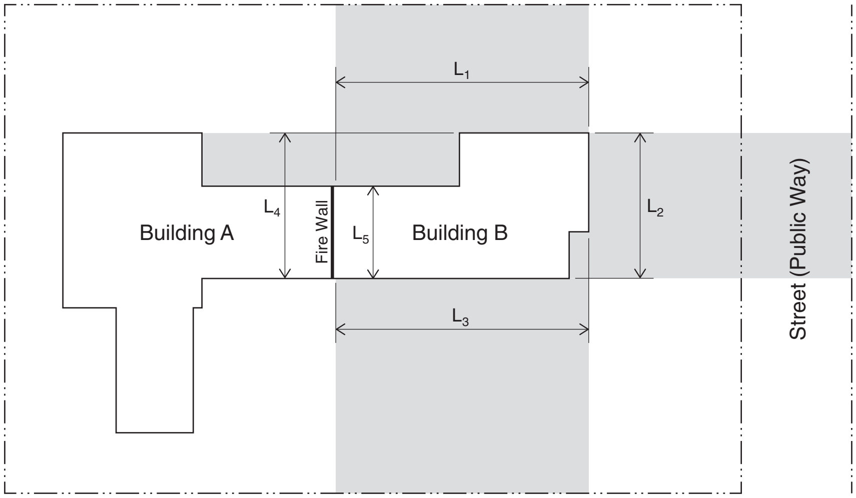


FIGURE 7.3.1-1. Allowable open spaces that may be used for a frontage increase.



Building B

Building Perimeter (P) = $L_1 + L_2 + L_3 + L_4$

Shaded areas are applicable open spaces for frontage (Assume all are 20 feet or greater)

Perimeter with Frontage (F) = $P - L_5$

FIGURE 7.3.1-2. Perimeter and frontage of a building separated by *fire walls*. The figure considers building B, but the perimeter and frontage for building A would be similar.

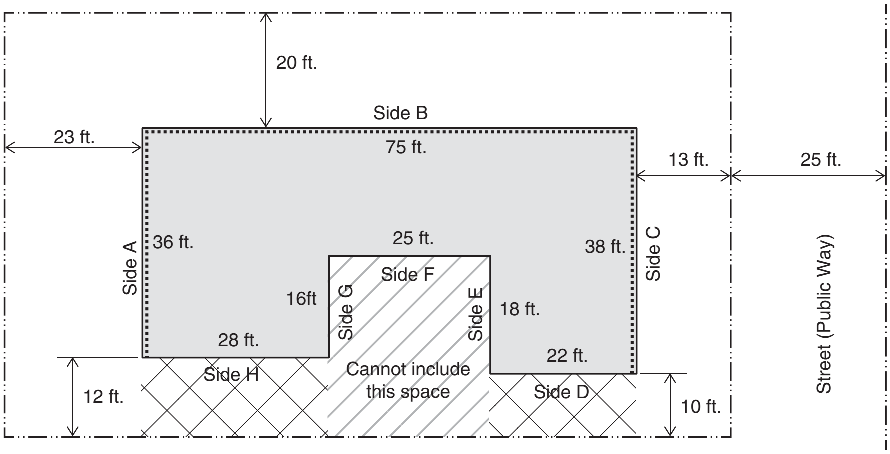


FIGURE 7.3.1-3. When determining the value of F, the building indicated may only include portions of the perimeter indicated as sides A, B, and C (indicated with dotted line). Sides D and H cannot be included, since each of the distances are less than 20 feet. Sides E, F, and G must also be excluded, even though their distances are greater than 20 feet, because those portions of the perimeter cannot be accessed by open spaces having the minimum distance.

20 feet or more, that portion of the building perimeter cannot be included. Similarly, if a building has *fire walls*, the portion of a building's perimeter consisting of *fire walls* will have no open space and cannot be included in the value of F (Figure 7.3.1-2). If an open space does have the minimum distance but must be accessed by open spaces that do not have the required minimum distance, then that portion cannot be included either (Figure 7.3.1-3).

Per IBC Section 506.3.2, the value of W must be at least 20 feet. However, if the width of the *public way* or open space exceeds 30 feet, then the value of W must be 30 feet; thus, the result of $W/30$ cannot exceed 1. The IBC does provide an exception that allows W to not exceed 60 feet if W is greater than 30 feet and the building qualifies for an unlimited area building per IBC Section 507 with the exception for compliance with the 60-foot *yard* (unlimited area buildings are discussed later in Step 7.3.4).

When all open spaces or *public ways* have a width of 30 feet or more, the calculation is very simple. For example, if a building has a full perimeter (P) of 300 feet, and 200 feet of that perimeter (F) has an open space of 30 feet or more (W), then the calculation would be as follows:

$$I_f = [200'/300' - 0.25]30'/30$$

$$I_f = [0.67 - 0.25]1$$

$$I_f = 0.42$$

The calculation becomes more complex when the open spaces and *public ways* surrounding a building have widths that vary between 20 and 30 feet.

To determine the value of W when the widths of the open spaces vary, a weighted average is calculated per IBC Equation 5-4:

$$W = (L_1 \times w_1 + L_2 \times w_2 + L_3 \times w_3 \; \dots)/F$$

where:

W = Weighted width to be used in Equation 5-5 (feet)

L_n = Length of perimeter wall with a width of w_n (feet)

w_n = Width of open space or *public way* for length L_n (feet). The value of w_n cannot be greater than 30 feet (60 feet per the exception).

F = Building perimeter that fronts a *public way* or open space with the minimum width (feet)

Using the building in Figure 7.3.1-3, the calculation for determining the value of W would be as follows:

$$W = (36' \times 23' + 75' \times 20' + 38' \times 30')/149'$$

$$W = (828 \text{ sq. ft.} + 1,500 \text{ sq. ft.} + 1,140 \text{ sq. ft.})/149'$$

$$W = 3,468 \text{ sq. ft.}/149'$$

$$W = 23.28'$$

Thus, the frontage increase would be calculated as follows:

$$I_f = [149'/258' - 0.25]23.28'/30$$

$$I_f = [0.58 - 0.25]0.78$$

$$I_f = [0.33]0.78$$

$$I_f = 0.26$$

The calculation of frontage increase for allowable area is essentially the ratio of the building perimeter with complying open space to the full perimeter of the building less the 25% of minimum frontage that is required in order to use the increase. The ratio is then further modified by the size of the open spaces; therefore, the larger the open spaces, the greater the increase permitted.

7.3.2 ALLOWABLE AREA OF SINGLE-OCCUPANCY AND NONSEPARATED MIXED-OCCUPANCY BUILDINGS

Calculating allowable area for a single-occupancy building is the simplest of the area calculations. Similarly, since nonseparated occupancies are limited to the allowable area for the most restrictive occupancy group, the allowable area will be the same as that for a single-occupancy building. Therefore, the calculations presented in this section are also to be used for buildings where all the occupancies in a building are considered nonseparated using the area requirements for the most restrictive occupancy group.

There are two separate processes for calculating allowable area of single-occupancy buildings: one for single-story buildings (Examples 7-A and 7-B) and one for multistory buildings (Examples 7-C and 7-D). Since the values provided in IBC Table 506.2 are for a single *story*, the allowable area for a single-story building is that value, unless increased for frontage. For multistory buildings, the total allowable area for the building is the value from IBC Table 506.2 plus any applicable increase for frontage multiplied by the number of *stories* up to three *stories*.

For single-story buildings, IBC Equation 5-1 is used:

$$A_a = A_t + (NS \times I_f)$$

where:

A_a = Allowable area (square feet)

A_t = Tabular allowable area per IBC Table 506.2 based on the building's sprinklered condition (NS, S13R, or S1) (square feet)

NS = Allowable area for a nonsprinklered building per IBC Table 506.2 (square feet)

I_f = Frontage increase factor

EXAMPLE 7-A: ALLOWABLE AREA FOR A SINGLE-STORY SINGLE-OCCUPANCY BUILDING

Given: A single-story, sprinklered Group B office building of Type VB construction. The building has a designed floor area of 38,500 sq. ft. Is the designed floor area within the allowable area?

Step 1: Use IBC Table 506.2 to find the tabular allowable area (A_t) for a Group B single-story building sprinklered per NFPA 13 (S1):

$A_t = 36{,}000$ sq. ft.

Note: If the building does not meet the requirements for a frontage increase, the determination of allowable area stops here, and the allowable area for the building is the area from IBC Table 506.2. Proceed to the next step if a frontage increase will be used.

Since the designed floor area in this example exceeds the tabular allowable floor area, a frontage increase must be considered or one of the options discussed in Step 7.5 must be implemented.

Step 2: Use IBC Table 506.2 to find the tabular allowable area for a nonsprinklered (NS) Group B building:

$NS = 9{,}000$ sq. ft.

Step 3: Calculate frontage increase (I_f). For purposes of this example, assume the following for the frontage increase:

$I_f = 0.35$

Step 4: Calculate the allowable area using IBC Equation 5-1:

$A_a = 36{,}000 \text{ sq. ft.} + (9{,}000 \text{ sq. ft.} \times 0.35)$

$A_a = 36{,}000 \text{ sq. ft.} + 3{,}150 \text{ sq. ft.}$

$A_a = 39{,}150 \text{ sq. ft.}$

The allowable area of 39,150 sq. ft. exceeds the designed floor area of 38,500 sq. ft.; therefore, the building complies with the code.

EXAMPLE 7-B: ALLOWABLE AREA FOR A SINGLE-STORY NONSEPARATED MIXED-OCCUPANCY BUILDING

Given: Using the building in Example 7-A, the program now includes an employee cafeteria, which is classified as a Group A-2 occupancy. The design professional does not want the cafeteria to be separated from the rest of the building with fire-resistive assemblies; therefore, the nonseparated occupancies method is used. Will the designed floor area still comply with the code for allowable area?

Step 1: Use IBC Table 506.2 to determine which occupancy group is the most restrictive for tabular allowable area (A_t) using the values for sprinklered single-story buildings (S1):

A_t (Group A-2) $= 24,000$ sq. ft.
A_t (Group B) $= 36,000$ sq. ft.

Since the allowable area for the Group A-2 occupancy is less than the allowable area for the Group B occupancy, Group A-2 is the most restrictive and will be used in the equation.

Step 2: Use IBC Table 506.2 to find the tabular allowable area for a nonsprinklered (NS) Group A-2 building:

$NS = 6,000$ sq. ft.

Step 3: Calculate frontage increase (I_f). For purposes of this example, assume the following for the frontage increase:

$I_f = 0.35$

Step 4: Calculate the allowable area using IBC Equation 5-1:

$A_a = 24,000$ sq. ft. $+$ $(6,000$ sq. ft. $\times$ $0.35)$
$A_a = 24,000$ sq. ft. $+$ $2,100$ sq. ft.
$A_a = 26,100$ sq. ft.

The allowable area of 26,100 sq. ft. is less than the designed floor area of 38,500 sq. ft.; therefore, the building does not comply with the code. See Step 7.5 for options available to the design professional when a building's designed floor area exceeds the allowable floor area.

Calculating allowable area for multistory, single-occupancy buildings is similar to that for single-story buildings. However, there is an added step for determining the total allowable *building area*, which includes multiplying the allowable area per *story* by the number of *stories* up to three *stories*. Thus, IBC Equation 5-2 is used:

$$A_a = [A_t + (NS \times I_f)] \times S_a$$

where:

A_a = Allowable area (square feet)
A_t = Tabular allowable area per IBC Table 506.2 based on the building's sprinklered condition (NS, S13R, or SM) (square feet)
NS = Allowable area for a nonsprinklered building per IBC Table 506.2 (square feet)
I_f = Frontage increase factor
S_a = Number of *stories* up to a maximum of three. If the building is sprinklered per NFPA 13R, the maximum number is four *stories*. To determine the allowable area for an individual *story*, S_a must equal 1.

EXAMPLE 7-C: ALLOWABLE AREA FOR A SINGLE-OCCUPANCY BUILDING WITH THREE OR LESS STORIES

Given: A two-story, sprinklered Group A-3 museum building of Type IIA construction. The building has a designed floor area of 42,200 sq. ft. per story and a total designed building area of 84,400 sq. ft. Is the designed floor area and the total designed building area within the allowable areas?

Step 1: Determine the tabular allowable area (A_t) for an individual story.

Use IBC Table 506.2 to find the tabular allowable area (A_t) for a Group A-3 multistory building sprinklered per NFPA 13 (SM):

$A_t = 46{,}500$ sq. ft.

Step 2: Calculate the allowable area (A_a) for an individual story.

Since the tabular allowable area exceeds the designed floor area, it is unnecessary to calculate an increase for frontage. Therefore, the value of NS × I_f will equal zero square feet, S_a will equal one story, and the allowable area per story in accordance with IBC Equation 5-2 will be as follows:

$A_a = [46,500 \text{ sq. ft.} + (0 \text{ sq. ft.})] \times 1 \text{ story} = 46,500 \text{ sq. ft.}$

Step 3: Determine the value of S_a.

Since the building is designed to be two stories, the total allowable building area can be twice the area permitted per story:

$S_a = 2$ stories

Step 4: Calculate the allowable area for the building using IBC Equation 5-2:

$A_a = [46,500 \text{ sq. ft.} + (0 \text{ sq. ft.})] \times 2 \text{ stories}$
$A_a = 46,500 \text{ sq. ft.} \times 2 \text{ stories}$
$A_a = 93,000 \text{ sq. ft.}$

The total allowable building area of 93,000 sq. ft. exceeds the total designed building area of 84,400 sq. ft.; therefore, the building complies with the code.

EXAMPLE 7-D: ALLOWABLE AREA FOR A SINGLE-OCCUPANCY BUILDING WITH MORE THAN THREE STORIES

Given: The client has decided to double the size of the building in Example 7-C and increase the building to four stories. (A Group A-3 of Type IIA construction is allowed four stories per IBC Table 504.4.) Each story will remain the same size at 42,200 sq. ft.; thus, it will increase the total designed building area to 168,800 sq. ft. Is the total designed building area still within the total allowable building area?

Step 1: Determine the tabular allowable area (A_t) for an individual story.

Use the tabular allowable area per story determined in Step 1 of Example 7-C:

$A_t = 46,500 \text{ sq. ft.}$

Step 2: Calculate the allowable area (A_a) for an individual story.

The allowable area per story is the same as that calculated in Step 2 of Example 7-C:

$A_a = 46,500 \text{ sq. ft.}$

Step 3: Determine the value of S_a.

The building is now to be designed as a four-story building; however, the total allowable building area can only be three times the area permitted per story:

$S_a = 3$ stories

Step 4: Calculate the allowable area for the building using IBC Equation 5-2:

$A_a = [46,500 \text{ sq. ft.} + (0 \text{ sq. ft.})] \times 3 \text{ stories}$

$A_a = 46,500 \text{ sq. ft.} \times 3 \text{ stories}$

$A_a = 139,500 \text{ sq. ft.}$

The total allowable building area of 139,500 sq. ft. is less than the total designed building area of 168,800 sq. ft.; therefore, the building does not comply with the code. However, it may comply if a frontage increase is considered.

Step 5: find the tabular allowable area for a nonsprinklered (NS) building per IBC Table 506.2.

For a Group A-3 building: $NS = 15{,}500$ sq. ft.

Step 6: Calculate frontage increase (I_f).

For purposes of this example, assume the following for the frontage increase:

$I_f = 0.70$

Step 6: Calculate the allowable area for the building using IBC Equation 5-2:

$A_a = [46,500 \text{ sq. ft.} + (15,500 \text{ sq. ft.} \times 0.70)] \times 3 \text{ stories}$

$A_a = [46,500 \text{ sq. ft.} + 10,850 \text{ sq. ft.}] \times 3 \text{ stories}$

$A_a = 57,350 \text{ sq. ft.} \times 3 \text{ stories}$

$A_a = 172,050 \text{ sq. ft.}$

The total allowable building area of 172,050 sq. ft. exceeds the total designed building area of 168,800 sq. ft.; therefore, the building complies with the code.

7.3.3 ALLOWABLE AREA OF SEPARATED MIXED-OCCUPANCY BUILDINGS

For separated mixed-occupancy buildings, there is no maximum allowable area to calculate like that for single-occupancy and nonseparated mixed-occupancy buildings. Rather, the allowable area of a separated mixed-occupancy building is based on the sum of the ratios of actual areas to allowable areas. Thus, the allowable area for each occupancy group present in the building must be calculated.

The calculation of allowable area for each occupancy group follows the same procedures used for single-occupancy buildings. For each occupancy group on each *story*, the ratio of actual floor area (or design floor area due to the early phase of the project) to allowable floor area is accomplished by dividing the actual area by the allowable area. Next, the ratios for each *story* are totaled and if the sum is less than or equal to 1, then the area of that *story* complies with the code. For multistory buildings, the sum of all ratios of all floors cannot exceed 2 for two-*story* buildings or 3 for buildings having three or more *stories*.

At this stage of the design process, actual areas are not known, so the programmed areas are used as a starting point. As the design is refined, the area calculations will need to be modified to ensure the allowable areas are based on the most current information.

For single-story buildings with separated mixed occupancies, IBC Equation 5-1 is also used:

$$A_a = A_t + (NS \times I_f)$$

where:

A_a = Allowable area (square feet)

A_t = Tabular allowable area per IBC Table 506.2 based on the building's sprinklered condition (NS, S13R, or S1) (square feet)

NS = Allowable area for a nonsprinklered building per IBC Table 506.2 (square feet)

I_f = Frontage increase factor

EXAMPLE 7-E: ALLOWABLE AREA FOR A SINGLE-STORY SEPARATED MIXED-OCCUPANCY BUILDING

Given: A single-story sprinklered fire station of Type VB construction includes the following spaces with their respective assigned occupancy groups and floor areas:

Breakdown of Building Area by Space and Occupancy Group

Space	Occupancy Group	Designed Floor Area
Office Area	Group B	7,200 sq. ft.
Apparatus Bays	Group S-2	16,800 sq. ft.
Sleeping Area	Group R-2	3,600 sq. ft.
Day Room	Group A-3	2,000 sq. ft.
Training Room	Group A-3	1,600 sq. ft.
Total		31,200 sq. ft.

Is the designed area within the allowable area?

Step 1: Determine the tabular allowable areas (A_t) for each occupancy group using the values for a single-story building sprinklered per NFPA 13 (S1) per IBC Table 506.2.

A_t (Group A-3) $= 24,000$ sq. ft.

A_t (Group B) $= 36,000$ sq. ft.

A_t (Group R-2) $= 28,000$ sq. ft.

A_t (Group S-2) $= 54,000$ sq. ft.

Step 2: Determine the tabular allowable area for each occupancy group using the values for a nonsprinklered (NS) building per IBC Table 506.2.

NS (Group A-3) $= 6,000$ sq. ft.

NS (Group B) $= 9,000$ sq. ft.

NS (Group R-2) $= 7,000$ sq. ft.

NS (Group S-2) $= 13,500$ sq. ft.

Step 3: Calculate frontage increase (I_f).

For purposes of this example, assume the following for the frontage increase:

$I_f = 0.32$

Step 4: Calculate the allowable area for each occupancy group using IBC Equation 5-1:

Group A-3:

$A_a = 24,000$ sq. ft. $+$ $(6,000$ sq. ft. $\times$ $0.32)$

$A_a = 24,000$ sq. ft. $+$ $1,920$ sq. ft.

$A_a = 25,920$ sq. ft.

Group B:

$A_a = 36,000 \text{ sq. ft.} + (9,000 \text{ sq. ft.} \times 0.32)$

$A_a = 36,000 \text{ sq. ft.} + 2,880 \text{ sq. ft.}$

$A_a = 38,880 \text{ sq. ft.}$

Group R-2:

$A_a = 28,000 \text{ sq. ft.} + (7,000 \text{ sq. ft.} \times 0.32)$

$A_a = 28,000 \text{ sq. ft.} + 2,240 \text{ sq. ft.}$

$A_a = 30,240 \text{ sq. ft.}$

Group S-2:

$A_a = 54,000 \text{ sq. ft.} + (13,500 \text{ sq. ft.} \times 0.32)$

$A_a = 54,000 \text{ sq. ft.} + 4,320 \text{ sq. ft.}$

$A_a = 58,320 \text{ sq. ft.}$

Step 5: Calculate the ratios of designed floor area to allowable area.

Group A-3: $3,600 \text{ sq. ft.} \div 25,920 \text{ sq. ft.} = 0.14$

Group B: $7,200 \text{ sq. ft.} \div 38,880 \text{ sq. ft.} = 0.19$

Group R-2: $3,600 \text{ sq. ft.} \div 30,240 \text{ sq. ft.} = 0.12$

Group S-2: $16,800 \text{ sq. ft.} \div 58,320 \text{ sq. ft.} = 0.29$

Step 6: Sum the ratios calculated in Step 5.

$0.14 + 0.19 + 0.12 + 0.29 = 0.74$

The sum of ratios (0.74) is less than 1; therefore, the building complies with the code.

Similar to single-story buildings with separated mixed occupancies, the sum of ratios of actual to allowable areas for each occupancy group on each *story* cannot exceed 1. The allowable areas are calculated using IBC Equation 5-3, which is similar to IBC Equation 5-1. The sum of ratios for all *stories* cannot exceed 2 for two-story buildings or 3 for buildings with three or more *stories*. When a building is sprinklered throughout using a NFPA 13R system, the sum of the ratios cannot exceed 4 for a building with four *stories*.

EXAMPLE 7-F: ALLOWABLE AREA FOR A MULTIPLE-STORY SEPARATED MIXED-OCCUPANCY BUILDING

Given: The building is similar to the fire station in Example 7-E, but some areas have been moved to a second story and the building is increased in area. Therefore, this example will be a two-story sprinklered fire station of Type VB construction, which includes the following spaces with their respective assigned occupancy groups and floor areas:

Breakdown of 1st-Story Floor Area by Space and Occupancy Group

Space	Occupancy Group	Designed Floor Area
Office Area	Group B	12,400 sq. ft.
Apparatus Bays	Group S-2	25,600 sq. ft.
Total		38,000 sq. ft.

Breakdown of 2nd-Story Floor Area by Space and Occupancy Group

Space	Occupancy Group	Designed Floor Area
Sleeping Area	Group R-2	7,200 sq. ft.
Day Room	Group A-3	2,000 sq. ft.
Training Room	Group A-3	3,200 sq. ft.
Total		12,400 sq. ft.

Is the designed area per story and for the total building area within the allowable area?

Step 1: Determine the tabular allowable areas (A_t) for each occupancy group using the values for a multistory building sprinklered per NFPA 13 (SM) per IBC Table 506.2. If a building is not sprinklered or is sprinklered only with a NFPA 13R system, then the nonsprinklered (NS) values are used for A_t.

A_t (Group A-3) = 18,000 sq. ft.
A_t (Group B) = 27,000 sq. ft.
A_t (Group R-2) = 21,000 sq. ft.
A_t (Group S-2) = 40,500 sq. ft.

Step 2: Determine the tabular allowable area for each occupancy group using the values for a nonsprinklered (NS) building per IBC Table 506.2.

NS (Group A-3) = 6,000 sq. ft.
NS (Group B) = 9,000 sq. ft.
NS (Group R-2) = 7,000 sq. ft.
NS (Group S-2) = 13,500 sq. ft.

Step 3: Calculate frontage increase (I_f).

For purposes of this example, assume the following for the frontage increase:

$I_f = 0.32$

Step 4: Calculate the allowable area for each occupancy group using IBC Equation 5-3:

Group A-3:

$A_a = 18{,}000$ sq. ft. $+$ (6,000 sq. ft. $\times$ 0.32)
$A_a = 18{,}000$ sq. ft. $+$ 1,920 sq. ft.
$A_a = 19{,}920$ sq. ft.

Group B:

$A_a = 27{,}000$ sq. ft. $+$ (9,000 sq. ft. $\times$ 0.32)
$A_a = 27{,}000$ sq. ft. $+$ 2,880 sq. ft.
$A_a = 29{,}880$ sq. ft.

Group R-2:

$A_a = 21{,}000$ sq. ft. $+$ (7,000 sq. ft. $\times$ 0.32)
$A_a = 21{,}000$ sq. ft. $+$ 2,240 sq. ft.
$A_a = 23{,}240$ sq. ft.

Group S-2:

$A_a = 40{,}500$ sq. ft. $+$ (13,500 sq. ft. $\times$ 0.32)
$A_a = 40{,}500$ sq. ft. $+$ 4,320 sq. ft.
$A_a = 44{,}820$ sq. ft.

Step 5: Calculate the ratios of designed floor area to allowable area for each story.

First Story:

Group B: 12, 400 sq. ft. ÷ 29, 880 sq. ft. = 0.41

Group S-2: 25, 600 sq. ft. ÷ 44, 820 sq. ft. = 0.57

Second Story:

Group A-3: 5, 200 sq. ft. ÷ 19, 920 sq. ft. = 0.26

Group R-2: 7, 200 sq. ft. ÷ 23, 240 sq. ft. = 0.30

Step 6: Sum the ratios calculated in Step 5 for each story.

First Story: 0.41 + 0.57 = 0.98

Second Story: 0.26 + 0.30 = 0.56

The sum of ratios for each story is less than 1; therefore, the building so far complies with the code.

Step 7: Sum the ratios calculated in Step 6 to determine if the building complies.

0.98 + 0.56 = 1.54

The sum of ratios for the building is less than 2 (for a two-story building); therefore, the building complies with the code.

7.3.4 UNLIMITED AREA BUILDINGS (IBC SECTION 507)

A building may be permitted unlimited area if it conforms to certain minimal requirements provided within one of the conditions described in IBC Section 507. Buildings of Type I construction that are allowed unlimited area and height per IBC Table 506.2 are not required to comply with the requirements of IBC Section 507 per IBC Section 503.1.3. For each of the conditions provided in IBC Section 507, buildings may not have *basements* that are more than one *story* below the *grade plane*. Additionally, each condition is independent and cannot be combined with other conditions.

Where a condition requires the building to be surrounded by *public ways* or *yards* of 60 feet or more, the widths of the open spaces shall be determined as described in Step 7.3.1 for frontage increases, except that the measurement shall be in all directions from the building and not just perpendicular to the face of the building. Some conditions allow the reduction of the required open space width to not less than 40 feet. As a compromise to the reduced width, the following is required:

- The reduced width cannot apply to more than 75% of the building perimeter.
- The *exterior walls* that face the reduced width must be of fire-resistive construction having a rating of 3 hours or more with openings having an equal *fire protection rating*.

Table 7.3.4-1 is a summary of the 11 conditions that allow unlimited area buildings.

7.4 SPECIAL PROVISIONS (IBC SECTION 510)

The IBC provides eight special provisions that are exemptions or modifications to the requirements within IBC Chapter 5. These special provisions are not applicable to all occupancy groups or construction types, but they will offer greater flexibility to the design team for many common conditions.

- **Horizontal Building Separation Allowance (IBC Section 510.2):** This special provision takes the *fire wall* concept and uses it in a horizontal condition and creates two or more buildings, one or more on top of the other (Figure 7.4-1). This is commonly referred to as “podium construction.” However, this allowance has some conditions that are required:

TABLE 7.3.4-1. Conditions Where Unlimited Area Buildings Are Permitted

Condition and IBC Section	**Occupancy Groups**	**60 ft. *Yards* Required / Reduction Allowed**	**Other Requirements**
Nonprinklered, one-story buildings; IBC Section 507.3	F-2 or S-2	Yes / Yes	None
Sprinklered, one-story buildings; IBC Section 507.4	A-4, B, F, M, or S	Yes / Yes	• Group A-4 is limited to construction types other than Type V construction. • Other occupancy groups can be of any construction type. • Sprinkler system must comply with NFPA 13. • Exceptions apply.
Mixed-occupancy buildings with Groups A-1 and A-2; IBC Section 507.4.1	A-1 and A-2 permitted within buildings complying with IBC Section 507.4	Yes / Yes	• Limited to buildings of Type I, II, III, and IV construction. • Groups A-1 and A-2 must be separated per IBC Section 508.4.4 with no reduction for the sprinkler system. • The areas of the Group A-1 and A-2 occupancies cannot exceed the areas allowed per IBC Section 503.1. • *Exit* doors from Group A-1 and A-2 occupancies to open directly to the exterior.
Sprinklered, two-story buildings;	B, F, M, or S	Yes / Yes	Sprinkler system must comply with NFPA 13.
IBC Section 507.5 Group A-3, Type II, sprinklered, one-story buildings; IBC Section 507.6	A-3	Yes / Yes	• Must be used as a place of religious worship, community hall, exhibition hall, gymnasium, lecture hall, indoor swimming pool, or indoor tennis court. • Cannot have a *stage* (*platforms* are permitted). • Sprinkler system must comply with NFPA 13.
Group A-3, Type III or IV, sprinklered, one-story buildings; IBC Section 507.7	A-3	Yes / No	• Must be used as a place of religious worship, community hall, exhibition hall, gymnasium, lecture hall, indoor swimming pool, or indoor tennis court. • Cannot have a *stage* (*platforms* are permitted). • Sprinkler system must comply with NFPA 13. • Floor elevation must be within 21 inches of street or grade level. • *Exits* must be provided with *ramps* to street or grade level.
Group H-2, H-3, and H-4 occupancies; IBC Section 507.8	H-2, H-3, and H-4 permitted within buildings complying with IBC Sections 507.4 and 507.5 having Group F or S occupancies	As permitted per IBC Sections 507.3 and 507.4	• The aggregate area of Group H occupancies cannot exceed 10% of building floor area or the allowable area determined per IBC Section 506 with any frontage increase based on the perimeter of each Group H that has an *exterior wall* fronting a *public way* or open space. • If the frontage is 25% or less of the Group H perimeter, no increase is permitted; however, Groups H-2 and H-3 must have at least 25% of their perimeter on an *exterior wall*. • The aggregate area of Group H occupancies with no *exterior walls* are limited to 25% of the allowable area determined per IBC Section 506.

(*continued*)

TABLE 7.3.4-1. (*Continued*)

Condition and IBC Section	**Occupancy Groups**	**60 ft. *Yards* Required / Reduction Allowed**	**Other Requirements**
			• Liquid dispensing and mixing rooms not exceeding 500 sq. ft., liquid storage rooms not exceeding 1000 sq. ft., and spray paint booths are not required to be located at the building perimeter. • Group H occupancies must be separated from the rest of building per IBC Table 508.4. • In two-story buildings, Group H occupancies are limited to not more than one *story above grade plane* unless permitted by IBC Section 504.
Unlimited mixed-occupancy buildings with Group H-5; IBC Section 507.9	B, F, H-5, M, or S	Yes / No	• Limited to two *stories* in height. • Limited to Type I or II construction. • Group H-5 must be separated from other occupancies per IBC Sections 415.11 and 508.4. • Group H-5 cannot exceed the allowable area permitted per IBC Section 503.1 including modifications, unless separated into areas less than allowable by 2-hour *fire barriers*.
Aircraft paint hangars; IBC Section 507.10	H-2	No / No	• Limited to one *story above grade plane*. • Comply with IBC Section 412.6. • Surrounded by *public ways* or yards not less than 1.5 times the *building height*.
Sprinklered Group E buildings; IBC Section 507.11	E	Yes / No	• Limited to one *story above grade plane*. • Limited to Type II, IIIA, or IV construction. • Each classroom must have not less than two *means of egress* with one being direct to the exterior. • Sprinkler system must comply with NFPA 13.
Motion picture theaters; IBC Section 507.12	A-1	Yes / Yes	• May be part of a mixed-occupancy building. • Limited to Type II construction. • Must be located on the first *story above grade plane*. • Building is sprinklered throughout per NFPA 13.
Covered and *open mall buildings* and *anchor buildings*; IBC Section 507.13	All occupancy groups permitted in *mall* and *anchor buildings*	Yes / Yes, per IBC Section 402.1.1	• Must comply with IBC Section 402. • Limited to three stories above grade plane.

- The horizontal separation between buildings is required to be a 3-hour *horizontal assembly*.
- Multiple buildings are permitted above the *horizontal assembly*. If buildings above the *horizontal assembly* are separated by *fire walls*, the *fire walls* are not required to extend below the *horizontal assembly*.
- The height of the combined buildings in feet is limited to the height (or heights) for a building (or buildings) located above the *horizontal assembly* per IBC Table 503, including any permitted increase; however, this height is measured from the *grade plane* and not the *horizontal assembly*.
- The building located below the *horizontal assembly* must comply with the following:
  - Must be of Type IA construction
  - Can be of any occupancy group or groups, except for Group H

    - Must be sprinklered throughout with a NFPA 13 system
    - Can be of multiple *stories*
  - The building (or buildings) above the *horizontal assembly* must comply with the following:
    - Can be of any construction type
    - Is limited to Group B, M, R, or S occupancies or one or more Group A occupancies, each with an *occupant load* less than 300
    - Is limited in *building height* in *stories* as determined per IBC Section 504, including a sprinkler increase if permitted. The number of *stories* is determined starting at the *horizontal assembly* and does not include the number of *stories* below the *horizontal assembly*.
    - Is limited in *building area* as determined per IBC Section 506, including permitted increases for a sprinkler system or frontage, if applicable
  - The *fire-resistance rating* of any *shafts*, *stairway* or *ramp* enclosures, or escalator openings penetrating the 3-hour *horizontal assembly* must be of 2-hour construction. However, if the enclosures below the *horizontal assembly* are of 3-hour construction, the enclosures above the *horizontal assembly* are permitted to be of 1-hour *fire barriers*, provided each of the following are met:
    - The building above the *horizontal assembly* is not of Type I construction.
    - The enclosures connect no more than three *stories*.
    - Openings in the 1-hour *fire barriers* above the *horizontal assembly* have a 1-hour *fire protection rating*.

- **Group S-2 Enclosed Parking Garage with Group S-2 Open Parking Garage above (IBC Section 510.3):** This special provision allows an *open parking garage* complying with IBC Section 406.5.4.1 to have enclosed parking levels at or below the *grade plane*. The enclosed parking garage portion complying with this special provision is considered a separate building. To utilize this special provision, five conditions must be met:

1. The allowable area of the building below the *open parking garage* shall be the sum of ratios of actual areas to allowable areas for each occupancy group as required for separated occupancies per IBC Section 508.4 and the sum of ratios shall not exceed 1.
2. The enclosed parking garage is of Type I or II construction but is not less than the fire resistance required for the *open parking garage*.
3. The height and number of tiers of the *open parking garage* complies with the limitations in IBC Section 406.5.4.
4. The floor assembly separating the enclosed parking garage from the *open parking garage* shall have a *fire-resistance rating* not less than the rating required for floor assemblies of the enclosed parking garage. The IBC does not require openings within the floor assembly to be protected.
5. The enclosed parking garage must be limited to private motor vehicles, either for storage or for parking. The enclosed parking garage may have an office and toilet room that does not have a total area exceeding 1,000 sq. ft., and it may also have mechanical rooms that are incidental to the operation of the parking garage.

- **Parking beneath Group R (IBC Section 510.4):** This special provision allows a Group R occupancy to have the number of *stories* allowed by the construction type to be determined from above a Group S-2 parking garage located below. The parking garage can be either open or enclosed and is limited to one *story* above the *grade plane* with an entrance at grade. The height of the building in feet is based on the construction type of the Group R and is measured from the *grade plane*.

The construction type for an *open parking garage* can be either Type I or IV, but if the parking garage is enclosed or is partially enclosed, then the construction type is limited to Type I. The floor separating the parking garage from the Group R shall conform to the construction selected for the parking garage. The *fire-resistance rating* for the floor separation shall be either 1 hour for a sprinklered building or 2 hours for a nonsprinklered building per IBC Table 508.4.

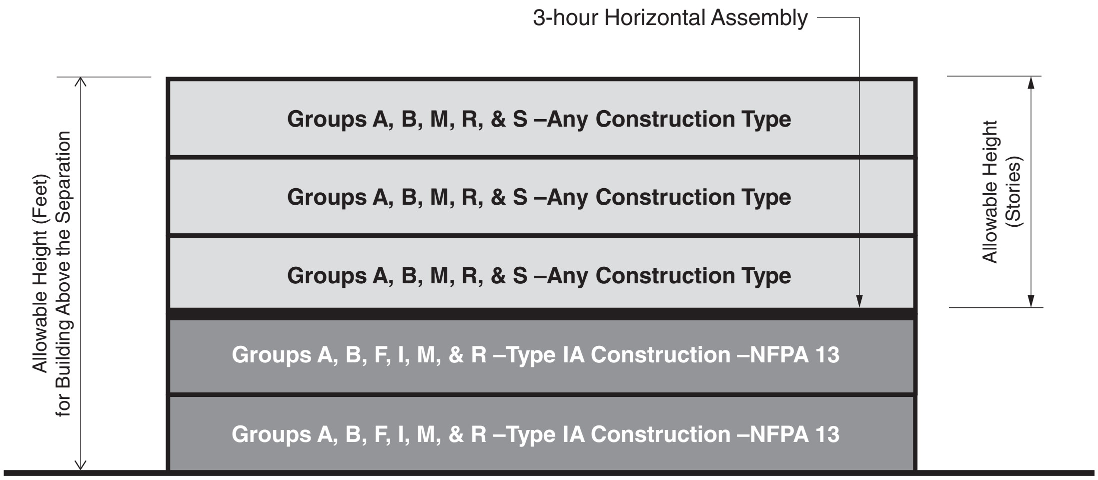


FIGURE 7.4-1. Horizontal building separation allowance requirements.

- **Group R-1 and R-2 Buildings of Type IIIA Construction (IBC Section 510.5):** This special provision allows a Group R-1 and R-2 building of Type IIIA construction to be constructed at six *stories* and 75 feet in height. Normally, a building of this construction type and occupancy groups would be limited to four *stories* and 60 feet if using a NFPA 13R sprinkler system; if a NFPA 13 sprinkler system is provided, this special provision would only increase the number of *stories* from five to six but reduce the allowable height from 85 to 75 feet.

The conditions required to use this special provision include constructing the first *story* of 3-hour construction, including the first floor assembly above the *grade plane*. The building shall also be divided into floor areas not exceeding 3,000 sq. ft. by *fire walls*. The *fire walls* must extend from the foundation to the roof and have 2-hour *fire-resistance ratings*.

- **Group R-1 and R-2 Buildings of Type IIA Construction (IBC Section 510.6):** Similar to the previous special provision, this special provision allows Group R-1 or R-2 buildings of Type IIA construction to be constructed at nine *stories* and 100 feet in height. The conditions for this special provision include the following:
  - Provide 50-foot open spaces between the building and adjacent *lot lines* and other buildings on the same *lot*.
  - Enclose *exits* with 2-hour *fire-resistance-rated fire walls* that extend from the foundation to the roof.
  - Provide a 1 1/2-hour *fire-resistance rating* for the first floor assembly above the *grade plane*. (Normally, a 1-hour assembly is required for Type IIA construction for floor assemblies.) This will require an equal rating for construction supporting the *horizontal assembly*.
- **Open Parking Garage beneath Groups A, I, B, M, and R (IBC Section 510.7):** This special provision allows an *open parking garage* complying with the requirements of IBC Section 406.5 to be located under *stories* including one or more of the occupancy groups indicated. Construction types may be mixed in the building; however, the *fire-resistance ratings* for structural members of the parking garage must be equal to or greater than that required for the portion of the building located above the parking garage. Because this special provision is limited, the use of IBC Section 510.2 might provide more flexibility. The conditions for this special provision include the following:
  - The part of the building located above the parking garage is limited in height and area per the requirements of IBC Section 503; however, the height in *stories* and in feet must be measured from the *grade plane* and must include the parking garage.

- *Means of egress* from the portion of building above the parking garage must comply with IBC Chapter 10 and be separated from the parking garage with 2-hour *fire barriers*.
- *Means of egress* from the *open parking garage* must comply with IBC Section 406.5.

• **Group B or M Buildings with Group S-2 Open Parking Garage Above (IBC Section 510.8):** This special provision allows an *open parking garage* located above the occupancy groups indicated and is the reverse of several other special provisions. The Group S-2 *open parking garage* and the Group B and M occupancies below are considered separate buildings and must be separated by a 2-hour *horizontal assembly*. In addition to these requirements, the following conditions must also be met:

- The construction type of the *open parking garage* must be of an equal or lesser type than that for the building below the *horizontal assembly*.
- The building below the *horizontal assembly* must be of Type IA construction. As an exception, the building may be of Type IB or II construction provided it is not less than the type of construction for the *open parking garage* and the building below the *horizontal assembly* is not more than one *story* above the *grade plane*.
- The building below the *horizontal assembly* cannot exceed the height and area provisions per IBC Section 503, which allows the utilization of applicable increases.
- The *open parking garage* above the *horizontal assembly* cannot exceed the height and area provisions of IBC Section 406.5. The height in feet and *stories* must be measured from the *grade plane*, which includes the building below the *horizontal assembly*.

• **Multiple Buildings above a Horizontal Assembly (IBC Section 510.9):** This special provision expands upon the requirements of IBC Sections 510.2, 510.3, and 510.8. The *horizontal assemblies* in these special provisions create at least two buildings: one below the *horizontal assembly* and one above the *horizontal assembly*. However, this section further specifies that more than one building is permitted above a complying *horizontal assembly*. Further, the buildings above the *horizontal assembly* can be completely separated buildings with open space between or they can be separated by *fire walls*. When *fire walls* are used, they must comply with the continuity requirements of IBC Section 706, except that the vertical continuity may terminate at the *horizontal assembly* instead of continuing to the foundation.

7.5 DESIGN OPTIONS

There is a possibility that the programmed *building area* or *building height* will exceed the allowable area or height based on early design decisions in the previous steps. If the allowable area or height is exceeded, there are several options available to the design professional that will permit the building to be designed without reducing the programmed area. However, most of the options may increase the cost of the project to varying degrees. It is for this reason that allowable area and height should be determined early in the design process so that adjustments can be made to either the program or the budget to compensate for code compliance.

• **Modify the Owner's Program:** Changing program requirements to comply with the building code is obviously not the best solution; however, it may be the only alternative if other solutions described later prove to be too costly to implement.

The easiest approach, but probably the least desirable from the project owner's perspective, is reducing the program scope. This usually involves reducing square footage across all programmed spaces, eliminating nonessential spaces, or a combination of both.

If *building height* is the issue, then programmed spaces located on *stories* above that allowed per IBC Chapter 5 will need to be reallocated to *stories* that are within the allowable height for those occupancy groups. If this method is considered, then the floor areas of the *stories* that are increased will need to be checked to ensure they do not exceed the allowable area per *story*. Another option is to move some of the spaces to one or more *basement* levels, which are not included in determining *building height*.

- **Add a Fire Wall:** As described in Part I, *fire walls* are used to divide a large building into two or more smaller buildings. Each building is treated independent of the other; thus, the height and area requirements for each building divided by a *fire wall* is calculated separately. Therefore, if a *fire wall* is used, Step 7 will need to be repeated to calculate the allowable area using revised information.

The cost of adding a *fire wall* to a project will vary depending on the length and height of the *fire wall*, the materials used, and the number of openings within the *fire wall*. In addition to cost, the inclusion of a *fire wall* could have an impact on the design of the building, especially if schematic floor plans have already been developed. Integrating a *fire wall* into a building design after the fact can prove challenging for the design team. A decision to use a *fire wall* should be made at the earliest possible time in the design process, which is why this step and the previous steps should be accomplished prior to initiating any type of design work.

- **Change Construction Type:** The construction type determined in Step 4 can be changed to a construction type that affords more allowable area or an increase in height. This option will also require repeating Step 7 using the new construction type. Changing the construction type will likely increase a project's cost, since materials, fire resistance, or both will require upgrading.
- **Add a Sprinkler System:** If a NFPA 13 sprinkler system is not already considered for the project, then the addition of one would definitely increase the allowable area. If the allowable height is exceeded by only one *story* or by less than 20 feet, then the addition of a sprinkler system will provide that needed extra *story* and 20 feet. Neither the NFPA 13R nor the 13D system will allow an area increase; however, the NFPA 13R system will allow for residential occupancies an additional *story* up to four *stories* and an additional 20 feet in height up to 60 feet, per IBC Tables 504.3 and 504.4. See Step 7.3 for further discussion on sprinkler system increases.

The installation of a sprinkler system will definitely have an impact on the project budget, but, unlike *fire walls*, sprinklers are much easier to integrate into a building design that has progressed into the floor plan stage.

- **Consider an Unlimited Area Building Application:** Verify if the building could meet one of the conditions for an unlimited area building. If the building exceeds the allowable height, whether in number of *stories* or in feet, this option will not resolve that problem. See Step 7.3.3 for further discussion on unlimited area buildings.
- **Use the Separated Occupancies Method:** If the allowable area is calculated based on the non-separated occupancies method, then the conversion to the separated occupancies method, either partially or completely, may allow a building with greater floor area. This may also be the case in regard to allowable height. By separating floors per the separated occupancies method, occupancy groups with greater allowable heights can be located on *stories* higher than those with lower allowable heights.

The implementation of this option will have its disadvantages. The cost of *fire barriers*, *horizontal assemblies*, and their respective protected openings will impact the budget. Additionally, the fire-resistive assemblies may limit the openness between spaces, if that was a design goal.

- **Consider a Special Provision Application:** The special provisions in IBC Section 510 may allow increasing the *building height* or *building area* with minimal impact to the construction budget.

EXAMPLE PROJECT—STEP 7

To prepare for this step, the information from previous steps are summarized below:

Step 2:

- Total Building Area: 60,000 sq. ft. (not including basement)
- Number of Stories: 4 stories
- Building Area per Story:
  - Basement: 15,000 sq. ft. (Parking)
  - 1st Story: 15,000 sq. ft.
  - 2nd Story: 15,000 sq. ft.
  - 3rd Story: 15,000 sq. ft.
  - 4th Story: 15,000 sq. ft.
- Building Height in Feet: 42 feet
- Sprinkler System: NFPA 13R

Step 3:

- The occupancy groups assigned to the programmed building spaces in Step 3 are listed below with their respective programmed floor areas for the first story:

Breakdown of 1st-Story Floor Area by Space and Occupancy Group

Occupancy Group	Programmed Spaces	Designed Floor Area
Group A-2	Dining Hall and Kitchen, Public Restrooms, Circulation	7,700 sq. ft.
Group A-3	Lounge and Covered Outdoor Patio	1,600 sq. ft.
Group B	Management Office, Exercise Room, Study Rooms	2,000 sq. ft.
Group M	Convenience Shop	950 sq. ft.
Group R-2	Manager's Apartment, Trash Room, Mechanical Room	2,450 sq. ft.
Group S-1	Mail Room	300 sq. ft.
Total		15,000 sq. ft.

- Stories 2 through 4 are entirely Group R-2.

Step 4:

- Construction Type: VA

Step 5:

- Mixed Occupancies: Combination of separated and nonseparated occupancies. First story is nonseparated, but it is separated from the second story and the basement.

Step 6:

- Parking Garage: Parking in basement is treated as a Group S-2 enclosed parking garage.

ALLOWABLE HEIGHT

- Height in Feet:
  - Per IBC Table 504.3, the maximum height in feet for all occupancy groups in the building, except Group R-2, is 50 feet. Group R-2 is allowed 60 feet with the NFPA 13R system (S13R).

- The building height is 42 feet, which is less than 50 feet; therefore, the height in feet complies with the code.
- Height in Stories:
  - With the exception of Group R-2, all occupancies are located on the first story per IBC Table 504.4. Therefore, all occupancies, except Group R-2, are within the allowable height in stories if the first story is separated from the second story per the requirements for separated occupancies.
  - Group R-2 occupancies per IBC Table 504.4 allows four stories with a NFPA 13R system (S13R). Since a Group R-2 occupies the fourth story, and the maximum height of the building is four stories, then the building complies with the code.

ALLOWABLE AREA

Based on the information provided in previous steps, the determination of the allowable area for the Example Project can proceed following the process used in Example 7-F, since the building is a mixed-occupancy, multistory building:

Step 1: Determine the tabular allowable areas (A_t) for each occupancy group using the values for nonsprinklered buildings (NS) and values for buildings sprinklered per NFPA 13R (S13R), where applicable.

A_t (Group A-2) = 11,500 sq. ft. (Most Restrictive)
A_t (Group A-3) = 11,500 sq. ft. (Most Restrictive)
A_t (Group B) = 18,000 sq. ft.
A_t (Group R-2) = 12,000 sq. ft.
A_t (Group S-1) = 14,000 sq. ft.
A_t (Group S-2) = 21,000 sq. ft.

Step 2: Determine the tabular allowable area for each occupancy group using the values for a nonsprinklered (NS) building per IBC Table 506.2, which are the same values determined in Example Step 1.

NS (Group A-2) = 11,500 sq. ft. (Most Restrictive)
NS (Group A-3) = 11,500 sq. ft. (Most Restrictive)
NS (Group B) = 18,000 sq. ft.
NS (Group R-2) = 12,000 sq. ft.
NS (Group S-1) = 14,000 sq. ft.
NS (Group S-2) = 21,000 sq. ft.

Since the Group A occupancies are the most restrictive, the allowable area for that occupancy group will be used to determine allowable area for the first story.

Step 3: Calculate frontage increase (I_f).

At this point, no design has been produced to determine how it is situated on the site in order to establish the fire separation distances. However, since the area of the building and the site dimensions are known, some assumptions based on a logical analysis can be generated.

At 15,000 sq. ft., the building dimensions could be about 122 feet square. Since the narrow side of the site is 108 feet wide, this would exceed the lot size. To allow 100% of the building perimeter, the yards on the north, east, and west sides need to be at least 20 feet. Assuming the zoning requires 10-foot setbacks at streets, this leaves a maximum width of 78 feet on the short sides. Thus, the north and south dimensions will be approximately 193 feet based on a 15,000 sq. ft. building area (15,000 ft. ÷ 78 ft. = approx. 193 ft.). The open space on all sides will be greater than 30 feet (See Example Project Figure 7-1).

Since all spaces have open spaces greater than 30 feet, the value of *W* will be 30 feet:

$I_f = [F/P - 0.25]W/30$ (IBC Equation 5-5)

$F = 542$ ft.

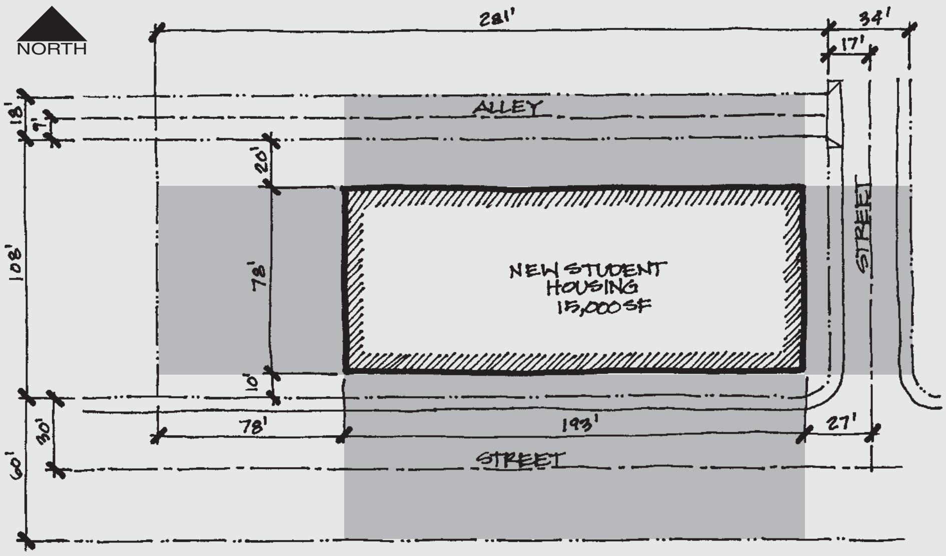
$P = 542$ ft.

$W = 30$ ft.

$I_f = [542 \text{ ft.}/542 \text{ ft.} - 0.25]\ 30 \text{ ft.}/30 \text{ ft.}$

$I_f = [1 - 0.25]1$

$I_f = 0.75$



EXAMPLE PROJECT FIGURE 7-1. Assumed building location on the project site for purposes of determining frontage increase at this preliminary stage of design. Shaded areas indicate eligible open spaces for a frontage increase.

Step 4: Calculate the allowable area for each occupancy group using IBC Equation 5-3:

Group A-2:

$A_a = 11,500 \text{ sq. ft.} + (11,500 \text{ sq. ft.} \times 0.75)$

$A_a = 11,500 \text{ sq. ft.} + 8,625 \text{ sq. ft.}$

$A_a = 20,125 \text{ sq. ft.}$

Group R-2:

$A_a = 12,000 \text{ sq. ft.} + (12,000 \text{ sq. ft.} \times 0.75)$

$A_a = 12,000 \text{ sq. ft.} + 9,000 \text{ sq. ft.}$

$A_a = 21,000 \text{ sq. ft.}$

Group S-2:

$A_a = 21,000 \text{ sq. ft.} + (21,000 \text{ sq. ft.} \times 0.75)$

$A_a = 21,000 \text{ sq. ft.} + 15,750 \text{ sq. ft.}$

$A_a = 36,750 \text{ sq. ft.}$

Step 5: Calculate the ratios of designed floor area to allowable area for each story.

Basement: Group S-2: 15,000 sq. ft. ÷ 36,750 sq. ft. = 0.41
1st Story: Group A-2: 15,000 sq. ft. ÷ 20,125 sq. ft. = 0.76
2nd Story: Group R-2: 15,000 sq. ft. ÷ 21,000 sq. ft. = 0.71
3rd Story: Group R-2: 15,000 sq. ft. ÷ 21,000 sq. ft. = 0.71
4th Story: Group R-2: 15,000 sq. ft. ÷ 21,000 sq. ft. = 0.71

Step 6: Sum the ratios calculated in Step 5 for each story.

Basement: 0.41 ≤ 1, therefore, okay
1st Story: 0.76 ≤ 1; therefore, okay
2nd Story: 0.71 ≤ 1; therefore, okay
3rd Story: 0.71 ≤ 1; therefore, okay
4th Story: 0.71 ≤ 1; therefore, okay
The sum of ratios per story is less than 1; therefore, the building so far complies with the code.

Step 7: Sum the ratios calculated in Step 6 to determine if the building complies.

The basement is not included, since one basement level can be excluded from the allowable building area:

$0.76 + 0.71 + 0.71 + 0.71 = 2.89 \leq 4$

The sum of ratios for the building is less than 4 (for a four-story building per the exception to IBC Section 506.2.4); therefore, the building complies with the code.

STEP 8

Calculate Occupant Load

STEP OVERVIEW

Calculating *occupant loads* is one of the most critical steps in applying the building code. *Occupant load* has a significant impact on the capacity of the *means of egress* system, the number of *exits* required, and the number of plumbing fixtures required. Additionally, if a sprinkler system is not already considered, the *occupant load* may require that a system be installed.

8.1 INTRODUCTION TO OCCUPANT LOADS

During this phase of design, accurate sizes of rooms and spaces may not be well defined, especially if this step is performed during the programming phase before any design work has begun. Therefore, the *occupant loads* determined during this phase will be a rough order of magnitude that initializes the development of the *means of egress* system. As the building design is developed further, this step will need to be revisited to ensure that the *occupant loads* are based on the most current information.

Each space within a building will have a predetermined use that is then compared to IBC Table 1004.1.2 to determine the *occupant load* factor for that use. This use may or may not directly correlate with the occupancy group classification in which the space was assigned per Step 5. For example, an office building, classified as a Group B occupancy, would be considered a "business area" per IBC Table 1004.1.2, which would correlate very well. However, the office building may also include a small employee training classroom, also classified as a Group B (*occupant load* is less than 50 per IBC Section 303.1.2), but would have a use more in line with the "Classroom area" load factor per IBC Table 1004.1.2.

As previously mentioned, the *occupant load* is used to determine *means of egress* and plumbing fixtures, which have significant influence on the design of a building. In regard to *means of egress*, the *occupant*

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load will determine the number of *stairways* required for *stories* located above and below the *level of exit discharge*. If the *occupant load* is calculated too low early in design but is corrected later after the floor plans are developed, it will be very difficult to insert an extra *stairway* if the revised *occupant load* requires another *exit*. Likewise, if the plumbing fixture count is based on an underdetermined *occupant load*, then the task of inserting additional fixtures into a restroom may prove problematic if the floor plan has been developed.

8.2 CALCULATING OCCUPANT LOADS

The *occupant load* of each space and *story*, as well as for the entire building, is determined based on the function of the spaces within the building. For most areas, the *occupant load* is determined using *occupant load* factors provided in IBC Table 1004.1.2. However, some assembly spaces are based on the permanent seating provided.

The *occupant load* factors in IBC Table 1004.1.2 are given as either "gross" or "net" floor areas, which are defined by the IBC. The significant difference between the two is what is and is not specifically included in determining those values.

Gross floor area, like *building area*, includes everything within the *exterior walls* and any usable space under the projection of the roof or floor above. The definition specifies further that no deduction is to be made for *corridors*, *stairways*, closets, walls, columns, and other features of the building. However, if a *shaft* is provided and there are no means to allow a person to occupy the area within that *shaft*, then the area of the *shaft* may be excluded. Likewise, vent *shafts* and *courts* are also excluded (see Step 2.1 for discussion on *building area*, vent *shafts*, and *courts*).

Net floor area includes only the occupiable area of the floor within a space. Thus, it excludes walls, columns, and built-in fixtures like cabinets as well as all of the other features included in the *gross floor area*.

For areas without fixed seating, IBC Section 1004.1.2 has an exception that allows the use of an *occupant load* that is less than the load determined through calculation. In order to use this exception, the design professional is advised to obtain the required approval from the *building official* early in a project's design process. It could prove detrimental if a reduced *occupant load* is incorporated into the design only to have it later denied by the *building official*.

On the other hand, IBC Section 1004.2 allows any *occupant load* to be greater than the load calculated. There are a couple of restrictions when using this option:

- All *means of egress* components must be sized for the increased *occupant load*.
- The *occupant load* cannot exceed 7 sq. ft. per occupant.

For areas with fixed seating, the *occupant load* is based on the capacity of the seating provided. For seating with arms, the *occupant load* is based on one person per seat. The *occupant load* for seating without arms, such as bench seating and pews, is calculated based on the length of the seat divided by 18 inches per occupant (Figure 8.2-1(a)). For booths, such as that used in a restaurant, the *occupant load* is based on one person for every 24 inches of booth length measured at the seat back (Figure 8.2-1(b)).

Outdoor areas, such as *courts*, patios, and *yards*, must also be provided with a *means of egress*. IBC Section 1004.5 states that the *building official* will assign the *occupant load* for those spaces based on the expected use. However, at this phase of the design, the *building official* or someone representing

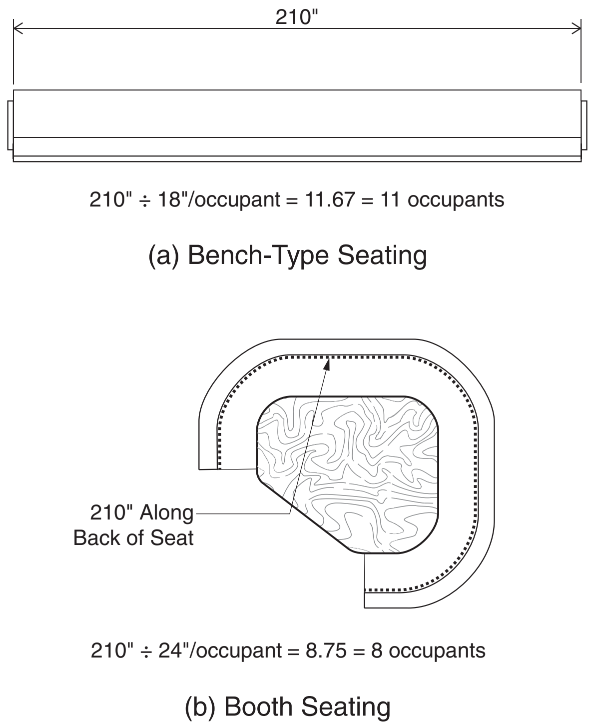


FIGURE 8.2-1. Determining occupant for seating without arms.

the *building official* may not be involved on the project yet. Therefore, an *occupant load* factor that is most representative of the expected use should be assigned. For example, if a patio is used for outdoor dining with tables and chairs, then the application of the unconcentrated assembly load factor would be appropriate.

If the occupants of an outdoor area are required to egress through the interior of the building, then the egress components used by the outdoor *occupant load* must be sized for the sum of the outdoor and indoor *occupant loads* using the same egress components. The only exceptions to this provision are outdoor spaces of Group R-3 and *dwelling units* of Group R-2, and spaces used solely for the purpose of servicing the building are only required to have one *means of egress*.

Knowing these details for calculating *occupant loads* is important, but since this step is initially performed during the schematic design or programming phase, the details have little meaning when the design itself has no details. Consequently, whether the initial *occupant load* is based on programming data or roughly sketched floor plans, the *occupant loads* will generally be based on *gross floor areas*. For example, per the IBC the *occupant load* for an assembly space or classroom is based on the *net floor area*, but wall thicknesses, column locations, cabinetry, and other fixed elements of the space are not yet defined. Therefore, the true net area of the space cannot be determined and the *occupant load* should be based on the gross programmed area until the design develops to a more refined level.

8.2.1 CALCULATING OCCUPANT LOADS FOR MALL BUILDINGS

The determination of *occupant loads* for *covered mall buildings* and *open mall buildings* differs from the process used for other building types. The *occupant load* factor of the *mall* is based on the *gross leasable area*, which is the floor area dedicated for tenant use only. The *gross leasable area* does not include the *anchor buildings*. Tenant spaces that have their own *means of egress* independent of the *mall* are not required to be included in the *gross leasable area*. To calculate the *occupant load* factor, IBC Equation 4-1 is used:

$$OLF = (0.00007)(GLA) + 25$$

where:

OLF = *Occupant load factor*, which is the required area per occupant in square feet

GLA = *Gross leasable area* in square feet

The *OLF* is not required to be less than 30 and cannot be more than 50. The total *occupant load* for the purpose of determining *means of egress* sizing is calculated by multiplying the *OLF* by the area of the *mall*. If the *mall* includes a *food court*, the *occupant load* of the *food court* shall be determined per IBC Section 1004 and added to the *occupant load* of the *mall*. The *occupant loads* of tenant spaces within a *covered mall building* or *open mall building* and of *anchor buildings* are required to be determined individually per IBC Section 1004. Example 8-A provides the process for determining the *occupant load* for a *covered mall building*.

EXAMPLE 8-A: CALCULATING MALL OCCUPANT LOAD

Given: A covered mall building with gross leasable area of 38,940 sq. ft., mall area of 16,150 sq. ft., food court area of 4,050 sq. ft., and tenant and anchor building areas as indicated in the table below. What are the occupant loads for each portion of the covered mall building and anchor buildings?

Breakdown of Floor Areas for Tenant Spaces and Anchor Buildings

Space	Floor Area
Anchor Building "A"	38,840 sq. ft.
Anchor Building "B"	32,720 sq. ft.
Tenant Space "A"	15,530 sq. ft.
Tenant Space "B"	13,520 sq. ft.
Tenant Space "C"	9,900 sq. ft.

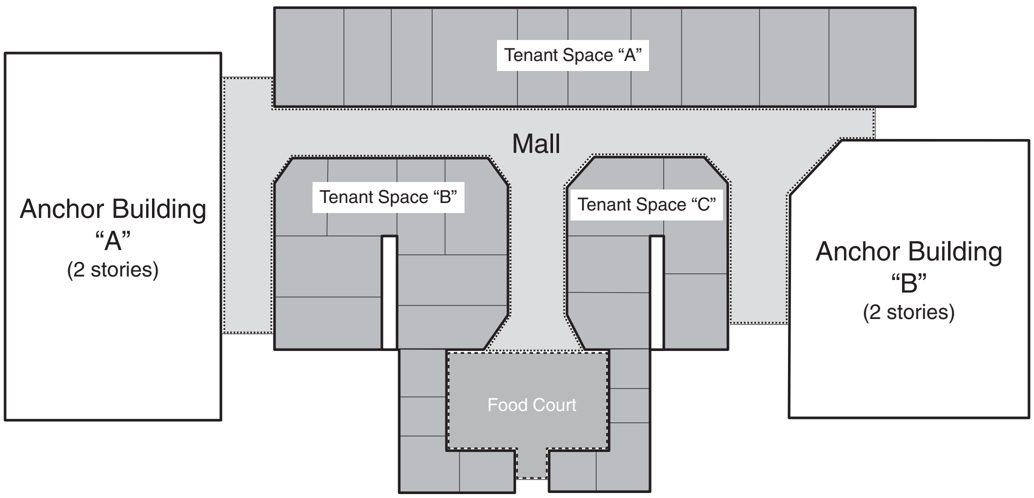


FIGURE 8-A-1. Covered mall floor plan.

Step 1: Calculate occupant load factor (*OLF*) based on area of the gross leasable area using IBC Equation 4-1.

$OLF = (0.00007)(38,940 \text{ sq. ft.}) + 25$

$OLF = 27.73$ sq. ft. per occupant, use 30 sq. ft. per occupant (IBC Section 402.8.2.2)

Step 2: Calculate occupant load of the mall using *OLF* calculated in Example Step 1.

16,150 sq. ft. ÷ 30 sq. ft. per occupant = 538 occupants

Step 3: Calculate occupant load of the food court.

4,050 sq. ft. ÷ 15 sq. ft. per occupant = 270 occupants

Step 4: Calculate occupant load of the mall with food court.

538 occupants + 270 occupants = 808 occupants

Step 5: Calculate occupant load of anchor buildings and tenant spaces.

Note: The areas for individual spaces shown are provided as examples. Use programming data or rough schematic drawings to determine areas for each type of use listed in IBC Table 1004.1.2.

Breakdown of Occupant Loads for Anchor Building "A"

Space	Area	Occupant Load Factor per IBC Table 1004.1.2	Occupant Load
Anchor Building "A" Retail Areas	29,140 sq. ft.	60 sq. ft./occ.	485
Anchor Building "A" Stock Rooms	7,760 sq. ft.	300 sq. ft./occ.	25
Anchor Building "A" Office/Restroom Area	1,940 sq. ft.	100 sq. ft./occ.	19
		Total	529

Breakdown of Occupant Loads for Anchor Building "B"

Anchor Building "B" Retail Areas	24,550 sq. ft.	60 sq. ft./occ.	409
Anchor Building "B" Stock Rooms	6,540 sq. ft.	300 sq. ft./occ.	21
Anchor Building "B" Office/Restroom Area	1,630 sq. ft.	100 sq. ft./occ.	16
		Total	446

Breakdown of Occupant Loads for Tenant Spaces

Tenant Space "A" Retail Areas	12,430 sq. ft.	60 sq. ft./occ.	207
Tenant Space "A" Stock Rooms	3,100 sq. ft.	300 sq. ft./occ.	10
Tenant Space "B" Retail Areas	8,690 sq. ft.	60 sq. ft./occ.	180
Tenant Space "B" Stock Rooms	2,700 sq. ft.	300 sq. ft./occ.	9
Tenant Space "B" Food Vendor Area	2,130 sq. ft.	100 sq. ft./occ.	21
Tenant Space "C" Retail Areas	5,980 sq. ft.	60 sq. ft./occ.	99
Tenant Space "C" Stock Rooms	1,980 sq. ft.	300 sq. ft./occ.	6
Tenant Space "C" Food Vendor Area	1,940 sq. ft.	100 sq. ft./occ.	19
		Total	551

When sizing the means of egress in Step 19, the anchor buildings are required to provide means of egress for their individual occupant loads. The mall's means of egress will be based on the mall's and food court's occupant loads per Example Step 4 and the occupant loads of the tenant spaces that egress through the mall.

8.3 ORGANIZING OCCUPANT LOAD DATA

The *occupant loads* should be organized by *story*, since each *story* must be provided with *exits* to support the *occupant load* within a *story*. Step 9 will use this data to determine the number of *exits* required. Eventually, the total building *occupant load* (the sum of all occupants within a building) will need to be determined for the final code data for the code sheets per Step 28.

If some portions of a building will have separate *means of egress* that are not used by other areas of the building, those *occupant loads* should be separated so that the *means of egress* for each portion can be determined using the *occupant loads* they will support.

Some building officials will require that the *occupant load* of each space be shown, even if the space is part of a *gross floor area* used to determine the *occupant load*. This is understandable, since each space is required to have the *means of egress* capacity to handle the *occupant load*. However, if the *occupant load* for the *story* is determined based on the sum of the *occupant loads* for each individual space, then the total may be more or less than the *occupant load* would be if determined using gross area due to rounding.

As an example, many office buildings include several smaller offices in the overall *gross floor area* for the "Business areas" within a *story*. If a block of five offices had a gross area of 600 sq. ft., each with a gross area of 120 sq. ft., then the total *occupant load* of the gross area for all five offices would be 6 occupants. However, if the *occupant load* was based on the sum of the occupants in each space, then the *occupant load* for the same 600 sq. ft. area would be 5 or 10 occupants, depending on how rounding was handled (120 sq. ft./100 sq. ft. per occupant = 1.2 occupants—2 occupants if rounded up or 1 occupant if rounded down).

EXAMPLE PROJECT—STEP 8

Since a floor plan has not been created, the occupant load of the Example Project can be determined using the programmed areas.

IBC Table 1004.1.2 has several uses that will be applicable to this Example Project, but the programming information is not specific enough to be able to determine their exact application. For example, the dining hall will have a kitchen, but the architectural program does not identify the area occupied by the kitchen. Therefore, for preliminary purposes, the kitchen is assumed to use 25% of the dining hall program area. Additionally, with no walls to define spaces, there is no need to be concerned about "net" and "gross" floor areas at this time.

Occupant Load (OL) per Story

Story	Space	Floor Area	IBC Table 1004.1.2 Use	OL Factor	OL
B	Parking	15,000 sq. ft.	Parking garages	200 gross	75
1	Mixed Use	15,000 sq. ft.	(See 1st-Story Table)	Varies	391
2	Apartments	15,000 sq. ft.	Residential	200 gross	75
3	Apartments	15,000 sq. ft.	Residential	200 gross	75
4	Apartments	15,000 sq. ft.	Residential	200 gross	75
				Total	691

Occupant Load (OL) for First Story

Space	Floor Area	IBC Table 1004.1.2 Use	OL Factor	OL
Dining Hall (Dining)	3,375 sq. ft.	Assembly, Unconcentrated	15 net	225
Dining Hall (Kitchen)	1,125 sq. ft.	Kitchens, Commercial	200 gross	5
Convenience Shop	950 sq. ft.	Mercantile	60 gross	15
Study Room (1)	350 sq. ft.	Assembly, Unconcentrated	15 net	23
Study Room (2)	350 sq. ft.	Assembly, Unconcentrated	15 net	23
Lounge	800 sq. ft.	Assembly, Unconcentrated	15 net	53
Restrooms	500 sq. ft.	Business Areas	100 gross	5
Exercise Room	600 sq. ft.	Exercise Rooms	50 gross	12
Manager's Apartment	1,100 sq. ft.	Residential	200 gross	5
Management Office	700 sq. ft.	Business Areas	100 gross	7
Mechanical Room	1,100 sq. ft.	Accessory Storage Areas, Mechanical Equipment Room	300 gross	3
Trash Room	250 sq. ft.	Accessory Storage Areas, Mechanical Equipment Room	300 gross	1
Mail Room	300 sq. ft.	Accessory Storage Areas, Mechanical Equipment Room	300 gross	1
Circulation	2,700 sq. ft.	Residential	200 gross	13
			Total	391

Even though the second through fourth stories are only apartments and the residential occupant load factor is based on the gross area of the story, it is still advisable to determine the occupant load of individual apartments based on the gross area of each apartment area.

Occupant Load (OL) for Each Apartment Type

Apartment Type	Floor Area	OL Factor	OL
Two-Bedroom Apartments	750 sq. ft.	200 gross	3
Three-Bedroom Apartments	1,000 sq. ft.	200 gross	5
Four-Bedroom Apartments	1,250 sq. ft.	200 gross	6

STEP 9

ESTABLISH POINTS OF EGRESS

STEP OVERVIEW

Next to calculating the *occupant load*, determining how that *occupant load* egresses a building is also a critical element to building design. As previously mentioned, the *occupant load* will determine the number of required *exits*. However, just knowing the number of *exits* is not enough—they must be located so that they are sufficiently separated to allow alternate egress paths should one be blocked. Additionally, the door operation (i.e., swinging, sliding, folding, accordion, revolving, etc.) must be established so as not to impede the efficient egress of occupants.

9.1 INTRODUCTION TO THE MEANS OF EGRESS SYSTEM

If there is one thing that is most associated with building codes, it would probably be getting people out of a building during an emergency event, such as a fire. The system of building elements used to facilitate the smooth movement of occupants from within the building to the exterior is called the *means of egress* system. The *means of egress* system, as defined by the IBC, includes three separate components:

Exit Access: The *exit access* is the portion of the *means of egress* system that starts within any occupied space and terminates at an *exit*. The *exit access* is typically of unprotected construction but frequently includes *corridors* constructed of *fire partitions*.

Exit: The *exit* is a protected pathway constructed of fire-resistant assemblies that lead from the termination of the *exit access* to the *exit discharge*.

Exit Discharge: The *exit discharge* begins at the termination of the *exit* and leads to a *public way*. A *public way*, as defined by the IBC, is any area that is open to the air that leads to a street. The *public way* can be a street, an alley, or any parcel of land specifically designated for public use.

Applying the Building Code: Step-by-Step Guidance for Design and Building Professionals. Ronald L. Geren, FCSI, AIA

The *means of egress* system will be refined as the design progresses, but this step is to define the specific number and locations where occupants can egress a space, a *story*, and the building. Later steps will focus on the egress paths and the physical width of those paths.

9.2 NUMBER OF EGRESS DOORS

It probably goes without saying that the more ways an occupant has to egress from a space, *story*, or building, the greater the chance for survival. More points of egress will allow more people to escape simultaneously and quickly. Therefore, the building code will set minimum requirements for the number of egress locations based on the *occupant load* as well as other conditions.

9.2.1 NUMBER OF DOORWAYS FROM SPACES

Rooms and other spaces are typically enclosed with surrounding walls to define the space, provide security, control sound, or any other number of reasons. If a space is enclosed, it must be provided with means of egressing that space, such as a door. In many cases, more than one door is required from the space due to the number of occupants in the space as determined during Step 8. These doors are referred to in the IBC as *exit access doorways*. (For clarity, this step will use "egress doorways," which will apply to either *exit access doorways* or *exit* doorways.)

Per IBC Section 1006.2, each space within a *story* or *basement* must be provided with two egress doorways. However, spaces are permitted to have a single egress doorway when the *occupant load* of the space does not exceed the *occupant load* per IBC Table 1006.2.1. One exception to IBC Section 1006.2.1 allows *dwelling units* in Groups R-2 and R-3 to have one egress doorway if the *occupant load* is not more than 20 and the building is sprinklered throughout with a NFPA 13 or 13R system. Another exception allows a single egress doorway from *care suites* in Group I-2 occupancies.

Even if the *occupant load* does not exceed the maximum per IBC Table 1006.2.1, two egress doorways may still be required based on the distance to the door, called the *common path of egress travel*, which is covered in detail in Step 10.2.2. If the *occupant load* of a space exceeds 500, then three egress doorways are required. If the *occupant load* exceeds 1,000, then four egress doorways are required.

In *covered mall buildings* and *open mall buildings*, tenant spaces that have a travel distance greater than 75 feet to the *mall* or more than 50 occupants are required to have two *means of egress*. If an assembly occupancy within a *covered mall building* has an *occupant load* of 500 or more, then one-half of its occupants shall egress directly to the exterior and have its main entrance into the *mall* immediately adjacent to the *mall's* main entrance. Assembly occupancies within the perimeter line of an *open mall building* are permitted to have their main *exit* open to the *open mall*.

9.2.2 NUMBER OF EGRESS POINTS FROM STORIES

Similarly, *stories* are required to have the minimum number of egress locations based on the *occupant load* of the *story*. It is most critical to define the points of egress from each *story*, especially if the building includes more than two *stories*. *Stairways* are the most common *means of egress* from *stories*, and since *stairways* include vertical enclosures that extend through multiple *stories*, they must align from *story* to *story*. Therefore, the location of *stairway* enclosures is essential early in the floor planning process. If two or more *exits* are required, up to 50% of those may be through a *horizontal exit* per IBC Section 1026 (see Step 9.2.2.4). For *high-rise buildings* greater than 420 feet in *building height* (except for Group R-2), an additional *stairway* is required (see Step 6.2); however, an occupant evacuation elevator may be provided in lieu of the additional *stairway* (see Step 21.4.3).

It is important to point out that IBC Table 1006.2.1, mentioned previously, does not apply to *stories*. Each *story* must be provided with no less than two *exits* or have access to two *exits* per IBC Table 1006.3.1.

Not unlike spaces, *stories* are required to have more *exits* when *occupant loads* reach certain thresholds. If the *occupant load* of the *story* exceeds 500, then three *exits* are required, and if the *occupant load* exceeds 1,000, four *exits* are required. For *stories* located above or below the *level of exit discharge*, a *horizontal exit* may be used in lieu of a *stairway* (see Step 10.3.3).

Assembly spaces with more than 300 occupants must be provided with a main *exit* per IBC Section 1029.2. If the building is a Group A occupancy, then the main *exit* must front a street or an unoccupied space that has a width of not less than 10 feet and leads to a street or other *public way*. If the building has no well-defined main *exit*, like that found in many arenas and stadiums, then the required number of *exits* must be distributed around the building.

There are circumstances permitted by the IBC that would allow a single *exit* from a *story*, but these are dependent on the occupancy group, number of *stories*, *occupant load*, and *common path of egress travel*. To qualify for a single *exit*, one of two tables will apply.

9.2.2.1 One Exit from Stories of Group R-2 Dwelling Units—IBC Table 1006.3.2(1)

A cluster of Group R-2 *dwelling units* are allowed a shared single *exit* only from a *basement* or from the first, second, or third *story* above the *grade plane*. Anything over three *stories* is not permitted to have a single *exit*. To be permitted the single *exit*, the *story* cannot have more than four *dwelling units* using the single *exit*. Other requirements include having a sprinkler system per NFPA 13 or 13R (Group R occupancies are required to be sprinklered, anyway) and each room used for sleeping must be provided with an *emergency escape and rescue opening* per IBC Section 1030. See Step 9.4 for more guidance on *emergency escape and rescue openings*.

9.2.2.2 One Exit from Stories of Other Occupancies—IBC Table 1006.3.2(2)

All other occupancies, with the exception of Groups H-1 and R-3, are permitted a single *exit* per the IBC table. Group R-3 is permitted a single *exit* per Exception 4 to IBC Section 1006.3 and a Group H-1 must always have at least two *exits* for a *story* but is allowed a single *exit* from a space within a *story* per IBC Table 1006.2.1. Group R-2 is also listed, but Group R-2 in this table applies only to buildings with *sleeping units*. Group R-2 with *dwelling units* must utilize IBC Table 1006.3.2(1).

The IBC table allows a single *exit* from the first *basement* level below the *grade plane* and the first *story* above the *grade plane*. However, a single *exit* from a second *story* is only permitted for Groups B, F, M, and S. No occupancy group is permitted a single *exit* from the third *story* or higher.

For the occupancies identified in the IBC table, the single *exit* allowance is predicated on two conditions: *occupant load* and *common path of egress travel*. The *common path of egress travel* is discussed in detail in Step 10.2.2. The *occupant loads* vary between the different occupancy groups and are consistent with the maximum *occupant loads* permitted for spaces with one *exit* or *exit access doorway*.

9.2.2.3 One Exit for Mixed Occupancies

Where a *story* consists of a mixed occupancy, each occupancy must comply with the requirements for that occupancy per IBC Tables 1006.3.2(1) and 1006.3.2(2). When a cumulative *occupant load* from mixed occupancies uses a single *exit*, the maximum load served by the single *exit* shall be such that the sum of the ratios of actual *occupant loads* divided by the allowable occupancy loads does not exceed 1 (Example 9-A).

EXAMPLE 9-A: ONE EXIT FOR MIXED OCCUPANCIES

Given: The basement below the first story of a retail shop has the following occupant loads: the Group B office area has an occupant load of 6, the Group M retail space has an occupant load of 35, and the Group S-2 stock room has an occupant load of 4. Can the basement have a single exit?

Step 1: Determine the allowable occupant loads for each occupancy group in accordance with IBC Table 1006.3.2(2).

Group B: 49 occupants
Group M: 49 occupants
Group S-2: 29 occupants

Step 2: Calculate the ratios of actual occupant loads to allowable occupant loads.

Group B : 6 occupants ÷ 49 occupants = 0.12
Group M : 35 occupants ÷ 49 occupants = 0.71
Group S-2 : 4 occupants ÷ 29 occupants = 0.14

Step 3: Sum the ratios calculated in Example Step 2.

0.12 + 0.71 + 0.14 = 0.97
The sum of ratios is less than 1; therefore, the basement is permitted to have a single exit.

If the mixed occupancy includes Group R-2 *dwelling units* with other occupancy groups, then the ratio of actual units to the allowable four *dwelling units* shall be added to the ratios of the *occupant loads* (Example 9-B).

EXAMPLE 9-B: ONE EXIT FOR MIXED OCCUPANCIES, INCLUDING DWELLING UNITS

Given: Two dwelling units are located on the second story of an apartment building. Also located on the second story is a storage area with lockers used by all residents of the apartment complex to store personal items. If the storage room has an occupant load of 14, can a single exit be provided from the second story?

Step 1: Determine the allowable occupant loads for each occupancy group in accordance with IBC Table 1006.3.2(2).

Group S-1 : 29 occupants

Step 2: Calculate the ratios of actual occupant loads to allowable occupant loads.

Group S-1 : 14 occupants/29 occupants = 0.48

Step 3: Calculate the ratio of actual dwelling units to the allowable dwelling units.

Dwelling Units : 2 units/4 units = 0.50

Step 4: Sum the ratios calculated in Example Steps 2 and 3.

0.48 + 0.50 = 0.98
The sum of ratios is less than 1; therefore, the second story is permitted to have a single exit.

9.3 SEPARATION OF EXIT AND EXIT ACCESS DOORWAYS

If a space or *story* requires more than one *exit* or *exit access doorway*, then those doorways cannot be located right next to each other—they must be separated from each other by a reasonable distance. If egress doorways are not sufficiently separated, then egress from a space can be severely restricted, if not eliminated, should doorways be blocked for some reason.

IBC Section 1007.1 provides the criteria for separating *exit* and *exit access doorways*. The basic requirement requires a separation by not less than one-half of the greatest overall diagonal dimension of the area being served by the doorways. Thus, if a *story* requires two *exit* or *exit access doorways*, then the greatest overall diagonal of the *story* is used, whereas if a space requires two *exit* or *exit access doorways*, then the overall diagonal of the space is used (Figures 9.3-1 and 9.3-2). The measurement between doorways is to be a straight line. There are two exceptions to these requirements:

- **Sprinklered Buildings:** Buildings that are sprinklered throughout with a NFPA 13 or 13R system are permitted to reduce the minimum separation to one-third of the greatest overall diagonal dimension.
- **Exit Stairways or Ramps Connected by a 1-Hour Corridor:** In lieu of a straight line, the measurement between doorways shall follow the most direct path of travel within the *corridor*. The construction of the *corridor* must conform to the requirements of IBC Section 1020 (Figure 9.3-3).

Even though the figures show the measurement of *exit* or *exit access doorway* separation to the near edges of the door, the points for measurement of the separation can be located anywhere between the widths of the doorways (Figure 9.3-4). Although this section is focused on doorways, enclosed or

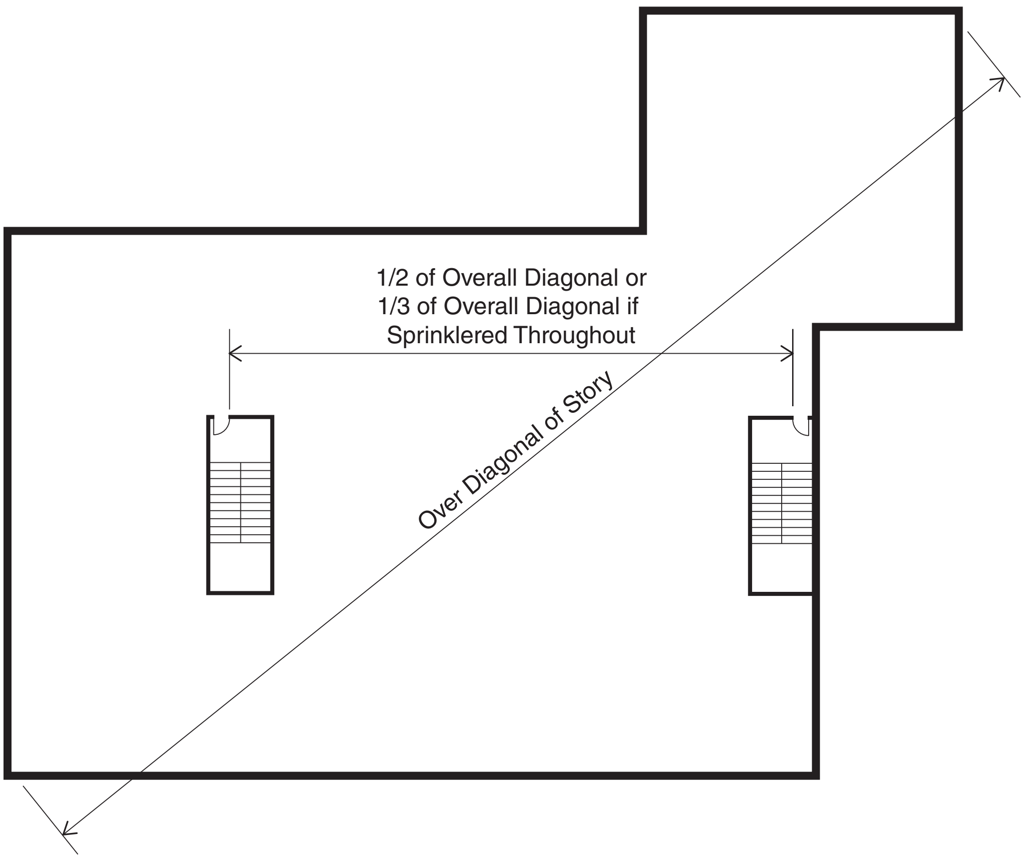


FIGURE 9.3-1. Separation of *exit* or *exit access doorways* for a *story*.

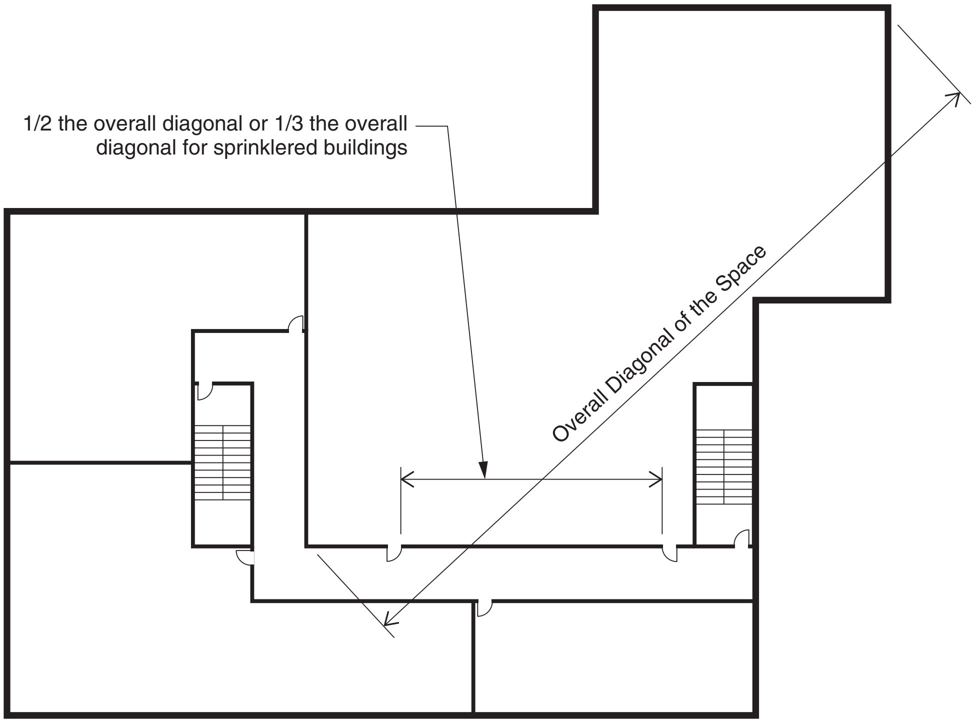


FIGURE 9.3-2. Separation of *exit* or *exit access doorways* for a space.

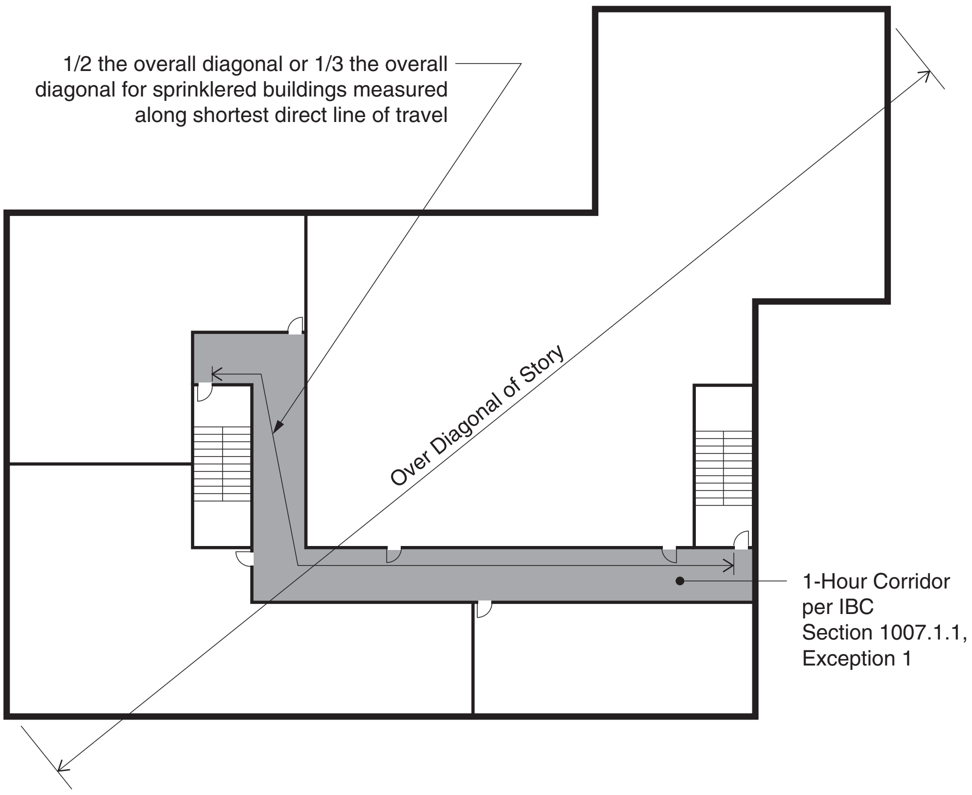


FIGURE 9.3-3. Measurement of *exit* separation when *exits* are separated by a 1-hour *corridor*.

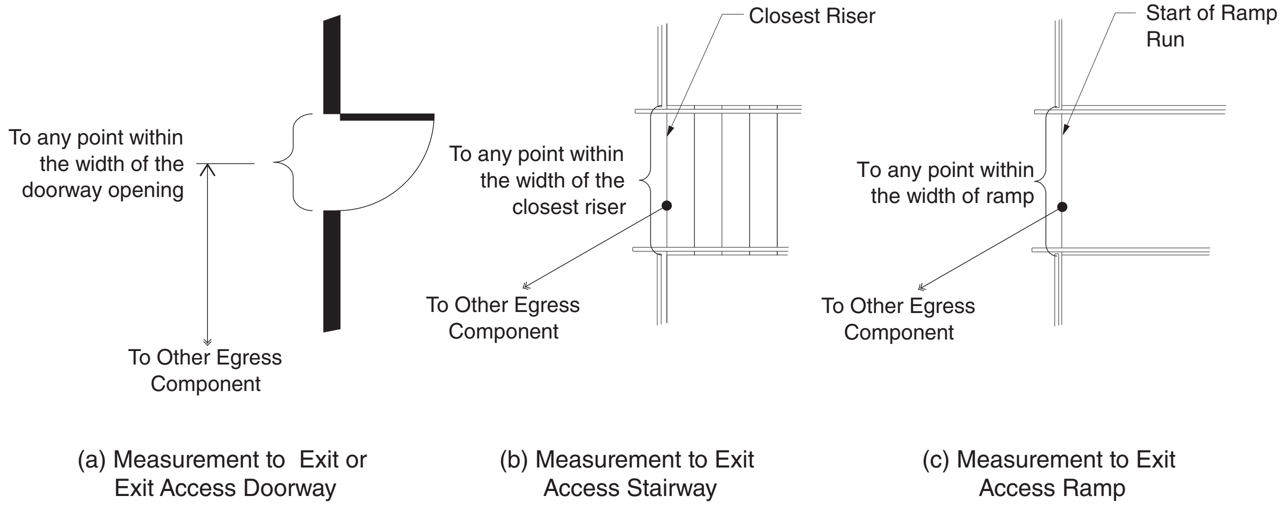


FIGURE 9.3-4. Measurement of separation distance for *exit* or *exit access doorways* (a), *exit access stairways* (b), and *exit access ramps* (c).

unenclosed *exit access stairways* and *exit access ramps* are measured to the closest riser for *stairways* and the beginning of the slope for *ramps*.

When three or more *exit* or *exit access doorways* are required, only two of the doorways are required to be separated per these requirements. However, IBC Section 1007.1.2 states that other required doorways be separated a reasonable distance so that if one is blocked the other doorways will remain available. Since “reasonable distance” is not defined, the designer will have to use his or her judgment to determine a suitable separation distance. If a condition occurs that could bring a proposed separation into question and the location of *exits* is critical to the design, then it might be prudent to obtain an early decision by the *building official* before proceeding with the design. Of course, it would also be prudent to obtain the *building official’s* decision in writing if the questionable condition is acceptable.

If *exit access stairways* or *exit access ramps* are used to reach *exits* on another *story*, the separation of the *exit access* pathways on the adjacent *story* shall be maintained to the *exits* per IBC Section 1007.1.3. In other words, the two separate *means of egress* that begin on one *story* and extend to an adjacent *story* cannot converge on the adjacent *story* nor shall they come any closer than the separation distance required for the egress points on the originating *story*.

9.4 DOOR OPERATION

The basic requirement for door operation, per IBC Section 1010.1.2, is that they be of the swinging type using pivots or hinges. If the doors serve an *occupant load* of 50 or more, they are required to swing in the direction of egress travel. The number of occupants is based on the total occupants of the *story* or space and not the portion assigned to it as determined later in Step 19. The IBC section provides nine exceptions that allow doors other than the swinging type:

- Small spaces with an *occupant load* of 10 or less, such as *private garages*, office areas, factory, and storage areas
- Areas of detention in Group I-3 occupancies
- Patient rooms of critical and intensive *care suites* in health care occupancies

- Doors throughout a Group R-2 or R-3 *dwelling unit*, including entrance doors
- Revolving doors complying with IBC Section 1010.1.4.1. Does not apply to Group H occupancies. Revolving doors are required to have a side-hinged swinging door within 10 feet of the revolving door.
- Sliding, accordion, or folding doors complying with IBC Section 1010.1.4.3. Does not apply to Group H occupancies. Doors must be power operated with the ability to be manually operated.
- Power-operated doors complying with IBC Section 1010.1.4.2. They must be capable of being operated manually by utilizing a breakout swinging operation.
- Bathroom doors within a Group R-1 *sleeping unit*
- Manually operated sliding doors from rooms with an *occupant load* of 10 or less. Does not apply to Group H occupancies.

EXAMPLE PROJECT—STEP 9

For the Example Project, a rough floor plan is prepared to see how the space configuration will work and where would be the best location for the exits and exit access doorways. The number of exits must be determined by space and by story.

POINTS OF EGRESS FOR SPACES

The number of exits or exit access doorways from spaces per IBC Table 1006.2.1 is indicated in the table below:

Required Number of Exits or Exit Access Doorways per Space

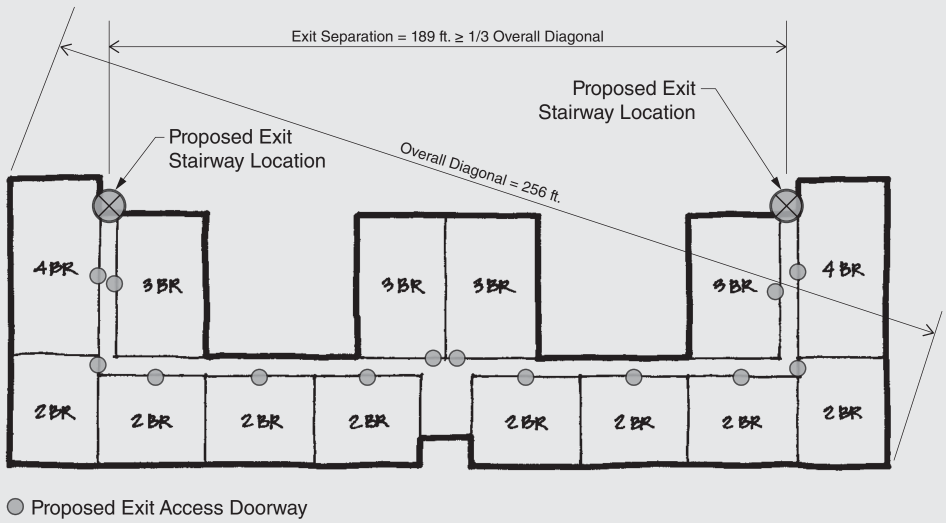
Space	OL	Max. OL for One Exit or Exit Access Doorway	Required No. of Exit or Exit Access Doorways
Dining Hall (Dining)	225	49	2
Dining Hall (Kitchen)	5	49	1
Convenience Shop	15	49	1
Study Room (1)	23	49	1
Study Room (2)	23	49	1
Lounge	53	49	2
Restrooms	5	49	1 (each)
Exercise Room	12	49	1
Manager’s Apartment	5	10	1
Management Office	7	49	1
Mechanical Room	3	10	1
Trash Room	1	10	1
Mail Room	1	29	1
Two-Bedroom Apartment	4	10	1
Three-Bedroom Apartment	5	10	1
Four-Bedroom Apartment	6	10	1

The spaces that are required to have a minimum of two exit or exit access doorways must have those doorways separated by at least one-third the overall diagonal of the space (see Example Project Figure 9-2).

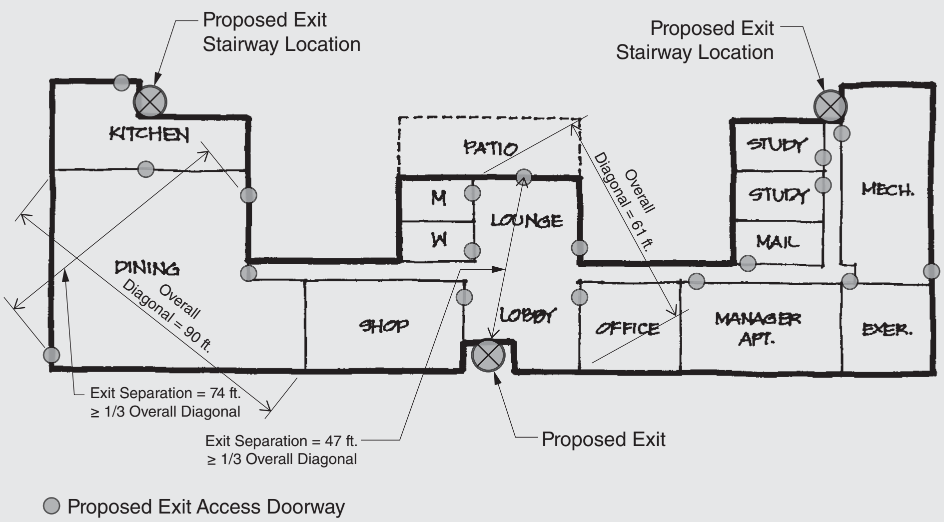
POINTS OF EGRESS FOR STORIES

Per IBC Table 1006.3.1, the second, third, fourth, and basement stories will require a minimum of two exits or have access to two exits. The first story has a total of 391 occupants, so it, too, is only required to have two exit or exit access doorways.

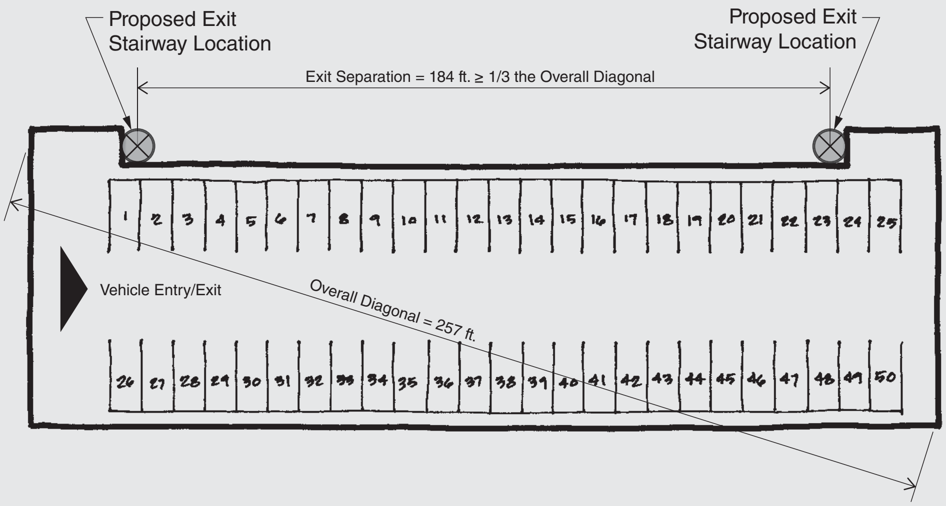
Similar to spaces, stories that are required to have two exits or access to two exits (which is every story and the basement in this project) are also required to have those points of egress separated by one-third the overall diagonal of the story they serve (see Example Project Figures 9-1, 9-2, and 9-3).



EXAMPLE PROJECT FIGURE 9-1. Location of exit and exit access doorways on the second, third, and fourth stories.



EXAMPLE PROJECT FIGURE 9-2. Location of exit and exit access doorways on the first story.



EXAMPLE PROJECT FIGURE 9-3. Location of exit and exit access doorways in the basement parking garage.

STEP 10

Check Egress Pathways

STEP OVERVIEW

The points of egress determined in Step 9 would not be effective unless occupants have a clear and unobstructed path to those egress points. Therefore, after the egress locations are identified, this step begins the process that will ensure that the pathways to those egress locations meet the minimum requirements of the code.

10.1 GENERAL REQUIREMENTS

Regardless of the type of *means of egress* component utilized, there are some basic minimum requirements that apply to all components of the *means of egress* system. The minimum widths for egress pathways, which are covered in this step for initial planning, are contingent upon the type of *means of egress* component that is utilized; however, prescriptive minimums may not be sufficient if the *occupant load* they are serving is of significant size. (Step 10.6 provides a table that summarizes the types of egress components, the minimum widths, and the maximum *occupant loads*.) Step 19 will address egress widths based on the actual *occupant load* that will utilize the *means of egress* system. IBC Section 1003 addresses these general requirements and includes the following requirements.

- **Minimum Ceiling Height:** All components must have a minimum height of 7 feet 6 inches, which is also the minimum height required for *habitable spaces* per IBC Section 1208.2. There are several exceptions to this requirement:
  - Sloped ceilings complying with Exception 2 of IBC Section 1208.2 requires that a space with a sloped ceiling must have minimum ceiling height of 7 feet 6 inches for at least 50% of the space. Any floor area of a space where the ceiling is less than 5 feet above the finished floor must be excluded from the area when determining the 50% requirement.

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- The following items are allowed to have a minimum clear height of 7 feet:
  - *Corridors* in Group R *dwelling units* and *sleeping units* per Exception 4 of IBC Section 1208.2
  - Vehicle and pedestrian areas of public parking garages per IBC Section 406.4.1
  - Ceilings above and below *mezzanines*
  - Although not identified as an exception to IBC Section 1003.2, vehicle and pedestrian areas of *private garages* and carports per IBC Section 406.3.2
- The following items are allowed to have a minimum height of 80 inches:
  - The headroom for *stairs* per IBC Section 1011.3 measured vertically from the line connecting the edge of the *stair nosings*
  - The height of doorways per IBC Section 1010.1.1
  - The headroom for *ramps* per IBC Section 1012.5.2
- Protruding objects (see next general requirement).

- **Protruding Objects:** Objects, such as signage, *awnings*, and light fixtures that project into *circulation paths* are permitted provided they do not project any lower than 80 inches per IBC Section 1003.3. This is consistent with typical accessibility standards, such as ICC/ANSI A117.1 and the 2010 ADA standards.

  The reduced height of *circulation paths* cannot exceed 50% of the ceiling area for the *circulation path*. If a door includes a closer and/or overhead stop, the height can be reduced to no less than 78 inches. If an object projects from the side, it cannot project more than 4 inches into the *circulation path* if the bottom edge of the projecting element is more than 27 inches above or less than 80 inches above the floor surface. The only exception to this requirement is the allowance for *handrails* to project into the path by 4 1/2 inches.

- **Elevation Changes:** If there is a change in elevation along the *means of egress* path that is less than 12 inches, then a sloped surface is required. If the sloped surface has an incline greater than 1:20, then the slope surface is considered a *ramp* and must comply with the requirements of IBC Section 1012. If a *ramp* is provided and the change in elevation is greater than 6 inches, then *handrails* complying with IBC Section 1014 are required. There are three exceptions provided:
  - Doors that are not required to be *accessible* are permitted to have a single step with a maximum riser height of 7 inches. This exception, however, only applies to Groups F, H, R-2, R-3, S, and U.
  - A *stair* consisting of not more than two risers and one tread is permitted where the path is not required to be *accessible*. At least one *handrail* is required within 30 inches of the path centerline.
  - Within seating areas, a step is permitted in *aisles* provided the *aisle* is not required to be *accessible*. Details for steps in *aisles* are covered in Step 23.
- **Continuity of Means of Egress:** A *means of egress* component cannot be interrupted by any other type of building element other than another acceptable *means of egress* component.
- **Elevators, Escalators, and Moving Walkways:** These elements may not be used as a part of the required *means of egress*, except when elevators are used as a part of an *accessible means of egress*.

Other egress components also have some general limitations that are not covered in IBC Section 1003. These limitations must be considered at this phase of design so that their use is not relied upon only to find out later that they cannot be used or must be modified. The special egress components include the following:

- **Spiral Stairways:** These are only permitted IBC Section 1011.9 as a *means of egress* in *dwelling units* or from spaces with 250 sq. ft. or less of floor area and with an *occupant load* of 5 or less per IBC Section 1011.10.
- **Curved Stairways:** These are permitted per IBC Section 1011.9 provided that the smallest radius is not less than twice the minimum width or capacity of the *stairway* (see Step 19). This restriction does not apply to Group R-3 occupancies and individual *dwelling units* in Group R-2 occupancies.

- **Ladders:** These cannot be part of a *means of egress* except under the conditions listed in IBC Section 1011.16.
- **Vertical Rise of Stairways:** A single *flight* of *stairs* cannot have a total rise greater than 12 feet per IBC Section 1011.8. If a run of *stairs* must connect two levels that are more than 12 feet apart vertically, a landing will have to be incorporated into the run of *stairs*.

10.2 THE EXIT ACCESS (IBC SECTION 1016)

As discussed in Step 9.1, the *exit access* is the portion of a *means of egress* system that starts within any space in the building and leads to an *exit*. Since the *exit access* is the least protected portion of the *means of egress* system within a building, there are specific requirements that must be reviewed at this phase of the project to minimize, if not avoid, potential *means of egress* issues as the project progresses through the design process.

The *exit access* can include any of the following elements within a building:

- Rooms or spaces within the building
- *Aisles*
- *Corridors* (fire-rated or non-fire-rated)
- *Atriums*
- Egress balconies
- *Exit access stairways* (enclosed or unenclosed)
- *Exit access ramps* (enclosed or unenclosed)
- *Malls*

The *exit access* is permitted to pass through intervening rooms provided the intervening rooms comply with the requirements of IBC Section 1016.2, which include the following:

- **Enclosed Elevator Lobbies:** The *exit access* may pass through an enclosed elevator lobby provided that access to one of the required *exits* does not require passage through an enclosed elevator lobby required by IBC Section 3006 (see Step 10.2.5).
- **Adjoining Rooms:** The *exit access* cannot pass through adjoining rooms unless the adjoining rooms are accessory to each other and are not classified as a Group H occupancy. The path through the rooms must provide a separate and distinct path of travel to an *exit*.
  The exception to this requirement allows travel from a Group H, S, or F occupancy through any adjoining space provided the adjoining space is of an equal or lesser hazard occupancy.
- **Lockable Rooms:** If a room or space can be locked that would prevent egress, then the room or space cannot be used as part of the *exit access* from an adjoining room.
- **Group R or Group I:** *Dwelling units* and sleeping areas in Group R and I occupancies cannot pass through other sleeping areas, toilet rooms, or bathrooms.
- **Utility Spaces:** The *exit access* cannot pass through utilitarian spaces such as kitchens, storage rooms, or closets, except under the following conditions:
  - Egress travel within *dwelling units* and *sleeping units* may pass through kitchens that are part of the same *dwelling unit* or *sleeping unit*.
  - Egress travel may pass through a stockroom of a Group M occupancy provided the materials in the stockroom are of the same hazard classification of the materials found in the main retail area, not more than 50% of the *exit access* is through the stockroom, the stockroom cannot be locked to prevent egress, and a path is clearly marked using full or partial height walls or other similar construction from the retail area directly to an *exit* without any obstructions.

- **Multiple Tenants:** Tenant spaces, *dwelling units*, and *sleeping units* must have their own access to *exits* without passing through another tenant space, *dwelling unit*, or *sleeping unit*. A smaller tenant space is permitted to pass through a larger tenant space provided the smaller tenant space does not encompass more than 10% of the larger tenant space, is of the same or similar occupancy group, and provides a discernible path to an *exit* and the larger tenant space cannot be locked so that it would prevent the egress from the smaller tenant space. Egress from the larger tenant space cannot pass through any smaller tenant space.

10.2.1 EXIT ACCESS TRAVEL DISTANCE (IBC SECTION 1017)

Although not officially defined in the code, travel distance is essentially the shortest possible path that an occupant must travel before an *exit* is reached (Figure 10.2.1-1). The concern with travel distance is to ensure that occupants can reach an exterior door or protected *exit* enclosure without having to take an extremely long path to get there, thus reducing the occupants' exposure to a potential hazard.

IBC Table 1017.2 provides the limitations on travel distance based on occupancy and the installation of a NFPA 13 or 13R sprinkler system. For most nonsprinklered occupancy groups, this distance is 200 feet. With a sprinkler system installed, this distance increases to 250 feet, but for B occupancies, it increases to 300 feet. Nonsprinklered Groups F-2, S-2, and U are limited to 300 feet (400 feet when sprinklered). Group I and H occupancies have various travel distances listed but are limited to only sprinklered buildings, since these occupancies are required to be sprinklered (see Step 2.5). Check the footnotes regarding which sprinkler system is applicable in order to earn the added distance—some occupancies are only allowed the NFPA 13 system and Group H occupancies have additional requirements per IBC Section 903.2.5.

According to IBC Section 1017.3, the measurement of travel distance within a space must follow a path that would ordinarily be followed. In most cases, a space will be filled with furniture, fixtures, and equipment (FF&E) that would typically require an orthogonal path of travel through the space to reach the *exit* or *exit access doorway* (Figure 10.2.1-2). However, using a direct path to the doorway would not provide a realistic path (Figure 10.2.1-3)—only in a very few situations would such a path be acceptable.

There is no codified method for determining travel distance, but the simplest approach is to start at the farthest point and follow the perimeter of the space until an *exit* or *exit access doorway* is reached using the shortest route possible (Figure 10.2.1-4). However, it is not necessary to take the measurement right

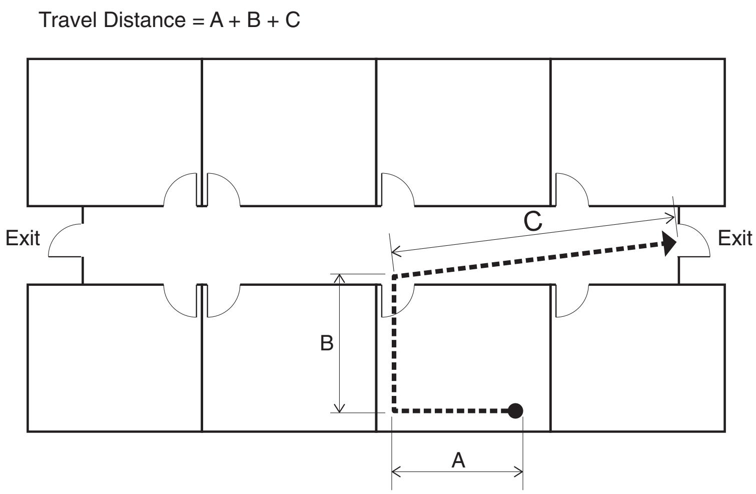


FIGURE 10.2.1-1. Determining travel distance.

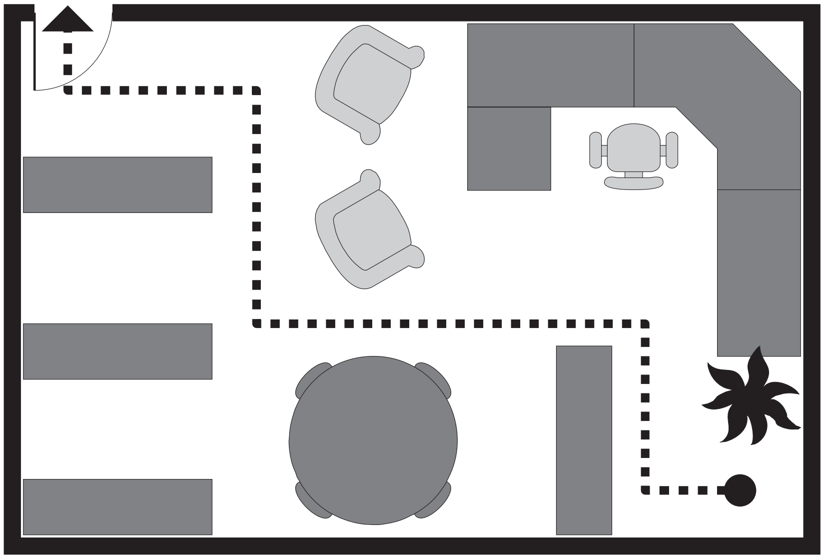


FIGURE 10.2.1-2. Orthogonal path through FF&E.

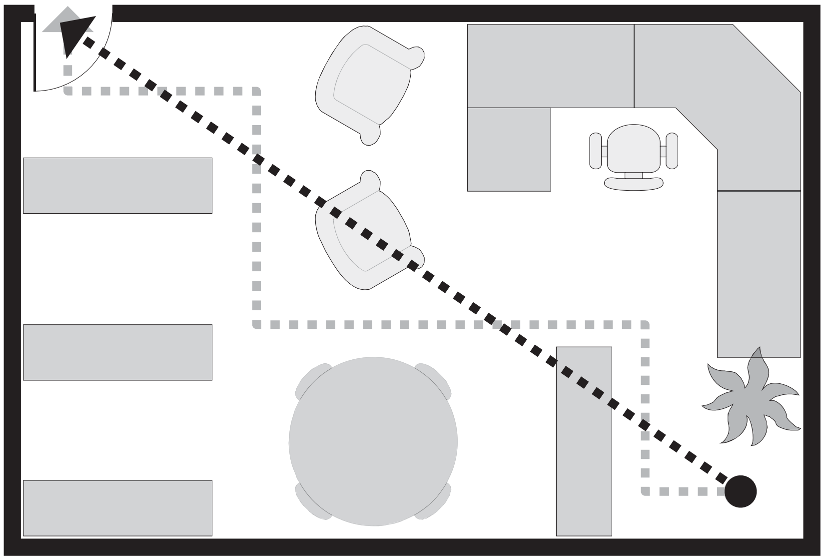


FIGURE 10.2.1-3. Improper direct travel distance path.

at the wall. Since an occupant will follow a path that allows some clearance from objects such as walls, measuring the path at a reasonable distance from the wall is acceptable. The IBC does not prescribe a distance, but NFPA 101 establishes a 12-inch clearance, which may be used as a guide.

Although this method is imprecise, it delineates a path having a distance comparable to one that weaves through FF&E. It is understandable that the FF&E layout could create a path that is shorter or longer than the method described above, but since the layout of a space is unknown and can vary throughout a building's life, the method described above is generally accepted by building officials.

IBC Section 1017.3 states that travel distance is limited to "within a *story*." The exception to that limitation is when the required *means of egress* includes *exit access stairways* and *exit access ramps*. When *exit access stairways* or *exit access ramps* are used, the travel distance measurement must include the path of

FIGURE 10.2.1-4. Acceptable travel distance path.

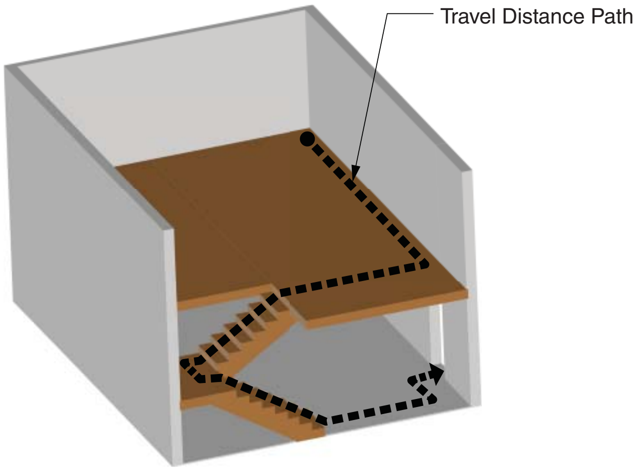


FIGURE 10.2.1-5. Travel distance along *exit access stairways* or *ramps*.

travel along these egress components until an *exit* is reached (Figure 10.2.1-5). For *stairways*, the measurement is taken parallel to the slope made by the *stair* tread *nosings* and not parallel to the treads (Figure 10.2.1-6).

There are special conditions that are found under footnote "a" of IBC Table 1017.2 that may restrict or extend the travel distances listed in the table. These special conditions include the following:

- **Mall Buildings:** *Covered mall buildings* and *open mall buildings* have special circumstances unique to that building type. Therefore, the general requirements for travel distance within them are modified in IBC Section 402.8.5. Within tenant spaces, the travel distance is limited to 200 feet from any point to an *exit* or the entrance to the *mall*. Additionally, another 200 feet is permitted from any point within the *mall* to an *exit*. Therefore, a Group M *mall* building can have a travel distance up to 400 feet compared to the 250 feet allowed by IBC Table 1017.2. (The distance for a sprinklered building is used since *covered mall buildings* and *open mall buildings* are required to be sprinklered per IBC Section 402.5.)

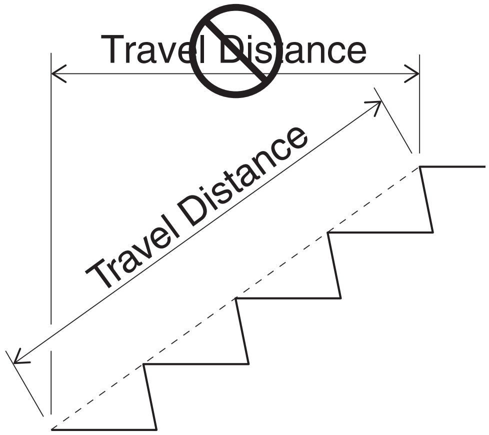


FIGURE 10.2.1-6. Measurement of travel distance along *stairways* is parallel to the *stairway* slope.

- **Atriums:** If the required *means of egress* is through an *atrium* on a floor other than the *level of exit discharge*, only 200 feet of the permitted travel distance can be within the *atrium* per IBC Section 404.9. However, the *exit access* travel distance on the *level of exit discharge* is limited to the distance in IBC Table 1017.2 with no restriction on the distance within the *atrium*. IBC Section 1023.2, Exception 2, allows *stairways* within *atriums* to be considered *interior exit stairways* and not *exit access stairways*. This creates an issue regarding the measurement of *exit access* travel distance—an issue that is not addressed by the IBC. For lack of any specific guidance by the IBC, travel distance should be measured to the closest riser, which is similar to the measurement for *stairways* in *open parking garages* per the exception to IBC Section 1017.3.
- **Group I-2:** For sleeping rooms not located within a *care suite*, the portion of the travel distance from any location within the sleeping room to an *exit access doorway* in that room cannot exceed 50 feet per IBC Section 407.4.2.
- **Group I-3:** If *smoke compartments* are required for resident sleeping areas per IBC Section 408.6, then the travel distance from within any room to a door in a *smoke barrier* cannot exceed 200 feet. Additionally, the portion of the travel distance from any required *exit access doorway* to a door in a *smoke barrier* cannot exceed 150 feet. Thus, if the length of travel within a room to an *exit access doorway* is less than 50 feet, the overall travel distance will be less than the 200 feet permitted.
- **Special Amusement Buildings:** The reference to the *special amusement building* requirements in IBC Section 411.4 points to the exception that does not modify the travel distance in IBC Table 1017.2 but makes the user aware that a sprinkler system is not required in temporary amusement buildings if the travel distance is less than 50 feet.
- **Aircraft Manufacturing Facilities:** The travel distance in aircraft manufacturing *facilities* can be increased per IBC Table 412.7. The table is based on the manufacturing area and the height of the building. Travel distances can be anywhere between 200 feet per IBC Table 1017.2 to 1,500 feet per IBC Table 412.7.
- **Refrigeration Machinery Rooms:** The distance to an *exit* or *exit access doorway* within refrigeration machinery rooms is limited to 150 feet per IBC Section 1006.2.2.2; however, the overall travel distance cannot exceed the distances indicated in IBC Table 1017.2.
- **Refrigerated Rooms or Spaces:** The distance to an *exit* or *exit access doorway* within refrigerated rooms or spaces is limited to 150 feet per IBC Section 1006.2.2.3 if the room or space does not have a sprinkler system; however, the overall travel distance cannot exceed the distances indicated in IBC Table 1017.2.

- **Buildings with One Exit:** Step 9 addresses buildings with one *exit*. If a building is allowed one *exit*, then the travel distance is limited by the *common path of egress travel*, which is discussed in Step 10.2.2.
- **Groups F-1 and S-1:** Per IBC Section 1017.2.2, the travel distance in the Group F-1 and S-1 occupancies can be increased to 400 feet if the occupancies are limited to one *story* in height, the clear height within the occupancies is a minimum of 24 feet, and the building is sprinklered throughout with a NFPA 13 system.
- **Assembly Seating:** The travel distance is limited to 200 feet (250 feet in sprinklered buildings) and must be measured along the *aisles* and *aisle accessways* to an *exit* per IBC Section 1029.7. An *aisle accessway* is the path within the rows of seating that lead to the main *aisles*. Exceptions to this general requirement include the following:
    - For buildings with open-air seating, the travel distance is limited to 400 feet; however, if the buildings are of Type I or II construction, the travel distance is permitted to be unlimited.
    - For buildings with *smoke-protected assembly seating*, a travel distance of 200 feet is measured from a seat to the entrance of a vomitory or concourse and an additional 200 feet is measured from the entrance to the vomitory or concourse to an exterior *stairway*, *ramp*, or walk. Thus, the total maximum travel distance is 400 feet, but each part cannot exceed the allowable for that segment.
- **Temporary Structures:** For *structures* that are erected for a period of 180 days or less, the maximum travel distance is 100 feet, regardless of occupancy of the temporary *structure* per IBC Section 3103.4.
- **Pedestrian Walkways:** IBC Section 3104.9 allows *pedestrian walkways* to have a travel distance of 200 feet, which is measured from the most remote point in the *pedestrian walkway* to an exit in either building. This distance can be increased by one of the following exceptions:
    - If the *pedestrian walkway* is sprinklered throughout with a NFPA 13 system, the distance can be increased to 250 feet.
    - If both sides of the *pedestrian walkway* are 50% or more open, the travel distance can be increased to 300 feet.
    - If a sprinkler system is installed throughout per NFPA 13 and both sides are 50% or more open, then the travel distance within the *pedestrian walkway* can be increased to 400 feet.

Another provision in IBC Section 1017.2.1 for exterior egress balconies allows an extension up to 100 feet to the travel distances permitted in IBC Table 1017.2. This provision can apply to any occupancy group when the last portion of the *exit access* leading to an *exit* occurs on an exterior egress balcony. Therefore, the travel distance to the beginning of the exterior egress balcony can be no longer than the distance indicated in IBC Table 1017.2, and the travel distance on the balcony to an *exit* can be no longer than 100 feet.

10.2.2 COMMON PATH OF EGRESS TRAVEL (IBC SECTION 1006)

During a fire event, there is always the possibility that an egress path will be blocked by either the fire itself or debris from construction that may have collapsed. The farther an occupant is required to travel within the building, the greater the risk of running into a blocked path, thus the requirement for limiting the travel distance. However, if an occupant is required to take a single path, the risk of an egress pathway being blocked increases. Because of this increased risk, single paths are severely limited, even if the permitted travel distance is significantly longer.

The *common path of egress travel* is that portion of the permitted travel distance that an occupant must use before the occupant has the option of taking one of at least two separate and distinct paths to

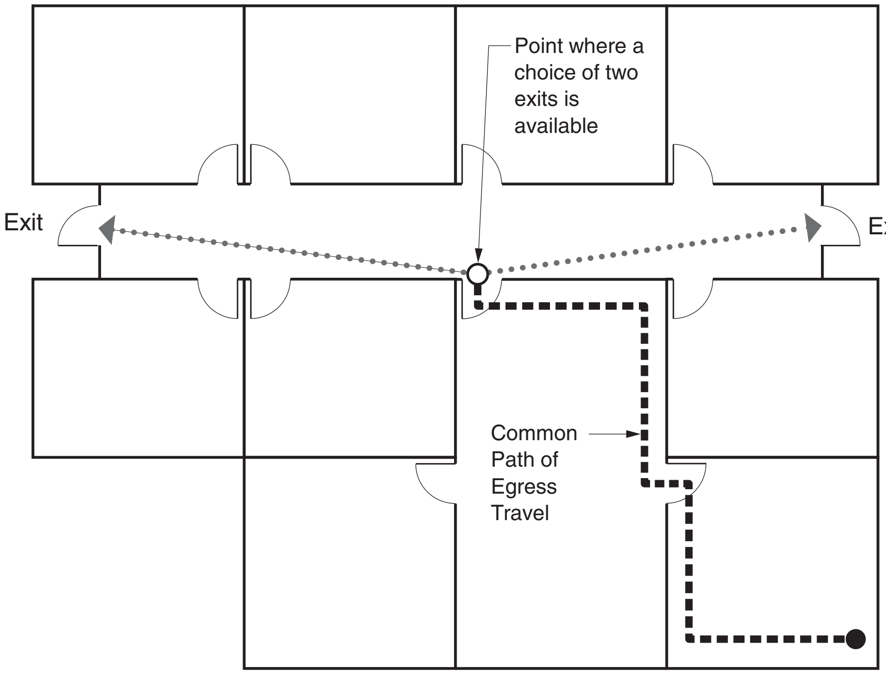


FIGURE 10.2.2-1. Determination of *common path of egress travel*.

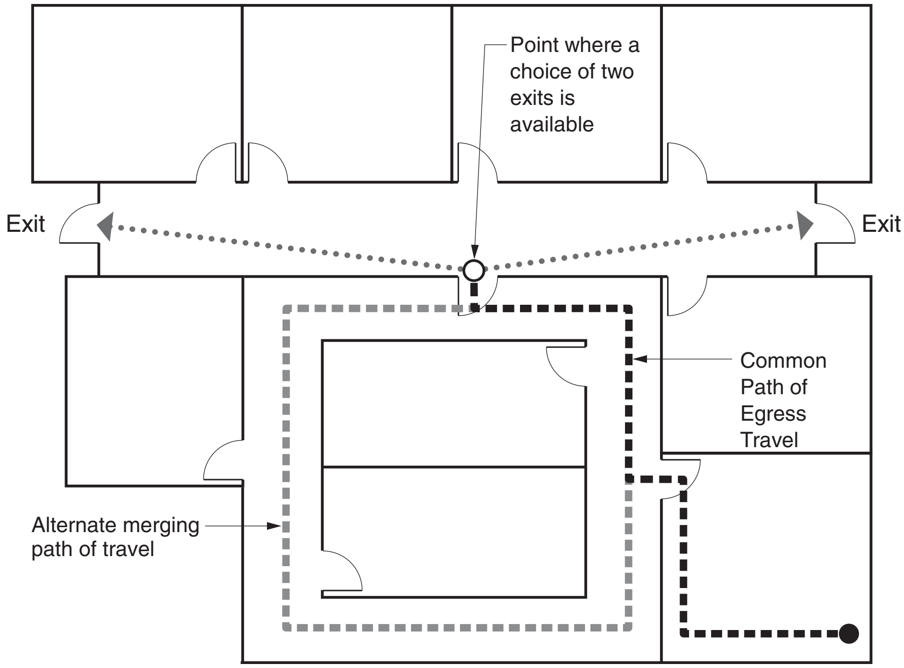


FIGURE 10.2.2-2. Merging paths are still considered a *common path of egress travel*.

two separate *exits* (Figure 10.2.2-1). If the occupant has access to two separate paths but those paths merge before an *exit* is reached, then those paths are still considered a *common path of egress travel* (Figure 10.2.2-2). If a space is required to have two or more *exit access doorways*, it is very unlikely that there will be a *common path of egress travel*.

IBC Table 1006.2.1 indicates the permitted distances for *common paths of egress travel*. These distances are based on occupancy group and the presence of a NFPA 13 or 13R sprinkler system throughout the building. For example, for a sprinklered Group B building, the travel distance per IBC Table 1017.2 is 300 feet, but the *common path of egress travel* for the initial portion of the travel distance is limited to 100 feet per IBC Table 1006.2.1.

If a *common path of egress travel* within a building design exceeds the distance permitted in IBC Table 1006.2.1, then another pathway will need to be introduced into the design. This may require the addition of another *exit* or *exit access doorway* from a space. Any new paths created to overcome *common path of egress travel* issues will need to be checked to ensure that new paths do not merge and do not violate the provisions for intervening rooms as discussed in Step 10.2.

In addition to the general requirements for *common path of egress travel*, IBC Section 1029.8 establishes requirements for common paths within assembly spaces and IBC Section 1018.4 has common path requirements for Group M occupancies. In assembly spaces, the *common path of egress travel* from any seat to a point where two paths are available is limited to 30 feet. For *smoke-protected assembly seating*, the *common path of egress travel* is limited to 50 feet. For Group M occupancies, the *common path of egress travel* from any point within a *merchandise pad* is limited to 30 feet (Figure 10.2.2-3). For all applications, if the *occupant load* of the space is less than 50, then the *common path of egress travel* cannot exceed 75 feet.

10.2.3 AISLES (IBC SECTIONS 1018 AND 1029)

Aisles and *aisle accessways* are part of the *exit access* portion of the *means of egress* system and must be included as part of the travel distance measurement. *Common path of egress travel* requirements apply to *aisles* and *aisle accessways* within assembly spaces (see Note) and they also apply to *aisle accessways* within *merchandise pads* of Group M occupancies (see Step 10.2.2).

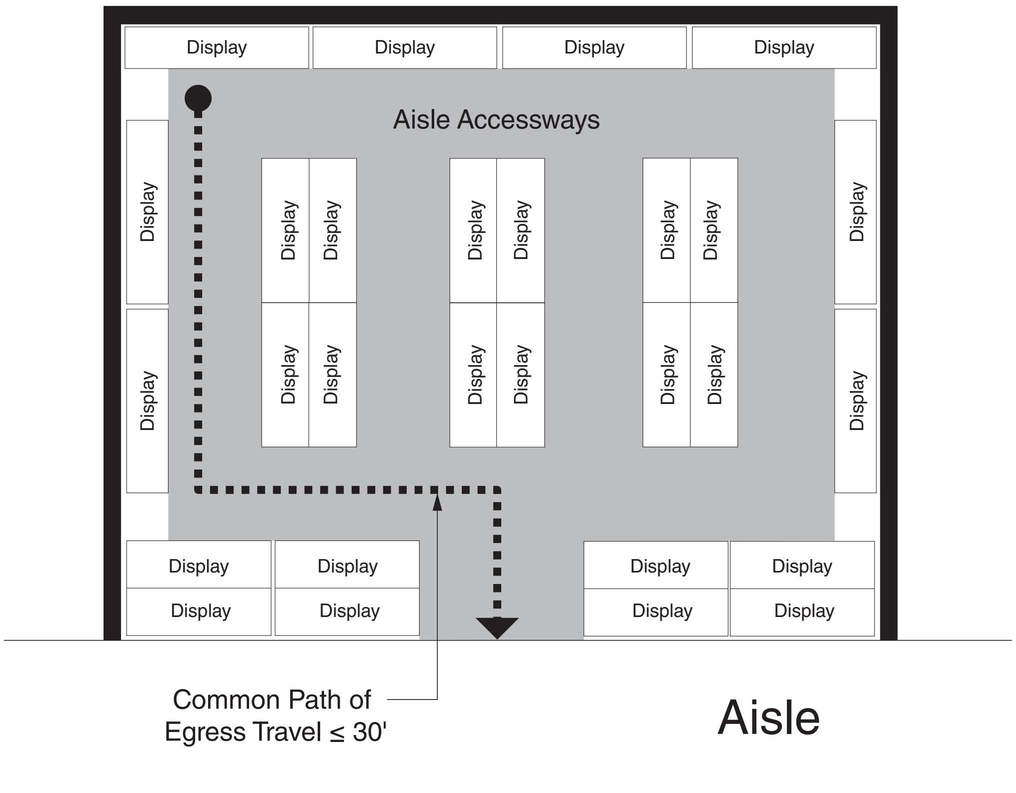


FIGURE 10.2.2-3. *Common path of egress travel* within a *merchandise pad* in Group M occupancies.

> **NOTE:**
>
> It is important to note that, when the IBC uses "assembly spaces," "rooms or spaces for assembly purposes," or similar phraseology, it is referring to any space used for assembly-type functions whether it is classified as a Group A occupancy or not. For example, a lecture hall with an *occupant load* less than 50 is an assembly use but is not classified as a Group A-3. If a requirement applies to any of the Group A occupancies specifically, the applicable occupancy groups will be identified.

The minimum width of an *aisle* in all spaces other than assembly spaces is 44 inches, but if the *occupant load* is less than 50, then the minimum width is permitted to be 36 inches. If an *aisle* is not available to the public, it is not required to be *accessible* (see Step 20), and if the *occupant load* is less than 50, then the *aisle* width is permitted to be 28 inches. The width of *aisle accessways* within *merchandise pads* may be 30 inches if they are not required to be *accessible*.

The minimum widths for *aisles* in assembly spaces (IBC Section 1029.9) vary depending on the arrangement of rows, the number of rows served, or the number of seats served. The measurement is the clear width between walls, edges of seating, and tread edges. For measurement of *aisles* with seating at tables, the measurement may be in accordance with the requirements for *aisle accessways* discussed later in this step. The minimum *aisle* width requirements include the following:

- Stepped *aisles* with seating on both sides: 48 inches.
- Stepped *aisles* with seating on both sides (serving less than 50 seats): 36 inches.
- Stepped *aisles* with seating on both sides with mid-*aisle handrail* or *guard*: 23 inches measured between *handrail* or *guard* and the seating.
- Stepped *aisles* with seating on one side only: 36 inches.
- Stepped *aisles* serving five or less rows: 23 inches measured between the *handrail* and the seating.
- Level or ramped *aisles* with seating on both sides: 42 inches.
- Level or ramped *aisles* with seating on both sides (serving less than 50 seats): 36 inches.
- Level or ramped *aisles* with seating on both sides (serving less than fifteen seats): 30 inches.
- Level or ramped *aisles* with seating on one side only: 36 inches.
- Level or ramped *aisles* with seating on one side only and not part of an *accessible route* (serving less than 15 seats): 30 inches.

Aisle accessway widths in assembly spaces depend on the type of seating arrangement: seating at tables or seating in rows.

- **Seating at Tables:** The minimum clear width is 12 inches for *aisle accessways* having a length of 12 feet or less. If the length of the *aisle accessway* exceeds 12 feet, then the minimum width shall be increased by 1/2 inch for every additional foot, or a fraction thereof, in length beyond 12 feet. The length of an *aisle accessway* is measured from the edge of an *aisle* to the center of the furthest seat on the *aisle accessway* (Figure 10.2.3-1).
    - **Non–Fixed Seating at Tables:** The measurement of *aisle accessways* is to a line located 19 inches away and parallel to the edge of a table or counter. The measurement must be perpendicular to the line, and the other end of the measurement shall extend to a wall, another edge of seating, or the edge of treads for stepped *aisle accessways*.
    - **Fixed Seating at Tables:** The measurement of *aisle accessways* shall be to the back of the seating. The other end of the measurement shall extend to a wall, another edge of seating, or the edge of treads for stepped *aisle accessways*.

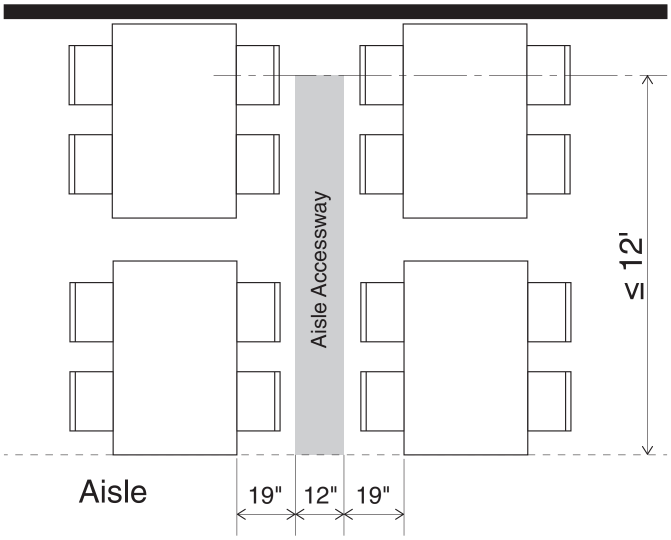


FIGURE 10.2.3-1. Measurement of *aisle accessway* width for seating at tables.

- **Seating in Rows:** For rows with less than 15 seats, the distance between the back of the seating of the row in front to the nearest edge of the seating of the row in question cannot be less than 12 inches. If the seating has self-rising seats, the measurement is based on the seat in the raise position. If folding tablet arms are installed on the seats, then the measurement shall be determined when the tablet arms are in the unfolded position, unless the tablet arm returns to the folded position automatically due to gravity.
    - **Rows with Access at Each End (Dual Access):** Rows must be accessed by *aisles* or doorways at both ends and are limited to 100 seats each and shall have a clear width of 12 inches between rows. For every seat over 14 seats, the clear width must be increased by 0.3 inch. If the seats do not have backrests, then the increase is per seat over 21 seats. However, no *aisle accessway* is required to be more than 22 inches in clear width.
    - **Rows with Access at One End Only (Single Access):** Rows must be accessed by an *aisle* or doorway and shall have a clear width of 12 inches between rows. For every seat over 7 seats, the clear width for the entire row must be increased by 0.6 inch. If the seats do not have backrests, then the increase is per seat over 10 seats. However, no *aisle accessway* is required to be more than 22 inches in clear width.
    - **Smoke-Protected Assembly Seating:** The maximum number of seats permitted in a row with a 12-inch clear width *aisle accessway* shall comply with IBC Table 1029.12.2.1 for either dual-access or single-access rows. Rows that exceed the number of seats in IBC Table 1029.12.2.1 are required to be increased per the requirements for dual-access or single-access rows as applicable.

10.2.4 EXIT ACCESS STAIRWAYS AND RAMPS (IBC SECTION 1019)

Exit access stairways and *exit access ramps* are *stairways* and *ramps* that do not meet the minimum requirements for *exits*. They may be either enclosed or unenclosed depending on the number of *stories* they connect and the occupancy group in which they are located. The concept of enclosed *stairways* and *ramps* that are part of the *exit access* may be initially confusing to some; however, the concept is quite simple. For example, a company with a five-story office building occupies only stories 3, 4, and 5, but they want a *stairway* that is internal to their company only and not able to be accessed by other occupants of the building. An enclosed *exit access stairway* can be provided that connects only those three stories.

For a *stairway* or *ramp* to be considered an *exit*, it must be enclosed with *fire-resistance-rated* assemblies and terminate at the *exit discharge* or *public way* or be extended to the *exit discharge* or *public way* by an *exit passageway* or *interior exit ramp*. (Some exceptions apply; see Step 10.3.) *Exit access stairways* and *exit access ramps*, on the other hand, do not terminate at the *exit discharge*—occupants using these *stairways* and *ramps* are discharged back into the *exit access* on another *story*. Therefore, *exit access stairways* and *exit access ramps* must be included in the travel distance as described in Step 10.2.1.

Exit access stairways and *exit access ramps* are required to be enclosed per the requirements of IBC Section 713. For occupancy groups other than Groups I-2 and I-3, IBC Section 1019.3 provides a list of conditions where *exit access stairways* and *exit access ramps* are not required to be enclosed; however, the conditions will not be applicable if the *exit access stairways* or *exit access ramps* are part of an egress path to an *exit* that includes *fire-resistance-rated corridors*. These conditions include the following:

- *Stairways* and *ramps* that connect two adjacent *stories* that are not open to other *stories*
- *Stairways* and *ramps* that connect not more than four *stories* and are contained entirely within *dwelling units*, *sleeping units*, or *live/work units* of Group R-1, R-2, or R-3 occupancies, as applicable
- *Stairways* contained within a Group R-3 congregate residence or a Group R-4 occupancy
- *Stairways* and *ramps* within a building that is sprinklered throughout per NFPA 13 and where the openings in the floor/ceiling assemblies do not exceed twice the horizontal (plan) area of the *stairway* or *ramp*. The openings are also required to be protected by draft stops and sprinklers per NFPA 13 (see Step 23.2 for detailed requirements). This condition is limited to four *stories* for all occupancy groups, except for Groups B and M.
- *Stairways* and *ramps* within an *atrium* conforming to the requirements of IBC Section 404
- *Stairways* and *ramps* within and only serving *open parking garages*
- *Stairways* and *ramps* serving open-air seating and complying with the *exit access* travel distances of IBC Section 1029.7, Exception 2, which allows a travel distance of 400 feet or, if of Type I or II construction, unlimited travel distance (see Step 10.2.1)
- *Stairways* and *ramps* connecting balconies, galleries, or press boxes with the main floor of assembly buildings, such as theaters, *places of religious worship*, auditoriums, and sports *facilities*

Group I-3 occupancies may have unenclosed *exit access stairways* and *exit access ramps* if the buildings conform to the requirements for IBC Section 408, which allows *spiral stairways* (IBC Section 408.3.4) and ship ladders (IBC Section 408.3.5) for certain uses as well as *stairs* or *ramps* connecting not more than two floors from any area on a *cell tier* within a *housing unit*.

10.2.5 CORRIDORS (IBC SECTION 1020)

A *corridor* is an enclosed egress pathway that provides a well-defined path to an *exit*. Where *corridors* are required to be *fire-resistance rated*, they must be continuous to an *exit* and cannot be interrupted by intervening rooms. In other words, once occupants enter a *fire-resistance-rated corridor* to egress, they shall be provided with that *corridor* protection until they reach an *exit*. If a *fire-resistance-rated corridor* terminates at an *exit access stairway* or *exit access ramp*, the *stairway* or *ramp* must also be protected per IBC Section 713. At the termination of the *stairway* or *ramp*, a *fire-resistance-rated corridor* shall continue the path to an *exit*.

IBC Section 1020.6 provides two exceptions that will permit a *fire-resistance-rated corridor* to terminate at spaces other than *exits*:

- When the room is a foyer, lobby, or reception area that is constructed with *fire-resistance-rated* assemblies and openings as required for *corridors*

- When the room is an enclosed elevator lobby as permitted by IBC Section 1016.2, Item 1 (see Step 10.2)

When two or more *exits* or *exit access doorways* are required, the *exit access* shall be designed so that *corridors* do not have dead ends that exceed 20 feet. The length of a dead end can be up to 50 feet in Group I-3 occupancies of Conditions 2, 3, or 4. Dead ends can also be up to 50 feet in buildings sprinklered throughout per NFPA 13 in Group B, E, F, I-1, M, R-1, R-2, R-4, S, and U occupancies. Another exception is when the length of a *corridor* dead end is no longer than 2.5 times the narrowest width of the *corridor* dead end. For example, if a *corridor* dead end has a minimum width of 10 feet, the length of the *corridor* dead end can be 25 feet.

Corridors in Group I-2 occupancies shall comply with IBC Section 407.2. *Corridors* are required to be separated from other areas of the building, except that the following areas are permitted to be open to corridors provided the applicable requirements are met:

- **Waiting and Similar Areas:** The areas, as well as the *corridors* within the same *smoke compartment*, are protected by an automatic fire detection system or the sprinkler system throughout the *smoke compartment* is equipped with quick-response sprinklers. The areas cannot obstruct the access to the *exits*.
- **Care Provider's Stations:** The stations must be constructed as required for the *corridors*.
- **Psychiatric Treatment Areas:** These areas are permitted when the floor area does not exceed 1,500 sq. ft., is located to allow supervision by facility staff, and is protected by an automatic fire detection system. The area cannot obstruct access to the *exits*. Only one such space is permitted within a *smoke compartment* and the space is constructed as required for the *corridors*.
- **Gift Shops:** Shops are permitted when the area is less than 500 sq. ft. and they are constructed as required for the *corridors*.
- **Nursing Home Housing Units:** Spaces such as shared living spaces, group meeting spaces, and multipurpose therapeutic spaces in Condition 1 occupancies are permitted when they are constructed as required for *corridors*, are not used as sleeping rooms, and do not obstruct access to the *exits*. The areas, as well as the *corridors* within the same *smoke compartment*, are protected by an automatic fire detection system or the sprinkler system throughout the *smoke compartment* is equipped with quick-response sprinklers.
- **Nursing Home Cooking Facilities:** Cooking areas that use residential-type cooking appliances in Condition 1 occupancies are permitted when the number of care recipients in the smoke compartment and those served by the cooking facility does not exceed 30. Only one cooking facility is permitted within a smoke compartment. The corridor path must be clearly marked by a distinguishable pattern, material, or color.

The minimum width of a *corridor* is dependent upon the *occupant load* and the occupancy group it serves. Calculation of *corridor* widths based on *occupant loads* in excess of the minimum capacities is covered in Step 19. Minimum capacities of the prescriptive *corridor* minimum widths are provided in a summary table in Step 10.6. IBC Table 1020.2 provides the minimum widths for different types of *corridor* applications.

10.2.6 EGRESS BALCONIES (IBC SECTION 1021)

An egress balcony is typically an exterior egress pathway that is elevated above a *level of exit discharge*. Egress balconies must comply with the requirements for *corridors*, except as modified within IBC Section 1021. Walls separating an egress balcony from the interior of the building are required to have the same *fire-resistance rating* and protected openings as required for *corridors*. However, if an egress balcony has two *stairways*, one on each end, and any dead ends (complying with *corridor* requirements) beyond the *stairways* do not have unprotected openings, then the wall between the egress balcony and the interior of the building is not required to be a *fire-resistance-rated* assembly.

Additional requirements to qualify as an egress balcony include the following:

- The area of an egress balcony's long side must be 50% open. The open area above the egress balcony *guard* must be evenly distributed along the length of the egress balcony. This is to avoid creating pockets within the egress balcony where smoke and other toxic gases can be trapped, preventing its effective use as an egress pathway.
- Egress balconies must have a *fire separation distance* of 10 feet measured at a 90-degree angle from the outside edge of the balcony. The other end of this distance shall be to adjacent *lot lines*, other portions of the same building, or other buildings on the same *lot*. If other portions of the building or other buildings on the same *lot* are protected as *exterior walls* and openings per IBC Section 705, then the 10-foot *fire separation distance* is not required.

10.3 THE EXIT (IBC SECTION 1022)

As discussed in Step 9.1, the *exit* is the portion of a *means of egress* system that begins at the end of the *exit access* and leads to the *exit discharge* or directly to the *public way*. Thus, the *exit* portion of the *means of egress* must terminate at the exterior of the building to the *exit discharge* or *public way*. The only exception to this rule is the *horizontal exit*. With few exceptions, the *exit* is the most protected portion of the *means of egress* system within a building. Since *exit access* travel distance is measured to the entrance of an *exit*, it is important to know exactly what is considered an *exit* by the IBC.

The *exit* can include any of the following elements within a building:

- Exterior doors at ground level
- Enclosed *interior exit stairways*
- Enclosed *interior exit ramps*
- *Exit passageways*
- *Horizontal exits*
- *Exterior exit stairways*
- *Exterior exit ramps*

Exits are intended for *means of egress*, but they may also serve as components for general circulation within the building. Nevertheless, *exits* are prohibited from being used for purposes that interfere with their function as a *means of egress*, such as intervening rooms or spaces. Doorways into *exits* shall be from other *exit* components, from *exit access* pathways leading to the *exits*, or to the *exit discharge*. Therefore, doors for storage or utility closets, elevators, trash chutes, etc., are not permitted.

10.3.1 INTERIOR EXIT STAIRWAYS AND RAMPS (IBC SECTION 1023)

Exit stairways and *exit ramps* located within the building are required to be enclosed. Since an *exit* must terminate at the *exit discharge* or a *public way*, the *stairways* or *ramps* must extend to the *level of exit discharge* or be continued by a combination of *exit passageways*, *interior exit stairways*, or *interior exit ramps* that eventually lead to the *exit discharge* or *public way*.

Stairways within an *atrium* enclosed per IBC Section 404.6 are permitted to be considered *interior exit stairways*. See Step 10.2.1 for a discussion on measuring travel distance to *interior exit stairways* within an *atrium*.

In *high-rise buildings*, where an *interior exit stairway* serves a floor more than 75 feet above the lowest level of fire department vehicle access, the *stairway* is required to be a *smokeproof enclosure*. Therefore, such *stairways* are required to be accessed through a vestibule or exterior balcony per IBC Section 909.20.5. The minimum width of the vestibule is 44 inches, but not less than the width of the *corridor* serving the vestibule. The length of the vestibule cannot be less than 72 inches measured in the direction of egress travel.

10.3.2 EXIT PASSAGEWAYS (IBC SECTION 1024)

Exit passageways are similar to *corridors* but have increased *fire resistance* and limitations on openings. They can only be used for *means of egress* or for internal circulation. If the *exit access* travel distance within a *corridor* exceeds the distance permitted, the remaining portion of the *corridor* can be converted into an *exit passageway*.

As previously mentioned, an *exit passageway* may connect *interior exit stairways* or *interior exit ramps* or they may extend those *stairways* and *ramps* to the *exit discharge* or *public way*. At the transition between an *exit passageway* and an *interior exit stairway* or *interior exit ramp*, there must be a doorway in accordance with IBC Section 1023.3.1. If an *exit passageway* is extending the *stairway* or *ramp* to the *exit discharge* and there are no other openings in the *exit passageway* other than the door to the *exit discharge*, then the doorway at the transition is not required.

10.3.3 HORIZONTAL EXITS (IBC SECTION 1026)

The *horizontal exit* is probably the least understood and most underutilized of all the *means of egress* components. In essence, the *horizontal exit* is an *exit* that allows occupants to egress from one side of a building to another side through a *fire-resistance-rated* assembly, such as a *fire wall* or *fire barrier*. The *horizontal exit* provides an additional layer of fire-resistive protection between the fire source and the occupants to allow them to safely egress through an *interior exit stairway* or some other *exit* component.

At the very basic level, *horizontal exits* cannot serve as the only type of *exit* from a portion of a building, and where two or more *exits* are required, no more than half of those can be *horizontal exits*. There are, however, exceptions to this provision.

The first exception is for Group I-2 occupancies, such as *hospitals* and *nursing homes*, where up to two-thirds of the required *exits* may be *horizontal exits*. In most cases, the occupants in this type of occupancy are nonambulatory, while some may even be bedridden. In this situation, the *horizontal exit* provides a refuge area, giving rescue workers additional time to evacuate all occupants.

The second exception is for Group I-3 occupancies, which include jails, prisons, and other *facilities* where the occupants are confined. This exception allows 100% of the required *exits* to be *horizontal exits*. For obvious reasons, the majority of occupants in this occupancy type need to be under control, even during an emergency. Therefore, the code permits the occupants to be transferred from one secure area of the building to another secure area.

Horizontal exits can operate in one direction or both directions. If operating in both directions and if the areas served on each side of the *horizontal exit* have *occupant loads* of 50 or more, then a minimum of two doorways will be required, each swinging in the direction of egress travel from the side served (Figure 10.3.3-1).

The benefit of using a *horizontal exit* is that it can replace a required *stairway* if three *exits* are required from a *story*. To illustrate this, assume a floor in a Group B office building has 650 occupants. In accordance with IBC Table 1006.3.1, three *exits* are required, which would typically be accomplished by providing three *interior* or *exterior exit stairways* (Figure 10.3.3-2).

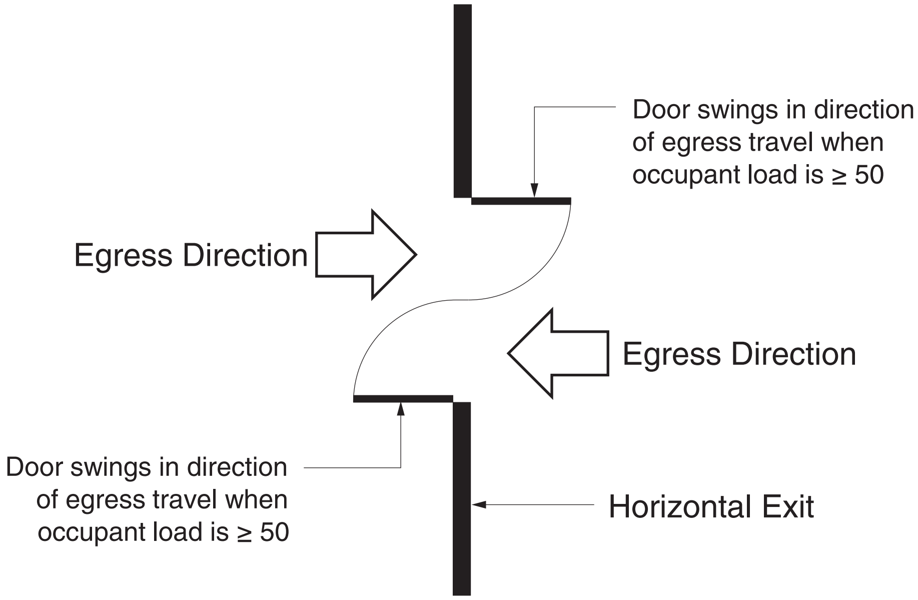


FIGURE 10.3.3-1. Doors in *horizontal exit* swinging in direction of egress travel when egress is considered from both sides and the *occupant load* is 50 or greater.

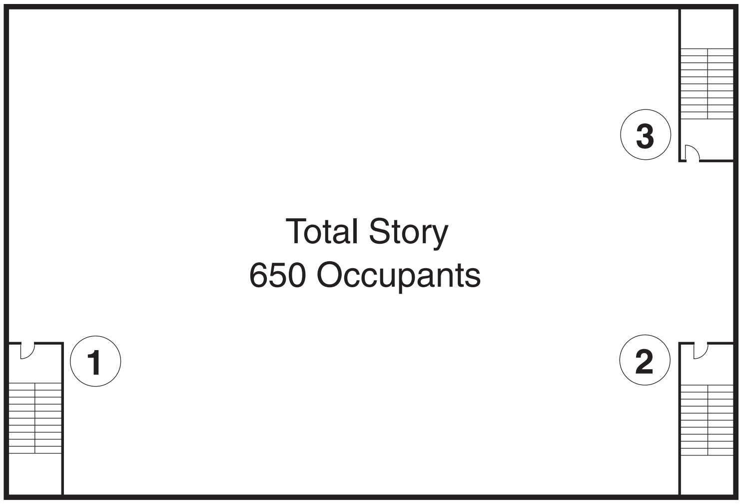


FIGURE 10.3.3-2. A floor plan of a building story indicating the three required *exits* based on the story's *occupant load*.

If one of those *stairways* is replaced with a *horizontal exit*, the *occupant load* of the *story* will be split depending on the location of the *horizontal exit* within the *story*. In the example, we will assume that the *horizontal exit* is situated so that 400 occupants are on one side (compartment A) of the *horizontal exit* and 250 occupants are on the other side (compartment B) (Figure 10.3.3-3). Since each compartment has 500 or less occupants, only two *exits* are required from each compartment: From compartment A, exits 1 and 2, and from compartment B, exits 2 and 3. Furthermore, the minimum three *exits* required by IBC Table 1006.3.1 for *occupant loads* exceeding 500 are provided, since the *horizontal exit* is considered one of the three required *exits*.

For purposes of planning egress pathways, it is important to understand that once occupants pass through a *horizontal exit* they must still have a pathway to another *exit* that leads to an *exit discharge* or

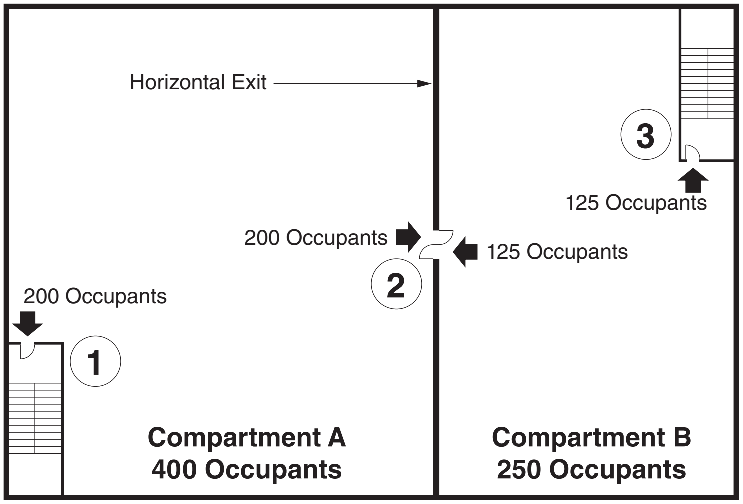


FIGURE 10.3.3-3. The same floor plan of the building story with a *horizontal exit* in lieu of one of the *interior exit stairways*.

public way. The area on the other side of a *horizontal exit* is considered a refuge area and must be sized to accommodate the number of occupants egressing through the *horizontal exit* plus the number of occupants existing within the refuge area.

The capacity of the refuge area is calculated by multiplying the sum of the *occupant loads* (original *occupant load* plus the *occupant load* through the *horizontal exit*) by 3 sq. ft. per occupant. The resultant area is the *net floor area* that is required for the refuge area. The *occupant load* through the *horizontal exit* is based on the capacity of the door through the *horizontal exit* and not the portion of the *occupant load* designated to egress through the door as determined per Step 19. The *net floor area* available should be the areas to which the occupants of the adjoining compartment would have access, such as *corridors*, lobbies, waiting areas, and other publicly accessible spaces. Nonpublic areas of the refuge area are permitted to be used as refuge areas for the original occupants.

Using the previous example, if the door from compartment B complies with the minimum clear width of 32 inches, then the capacity of the door would be 160 occupants determined by dividing the width (32 inches) by 0.20 inches (per IBC Section 1005.3.2). Thus, the *net floor area* of the refuge area in compartment A would need to be 1,680 sq. ft. (400 occupants in compartment A + 160 occupants from compartment B × 3 sq. ft. per occupant).

10.3.4 EXTERIOR EXIT STAIRWAYS AND RAMPS (IBC SECTION 1027)

To be considered an *exterior exit stairway* or *exterior exit ramp*, the *stairway* or *ramp* must be open on one side. The open side must provide an aggregate area of 35 sq. ft. for each floor level and for each intermediate landing, and the open area cannot be less than 42 inches above the floor or landing. Open areas next to the *exterior exit stairways* or *exterior exit ramps* must be a *yard*, *court*, or *public way*. The other sides of the *stairway* or *ramp* are allowed to be *exterior walls* of the building.

Exterior exit stairways and *exterior exit ramps* must have a *fire separation distance* of 10 feet measured at a 90-degree angle from the outside edge of the *stairway* or *ramp*. The other end of this distance shall be to adjacent *lot lines*, other portions of the same building, or other buildings on the same *lot*. If other portions of the building or other buildings on the same *lot* are protected as *exterior walls* and openings per IBC Section 705, then the 10-foot *fire separation distance* is not required.

10.4 THE EXIT DISCHARGE (IBC SECTION 1028)

At the point that an *exit* reaches the exterior, the *exit discharge* begins. The *exit discharge* can be a *public way*; otherwise, it shall lead to the *public way* unless the exception for a safe dispersal area is utilized. Once an occupant is within the *exit discharge*, they shall not be directed back into the building. To be considered a safe dispersal area, it must comply with the four criteria listed in the exception:

1. It must have an area not less than 5 sq. ft. per occupant.
2. It must be located on the same *lot* as the building and be located not closer than 50 feet from the building.
3. The area must be maintained and marked as a safe dispersal area.
4. The area must be accessed by a clear and safe path leading from the building.

Although an *exit* is required to discharge at the exterior, the IBC does allow some *exits* to discharge within the building through exception as long as some minimum conditions are met:

- Up to 50% of the number of *interior exit stairways* and *interior exit ramps* may egress through areas on the *level of exit discharge*. Additionally, no more than 50% of the required *exit* width (see Step 19) can egress through areas on the *level of exit discharge*. To use this exception, the following conditions are required:
  - The *exit* door to the exterior must be immediately visible upon leaving the *stairway* or *ramp* enclosure.
  - The entire *level of exit discharge* must be a *horizontal assembly* having a rating equal to the *stairway* or *ramp* enclosure.
  - The path from the *stairway* or *ramp* enclosure on the *level of exit discharge* must be sprinklered by a NFPA 13 or 13R system. For spaces on the *level of exit discharge* that have access to the egress pathway, they, too, must be sprinklered or separated from the pathway with *fire barriers* that have a *fire-resistance rating* equal to the *stairway* or *ramp* enclosure.
  - If an *interior exit stairway* or *interior exit ramp* serves the same *stories* as an *exit access stairway* or *exit access ramp* and they terminate on the same *level of exit discharge*, they must be separated by a distance of 30 feet or not less than $^1/_4$ the length of the overall diagonal of the building, whichever is shorter.
- Up to 50% of the number of *interior exit stairways* and *interior exit ramps* may egress through a vestibule. Additionally, no more than 50% of the required *exit* width (see Step 19) can egress through a vestibule. To use this exception, the following conditions are required:
  - The entire area of the vestibule must be a *horizontal assembly* having a rating equal to the *stairway* or *ramp* enclosure.
  - The depth of the vestibule cannot be greater than 10 feet and the length cannot be greater than 30 feet.
  - The vestibule is separated from all other areas of the *level of exit discharge* by *fire partitions*.
  - The vestibule can only be used for *means of egress* and must discharge directly to the exterior.

Just about any pathway that leads to the *public way* can be considered an *exit discharge* component, provided it has sufficient open area so as not to trap smoke and toxic gases. Unlike the *exit access* and the *exit*, which have several distinct components, the *exit discharge* has only one defined component called an *egress court*.

10.4.1 EGRESS COURTS (IBC SECTION 1028.4)

An *egress court* is a *court* used as an exterior pathway from the building, but, because a *court* is surrounded by the building's *exterior walls* on at least three sides, the *court* poses a greater risk to occupants than a typical sidewalk leading from a building.

The minimum width of an *egress court* is 44 inches (*egress courts* for Groups R-3 and U may be 36 inches wide), but it cannot be less than the sum of the required widths for all *exits* discharging into the *egress court*. If an *egress court* is less than 10 feet in width, the *exterior walls* for a height of 10 feet above the surface of the *egress court* is required to be *fire-resistance rated* (see Step 15). Although *courts* are required to be unobstructed to the sky, the clear height of the *egress court* is 7 feet, so any protruding objects must not be located lower than that height.

10.5 ACCESSIBLE MEANS OF EGRESS (IBC SECTION 1009)

The requirements for *accessible means of egress* should not be confused with the requirements for *accessible routes*. Although an *accessible route* is permitted to be considered one of the required *accessible means of egress*, other provisions for *accessible means of egress* would not qualify as components of an *accessible route*. The intent of the *accessible means of egress* is to provide a direct pathway for persons with disabilities out of a building or to a protected area within a building where they can wait until assistance out of the building can be provided.

All spaces are required to be provided with one *accessible means of egress*, but when two or more *means of egress* are required, at least two *accessible means of egress* are required. The IBC provides three exceptions to this requirement:

- Existing buildings are not required to be provided with an *accessible means of egress*.
- *Mezzanines* that are required to be *accessible* are only required to have one *accessible means of egress* using *stairways*, elevators, or platform lifts.
- Assembly areas with ramped or stepped *aisles* are permitted one *accessible means of egress* where the *common path of egress travel* is *accessible* and complies with IBC Section 1029.8 (see Step 10.2.2).

An *accessible means of egress* must provide a continuous path from all *accessible* spaces to a *public way* and may include one or more of the following egress components:

- *Accessible routes* per IBC Section 1104 (see Step 13)
- *Interior exit stairways* per IBC Section 1023 (see Step 10.3.1) and as modified by this section
- *Exit access stairways* per IBC Section 1019.3 or 1019.4 (see Step 10.2.4) and as modified by this section
- *Exterior exit stairways* per IBC Section 1027 (see Step 10.3.4) and as modified by this section
- Elevators
- Platform lifts
- *Horizontal exits* (see Step 10.3.3)
- *Ramps* (see Step 13.3.3)
- *Areas of refuge*
- Exterior areas for assisted rescue

10.5.1 STAIRWAYS (IBC SECTION 1009.3)

Although *stairways* do not qualify as part of an *accessible route*, they are permitted to be used as part of an *accessible means of egress* when they are modified specifically for that purpose. The basic requirement for *stairways* in the *accessible means of egress* is that they have a minimum clear width of 48 inches between the *handrails*. The *stairway* must also include an *area of refuge* or be accessed from an *area of refuge* (see Step 10.5.3). If a *stairway* is an *exit access stairway* that connects different floor levels within the same *story*, then it is not permitted to be used as part of an *accessible means of egress*.

Exceptions to the basic requirement consist of the following:

- *Exit access stairways* serving a *mezzanine* are permitted to be a part of an *accessible means of egress*.
- Buildings that are sprinklered throughout per NFPA 13 or 13R are not required to have the 48-inch minimum clear width between the *handrails*.
- *Stairways* that are accessed from a refuge area associated with a *horizontal exit* are not required to have the 48-inch minimum clear width between the *handrails* nor are they required to have *areas of refuge*.
- *Exit access stairways* are not required to have *areas of refuge* if a two-way communication system is provided at an adjacent elevator landing.
- Buildings that are sprinklered throughout per NFPA 13 or 13R are not required to have *areas of refuge* at *stairways*.
- *Open parking garages* are not required to have *areas of refuge* at *stairways*.
- *Smoke-protected assembly seating* areas are not required to have *areas of refuge*.
- Group R-2 occupancies are not required to have *areas of refuge*.

10.5.2 ELEVATORS (IBC SECTION 1009.4)

Elevators used as an *accessible route* are required to comply with additional requirements if used as part of an *accessible means of egress*. If a building has an *accessible* floor that is four *stories* above the *level of exit discharge* (i.e., a five-story building) or four *stories* below the *level of exit discharge*, then IBC Section 1009.2.1 requires that one of the required *accessible means of egress* include an elevator. An elevator complying with the requirements of this IBC section is not required for floors complying with one of the following exceptions:

- Floors with *horizontal exits* at or above the *level of exit discharge* within buildings that are sprinklered throughout per NFPA 13 or 13R
- Floors provided with *ramps* within buildings that are sprinklered throughout per NFPA 13 or 13R

For an elevator to qualify as an *accessible means of egress*, it must comply with American Society of Mechanical Engineers/American National Standards Institute (ASME/ANSI) A17.1 Section 2.27 "Emergency Operation and Signaling Devices." Additionally, the elevator must be provided with a *standby power system*.

Elevators that are part of an *accessible means of egress* must be accessed from an *area of refuge*. An *area of refuge* is not required when one of the following conditions apply:

- The elevator serves an *open parking garage*.
- The building is sprinklered throughout per NFPA 13 or 13R.
- The elevator is not required to be located in a *shaft* per IBC Section 712, which includes an elevator within an *atrium*, serving only two *stories*, within a single *dwelling unit* connecting not more than four *stories*, connecting a floor and a *mezzanine*, or within a parking garage and only serving the parking garage.
- The elevator serves a *smoke-protected assembly seating* area.
- The elevator is accessed for a refuge area in association with a *horizontal exit*.

10.5.3 AREAS OF REFUGE (IBC SECTION 1009.6)

Where required elsewhere by the IBC, *areas of refuge* must comply with the requirements of this section. Each *accessible* space must be able to reach an *area of refuge* by an *accessible means of egress* that is within the maximum *exit access* travel distance required by IBC Section 1017.1 (see Step 10.2.1).

An *area of refuge* must have direct access to a *stairway* or elevator as applicable. The size of the *area of refuge* must be able to accommodate the required number of *wheelchair spaces* without encroaching on the required minimum *exit* width. A *wheelchair space* must be provided for every 200 occupants or fraction thereof. The minimum size of a *wheelchair space* is 30 by 48 inches. *Wheelchair spaces* shall be arranged so that no *wheelchair space* is blocked by more than one adjoining *wheelchair space*.

An *area of refuge* is required to be separated by *smoke barriers* and *horizontal assemblies* (see Step 15) unless located within the *stairway* enclosure or is located in an outdoor *exit access* area that provides sufficient open area to the outside.

Each *area of refuge* is required to have a two-way communication system that connects with the *fire command center* or a central location that has been *approved* by the fire department. If a *fire command center* or a central constantly attended location is not available, the system is required to either connect with a monitoring service or 9-1-1. In addition to the audible features of the system, the system should have visible signals for the visually impaired.

10.5.4 EXTERIOR AREAS FOR ASSISTED RESCUE (IBC SECTION 1009.7)

When the *exit discharge* cannot provide an *accessible route* to the *public way*, an exterior area for assisted rescue can be provided. However, the path from the *exit discharge* to the exterior area for assisted rescue must comply with the requirements for an *accessible route*. Unless the building is sprinklered throughout per NFPA 13 or 13R, *stairways* are required to have a clear width of 48 inches between the *handrails* if the *stairways* are part of the *means of egress* serving the exterior area for assisted rescue. The size of exterior areas for assisted rescue shall conform to the same requirements for *areas of refuge*.

If the exterior area for assisted rescue is located adjacent to the *exterior walls* of the building, the walls are required to be protected (see Step 15). The openness of exterior areas of assisted rescue shall be no less than 50% of the wall areas that are not *exterior walls* of the building. The openings shall be equally distributed so as to prevent trapping smoke and toxic gases.

10.5.5 PLATFORM LIFTS (IBC SECTION 1009.5)

Platform lifts are acceptable in the *accessible means of egress*, provided they are allowed as part of an *accessible route* per IBC Chapter 11. The only use in IBC Chapter 11 that is not acceptable is when the platform lift is used to overcome exterior *site* issues. Platform lifts used for an *accessible means of egress* are required to be provided with *standby power systems*.

10.6 MINIMUM EGRESS PATHWAY CAPACITIES

Table 10.6-1 summarizes the minimum required widths and the maximum number of occupants (i.e., capacity) of each component based on sprinklered and nonsprinklered conditions. If a component serves an *occupant load* less than the maximum number of occupants indicated for that component, then the minimum width must be provided. If the *occupant load* served is greater than the maximum number of occupants indicated, then a larger egress width will be required.

To determine the required minimum width, Step 19 can be initiated early based on preliminary information or the width can be increased using the following rules of thumb:

- **Stairways:** Increase width by 1 foot for every 40 occupants over the minimum in nonsprinklered buildings and for every 60 occupants over the minimum in sprinklered buildings provided with an *emergency voice/alarm communications* system.
- **Other Egress Components:** Increase width by 1 foot for every 60 occupants over the minimum in nonsprinklered buildings and for every 80 occupants over the minimum in sprinklered buildings provided with an *emergency voice/alarm communications* system.

TABLE 10.6-1. *Means of Egress* Width Summary

Egress Component/Condition	Min. Clear Width (in.)	Max. Occupant Capacity	
		Nonsprinklered	Sprinklered
Aisles—Assembly Spaces [1]			
Stepped *aisles*, seating on both sides	48	240	320
Stepped *aisles*, seating on both sides, serving <50 seats	36	49	49
Stepped *aisles*, seating on one side only	36	180	240
Stepped *aisles*, seating on one side only, serving five or less rows	23 [2]	115	153
Stepped *aisles*, seating on both sides, with center *handrail*	23 [2]	115	153
Level or ramped *aisles*, seating on both sides	42	210	280
Level or ramped *aisles*, seating on both sides, serving <50 seats	36	49	49
Level or ramped *aisles*, seating on both sides, serving <15 seats	30	14	14
Level or ramped *aisles*, seating on one side only	36	180	240
Ramped *aisles*, seating on one side only, not on *accessible route*, serving <15	30	14	14
Aisle accessways, seating at tables (see Step 10.2.3)	12	—	—
Aisle accessways, seating in rows, dual-access, default requirement [3]	12	14	14
Aisle accessways, seating in rows, dual access	22	100	100
Aisle accessways, seating with backrests in rows, single access	12	7	7
Aisle accessways, seating without backrests in rows, single access	12	10	10
Aisle accessways, seating in rows, single access	22	Limited by *common path of egress travel* and seat width used. See Step 10.2.2.	
Aisle accessways, *smoke-protected assembly seating*	12	See IBC Table 1029.12.2.1	
Aisles—Groups B and M			
Default requirement [3]	44	220	293
Mechanical, plumbing, and electrical equipment access	24	120	160
Nonpublic	28	140	186
Group M *aisle accessway* (not accessible)	30	150	200
Aisles—Other			
Default requirement [3]	44	220	293
Occupant load < 50	36	49	49
Mechanical, plumbing, and electrical equipment access	24	120	160
Corridors			
Default requirement [3]	44	220	293
Mechanical, plumbing, and electrical equipment access	24	120	160
Occupant load <50	36	49	49
Within *dwelling unit*	36	180	240
Group E (*occupant load* ≥100)	72	360	480
Ambulatory care facilities with stretcher traffic	72	360	480
Group I-2 for bed movement	96	480	640
From *malls*	66	330	440
Doors [4]			
Default requirement [3] (approx. 35-in.-wide door)	32	160	213
36-in.-wide door	33	165	220
40-in.-wide door	37	185	246
44-in.-wide door	41	205	273
48-in.-wide door	45	240	320
Egress Balconies			
Default requirement [3]	44	220	293
Occupant load <50	36	49	49
Group E (*occupant load* ≥100)	72	360	480
Egress Courts			
Default requirement [3]	44	220	293
Groups R-3 and U	36	180	240

TABLE 10.6-1. (*Continued*)

Egress Component/Condition	Min. Clear Width (in.)	Max. Occupant Capacity	
		Nonsprinklered	Sprinklered
Exit Passageways			
Default requirement [3]	44	220	293
Occupant load <50	36	49	49
From *malls*	66	330	440
Malls			
Aggregate clear width	240	1,200	1,600
Ramps			
Default requirement [3]	44	220	293
Occupant load <50	36	49	49
Stairways			
Default requirement [3]	44	146	220
Occupant load <50	36	49	49

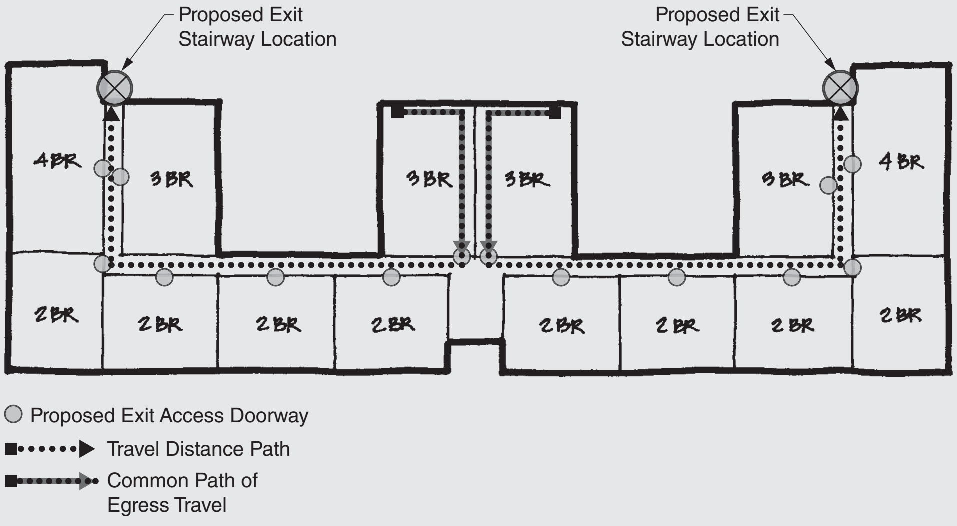
[1] Spaces used for assembly purposes but not classified as Group A must also comply with the widths within this category.
[2] Width is the clear width between *handrail* and seating.
[3] The default requirement applies when none of the other conditions for that component are applicable.
[4] The minimum clear width for a door is 32 inches; however, many standard door widths provide clear widths that exceed the minimum. Some standard door widths with their respective nominal clear widths are provided for planning purposes. Doors provided in pairs without an intermediate mullion will provide slightly larger clear widths and, thus, a slightly larger capacity. See Step 19 for more details on door widths.

EXAMPLE PROJECT—STEP 10

MEANS OF EGRESS

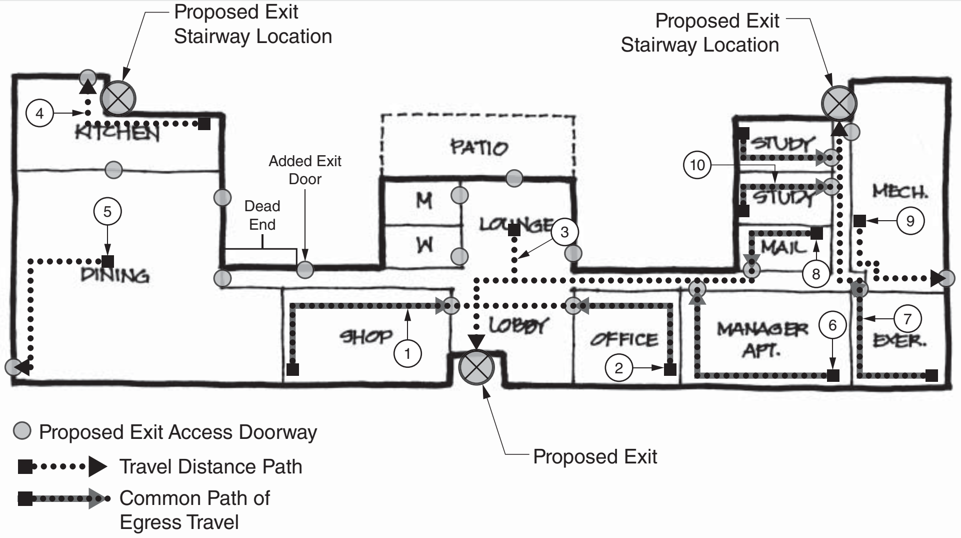
Regarding the residential floors, the egress pathways are simple. They lead from the most remote point in each apartment into the corridor to an interior exit stairway. The longest travel distance is from one of the center three-bedroom apartments to the nearest interior exit stairway as indicated in Example Project Figure 10-1. The travel distance, which has an approximate length of 197 feet, is less than the 250 feet permitted per IBC Table 1017.2. In the other direction, the travel distance is the same.

The longest common path of egress travel is within the center three-bedroom apartments. This common path of egress travel is measured from the beginning of the travel distance to the apartment entry door. The distance is approximately 59 feet, which is less than the 75 feet permitted by IBC Table 1006.2.1.



EXAMPLE PROJECT FIGURE 10-1. The egress paths for the second through the fourth stories. The longest travel distance and the longest common path of egress travel are from the center three-bedroom apartments

The egress paths for the first story are a little more complicated. Many spaces have exits directly to the exterior, so the travel distances are well within the permitted distances of IBC Table 1017.2. Each relevant travel distance and common path of egress travel are indicated in Example Project Figure 10-2. Where a space has access to two egress pathways, no common path of egress travel will apply.



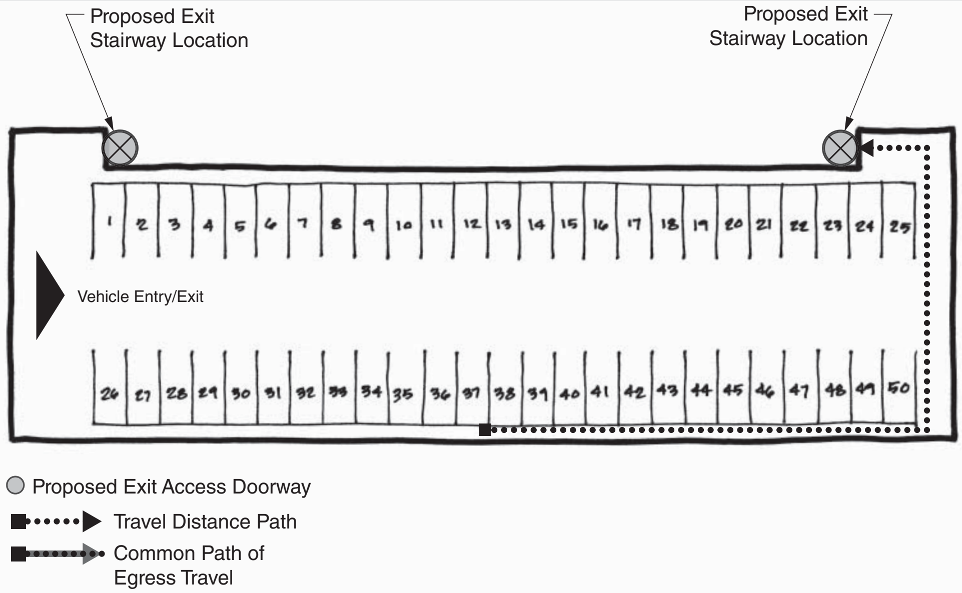
EXAMPLE PROJECT FIGURE 10-2. The egress paths for the first story. Each path is tagged with a number, which corresponds to the information indicated in the table below.

First-Story Egress Path Summary

Tag	Occupancy Group	Travel Distance	Max. Allowed Travel Distance per IBC Table 1017.2	Common Path of Egress Travel	Max. Allowed Common Path of Egress Travel per IBC Table 1006.2.1
1	M	83 ft.	250 ft.	63 ft.	75 ft.
2	B	84 ft.	300 ft.	47 ft.	100 ft.
3	A-3	43 ft.	250 ft.	0. ft.	75 ft.
4	A-2	36 ft.	250 ft.	0 ft.	75 ft.
5	A-2	51 ft.	250 ft.	0 ft.	75 ft.
6	R-2	136 ft.	250 ft.	63 ft.	125 ft.
7	B	55 ft.	300 ft.	48 ft.	100 ft.
8	S-1	120 ft.	250 ft.	31 ft.	100 ft.
9	R-2	46 ft.	250 ft.	0 ft.	125 ft.
10	B	61 ft.	250 ft.	33 ft.	100 ft.

The egress paths in the basement are very straightforward. The travel distance indicated in Example Project Figure 10-3 is 203 feet in length, which is less than the 400 feet permitted by IBC Table 1017.2. Since the parking garage is open with no interior walls, there is no common path of egress travel.

At this preliminary phase of design, the minimum widths of exit and exit access doorways throughout the building may consist of standard 36-inch-wide doors with a minimum clear width



EXAMPLE PROJECT FIGURE 10-3. The egress path for the basement parking garage.

of 33 inches per Table 10.6-1. This design decision is based on the occupant loads determined in Step 8, which will be less than the 220 occupant capacity indicated for that door size for a sprinklered building with an emergency voice/alarm communications system.

Similarly, the corridors may have the default requirement of 44 inches as indicated in Table 10.6-1. The only dead-end corridor is located toward the dining hall dining area. The distance of the dead-end corridor is 62 feet, which exceeds the 20-foot length permitted by IBC Section 1020.4 (Exception 2 does not apply, since the building is not sprinklered throughout with a NFPA 13 system). Therefore, another door was added to the exterior to reduce the dead end to 20 feet. Within dwelling units (i.e., apartments), corridors may have a width of 36 inches.

Interior exit stairways from the basement and stories above the first story may also consist of stairs that comply with the default requirement of 44 inches as indicated in Table 10.6-1.

Aisles and aisle accessways will be required in the convenience shop and the dining hall dining area. However, at this early phase of design, detailed configurations of these spaces have not been determined. When the design is refined and a proposed FF&E layout is prepared, application of the aisle and aisle accessway requirements can be applied.

ACCESSIBLE MEANS OF EGRESS

The egress pathways on the first story comply with the requirements for the accessible means of egress, so no additional consideration is required. On the second, third, and fourth stories, only two accessible means of egress are required. The elevator is not required to be one of the accessible means of egress per IBC Section 1009.2.1, since the building only has three stories above the level of exit discharge. Therefore, the two interior exit stairways will be considered the two accessible means of egress. The stairs are not required to have the minimum 48-inch clear width between the handrails per IBC Section 1009.3, Exception 2. Additionally, the areas of refuge are not required at the stairways per IBC Section 1009.3, Exception 5.

STEP 11

Determine Fixture Counts

STEP OVERVIEW

Using the *occupant loads* calculated in Step 8, this step determines the number of required plumbing fixtures. The size of a restroom is dependent upon the minimum number of fixtures required as well as other requirements regarding accessibility. An improper fixture count could cause space planning issues, particularly if the number was underdetermined. Therefore, a thorough understanding of fixture count calculations could minimize problems later in the design process. This step also discusses requirements associated with basic toilet room planning.

11.1 INTRODUCTION TO PLUMBING FIXTURES

Restroom sizes are rarely provided in the owner's architectural program. If they are provided, they may be based on historical information from the owner's previous projects or based on a percentage of the total *building area*. The former may provide too little area, since restroom requirements have significantly changed over time (especially since the passage of the ADA in 1990) by requiring more fixtures and clearances. The percentage of floor area method may provide too much area, which is not a bad thing for planning purposes, but could artificially increase early cost projections if they are based on square foot costs or some other unit of measurement.

It should be clearly understood that separate *facilities* for each sex are required. A single restroom *facility* may be provided for the following conditions:

- In *dwelling* and *sleeping units*
- In *structures* or tenant spaces where the *occupant load* is 15 or less. This includes both customers and employees.
- In mercantile occupancies that have an *occupant load* of 100 or less

If separate *facilities* are required and, by calculation, only one fixture is required for each sex, then family or assisted-use toilet rooms may serve as the required separate *facilities* and are not required to be identified with signage indicating each as either male or female.

The requirements for family or assisted-use toilet rooms are addressed in IBC Section 1109.2.1. Mercantile and assembly occupancies are required to have a family or assisted-use toilet room when the number of required male plus female water closets totals six or more. If six water closets are not required but are provided, the requirement for the family or assisted-use toilet rooms is not applicable. If a building is a mixed-occupancy building, the only fixtures applicable to the six-water-closet threshold are those required for the assembly and mercantile occupancies. The types of fixtures in family or assisted-use toilet rooms are limited to a single water closet and a single lavatory; a urinal may be provided in addition to these fixtures but cannot be a substitute for the water closet.

The fixtures provided within family or assisted-use toilet rooms may count toward the required number of fixtures for either male or female but not both. For example, if one family or assisted-use toilet room is provided, then both fixtures may either be counted toward the male or female fixture count or split between the two (e.g., water closet toward the male count and lavatory to the female count) but cannot be double-counted for both.

In addition to the fixture requirements of the building code, there is another source for minimum requirements that are applicable to places of employment. OSHA requires, per 29 CFR Part 1910.141, that a minimum number of water closets are to be made available for employees. Table 11.1-1 provides the number of water closets required by OSHA.

It needs to be pointed out that the OSHA regulations apply only to employees and not to other occupants of a building. This differs from the building code, which is based on the total *occupant load* of a building that includes everyone: employees, visitors, guests, etc. If the number of fixtures calculated per the IBC meets or exceeds the number of fixtures required by OSHA and the employees have access to those fixtures, then the OSHA requirement has been satisfactorily met. However, footnote 1 of the table stipulates the maximum allowed substitutions for water closets with urinals. This may conflict with code limitations for urinal substitutions, which are dependent on the occupancy of the building. See Step 11.4 for substitution requirements per the IBC and IPC.

11.1.1 OCCUPANT LOAD FOR PLUMBING FIXTURES

To minimize duplication of work effort, the IBC requires the use of the *occupant loads* determined for the *means of egress* per Step 8. The number of males and females is determined by dividing the total

TABLE 11.1-1. OSHA Minimum Required Water Closets for Employees

Number of Employees	Minimum Number of Water Closets[1]
1 to 15	1
16 to 35	2
36 to 55	3
56 to 80	4
81 to 110	5
111 to 150	6
Over 150	[2]

[1]Where toilet *facilities* will not be used by women, urinals may be provided instead of water closets, except that the number of water closets in such cases shall not be reduced to less than 2/3 of the minimum specified.
[2]One additional fixture for each additional 40 employees.
Source: Table J-1, 29 CFR Part 1910.141.

occupant load in half. The IBC does not address how to handle odd number of *occupant loads*. For this situation, you can use the fractional number for each sex (see Example 11-B) or round the *occupant load* for each sex up to the next whole number.

Regarding number of occupants for each sex, the IBC does provide an exception that allows for the adjustment of male and female occupant distribution if statistical data support a ratio other than 50% of each sex. Of course, this must be *approved* by the *building official* prior to proceeding with an alternate male-to-female ratio.

There are a few occupancy groups that do not use *occupant loads* as a basis for determining the number of plumbing fixtures. These include Groups I-2, I-3, R-1, R-2, and R-3. Plumbing fixtures for those occupancy groups are based on the number of rooms, *cells*, *sleeping units*, or *dwelling units*, as applicable, and are not assigned to either sex. Example 11-D includes an application for a Group R-1 occupancy.

The service sink is another fixture that is also not based on *occupant load* but can be a conundrum for the design professional. For most occupancy groups, IBC Table 2902.1 indicates one service sink. It is the intent that all areas have access to at least one service sink. Therefore, if one service sink is provided in the building and all occupancies have access to that sink, then the requirement has been satisfied. However, this is not clearly reflected in the IBC provisions, thereby leaving it open for *building official* interpretation.

11.1.2 PLUMBING FIXTURE ACCESS AND LOCATION

Plumbing fixtures must be located where occupants can reasonably access them. Customers, patrons, and visitors must have access to toilet *facilities* in buildings intended for public use and must include the required plumbing fixtures calculated. Thus, if it is determined that an assembly occupancy is required to have 20 fixtures, those 20 fixtures need to be accessible to the assembly occupants. Toilet *facilities* for employees may be separate or combined with public toilet *facilities*.

The path of travel to a toilet *facility* cannot exceed 500 feet, or 300 feet for *covered mall buildings*. The distance for covered *malls* is measured from the entrance of a store or tenant space to the central toilet *facility*; but if employee *facilities* are not provided, then the distance is measured from the *employee work area*. Further, in multistory buildings, a *story* that is required to have access to toilet *facilities* must not have those *facilities* located more than one *story* above or below. In factory and industrial occupancies, this minimum distance can be exceeded for employee access to toilet *facilities*, but the distance must be *approved*.

For *covered mall buildings*, the IBC also mentions that required toilet *facilities* "shall be based on total square footage." However, there are no details on how this is to be applied. There are two ways to interpret this requirement:

- To proportionately distribute the toilet *facilities*, and the number of fixtures in each, throughout the *mall* based on the area served. In other words, it was meant to prohibit the intentional location of all but a few of the plumbing fixtures in one location and place the remaining few fixtures at locations just to comply with the path of travel distance, even though the number of occupants in those areas would demand more fixtures.
- To provide toilet *facilities* based on the total required fixtures for the occupancies within a *covered mall building* or within the perimeter line of an *open mall building*.

11.2 BASIC FIXTURE COUNT CALCULATIONS

There are two types of simple ratios used in the IBC. Example 11-A shows a simple ratio that is applied equally to both males and females and Example 11-B uses different ratios for males and females. The calculation process begins by dividing the total *occupant load* in half and then applying the ratios to each male and female *occupant load*. Please note that fixture count numbers are rounded up to the next whole number per IBC Section 2902.1.1.

Special fixtures such as drinking fountains, service sinks, kitchen sinks, bathtubs, showers, and clothes washer connections are required for certain occupancies identified. Drinking fountains are required in almost all occupancies except occupancies based on *dwelling units* and *sleeping units*. Per IBC Section 1109.5.1, a minimum of two drinking fountains are required. Therefore, if the calculations allow a number of drinking fountains that is less than two, the required number must be increased to two.

Only one service sink is typically required for each occupancy; however, this means that each occupancy must have access to one service sink and not that one for every occupancy group must be provided. If the service sink is not accessible to some occupancies, then those occupancies must be provided with their own service sink or sinks.

Kitchen sinks, bathtubs or showers, and clothes washer connections are required in Groups R-2 and R-3. In other residential occupancies and some Group I occupancies it is required to provide bathtubs or showers. In Group R-1 occupancies, some units are required to be provided with roll-in type showers (see Step 13.5.1).

EXAMPLE 11-A: CALCULATION WITH SAME SIMPLE RATIO FOR MALES AND FEMALES

Given: Group M store with 2,000 total occupants.

Step 1: Determine number of occupants for each sex.

2,000 occupants ÷ 2 = 1,000 males and 1,000 females

Step 2: Calculate the number of water closets using the ratios for each applicable occupancy group per IBC Table 2902.1.

Ratio is 1 per 500

Males: 1,000 × 1/500 = 2 water closets

Females: 1,000 × 1/500 = 2 water closets

Step 3: Calculate the number of lavatories using the ratios for each applicable occupancy group per IBC Table 2902.1.

Ratio is 1 per 750

Males: 1,000 × 1/750 = 1.33, round up to 2 lavatories

Females: 1,000 × 1/750 = 1.33, round up to 2 lavatories

Step 4: Calculate the number of drinking fountains using the ratios for each applicable occupancy group per IBC Table 2902.1.

Ratio is 1 per 1,000 (Use total occupant load): 2,000 × 1/1000 = 2 drinking fountains

Step 5: Provide the number of service sinks for each occupancy per IBC Table 2902.1.

1 service sink

EXAMPLE 11-B: CALCULATION WITH DIFFERENT SIMPLE RATIOS FOR MALES AND FEMALES

Given: Group A-1 theater with 1,155 total occupants.

Step 1: Determine number of occupants for each sex.

1,155 occupants ÷ 2 = 577.5 males and 577.5 females

Step 2: Calculate the number of water closets using the ratios for each applicable occupancy group per IBC Table 2902.1.

Ratios are 1 per 125 (males) and 1 per 65 (females)

Males: 577.5 × 1/125 = 4.62, round up to 5 water closets

Females: 577.5 × 1/65 = 8.88, round up to 9 water closets

Step 3: Calculate the number of lavatories using the ratios for each applicable occupancy group per IBC Table 2902.1.

Ratio is 1 per 200

Males: 577.5 × 1/200 = 2.89, round up to 3 lavatories

Females: 577.5 × 1/200 = 2.89, round up to 3 lavatories

Step 4: Calculate the number of drinking fountains using the ratios for each applicable occupancy group per IBC Table 2902.1.

Ratio is 1 per 500 (Use total occupant load): 1,155 × 1/500 = 2.31, round up to 3 drinking fountains

Step 5: Provide the number of service sinks for each occupancy per IBC Table 2902.1.

1 service sink

Another method of calculation used by the IBC to determine fixture counts is the graduated ratio. This method uses one ratio for an initial number of occupants and another ratio for the remaining number of occupants. In Example 11-C, the graduated method is used for the water closets and lavatories (drinking fountains and service sinks are determined in the same manner as previous examples).

EXAMPLE 11-C: CALCULATION WITH GRADUATED RATIOS

Given: Group B office building with 250 total occupants.

Step 1: Determine number of occupants for each sex.

250 occupants ÷ 2 = 125 males and 125 females

Step 2: Calculate the number of water closets using the ratios for each applicable occupancy group per IBC Table 2902.1.

Males: Ratios are 1 per 25 (for first 50) and 1 per 50 (for remainder exceeding 50)

50 × 1/25 = 2 water closets

(125 – 50) × 1/50 = 1.5, round up to 2 water closets

A total of 4 water closets are required.

Females: Ratios are 1 per 25 (for first 50) and 1 per 50 (for remainder exceeding 50).

50 × 1/25 = 2 water closets

(125 – 50) × 1/50 = 1.5, round up to 2 water closets

A total of four water closets are required.

Step 3: Calculate the number of lavatories using the ratios for each applicable occupancy group per IBC Table 2902.1.

Males: Ratios are 1 per 40 (for first 80) and 1 per 80 (for remainder exceeding 80)
80 × 1/40 = 2 lavatories
(125 – 80) × 1/80 = 0.56, round up to 1 lavatory
A total of 3 lavatories are required.

Females: Ratios are 1 per 40 (for first 80) and 1 per 80 (for remainder exceeding 80)
80 × 1/40 = 2 lavatories
(125 – 80) × 1/80 = 0.56, round up to 1 lavatory
A total of 3 lavatories are required.

Step 4: Calculate the number of drinking fountains using the ratios for each applicable occupancy group per IBC Table 2902.1.

Ratio is 1 per 100 (Use total occupant load): 250 × 1/500 = 0.5, round up to 2 drinking fountains*

Step 5: Provide the number of service sinks for each occupancy per IBC Table 2902.1.

1 service sink

*Two drinking fountains are provided as required by IBC Section 1109.5.1.

11.3 FIXTURE COUNT CALCULATIONS FOR MIXED OCCUPANCIES

When calculating the number of plumbing fixtures for a mixed-occupancy building, the determination of plumbing fixture counts becomes a little more complex. Per IBC Section 2902.1.1, plumbing fixture counts for buildings with multiple occupancies are determined for each individual occupancy as described in Step 11.2; however, the fractional numbers for each occupancy group are totaled first, then the sum for each fixture type is rounded up to the next whole number. If numbers are rounded prior to being totaled, then the total number of fixtures may be more than what is necessary. See Example 11-D for determining fixture counts in a multiple-occupancy building.

EXAMPLE 11-D: CALCULATION FOR MIXED OCCUPANCIES

Given: Hotel building with Group A-2, B, M, and R-1 occupancies. The Group A-2 has 500 occupants, the Group B has 75 occupants, and the Group M has 50 occupants. There are 150 sleeping units in the Group R-1.

Step 1: Determine number of occupants for each sex.

Group A-2: 500 total occupants ÷ 2 = 250 males and 250 females
Group B: 75 total occupants ÷ 2 = 37.5 males and 37.5 females
Group M: 50 occupants ÷ 2 = 25 males and 25 females
Sleeping Units: 150

Step 2: Calculate the number of water closets using the ratios for each applicable occupancy group per IBC Table 2902.1.

Group A-2: Ratios are 1 per 125 (males) and 1 per 65 (females)
Males: 250 × 1/125 = 2 water closets
Females: 250 × 1/65 = 3.8 water closets

Group B: Ratios are 1 per 25 (for first 50) and 1 per 50 (for remainder exceeding 50)
Males: 37.5 × 1/25 = 1.5 water closets
Females: 37.5 × 1/25 = 1.5 water closets

Group M: Ratio is 1 per 500

Males: 25 × 1/500 = 0.05 water closet

Females: 25 × 1/500 = 0.05 water closet

Group R-1: Ratio is 1 per sleeping unit = 150 water closets

Sum of Fractions:

Males: 2 + 1.25 + 0.05 = 3.3, round up to 4 water closets

Females: 3.8 + 1.5 + 0.05 = 5.35, round up to 6 water closets

Sleeping Units: 150 water closets

Step 3: Calculate the number of lavatories using the ratios for each applicable occupancy group per IBC Table 2902.1.

Group A-2: Ratio is 1 per 200

Males: 250 × 1/200 = 1.25 lavatories

Females: 250 × 1/200 = 1.25 lavatories

Group B: Ratios are 1 per 40 (for first 80) and 1 per 80 (for remainder exceeding 80)

Males: 37.5 × 1/40 = 0.94 lavatory

Females: 37.5 × 1/40 = 0.94 lavatory

Group M: Ratio is 1 per 750

Males: 25 × 1/750 = 0.03 lavatory

Females: 25 × 1/750 = 0.03 lavatory

Group R-1: Ratio is 1 per sleeping unit = 150 lavatories

Sum of Fractions:

Males: 1.25 + 0.94 + 0.03 = 2.22, round up to 3 lavatories

Females: 1.25 + 0.94 + 0.03 = 2.22, round up to 3 lavatories

Sleeping Units: 150 lavatories

Step 4: Calculate the number of drinking fountains using the ratios for each applicable occupancy group per IBC Table 2902.1.

Group A-2: Ratio is 1 per 500 (Use total occupant load)

500 × 1/500 = 1 drinking fountain

Group B: Ratio is 1 per 100 (Use total occupant load)

75 × 1/100 = 0.75 drinking fountain

Group M: Ratio is 1 per 1,000 (Use total occupant load)

50 × 1/1000 = 0.05 drinking fountains

Group R-1: Not required

Sum of Fractions: 1 + 0.75 + 0.05 = 1.8, round up to 2 drinking fountains

Step 5: Provide the number of service sinks for each occupancy per IBC Table 2902.1.

1 service sink (Provided all occupancies have access to the service sink)

Step 6: Provide the number of bathtubs or showers for each occupancy per IBC Table 2902.1.

Group R-1: Ratio is 1 per sleeping unit = 150 bathtubs or showers

11.4 SUBSTITUTIONS

IBC Table 2902.1 directs the code user to IPC Section 419.2 for substitution of water closets with urinals. The IPC allows up to 67% of the water closets in assembly and educational occupancies to be substituted and up to 50% in all other occupancies. The substitution is limited to the fixtures within a toilet room or bathroom and not for the overall fixture count. Therefore, if nine water closets are required, up to six may be converted to urinals if they are all located in a single toilet room, but if two toilet rooms are provided, one cannot have six urinals and the other with three water closets. See Examples 11-E and 11-F for some typical substitution applications. In the case of urinal substitutions, fractional numbers are rounded down, not up; otherwise the percentage would exceed that permitted.

EXAMPLE 11-E: URINAL SUBSTITUTIONS—ASSEMBLY AND EDUCATION OCCUPANCIES

Given: Assembly occupancy with 12 water closets required.

- **Arrangement #1:** Single toilet room
  $12 \times 67\% = 8.04$, round down to 8 urinals
  Provide 4 water closets and 8 urinals
- **Arrangement #2:** Multiple toilet rooms
  - Toilet Room A: 8 fixtures
    $8 \times 67\% = 5.36$, round down to 5 urinals
    Provide 3 water closets and 5 urinals
  - Toilet Room B: 4 fixtures
    $4 \times 67\% = 2.68$, round down to 2 urinals
    Provide 2 water closets and 2 urinals

Note: Only a total of 7 urinals are allowed under Arrangement #2 compared to the 8 urinals allowed under Arrangement #1.

EXAMPLE 11-F: URINAL SUBSTITUTIONS—OTHER OCCUPANCIES

Given: Business occupancy with 7 water closets required.

- **Arrangement #1:** Single toilet room
  $7 \times 50\% = 3.5$, round down to 3
  Provide 4 water closets and 3 urinals
- **Arrangement #2:** Multiple toilet rooms
  - Toilet Room A: 4 fixtures
    $4 \times 50\% = 2$ urinals
    Provide 2 water closets and 2 urinals
  - Toilet Room B: 3 fixtures
    $3 \times 50\% = 1.5$, round down to 1
    Provide 2 water closets and 1 urinal

In addition to urinals, there are substitutions permitted for drinking fountains. IBC Table 2902.1 references IPC Section 410, which provides the substitution requirements. For restaurants that provide drinking water free of charge, drinking fountains are not required. For other occupancies that require drinking fountains, up to 50% of the fountains can be substituted with bottled water dispensers.

11.5 TOILET ROOM PLANNING

It is not enough to just understand the required number of plumbing fixtures; the configuration of those fixtures within a toilet room is just as important. For the most part, toilet room planning is dictated by accessibility requirements, whether provided through the building code or the ADA standards. These requirements are discussed in detail in Step 13.5. However, there are some toilet room features that can be integrated either at this phase of a project's design or later, but they should be considered now so that they are not overlooked.

Surprisingly, basic toilet room planning requirements, other than those associated with accessibility, are found in IPC Section 405 for installation of fixtures. The placement of a plumbing fixture (i.e., water closets, urinals, lavatories, and bidets) cannot be closer than 15 inches to any wall, partition, vanity, or other obstruction. This measurement is from the nearest projection of the obstruction to the centerline of the fixture. The distance between adjacent plumbing fixtures is 30 inches measured between the centerlines of the fixtures. A minimum clearance of 21 inches is required between the front of a plumbing fixture and any obstruction, such as a wall, door, or other fixture.

Required lavatories for the *public (IPC)* and employees must be located in the same room as the required water closet. In toilet rooms with more than one water closet, each water closet used by the *public* or employees must be located within a toilet compartment. Single-occupant toilet rooms that are lockable do not require a separate compartment. Another exception allows a single water closet to be unenclosed in toilet rooms of child day care *facilities* where the toilet room has two or more water closets. Group I-3 housing areas, such as those for jails or prisons, are not required to have their toilet areas enclosed, either.

Urinals, when provided for *public* or employee use, must also be separated with walls or partitions. The minimum size of the partitions is 48 inches high by 18 inches deep or to a depth not less than 6 inches beyond the furthest point of the urinal fixture. The partition must be installed at a height of not less than 12 inches above the floor surface. If installed less than 12 inches, then the height of the partition will need to be increased so that the top edge is not less than 60 inches above the floor surface. Urinal partitions are not required in single-occupant toilet rooms or in family or assisted-use toilet rooms provided the toilet rooms have lockable doors. Additionally, toilet rooms of child day care *facilities* are allowed to have one urinal without partitions when two or more urinals are provided within the same toilet room.

EXAMPLE PROJECT—STEP 11

For the apartments, IBC Table 2902.1 requires that each apartment be provided with one water closet, one lavatory, one bathtub or shower, one kitchen sink, and one clothes washer connection.

For the remaining areas of the building, Example 11-D will provide the process to follow for a mixed-occupancy building.

Step 1: Determine number of occupants for each sex.

Group A-2: 248 total occupants ÷ 2 = 124 males and 124 females
Includes: Dining Hall (Dining and Kitchen), Restrooms, and Circulation = 225 + 5 + 4 + 13 = 247 occupants

Group A-3: 53 total occupants ÷ 2 = 26.5 males and 26.5 females
Includes: Lounge = 53 occupants

Group B: 65 total occupants ÷ 2 = 32.5 males and 32.5 females
Includes: Study Rooms, Exercise Room, and Management Office = 23 + 23 + 12 + 7 = 65 occupants

Group M: 15 occupants ÷ 2 = 7.5 males and 7.5 females
Includes: Convenience Shop = 15 occupants

Group R-2: Dwelling Units = 43

Group S-1: 5 occupants ÷ 2 = 2.5 males and 2.5 females
Includes: Mechanical Room, Trash Room, and Mail Room = 3 + 1 + 1 = 5 occupants

Step 2: Calculate the number of water closets using the ratios for each applicable occupancy group per IBC Table 2902.1.

Group A-2: Ratios are 1 per 75 (males) and 1 per 75 (females)

Males: 124 × 1/75 = 1.65 water closets

Females: 124 × 1/75 = 1.65 water closets

Group A-3: Ratios are 1 per 125 (males) and 1 per 65 (females)

Males: 26.5 × 1/125 = 0.21 water closets

Females: 26.5 × 1/65 = 0.41 water closets

Group B: Ratios are 1 per 25 (for first 50) and 1 per 50 (for remainder exceeding 50)

Males: 32.5 × 1/25 = 1.3 water closets

Females: 32.5 × 1/25 = 1.3 water closets

Group M: Ratio is 1 per 500

Males: 7.5 × 1/500 = 0.02 water closets

Females: 7.5 × 1/500 = 0.02 water closets

Group R-2: Ratio is 1 per dwelling unit = 43 water closets

Group S-1: Ratio is 1 per 100

Males: 2.5 × 1/100 = 0.03 water closets

Females: 2.5 × 1/100 = 0.03 water closets

Sum of Fractions:

Males: 1.65 + 0.21 + 1.3 + 0.02 +0.03 = 3.21, round up to 4 water closets

Females: 1.65 + 0.41 + 1.3 + 0.02 +0.03 = 3.41, round up to 4 water closets

Dwelling Units: 43 water closets

Step 3: Calculate the number of lavatories using the ratios for each applicable occupancy group per IBC Table 2902.1.

Group A-2: Ratio is 1 per 200

Males: 124 × 1/200 = 0.62 lavatory

Females: 124 × 1/200 = 0.62 lavatory

Group A-3: Ratio is 1 per 200

Males: 26.5 × 1/200 = 0.13 lavatory

Females: 26.5 × 1/200 = 0.13 lavatory

Group B: Ratios are 1 per 40 (for first 80) and 1 per 80 (for remainder exceeding 80)

Males: 32.5 × 1/40 = 0.81 lavatory

Females: 32.5 × 1/40 = 0.81 lavatory

Group M: Ratio is 1 per 750

Males: 7.5 × 1/750 = 0.01 lavatory

Females: 7.5 × 1/750 = 0.01 lavatory

Group R-2: Ratio is 1 per dwelling unit = 43 lavatories

Group S-1: Ratio is 1 per 100

Males: 2.5 × 1/100 = 0.03 lavatory

Females: 2.5 × 1/100 = 0.03 lavatory

Sum of Fractions:

Males: 0.62 + 0.13 + 0.81 + 0.01 + 0.03 = 1.6, round up to 2 lavatories

Females: 0.62 + 0.13 + 0.81 + 0.01 + 0.03 = 1.6, round up to 2 lavatories

Dwelling Units: 43 lavatories

Step 4: Calculate the number of drinking fountains using the ratios for each applicable occupancy group per IBC Table 2902.1.

Group A-2: Ratio is 1 per 500 (Use total occupant load)
$248 \times 1/500 = 0.50$ drinking fountain

Group A-3: Ratio is 1 per 500 (Use total occupant load)
$53 \times 1/500 = 0.11$ drinking fountain

Group B: Ratio is 1 per 100 (Use total occupant load)
$65 \times 1/100 = 0.65$ drinking fountain

Group M: Ratio is 1 per 1,000 (Use total occupant load)
$15 \times 1/1000 = 0.02$ drinking fountain

Group R-2: Not required

Group S-1: Ratio is 1 per 1,000 (Use total occupant load)
$5 \times 1/1000 = 0.01$ drinking fountain

Sum of Fractions: $0.50 + 0.11 + 0.65 + 0.02 + 0.01 = 1.29$, round up to 2 drinking fountains

Step 5: Provide the number of service sinks for each occupancy per IBC Table 2902.1.

1 service sink (Provided all occupancies have access to the service sink)

Step 6: Provide the number of bathtubs or showers for each occupancy per IBC Table 2902.1.

Group R-2: Ratio is 1 per dwelling unit = 43 bathtubs or showers

Water closets can be replaced with urinals in the men's restroom. Per IPC Section 419.2, up to 67% of the water closets for assembly uses can be replaced with urinals. Per the calculations, two water closets are required for Groups A-2 and A-3 (rounded up from 1.31). At 67%, no more than one water closet will be allowed to be replaced. The other occupancy groups, which also require two water closets, are permitted to replace 50% of the water closets. Thus, one of those water closets will be replaced with a urinal. Therefore, two water closets and two urinals will be provided in the men's room.

STEP 12

Identify Fire Department Access Roads

STEP OVERVIEW

This step ensures that the servicing fire department will have sufficient access to fight a fire should one occur in a building. Access roads must meet minimum requirements so that fire department vehicles can approach the building within an adequate distance to allow firefighters to reach all sides of a building.

12.1 MINIMUM REQUIREMENTS

A fire department vehicle, called a "fire apparatus" in the IFC, must have access to within 150 feet of all portions of the *facility* and all portions of the *exterior walls* of a building at the first *story*. This distance is measured from the nearest edge of the *fire apparatus access road (IFC)*. The route used to determine compliance with the maximum must be *approved (IFC)*; thus, it would be advisable to obtain that approval early in the design process, since it could affect a building's location on the *site*, which affects the application of many code requirements (Figure 12.1-1).

Public roads, alleys, and on-site parking areas will qualify as *fire apparatus access roads*, on the condition they comply with the 150-foot limitation (or an *approved* extended length) and conform to the required design specifications. If these features do not qualify or do not provide sufficient reach (Figure 12.1-2), then a *fire apparatus access road* will be required to extend the fire department's reach around the building to within the required lengths (Figure 12.1-3).

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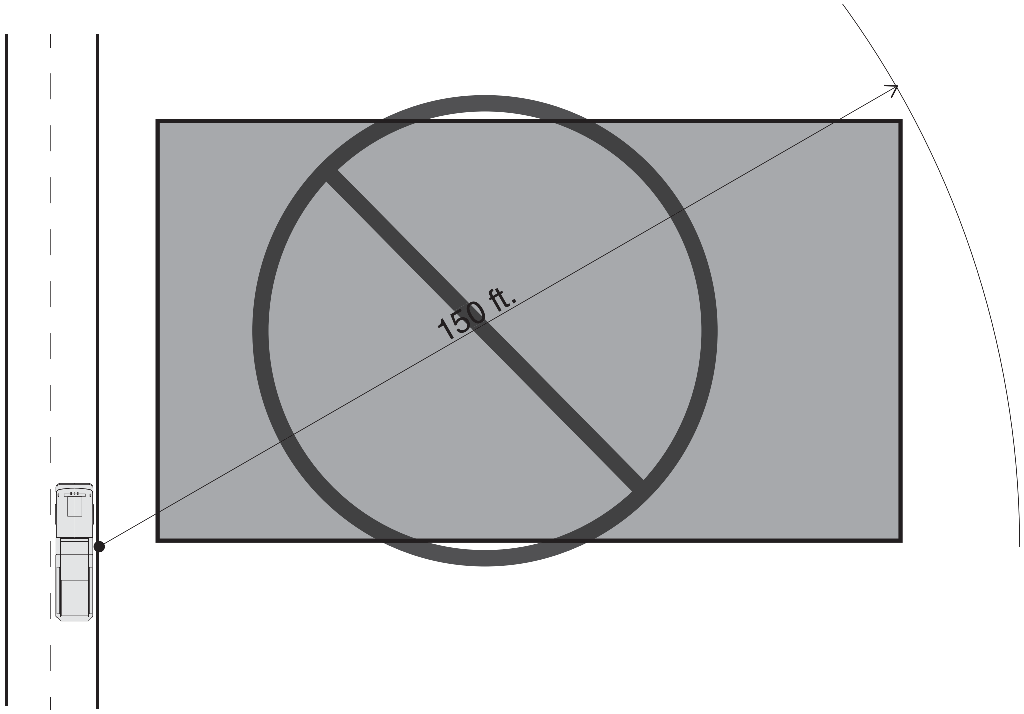


FIGURE 12.1-1. The dimension shown is not an acceptable method for determining 150-foot access around a building.

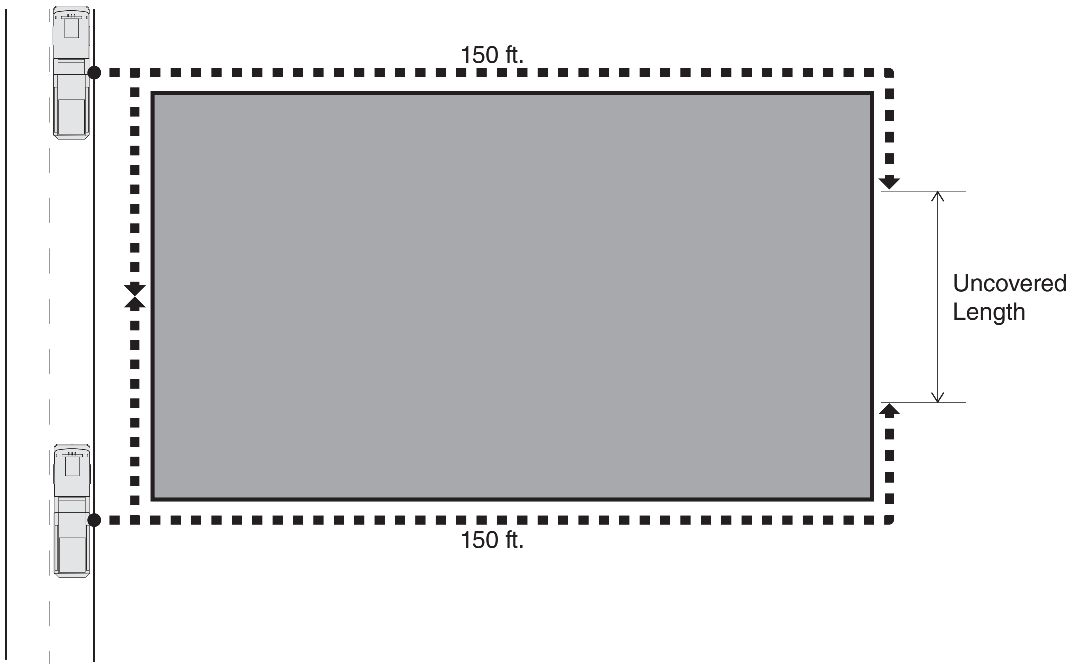


FIGURE 12.1-2. Insufficient reach from available *fire apparatus access road*.

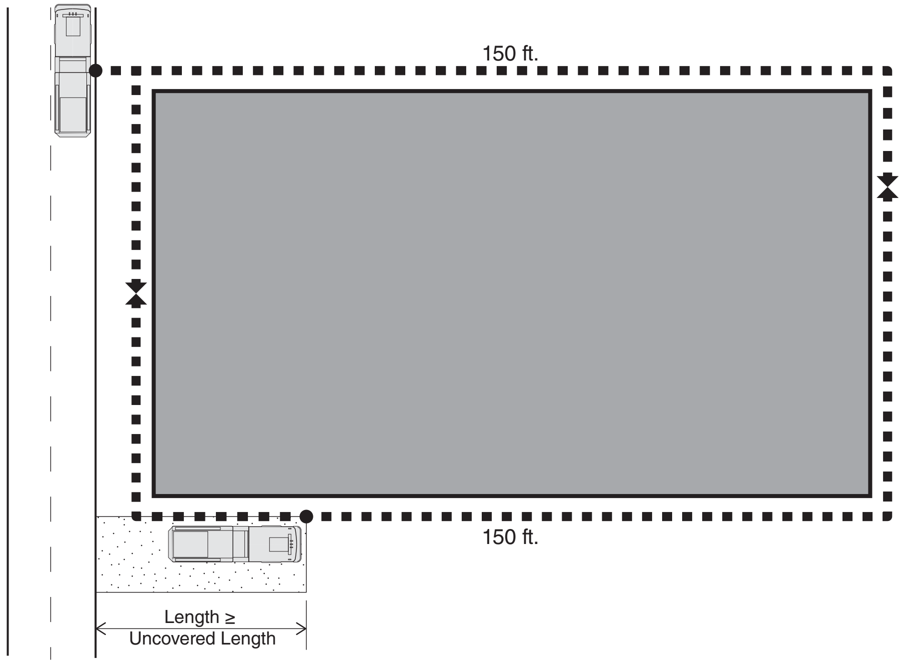


FIGURE 12.1-3. Use of a *fire apparatus access road* to extend reach around a building.

The maximum distance of 150 feet may be increased at the discretion of the *fire code official (IFC)* if one of the following conditions exists:

- The building is sprinklered throughout per NFPA 13, 13D, or 13R.
- The topography or other geographical features prevent the extension of the *fire apparatus access road* to within the required dimension on all sides. An *approved* alternative means of fire protection is required to compensate for the lack of access.
- The buildings subject to fire department access consist of not more than two Group R-3 or U occupancies.

The IFC does not specify what extended distance would be allowed—that would be up to the *fire code official*. However, some jurisdictions may have codified a specific distance through an amendment.

In addition to seeking approval for the route used in measuring the 150-foot dimension, there is another reason for meeting with the *fire code official* early in the design process. IFC Section 503.1.2 gives the *fire code official* broad authority to require additional access if there is concern about the potential limitations of providing a *fire apparatus access road* in accordance with the prescriptive requirements of the IFC. Such concerns may include but are not limited to congested traffic conditions, physical or operational limitations of responding fire department apparatus, and climatic factors.

12.2 ACCESS ROAD DESIGN

The design requirements for *fire apparatus access roads* are generally nonspecific, utilizing a more performance-based approach. However, some fire departments may have very specific criteria, which should be obtained early in the design process. The IFC includes Appendix D, "Fire Apparatus Access Roads," which provides more detailed information regarding the design of access roads. IFC Appendix D is not mandatory unless specifically adopted by the jurisdiction (see Step 1.2); however, if not adopted, it can be used as a preliminary design source until more specific guidance is provided by the jurisdiction.

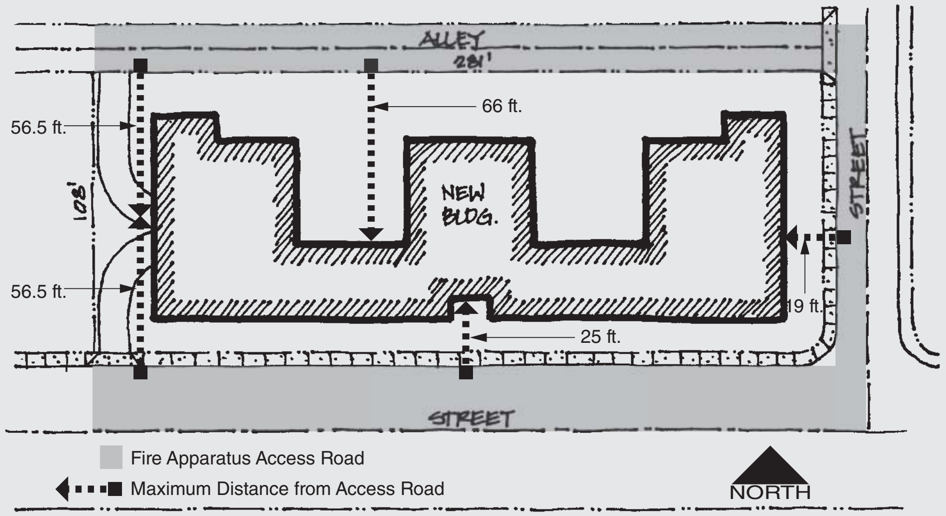
- **Dimensions:** The minimum width is 20 feet and the minimum clear height is 13 feet 6 inches. However, as previously stated, the *fire code official* has broad authority regarding the use and design of a *fire apparatus access road*. Therefore, there may be times when changes to the *fire apparatus access road* are requested without the backing of any specific code provision, except for IFC Section 503.2.2, which establishes that authority. If IFC Appendix D is adopted, then a minimum width of 26 feet is required where a fire hydrant is located on the *fire apparatus access road* (see IFC Appendix D Figure D103.1) or the length of a dead-end access road is greater than 500 feet.
- **Surface:** The surface of a *fire apparatus access road* is not defined in great detail in the IFC, but it does provide very basic performance criteria.
    - The first criterion is that it "support the imposed loads of fire apparatus." Since fire apparatus come in all sizes, shapes, and, of course, weights, it is difficult to ascertain what the imposed loads are without asking the fire department. If IFC Appendix D is adopted, the minimum imposed load is 75,000 pounds. Some jurisdictions may have codified a minimum load through a code amendment, while others may have an established policy that is referenced. In the absence of both, the only way to get the information is to ask.
    - The second criterion is that the surface "provide all-weather driving capabilities." Common pavement surfaces, such as asphalt and concrete (specifically mentioned in IFC Appendix D), will be acceptable, since they are used throughout the country as roadway surfacing. However, other surfacing materials may be acceptable depending on the climate of the building *site*. Concrete or brick pavers may be acceptable, provided the supporting substrates comply with the first criterion. The fire department may have a list of surfacing materials that it has approved for use on *fire apparatus access roads*.
- **Radius:** If the *fire apparatus access road* requires turning of the vehicles, the turn radius must be *approved* by the *fire code official*. This is stated in both IFC Section 503.2.4 and IFC Appendix D Section D103.3. Similar to the imposed loads, fire apparatus have different turning characteristics; therefore, the design should be based on the types of apparatus that would respond to a fire in the building.
- **Slope:** The slope of a *fire apparatus access road* is left to the *fire code official* to decide; however, IFC Appendix D establishes 10% as the maximum slope.
- **Dead Ends:** Ideally, the *fire apparatus access road* will loop around the building or connect to other paved surfaces that can be used as part of the required access. However, there may be cases where the *fire apparatus access road* cannot continue. If that becomes the case and the length of the dead end exceeds 150 feet, then the access road must be provided with a means for turning around the fire apparatus without having to back up the entire length.

The basic requirement only requires approval by the *fire code official*. IFC Appendix D, on the other hand, provides more definitive solutions. IFC Appendix D Figure D103.1 provides four different designs of turnarounds: a 96-foot-diameter cul-de-sac, 60-foot "Y," and two variations of a 120-foot hammerhead. Per IFC Appendix D, if the length of the dead-end access road exceeds 750 feet, then special approval is required.

- **Bridges and Elevated Surfaces:** A *fire apparatus access road* may utilize a bridge or other similar elevated surface to negotiate extreme topography or cross drainage channels and ditches. If provided, the design will need to conform to AASHTO HB-17.

EXAMPLE PROJECT—STEP 12

With floor plans developed for Step 9, a more refined site plan can be generated for this step. Example Project Figure 12-1 shows the project site with the latest building plan applied. The alley on the north side and the streets on the east and south sides of the site will provide the necessary means for the fire department to access the building site.



EXAMPLE PROJECT FIGURE 12-1. Site plan showing the reach around the building perimeter from the fire apparatus access roads.

If the alley does not provide a suitable surface, then a new surface may be required. Without the alley, the 150-foot maximum distance will be exceeded and other means of providing access for the fire department will be necessary. However, for purposes of this example, the alley is paved to allow access for backdoor delivery of adjacent local businesses and for access to resident parking for other apartments and homes in the area as well as parking access for this project.

STEP 13

Identify Accessible Routes and Requirements

STEP OVERVIEW

This step addresses some of the most common elements of *accessible* design that have an effect on early planning. Unlike *accessible means of egress* covered in Step 10, which only addresses egress in an emergency, this step focuses on the provisions that allow a person with disabilities to move freely inside and outside the building as a matter of normal activity. Also addressed in this step are *accessible* requirements that affect space planning, such as restroom requirements and *dwelling* and *sleeping units*.

13.1 INTRODUCTION TO ACCESSIBILITY IN THE BUILDING CODE

Since the enactment of the Americans with Disabilities Act of 1990 (ADA), the requirements for *accessible* design have increasingly been integrated into building code requirements. It is important to point out that the ADA is not part of the IBC—the ADA is a federal law that is enforced by the U.S. Department of Justice (DOJ) through civil action against owners and entities that are found to be in violation of the law. The ADA is divided into five parts or "titles":

Title I—Employment
Title II—Public Services
Title III—Public Accommodations
Title IV—Telecommunications
Title V—Miscellaneous

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In regard to building design, it is Titles II and III that require buildings used by the public to be made *accessible*. Title II applies to state and local governmental *facilities* and commuter rail services, whereas Title III applies to privately owned *facilities* that are open to the public, such as restaurants, hotels, theaters, stores, etc. However, Titles II and III do not stipulate the technical requirements that must be applied to ensure compliance.

In 1991, the DOJ adopted the *ADA Accessibility Guidelines* (ADAAG) as the standard upon which compliance was determined. Since then, the standards have been revised, and, in 2010, the DOJ adopted a new set of standards to replace the ADAAG titled the *2010 ADA Standards for Accessible Design* (ASAD). The ADAAG was never a part of a building code, nor is the ASAD part of the IBC, unless specifically adopted by a jurisdiction to supplant the accessibility requirements in the building code.

In lieu of the ASAD, the IBC references the 2009 edition of ICC/ANSI A117.1. Chapter 11 of the IBC is where this reference is made. Unlike the ASAD, which is an all-encompassing document, the accessibility requirements in the IBC are split. Chapter 11 is the scoping document, indicating where accessibility is required, whereas ICC/ANSI A117.1 is the technical document that provides the detailed requirements to implement the requirements within the scoping document. In other words, ICC/ANSI A117.1 is impossible to enforce unless a companion scoping document, like IBC Chapter 11, is provided.

The technical requirements within the ASAD and ICC/ANSI A117.1 are more closely aligned now than they ever have been in the past, but there are still some minor differences. However, when it comes to enforcement, the *building official* can only enforce what is adopted in the building code and the DOJ enforces the ADA through the ASAD. Therefore, the design professional must be aware of and incorporate the requirements of both the ASAD and ICC/ANSI A117.1. To complicate things further, there are three other accessibility standards that may also be applicable.

The first is the standard used for compliance with the 1968 Architectural Barriers Act (ABA), which requires that buildings involving federal funds be made *accessible*. The standard, *2004 ADA and ABA Accessibility Guidelines*, which forms the basis for the DOJ's ASAD, includes some varying requirements specifically for compliance with the ABA. The 2004 standard was an initial attempt to bring the technical specifications for the two laws (ADA and ABA) into better alignment. Prior to the *2004 ADA and ABA Accessibility Guidelines*, compliance with the ABA was based on the *Uniform Federal Accessibility Standards* (UFAS). The federal agencies subject to the ABA standards are the General Services Administration (GSA), Department of Defense (DOD), and the U.S. Postal Service (USPS). The U.S. Department of Housing and Urban Development (HUD) is also subject to the ABA but has yet to adopt the new standards. Therefore, for HUD facilities, the UFAS is still applicable.

The second accessibility standard is the one used to comply with the Fair Housing Act (FHA) of 1968, which is Title VIII of the Civil Rights Act of 1968. The FHA prohibits discrimination in the sale, leasing, and financing of housing, which, as subsequently amended, also includes prohibiting discrimination based on disability. HUD, which enforces the FHA, has identified 10 documents, including various editions of ANSI A117.1 (ICC and earlier CABO [Council of American Building Officials] versions) and the IBC, as "safe harbors." If a design professional conforms to the requirements of a safe harbor document, then the project will be deemed to be in compliance with the Act.

The third accessibility standard is the U.S. Department of Transportation's (USDOT) *ADA Standards for Transportation Facilities*, which was released for use in 2006. The USDOT standards are similar to the DOJ's ASAD, except it includes additional requirements for location of *accessible routes*, *detectable warnings (ICC/ANSI)* on *curb ramps (ICC/ANSI)*, bus boarding and alighting areas, and rail station platforms.

TABLE 13.1-1. Chapter Comparison of ICC/ANSI A117.1-2009 and the 2004 ADA and ABA Accessibility Guidelines [1]

Chapter Title	ICC/ANSI Chapter No.	ADA/ABA Chapter No.
Application and Administration [2]	1	1
Scoping Requirements[2,3]	2	2
Building Blocks	3	3
Accessible Routes	4	4
General Site and Building Elements	5	5
Plumbing Elements and Facilities	6	6
Communication Elements and Features	7	7
(ICC/ANSI) Special Rooms and Spaces (ADA/ABA) Special Rooms, Spaces, and Elements [4]	8	8
(ICC/ANSI) Built-in Furnishings and Equipment [5] (ADA/ABA) Built-in Elements	9	9
Dwelling Units and Sleeping Units	10	None
(ICC/ANSI) Recreational Facilities (ADA/ABA) Recreation Facilities	11	10

[1] The ADA standards used by the DOJ and USDOT and the ABA standards used by GSA, DOD, and USPS are based on this document.
[2] Although each document has this chapter, they are significantly different. The ADA/ABA standard has a separate chapter for each. The ABA section numbers are preceded with the letter "F" to differentiate them from the ADA sections.
[3] Although the ICC/ANSI standard has a scoping chapter, it is very limited and primarily points the user to the "administrative authority" for specific scoping requirements. A jurisdiction is the administrative authority when they adopt the IBC as its scoping document.
[4] The ADA/ABA standard has several sections within this chapter that do not appear in the ICC/ANSI standard. Notable are sections on *transient* lodging *guest rooms* and residential *dwelling units*, which are covered in Chapter 10 of the ICC/ANSI standard.
[5] The ICC/ANSI standard includes requirements for storage *facilities*, which are located in Section 811 of the ADA/ABA standard.

Since there are multiple resources that address the requirements of accessibility in buildings, sometimes referred to as "universal design," this step will address IBC accessibility requirements in a broad review, focusing only on those areas where emphasis is considered appropriate or necessary. Because the ICC/ANSI A117.1 standard and the new ADA/ABA standards are more closely coordinated, many of the ICC/ANSI sections referenced within this step are identical to those within the new ADA/ABA standards. Therefore, it will be easier to compare technical requirements between the two documents for any differences. Table 13.1-1 compares the content of the two standards.

13.2 SCOPING REQUIREMENTS (IBC SECTION 1103)

As previously mentioned, the IBC provides the scoping requirements for subsequent application of the technical requirements provided in ICC/ANSI A117.1. In general, this section requires that buildings, *structures*, and *facilities*, whether temporary or permanent, be *accessible*. Also, *sites* outside a building and *elements (ICC/ANSI)* and spaces within a building are required to be *accessible*. Only those buildings, *sites*, *structures*, *facilities*, *elements*, and spaces that are specifically exempt are not required to be *accessible*.

The following list contains specific areas or spaces with special exemption requirements for accessibility:

- **Employee Work Areas:** Areas that are less than 300 sq. ft. in area and are located 7 inches or more above or below the adjacent floor level, provided that the elevation change is necessary for proper use of the space. Otherwise, *employee work areas* are required to be *accessible*.
- **Detached Dwellings:** Detached one- and two-family *dwellings*, including their *sites* and accessory *facilities*.
- **Utility Buildings:** Group U occupancies, except for agricultural building paved work areas and *public-use areas*, and *private garages* or carports where *accessible* parking is provided.

- **Construction Sites:** Temporary *facilities* associated with the construction process, such as scaffolding, hoists, construction trailers, etc.
- **Raised Areas:** Elevated areas used for security, life safety, or fire safety.
- **Limited-Access Spaces:** Areas that are not open to the public and are accessed by ladders, catwalks, or other restricted openings.
- **Areas in Places of Religious Worship:** Areas that are less than 300 sq. ft. in area and are located 7 inches or more above or below the adjacent floor level, provided that the spaces are used for the performance of religious services or ceremonies.
- **Equipment Spaces:** Spaces that are accessed solely by personnel for the maintenance, repair, or monitoring of equipment.
- **Highway Toll Booths:** Booths that are accessed only by an overhead bridge or an underground tunnel.
- **Residential Group R-1:** Buildings containing five or less *sleeping units* for rent and containing a residence for the proprietor.
- **Day Care Facilities:** A *dwelling unit* that includes a day care *facility*; however, the portion of the *dwelling unit* used for the day care is not exempt.
- **Detention and Correctional Facilities:** *Common use* areas used only by residents and guards, provided they do not serve *cells* that are required to be *Accessible units*.
- **Walk-In Coolers and Freezers:** Units or spaces that are intended for employee access only.

13.3 ACCESSIBLE ROUTES (IBC SECTION 1104 AND ICC/ANSI A117.1 CHAPTERS 4 AND 5)

An *accessible route* is required to connect *site* arrival points to a building, connect two or more *accessible* buildings on a *site*, and connect all required *accessible* spaces within a building. *Site* arrival points that require an *accessible route* to a building include public transportation stops, *accessible* parking, *accessible* passenger loading zones, and public streets and sidewalks.

However, if the only connection between the *site* arrival points and the building is a vehicular driveway with no pedestrian access, then the *accessible route* is not required. This exception excludes *buildings* or *facilities* than serve or contain *Type B units*. Furthermore, an *accessible route* is not required between *accessible* buildings, *facilities*, *elements*, and spaces on the same *site* if the only access to each of them is a vehicular driveway with no pedestrian access.

Within a building, those portions that are required to be *accessible* shall have an *accessible route* provided from an *accessible* entrance to the building to all *accessible* spaces, including those on other *stories* and *mezzanines*. The requirements also include *accessible routes* to *employee work areas* that are connected by *circulation paths* for *common use* and to press boxes within assembly uses. For each of these requirements, the IBC provides some exceptions. A couple of exceptions worth noting apply to uses within a multistory building:

- *Stories* and *mezzanines* that have an aggregate area not greater than 3,000 sq. ft. are exempt. This exception, however, does not apply to Group M occupancies with five or more tenants, with one tenant located above or below the *accessible* level. Also excluded from this exception are Group B or I offices of health care providers, passenger transportation *facilities* (including airports), and government buildings.
- Two-story *buildings* or *facilities* are exempt where the *stories* or *mezzanines* have an *occupant load* not greater than 5 and do not include *public-use areas*.

The location of the *accessible route* must be as close as possible to, if not integrated with, the general *circulation path* within the *building* or *facility*. In other words, it is the intent of the code not to segregate persons with disabilities from all other persons using the same *building* or *facility*. With the exception of *stairways*, the *accessible means of egress* and general *means of egress* pathways have minimum requirements that conform to many of the basic requirements for *accessible routes*, such as minimum widths, limitations for protruding and projecting objects, and requirements for *ramps*. Thus, the effort provided in Step 10 will have established a good foundation for completing the work covered in this step, but even with this good head start, there are some detailed requirements for *accessible routes* that can to be integrated into a project at this phase of design.

13.3.1 TECHNICAL REQUIREMENTS FOR ACCESSIBLE ROUTES

Since this step is still within the schematic design phase, the technical requirements that should be addressed within this step should be limited to those that affect space configuration (i.e., door locations and maneuvering clearances) or that require special coordination such as elevators and platform lifts, if not already incorporated as an *accessible means of egress* component per Step 10.

As previously discussed, the *circulation paths* within a building are also used as portions of a *means of egress* system. Thus, if the components of a *means of egress* system comply with basic *accessible route* requirements, then most *circulation paths* within a building will comply with the technical requirements of an *accessible route*. However, there are some details of an *accessible route* that are not replicated in the *means of egress* requirements.

- **Clear Width (ICC/ANSI A117.1 Section 403.5):** With few exceptions, most *means of egress* components comply with the 36-inch minimum width requirement. Small segments of the *accessible route* are permitted to be as narrow as 32 inches. In some cases, openings that do not have doors are permitted to be less than 36 inches wide as long as the length of the narrowed portion does not exceed 24 inches and the clear width is not less than 32 inches (Figure 13.3.1-1). If there are a series of these narrow "pinch points" along an *accessible route*, then they must be separated by a distance not less than 48 inches.

  If an *accessible route* includes 180-degree turns (i.e., U-turns) around an object and the object is less than 48 inches wide, then the approaches to the turn must have a clear width of 42 inches, and the turn area must have a 48-inch clear width (Figure 13.3.1-2(a)). If the clear width of the turn area is 60 inches or greater, then the approaches to the turn are permitted to be 36 inches wide (Figure 13.3.1-2(b)).

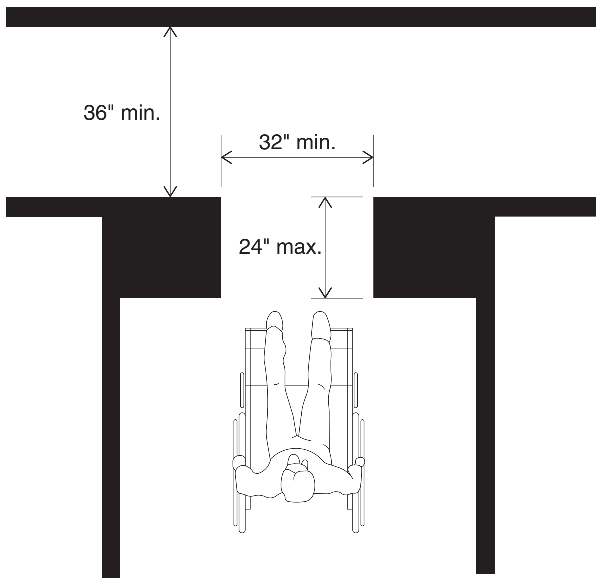


FIGURE 13.3.1-1. Minimum dimensions for narrow openings in an *accessible route*.

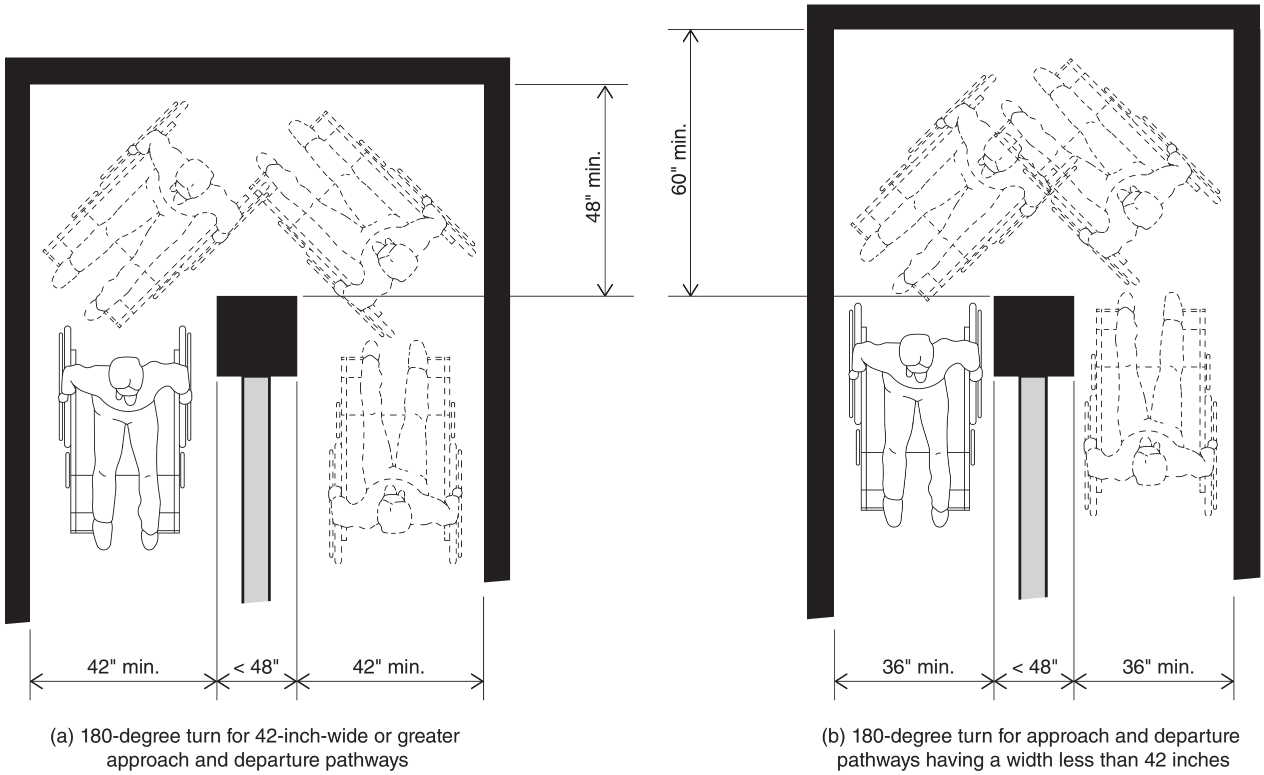


FIGURE 13.3.1-2. 180-degree turns on an *accessible route*.

Since these will likely occur within a *corridor* or *exit passageway* condition, the minimum width for those egress components is 44 inches unless the *occupant load* is less than 50, which then allows a 36-inch clear width. Therefore, use the following as guidelines:

- **Occupant Load of Pathway ≥ 50:** Minimum width is 44 inches, so ensure that the turn area is at least 48 inches wide.
- **Occupant Load of Pathway < 50:** Minimum width is 36 inches, so if the width is 42 inches or more, then ensure turn area is 48 inches. If the width is less than 42 inches, then ensure that the turn area is 60 inches in clear width.

- **Doors and Doorways (ICC/ANSI A117.1 Section 404):** All door openings, whether they are swinging, sliding, or folding, must provide a 32-inch clear width, which is also the building code minimum. However, maneuvering clearances are required on both sides of the door to allow a wheelchair-bound person or someone on crutches to position themselves in a way that is convenient to operate the door and remain clear of the door while it is moving.

ICC/ANSI A117.1 includes Tables 404.2.3.2 and 404.2.3.3, which provide the minimum maneuvering clearances for swinging doors and sliding and folding doors, respectively. Even better are the illustrations provided in ICC/ANSI A117.1 Figures 404.2.3.2 and 404.2.3.3. The figures show graphically the approach direction and the placement of the maneuvering clearance in relation to the door. To properly use these illustrations, each door must be analyzed from both sides using the appropriate illustration for each approach in relationship to the swing or operation direction of the door (Figure 13.3.1-3).

Doors that are recessed into a small alcove pose additional difficulties. If the door recess is greater than 8 inches, then the door will need to be considered as a forward approach door and the maneuvering

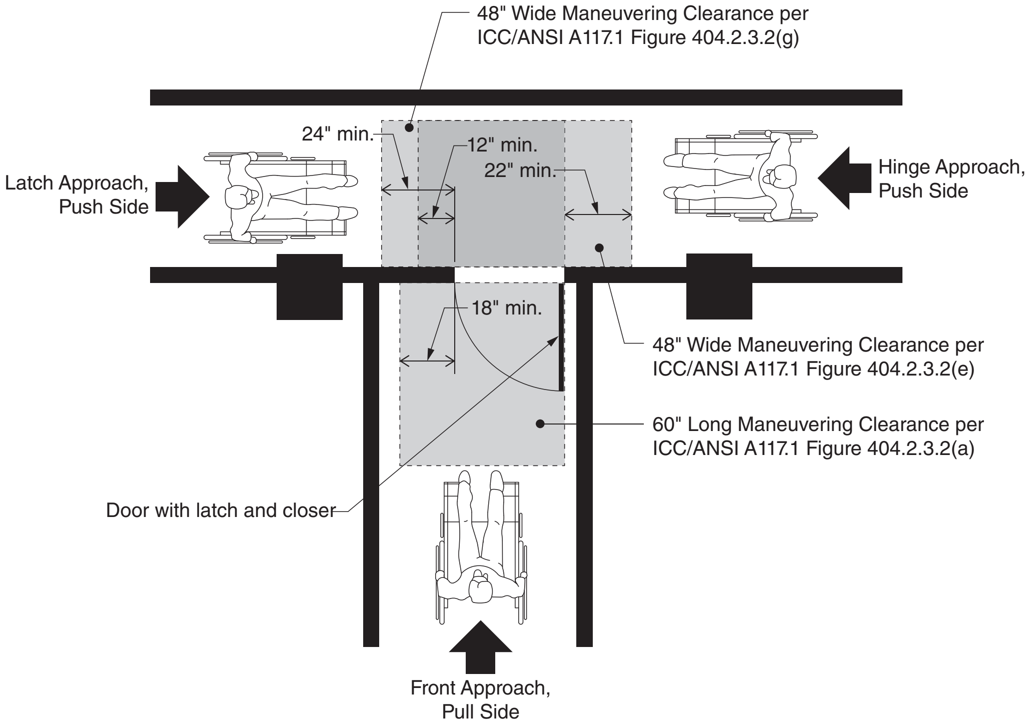


FIGURE 13.3.1-3. Application of door clearances to both sides of a doorway.

clearance for such an approach shall be applied. ICC/ANSI A117.1 Figure 404.2.3.5 provides illustrations on how this is accomplished.

If two or more doors are installed in a series, such as in a vestibule, the distance between the two doors will depend on the swing direction of the doors. ICC/ANSI A117.1 Figure 404.2.5 illustrates three configurations and the required dimensions.

- **Ramps (ICC/ANSI A117.1 Sections 405 and 406):** *Ramps* are used when an inclined surface exceeds a slope of 1:20. Slopes of 1:20 or less are not considered *ramps* and do not need to conform to the requirements for *ramps*. However, *ramp* inclines cannot have a slope that is more than 1:12. The maximum rise of any *ramp* run is 30 inches, at which point a landing will be required. Landings are required to be the full width of the *ramp* by 60 inches long. If the landing is used for a change in direction, then the landing must be able to accommodate a 60-inch-diameter turning space. Doors adjacent to landings may have the requisite maneuvering clearances overlap the landings.

Curb ramps (ICC/ANSI A117.1 Section 406) are used at exterior walkways that are separated from another surface by a raised curb. *Curb ramps* also have a maximum slope of 1:12; however, the flared sides of a *curb ramp* are permitted to have slopes of 1:10. The minimum width of the *curb ramp* (excluding flared sides) is 36 inches. The slope of the surface opposite of the *ramp* (e.g., roadways, driveways, parking areas, or other similar surfaces) cannot have a slope greater than 1:20 toward the *curb ramp*, such as the crown of a roadway sloping back toward the curb gutter. Most jurisdictions will likely have complying standard details for *curb ramps* for work within the jurisdiction's right-of-way. These details can also be used for *curb ramps* within the building *site*.

- **Elevators (ICC/ANSI A117.1 Sections 407, 408, and 409):** Elevators provide the most efficient means of accessing other floors within a multistory building. Neither the IBC nor ICC/ANSI A117.1 dictates the type of elevator to use, but it does specify requirements for some types of elevators. ICC/ANSI A117.1 covers commercial electric and hydraulic passenger elevators, limited-use/limited-application elevators, also referred to as LU/LA or LULA (pronounced "loo-lah"), and private residence elevators. All of these elevator types are required to conform to ASME/ANSI A17.1.

The only concern at this phase of a project's design is the size of the elevator and that all *stories* or floor levels required to be *accessible* are accessed by an elevator if not accessed by a *ramp*. The overall size of an elevator car and the size of its hoistway are not directly regulated by the *accessible route* requirements. They are, on the other hand, influenced by the inside dimensions of the elevator car, which are regulated by ICC/ANSI A117.1. The inside dimensions of a commercial passenger elevator car are partially dependent on the door configuration and width, and they can be found in ICC/ANSI A117.1 Table 407.4.1 and Figure 407.4.1. An elevator in an existing building is allowed narrower widths, provided the clear floor area is not less than 16 sq. ft. When an elevator car's interior dimensions are determined to be in compliance with the standard, the overall size of the car and its associated hoistway is dependent on the manufacturer of the elevator.

A LU/LA elevator is an elevator type that is somewhere between a commercial passenger elevator and a platform lift. The LU/LA elevator's sole purpose is to provide accessibility to otherwise nonaccessible *stories* or floor levels. Per ASME/ANSI A17.1, the LU/LA elevator is limited to a maximum rise of 25 feet; therefore, it can effectively only service a three-story building. Other limitations include size (18 sq. ft. maximum platform area) and capacity (1,400 pounds). ICC/ANSI A117.1 requires a LU/LA elevator to have a 15.75 sq. ft. clear floor area, but no inside dimension can be less than 42 inches clear. This can be reduced to 15 sq. ft. and 36 inches, respectively, for elevators in existing buildings.

Private residence elevators, as the name implies, are not for public use and serve only a private residence. Neither the IBC nor ICC/ANSI A117.1 restricts the application of a private residence elevator. The only restriction is found within ASME/ANSI A17.1, which limits this elevator type to applications in or at a private residence or in other buildings used as access to a private residence and cannot be used by the public or other occupants in the building. The minimum dimensions are 36 inches wide by 48 inches deep.

- **Platform Lifts (ICC/ANSI A117.1 Section 410):** Platform lifts are specifically limited in application per the scoping requirements of IBC Section 1109.8. Platform lifts are permitted as part of an *accessible route* to or within the following:
  - To performing areas on a *stage* or other elevated surface and speaker *platforms*
  - To the required *wheelchair spaces* distributed throughout an assembly use
  - To spaces not open to the public and with an *occupant load* of 5 or less
  - Within *dwelling units* and *sleeping units* that are required to be an *Accessible unit*, *Type A unit*, or *Type B unit*
  - To jury boxes, witness stands, judges' benches, and other elevated or depressed stations within a courtroom
  - To loading or from unloading areas of amusement rides.
  - To play structures
  - To team or player seating areas for *areas of sport activity*
  - To boating *facilities* and fishing piers/platforms in lieu of gangways
  - Within existing exterior areas that are infeasible for *ramps* or elevators

The minimum clear dimensions of a platform lift are 36 inches wide by 48 inches deep when one door or two doors at opposite ends are provided. Doors are required to be 32 inches in clear width minimum. If the platform has a door at one end and another door on the side, then the minimum platform size is required to be 42 inches wide by 60 inches deep and the side door is required to be 42 inches clear.

13.3.2 TECHNICAL REQUIREMENTS FOR ACCESSIBLE SITE ELEMENTS

Much of the *accessible route* requirements discussed in Step 13.3.1 apply also to routes outside of a building on the building *site*. As the requirement states for accessibility, an *accessible route* shall lead from *site* arrival points, which include parking spaces and passenger loading and unloading areas. Therefore, these *site elements* must also be designed for accessibility. Parking and passenger loading area scoping requirements are covered in IBC Section 1106.

- **Parking Spaces (ICC/ANS A117.1 Section 502):** IBC Table 1106.1 identifies the minimum required number of *accessible* parking spaces based on the total number of parking spaces. If parking is provided in separate *facilities*, whether provided as surface parking or in a parking garage, each *facility* is considered separately. Parking used solely for business vehicles, such as for buses or delivery trucks or motor pools that are available to the public but provided with an *accessible* passenger loading zone, are not required to be included in the total number of spaces under consideration. The IBC provides special parking requirements for Group I-1 and R occupancies, *hospital* outpatient *facilities*, and rehabilitation and outpatient physical therapy *facilities*.

  Accessible parking spaces are required to be located on the shortest *accessible route* from the parking area to the *accessible* entrance of the building. If the parking *facilities* do not serve a specific building, then an *accessible route* is required to connect the *accessible* parking to an *accessible* entrance to the parking. If a building has multiple *accessible* entrances, the required number of *accessible* parking spaces must be distributed to be as close as possible to each *accessible* entrance. For every six *accessible* parking spaces, or fraction thereof of, one van-accessible space is required.

  The minimum width of an *accessible* parking space is 96 inches, and the minimum width of a van-accessible parking space is 132 inches. There is no requirement for a minimum length—this will be dictated by the angle of the parking and may be regulated by local zoning requirements or other similar ordinance. A 60-inch aisle is required between every two *accessible* parking spaces. The length of the aisle must be as long as the space. Van-accessible parking spaces are permitted to be 96 inches wide if the adjacent aisle is also 96 inches wide. If a van-accessible space is angled, then the aisle must be located on the passenger side of the space. Vehicular routes, parking spaces, and access aisles for vans must have a clear height of 98 inches. In parking garages, all van-accessible parking may be located on a single level, which will allow lower heights for all other levels minimizing cost.

- **Passenger Load Zones (ICC/ANSI A117.1 Section 503):** IBC Section 1106.7 establishes the scoping requirements for passenger loading zones. Where passenger loading is provided, at least one *accessible* passenger loading zone is required for every 100 feet of continuous loading zone length. *Accessible* passenger loading zones are required at medical and long-term care *facilities*. If a *facility* provides valet services, then an *accessible* passenger loading zone is required.

  The size of a passenger loading zone is 96 inches wide by 20 feet long and shall have a 60-inch-wide access aisle. The clear height for passenger loading zones, including access aisles and vehicular routes to and from the loading zone, is required to have a clear height of 114 inches.

13.4 DWELLING AND SLEEPING UNITS (IBC SECTION 1107 AND ICC/ANSI A117.1 CHAPTER 10)

The IBC, in close alignment with the FHA, requires that *dwelling units* be made *accessible* to some degree. Also required to be *accessible* are *sleeping units* within other Group R occupancies and within some

Group I occupancies. The scoping requirements within the IBC identifies three types of units, which are defined in IBC Chapter 2, that have varying degrees of built-in accessibility:

- **Accessible Units:** These are fully *accessible dwelling units* or *sleeping units* that comply with the requirements of ICC/ANSI A117.1 Section 1002.
- **Type A Units:** These are units that are not fully *accessible* as required for *Accessible units* but provide more *accessible* features than what are required for *Type B units*. The requirements for *Type A units* are provided in ICC/ANSI A117.1 Section 1003.
- **Type B Units:** These are units that require some integrated *accessible* features but are more commonly referred to as "adaptable" units, since they must include other features that would allow future conversion of a unit to one that provides greater accessibility. It is the lowest level of accessibility that the IBC requires. The requirements for *Type B units* are provided in ICC/ANSI A117.1 Section 1004.

NOTE:

In the IBC, "*accessible* unit" (lowercase "a," unless beginning a sentence, and "unit" is not italicized) and "*Accessible unit*" (first word is always capitalized and both words are italicized) have two different meanings. For example, all *Accessible units* are *accessible* units, but not all *accessible* units are *Accessible units*. *Type A units* and *Type B units* are also *accessible* units.

ICC/ANSI A117.1 also identifies a "Type C (Visitable) Unit." This type of *accessible* unit is not included within any scoping requirement in the IBC, so it is not applicable to projects regulated under the IBC. However, local jurisdictions may adopt the Type C unit requirements for *dwelling units* that are not subject to the FHA, such as buildings with *dwelling units* for one, two, or three families. Check the jurisdiction's amendments to see if Type C units are required.

Common areas of a building or *facility* that are usable by the public or are available to residents in a building or *facility* that includes *Accessible units*, *Type A units*, or *Type B units* must be *accessible*. *Accessible routes*, as discussed in Step 13.3, are required from the entrances of *buildings* and *facilities* to each *Accessible unit*, *Type A unit*, and *Type B unit*. There are several exceptions listed in IBC Section 1107.4.

Not all buildings with residential or institutional occupancies are required to provide all three types of *accessible* units. The *accessible* unit types and quantities for each occupancy group and building type are summarized in Table 13.4-1.

13.5 TOILET AND BATHING FACILITIES (IBC SECTION 1109.2 AND ICC/ANSI A117.1 CHAPTER 6)

Every toilet and bathing *facility* is required to be *accessible*. If a floor is not required to be *accessible*, the only toilet and bathing *facilities* in the building cannot be located on that floor. Within each toilet or bathing room, at least one fixture of each type is required to be *accessible*, but no less than 5% of the water closet compartments and lavatories are required to be *accessible*.

The following list includes some of the exceptions to these general requirements:

- Nonpublic toilet or bathing rooms accessed only through a private office
- Toilet and bathing rooms in *dwelling units* and *sleeping units* that are not required to be *Accessible units*
- Toilet and bathing rooms with only one urinal are not required to have an *accessible* urinal

TABLE 13.4-1. Summary of Scoping Requirements for Dwelling Units and Sleeping Units

Occupancy Group	Building Type	No. of *Accessible Units*	No. of *Type A Units*	No. of *Type B Units*
Group I-1	Condition 1 Condition 2	4%; but not less than 1 10%; but not less than 1	NR	All remaining units[1, 6]
Group I-2	Nursing homes	50%; but not less than 1	NR	All remaining units intended to be occupied as a residence[2, 6]
	Hospitals	10%; but not less than 1		
	Rehabilitation facilities	100%		NR
Group I-3	Sleeping units	3%; but not less than 1 of each classification level	NR	NR
	Special holding *cells* or housing *cells* and rooms	One of each type[7]		
	Medical care facilities	One		
Group R-1	All	Per IBC Table 1107.6.1.1	NR	All remaining units intended to be occupied as a residence[2, 6]
Group R-2	Live/work units	Nonresidential portion only for all buildings	NR	Residential portion of all remaining live/work units[2, 6]
	Apartments, monasteries, and convents	NR	2%; but not less than 1[3, 6]	All remaining units intended to be occupied as a residence[2, 6]
	All others	Per IBC Table 1107.6.1.1	NR	
Group R-3[5]	All	NR	NR	All units intended to be occupied as a residence[2, 6]
Group R-4[5]	Condition 1	At least 1	NR	All units intended to be occupied as a residence[2, 6]
	Condition 2	At least 2		

NR = Not required
[1]Only required in *structures* with four or more *dwelling units* or *sleeping units*.
[2]Only required in *structures* with four or more *dwelling units*, *sleeping units*, or *live/work units* occupied as a residence.
[3]Only required when number of *dwelling units* or *sleeping units* within all Group R-2 units (except existing *structures*) on *site* exceeds 20. Each bedroom in monasteries and convents is counted as a *sleeping unit*. When *sleeping units* are in suites, only one *sleeping unit* in each suite will count toward the number of required *Type A units*.
[4]Each bedroom in *congregate living facilities* is counted as a *sleeping unit*. When *sleeping units* are in suites, only one *sleeping unit* in each suite will count toward the number of required *Accessible units*.
[5]Each bedroom in Group R-3 *congregate living facilities* or Group R-4 *facility* is counted as a *sleeping unit*.
[6]May be reduced in accordance with IBC Section 1107.7.
[7]Grab bars are not required in *cells* or rooms designed for suicide prevention.

- Toilet or bathing rooms for critical care or intensive care patient sleeping rooms
- Children's fixtures complying with ICC/ANSI A117.1

Each toilet and bathing room is required to provide a turning space per ICC/ANSI A117.1 Section 304, which is either a 60-inch-diameter circle or a T-shaped configuration that fits within a 60-inch-square space. The turning space may include the knee and toe clearances as described in ICC/ANSI A117.1 Section 306. The turning space cannot be provided within a water closet compartment. Doors are permitted to swing into the turning space; however, door swings are not permitted to overlap any fixture clear spaces described below.

The size of water closet clearances and compartments will have an impact on the toilet and bathing room layout. Water closets not located within a compartment is required to have a wall to the rear of the water closet and a wall on either side of the water closet. A clear space is required around the water closet having a depth of 56 inches measured perpendicular to the rear wall and a width of 60 inches measured perpendicular to the side wall. The clear space is permitted to overlap the water closet and toilet accessories, clear spaces of other fixtures, and the turning space. The location of the water closet must be 16 to 18 inches from the side wall.

ICC/ANSI A117.1 Section 604.9.2 provides the minimum sizes for wheelchair-accessible water closet compartments, which must provide clear dimensions equal to the clear space around a water closet as previously described. ICC/ANSI A117.1 Section 604.9.3 addresses the compartment door location, which requires a 42-inch clear width between the door side of the compartment and any obstruction. The size of an ambulatory water closet compartment is provided in ICC/ANSI A117.1 Section 604.10.2, which also requires a 42-inch clear width between the door side of the compartment and any obstruction.

Lavatories, from a floor plan perspective, do not have any special requirements. However, a clear space of 48 inches by 30 inches is required in front of the lavatory. The lavatory itself may overlap this clear space by no more than 25 inches per ICC/ANSI A117.1 Section 306.

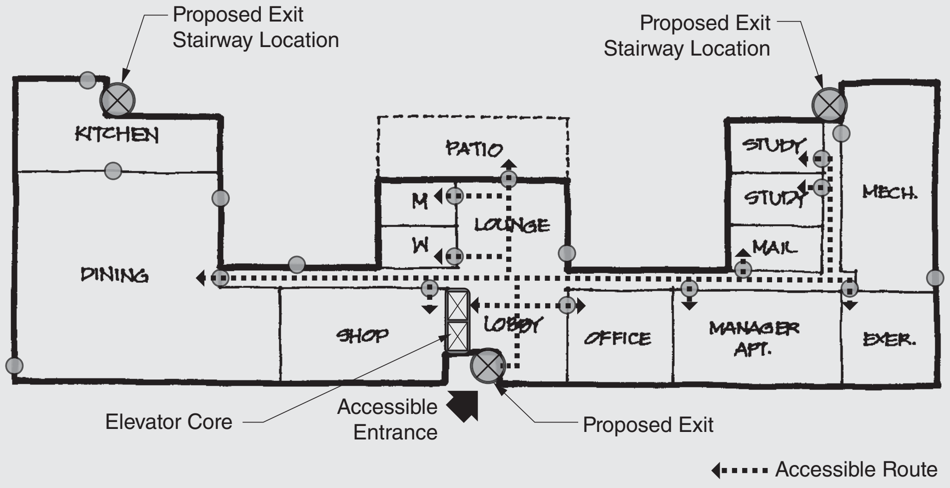
Bathtubs in *accessible* toilet and bathing rooms do not require any special sizes beyond the standard sizes available. However, the clear space required in front of the bathtub may affect room planning. Where bathtubs are not provided with a permanent seat, the clear space is required to extend the full length of the bathtub (i.e., 60 inches minimum) by 30 inches wide per ICC/ANSI A117.1 Section 607.2. If a permanent seat is provided at the head end of the bathtub (i.e., the end opposite of the controls), the clear space must extend 12 inches beyond the wall side of the permanent seat. The permanent seat is required to have a 15-inch minimum depth per ICC/ANSI A117.1 Section 610.2.

Unlike bathtubs, showers do have minimum sizes, which are provided in ICC/ANSI A117.1 Section 608.2. There are two types of showers specified in ICC/ANSI A117.1: transfer-type and roll-in-type shower compartments. The transfer-type shower compartment is required to have a 36-inch by 36-inch clear width. A clear space 48 inches long by 36 inches wide, oriented parallel to the shower compartment opening, shall be provided. One end of the clear space shall be aligned with the shower control wall.

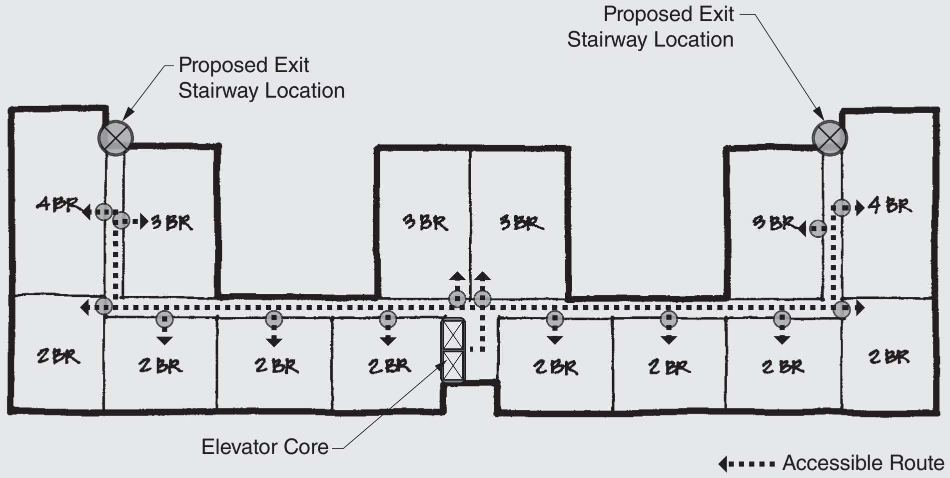
The roll-in-type shower can be provided in two configurations referred to as “standard” and “alternate” roll-in-type compartments. The standard configuration requires a compartment that is 60 inches wide by 30 inches deep. In addition to the compartment, a clear space with equal dimensions is required in front of the shower compartment. A lavatory, complying with the requirements above, is permitted within this shower clear space. The alternate configuration requires a slightly deeper compartment—36 inches—but does not require a clear space in front of the shower compartment. A 36-inch-wide opening is required at one end of the 60-inch minimum width. In Group R-1 occupancies, a certain number of *Accessible units* are required to have roll-in-type shower compartments, which are enumerated in IBC Table 1107.6.1.1. Illustrations of these shower compartment configurations are provided in ICC/ANS A117.1 Figures 608.2.2 and 608.2.3.

EXAMPLE PROJECT—STEP 13

The project site for the Example Project is located on a street that has access to public transportation, so an accessible route is available to the building. Example Project Figure 13-1 shows the accessible entrance which faces the street. An accessible route is then provided through the building to an elevator core that needs to be added. Per IBC Section 1104.4, elevator access is required to all floors in the building. On the residential floors, the elevators are centrally located in the building off the corridor (Example Project Figure 13-2).



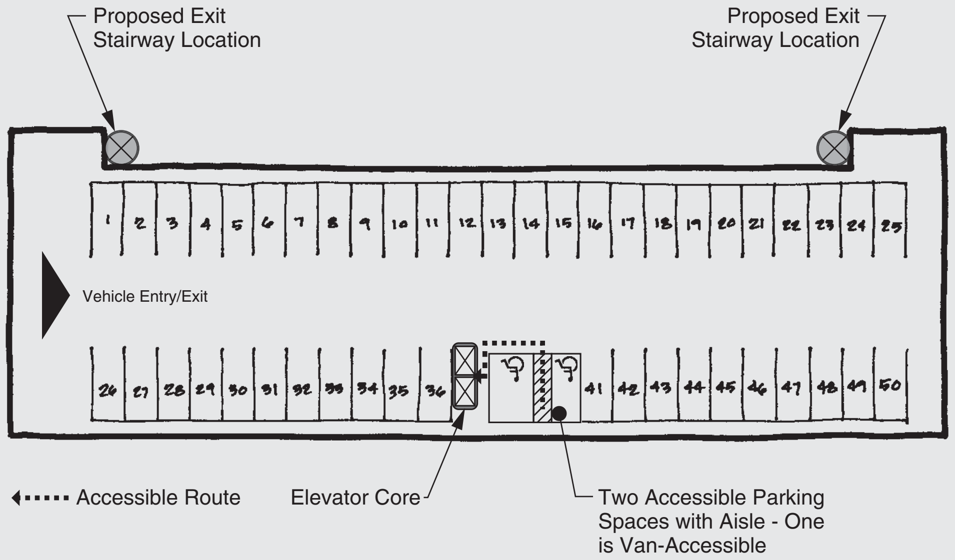
EXAMPLE PROJECT FIGURE 13-1. First story showing accessible entrance and route to elevators and all spaces required to be accessible.



EXAMPLE PROJECT FIGURE 13-2. A typical residential story showing the location of the elevator and the accessible routes to all dwelling units.

As an apartment building, the dwelling unit requirements of the IBC and ICC/ANSI A117.1 will be applied. Per Table 13.4-1, 2% of the apartment units are required to be Type A units. The rest of the apartments will need to comply with the requirements for Type B units. Accessible units are not required. Since the building will have 43 units (including the manager's apartment), 2% provides a number that is less than 1, so one apartment will need to comply with the requirements for a Type A unit.

In the basement, accessible parking will be required. Per IBC Table1106.1, two accessible parking spaces would be required, but IBC Section 1106.2, subparagraph 1, requires only 2%, but not less than one, of each type of parking be accessible. Since all spaces are of one type, only one space is required. However, since there are more spaces than the number of units, an extra space will also be made accessible. Each space will need to be 96 inches wide with a 60-inch aisle in between. The elevator and accessible parking will eliminate four standard parking spaces (Example Project Figure 13-3). However, with the two accessible parking spaces, the total number of parking spaces is only reduced to 48. Since one accessible space is required, it must be a van-accessible space, while the other can remain a standard accessible space.



EXAMPLE PROJECT FIGURE 13-3. The parking garage will have access to one elevator and will be adjacent to the required accessible parking.

PART III

Design Development

The design development phase begins when the owner approves the schematic design documents and gives the design professional authorization to proceed to the next phase. During the design development phase, the design professional will incorporate any changes made during the review of the schematic design documents and continue to develop the design to a greater level of detail. The documents at this phase must describe or show the character of the building's major elements, such as building materials, systems, and some finishes.

Since most of a building's features will have been confirmed during the review of the schematic design documents, they can be further developed. Thus, the more detailed requirements of the IBC and other codes can be considered and applied to the building.

Applying the Building Code: Step-by-Step Guidance for Design and Building Professionals. Ronald L. Geren, FCSI, AIA

STEP 14

CONFIRM STEPS 2 THROUGH 13

STEP OVERVIEW

It is not common for a design to go through a review process without any changes. Therefore, before proceeding with the development of the design, any changes required to be made after the review of the schematic design documents must be looked at closely to determine if their implementation would affect any code decisions made during the schematic design phase.

14.1 REVIEW OF CHANGES

During this step, each proposed change should be looked at to determine its impact on the code application to the project. A change on a project could have no effect on the code application, a small effect (i.e., a single code requirement), or a large effect (i.e., multiple code requirements, either individually or by a domino effect). A proposed change can originate for several reasons:

- During the review of the schematic design documents, the owner may make a list of comments of which some may require alteration of the design.
- The owner may make a change in project scope, such as increasing the size of the building by adding new functions, or some functions may be changed from what was originally indicated in the owner's programming document.
- The estimate of the cost of construction, which is required with the schematic design documents, may exceed the owner's construction budget. Therefore, the design professional will need to look at changes in the design to bring the cost estimate within the budget.
- There may be other influences outside of the owner's and design professional's control that could impact the design requiring change. Some examples may be the disapproval of a zoning variance that was anticipated to be approved or comments from a design review board.

Applying the Building Code: Step-by-Step Guidance for Design and Building Professionals. Ronald L. Geren, FCSI, AIA

Every change does not need to be looked at closely and evaluated for its impact, just those that have affected one or more of the following aspects of the project:

- Change to *building area* and/or *building height*
- Change in function and/or size of one or more spaces
- Change in building structural materials
- Change in space arrangement (i.e., floor plan changes)
- Change in location on *site*

14.2 CHANGES TO BUILDING AREA AND/OR HEIGHT

This type of change can be either an increase or a decrease, albeit a decrease in either height or area will have less of a detrimental impact, if any, on the project. Regardless, a decrease in height or area may relax the application of other code requirements (e.g., *automatic sprinkler system* or change in construction type), which the owner may pay for unnecessarily if not brought to the attention of the owner for a decision.

An increase in height and area, on the other hand, could have a significant impact on the project. In addition to the obvious cost increase due solely to the added floor area, the cost may be even greater due to the application of the code. An increase in *building area*, *building height*, or both may require a change in construction type or the introduction of a *fire wall* to split the building into smaller buildings—both will likely add cost to the project. Additionally, an increase may enlarge a *fire area* beyond the code threshold, thus requiring an *automatic sprinkler system*.

If a change in this area occurs, the following steps will need to be reevaluated:

Step 2: The building data has changed and will need to be revised.

Step 7: Verify if the allowable area has been exceeded. If so, change the construction type, add a sprinkler system (if not already added), use the frontage increase (if not already considered), insert a *fire wall*, or reevaluate the method of handling mixed-occupancy groups to stay within the allowable area.

Step 8: An increase in *building area* will possibly increase the *occupant load*, unless there are changes in the functions or sizes of spaces that offset the increase.

Step 9: If there is an increase in *occupant load* per Step 8, then the number of *exits* may need to be increased. A change in *building area* and in *building height* will very likely affect the location of *exits*, especially if the building increases from a one-story building to a two-story building.

Step 10: If the number or locations of *exits* changes, then it is highly probable that the pathways to those *exits* have changed too.

Step 11: If the *occupant load* increases in Step 8, the recalculation of plumbing fixtures must be done to see if additional fixtures are required.

Step 13: If the egress pathways are changed per Step 10, then there is a chance that the *accessible routes* have changed. The addition of a *story* may require that an elevator is now required.

14.3 CHANGES IN FUNCTION AND/OR SIZE OF SPACES

A change in a function or size of a space can have an impact in two areas of building code application:

- Occupancy group classification
- *Occupant load*

In regard to occupancy classification, a change in function in a space can also change it from one occupancy group to another. For example, if a developer is planning on an office building but sells a lease for a restaurant in a portion of the building, then that portion of the building needs to change from a Group B to a Group A-2. A change in function could also be small, requiring a change within an occupancy group. For example, if a storage room is changed from storing metal furniture to wood furniture, then the occupancy classification will need to change from Group S-2 to Group S-1.

Another function change that would cause a change in occupancy classification is a change in the scope of the function. For example, if the client for a *group home* project decides to increase the number of occupants under care from under 16 to more than 16, then the occupancy classification changes from a Group R-4 to a Group I-1. In this case, the function (i.e., *group home*) did not change, but the scope of the function (i.e., number of people under the home's care) changed, which increases the risk, thus moving the facility to an occupancy group that has more stringent requirements.

A change in the function of the space may not affect the occupancy classification, but it could have an impact on the *occupant load* of the space, the building, or both. For example, if a planned lab space in a college education building is changed to a standard classroom, then, per IBC Table 1004.1.2, the *occupant load* factor changes from 50 sq. ft. per occupant to 20 sq. ft. per occupant. Therefore, if the lab had an area of 900 sq. ft., the *occupant load* would change from 18 to 45.

In the previous example, if the lab was slightly larger, the change would also create a change in occupancy classification. If the lab had a *net floor area* of 1,000 sq. ft., the *occupant load* of the standard classroom at that floor area would be 50, thus making it an assembly occupancy group, requiring it to be classified as a Group A-3 rather than a Group B.

The size of a space could affect the *occupant load* of the building, the occupancy classification of the space, or both. It goes without saying that if you increase the floor area of the space the *occupant load* of the space will also increase, assuming the function of the space does not change. However, the increase in *occupant load* by the enlarged space could be offset by a decrease in *occupant load* in another area, especially if the *building area* does not change.

As previously stated, if a space has an increase in *occupant load*, the occupancy classification could also be affected. For example, if the dining room of a small restaurant has an *occupant load* under 50, then it is classified as a Group B occupancy per IBC Section 303.1.2. However, if the dining room is enlarged and the *occupant load* is 50 or more, then the dining room must be reclassified as a Group A-2 occupancy.

If a change in this area occurs, the following steps will need to be reevaluated:

- Step 3: Verify if any occupancy group has changed.
- Step 5: If any occupancy groups change, the method of handling mixed-occupancy groups will need to be reevaluated. Accessory and incidental occupancies will need to be checked to see if the 10% limitation is not exceeded.
- Step 6: Verify if a change in function or occupancy group requires special requirements.
- Step 7: Verify if the allowable area has been exceeded based on a change of occupancy groups. If so, change the construction type, add a sprinkler system (if not already added), use the frontage increase (if not already considered), insert a *fire wall*, or reevaluate the method of handling mixed-occupancy groups to stay within the allowable area.
- Step 8: An increase in size or function of the space will definitely affect the *occupant load* of the space and possibly the building.
- Step 9: If there is an increase in *occupant load* per Step 8, then the number of *exits* may need to be increased.

Step 10: If the number or locations of *exits* change, then it is highly probable that the pathways to those *exits* have changed too.

Step 11: If the *occupant load* increases in Step 8, the recalculation of plumbing fixtures must be done to see if additional fixtures are required.

Step 13: If the egress pathways are changed per Step 10, then there is a chance that the *accessible routes* have changed as well.

14.4 CHANGES IN BUILDING STRUCTURAL MATERIALS

The materials used for the structural system may change for a number of reasons, but it is a rare situation when it does occur. The most likely reason for a change in structural materials is if a project's cost estimate exceeds the owner's budget and a reduction is required. Changing the construction type of a building will have a major impact on the application of the code, but it is better to find out at this phase of a project rather than later.

Changing the materials for the structural system may or may not affect the construction type of the building. An example of not changing the construction type is if a Type IB building, originally designed with a cast-in-place concrete frame, is changed to a steel frame. As long as the steel has the *fire-resistance ratings* as required for Type IB construction, then there is no impact to the project from a code perspective. However, if the design professional wants to leave the steel unprotected, at a minimum the building will have to be evaluated as a Type IIB building.

If a change in this area occurs, the following steps will need to be reevaluated:

Step 4: This is where to begin, since it is the construction type that is being reevaluated.

Step 5: A change in construction type will definitely affect how mixed occupancies will be evaluated. If the nonseparated occupancies method was originally used, then the separated occupancies may need to be considered.

Step 6: Some special occupancies or uses may require certain construction types. If the building includes special occupancies or uses, then verify that the new construction is permitted.

Step 7: Verify if the allowable area has been exceeded based on a change of construction type. If so, change the construction type, add a sprinkler system (if not already added), use the frontage increase (if not already considered), insert a *fire wall*, or reevaluate the method of handling mixed-occupancy groups to stay within the allowable area.

14.5 CHANGES IN SPACE ARRANGEMENT

The owner may require a change in the functional layout of the building floor plan for multiple reasons. Changes may be based on new information provided by the owner, the owner not concurring with the submitted layout, or they may be the result of a change or changes in the functions or sizes of some spaces that necessitate a modification to the floor plan. Minor changes in space arrangement or configuration are common and should be expected to some degree throughout the design process.

If a change in this area occurs, the following steps will need to be reevaluated:

Step 6: Verify if a change in the floor plan arrangement is not impacted by special requirements.

Step 7: If a space is relocated to another *story*, verify that the space does not exceed the allowable height for the occupancy group for which the space is classified. If the relocation of a space changes the floor area of a *story*, then verify that the allowable area of the *story* has not been exceeded. If so, change the construction type, add a sprinkler system (if not already added), use the frontage increase (if not already considered), insert a *fire wall*, or reevaluate the method of handling mixed-occupancy groups to stay within the allowable area.

Step 8: An increase in size or function of the space will definitely affect the *occupant load* of the space and possibly the building.

Step 9: If there is an increase in *occupant load* per Step 8, then the number of *exits* may need to be increased.

Step 10: If the number or locations of *exits* change, then it is highly probable that the pathways to those *exits* have changed too.

Step 11: If the *occupant load* increases in Step 8, the recalculation of plumbing fixtures must be done to see if additional fixtures are required.

Step 13: If the egress pathways are changed per Step 10, then there is a chance that the *accessible routes* have changed as well.

14.6 CHANGES IN LOCATION ON SITE

Relocating the building on a *site* will likely not have a major impact on the application of the building code at this point in the design process. However, if a building's location is moved within close proximity of an established *lot line* or another building on the same *lot*, there could be significant code implications. The most notable impacts would be regarding fire department access and frontage increases. Other impacts on the building design would be *exit* locations if the building is located too close to a *lot line* that prohibits or limits opening sizes.

If a change in this area occurs, the following steps will need to be reevaluated:

Step 6: Some special occupancies, such as Group H, require specific distances from adjacent buildings and properties. Verify that the *site* relocation does not infringe on any of those minimum distances.

Step 7: If a frontage increase was used in determining allowable area, check to see if the relocation on the *site* has modified any of the distances used in the calculation.

Step 9: Verify that building *exits* are not affected by the relocation. If one or more *exits* are affected, then either they must be relocated or additional measures must be added to make them acceptable, such as recessing or protecting construction.

Step 10: If the locations of *exits* change, then it is highly probable that the pathways to those *exits* have changed too.

Step 12: Verify that the fire department still has access to all portions of the *exterior walls*.

Step 13: If the egress pathways are changed per Step 10, then there is a chance that the *accessible routes* have changed as well. Also, verify the *accessible route* to the building has not been affected by the relocation on the *site*.

EXAMPLE PROJECT—STEP 14

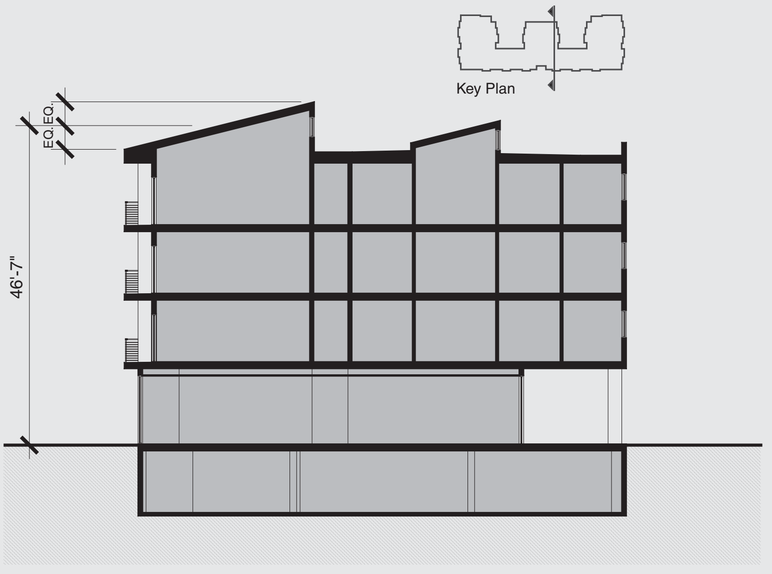
The project has seen some modifications, as is evident from the various sketches that were shown during the schematic design phase. At the end of schematic design, the project was even more refined and some spaces were relocated or modified. Using the categories of changes within Step 14, the following must be addressed:

CHANGES TO BUILDING AREA AND/OR HEIGHT

Since the building floor plan has been tightened up, the recalculation of building area should be done to determine if the allowable area has been exceeded. The current floor area for each story for the first through fourth stories is now 14,793 sq. ft., which are slightly less than the programmed areas used in Step 7. Therefore, there is no need for concern on the allowable area at this point. Revised calculations will still need to be accomplished for the final code information used for plan review.

For the parking garage in the basement, the floor area has been significantly increased. The current floor area for the basement parking garage is 17,473 sq. ft. compared to the 15,000 sq. ft. used for Step 7. As determined in Step 7, the tabular allowable area for the basement parking garage is 21,000 sq. ft. Since that area has not been exceeded, and since the area of a single basement level is not included in the total building area (see Step 2.1), the area of the basement level remains in compliance
with the code.

The height of the building has also increased with the addition of clerestory windows above the living areas of the fourth story. The sloped roof of the clerestory windows is highest at the two-bedroom units along the south side of the building (see Example Project Figure 14-1).



EXAMPLE PROJECT FIGURE 14-1. Revised height of building.

CHANGES IN FUNCTION AND/OR SIZE OF SPACES

None of the programmed spaces have changed in function; however, because of the refinement of the floor plan, some spaces are larger than programmed while others are smaller. The size of the lounge is now less than 750 sq. ft.; therefore, the occupancy classification can change from a Group A-3 to a Group R-2, which is the main occupancy. This, however, does not affect the allowable area, since the entire first story is considered a Group A-2 for nonseparated occupancies. The tables below reflect the occupant loads for the revised spaces. The overall occupant load has decreased slightly; thus, the current egress design is sufficient.

Occupant Load (OL) per Story

Story	Space	Floor Area	IBC Table 1004.1.2 Use	OL Factor	OL
B	Parking	17,879 sq. ft.	(See basement table)	Varies	88
1	Mixed Use	14,793 sq. ft.	(See 1st-story table)	Varies	377
2	Apartments	14,793 sq. ft.	Residential	200 gross	73
3	Apartments	14,793 sq. ft.	Residential	200 gross	73
4	Apartments	14,793 sq. ft.	Residential	200 gross	73
				Total	684

Occupant Load (OL) for Basement

Space	Floor Area	IBC Table 1004.1.2 Use	OL Factor	OL
Parking	17,177 sq. ft.	Parking garages	200 gross	85
Elevator Equipment	88 sq. ft.	Accessory storage areas, mechanical equipment room	300 gross	1
Storage	614 sq. ft.	Accessory storage areas, mechanical equipment room	300 gross	2
			Total	88

Occupant Load (OL) for First Story

Space	Floor Area	IBC Table 1004.1.2 Use	OL Factor	OL
Dining Hall (Dining)	3,333 sq. ft.	Assembly, unconcentrated	15 net	222
Dining Hall (Kitchen)	1,029 sq. ft.	Kitchens, commercial	200 gross	5
Convenience Shop	1,023 sq. ft.	Mercantile	60 gross	17
Study Room (1)	370 sq. ft.	Assembly, unconcentrated	15 net	24
Study Room (2)	339 sq. ft.	Assembly, unconcentrated	15 net	23
Lounge	698 sq. ft.	Assembly, unconcentrated	15 net	46
Restrooms	421 sq. ft.	Business areas	100 gross	4
Exercise Room	511 sq. ft.	Exercise rooms	50 gross	10
Manager's Apartment	1,115 sq. ft.	Residential	200 gross	5
Management Office	682 sq. ft.	Business areas	100 gross	6
Mechanical Room	1,022 sq. ft.	Accessory storage areas, mechanical equipment room	300 gross	3
Trash Room	281 sq. ft.	Accessory storage areas, mechanical equipment room	300 gross	1
Mail Room	194 sq. ft.	Accessory storage areas, mechanical equipment room	300 gross	1
Lobby	521 sq. ft.	Assembly, unconcentrated	15 net	34
Circulation	1,632 sq. ft.	Residential	200 gross	8
			Total	409

Occupant Load (OL) for Each Apartment Type

Apartment Type	Floor Area	OL Factor	OL
Two-Bedroom Apartments (Corner)	748 sq. ft.	200 gross	3
Two-Bedroom Apartments (South)	765 sq. ft.	200 gross	3
Three-Bedroom Apartments (East/West)	975 sq. ft.	200 gross	4
Three-Bedroom Apartments (Center)	956 sq. ft.	200 gross	4
Four-Bedroom Apartments (3-Bath)	1,174 sq. ft.	200 gross	5
Four-Bedroom Apartments (4-Bath)	1,229 sq. ft.	200 gross	6

The slight variation in the occupant load on the first story has no impact on the number of restroom fixtures.

CHANGES IN BUILDING STRUCTURAL MATERIALS

There are no significant changes in building structural materials. However, because of the introduction of large glazed areas, steel columns may need to be integrated into the first floor to support beams over the large openings. The building will remain Type VA construction.

CHANGES IN SPACE ARRANGEMENT

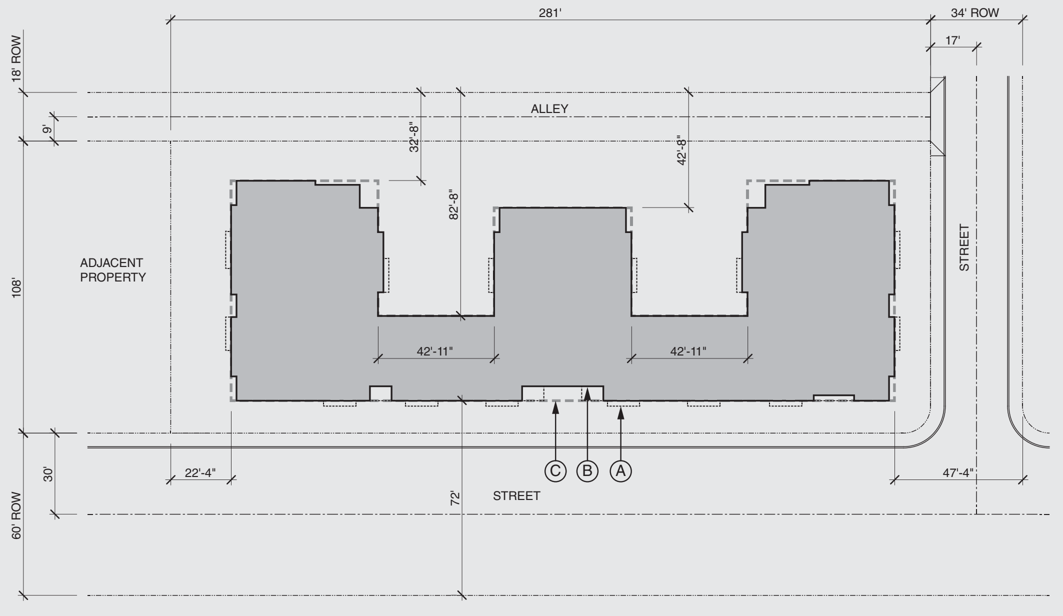
Some areas have seen slight modifications to their arrangement. The public restrooms on the first story are rotated and the locations of the exercise room and manager's apartment are transposed. The effect of these modifications on egress pathways and accessible routes are minimal and all remain within compliance of the code.

CHANGES IN LOCATION ON SITE

The location on the site has changed slightly; however, the building configuration on the site has changed significantly, which affects the building perimeter and, thus, the frontage increase calculated in Step 7.

The revised floor plans include balconies on the second, third, and fourth stories and there are recesses within the plane of the walls. There is no definition of what the "building perimeter" includes, so the conservative approach would be to include the balconies and all wall recesses in the building perimeter length. On the other hand, since IBC Section 705.2 considers exterior balconies as projections beyond the exterior wall, they could be excluded from the building perimeter using that section as justification, which is common for roof overhangs. The new building perimeter without the balconies is 903 feet; with the balconies it would be 916 feet—a minimal difference. Compare these perimeter lengths to the 542-foot perimeter used in Step 7.

The open spaces around the building have also been modified. Whether or not balconies are included, open space within a recess or between balconies must be considered, each with their own open space distances between facing walls or balcony railings. Therefore, another approach to simplify the process is to discount both the balconies and recessed areas at the balconies and use the distances between major portions of the exterior wall (see Example Project Figure 14-2). Thus, using the simplified process, the building perimeter will be 833 feet and the current open space dimensions are now as follows:



EXAMPLE PROJECT FIGURE 14-2. Revised building configuration and location on lot. (A) Indicates building perimeter at upper floors where balconies are included. (B) Indicates building perimeter at first story where balconies are not included. (C) Indicates simplified building perimeter.

North Elevations:

East and West Wings: 32′-8″

Center Wing: 42′-8″

Courts: 82′-8″

Between Facing Walls of Courts: 42′-11″

East Elevation: 47′-4″

South Elevation: 72′-0″

West Elevation: 22′-4″

Since there is now an open space that is less the 30 feet (i.e., west elevation), a weighted average for the value of *W* is now required:

IBC Equation 5-4: $W = (L_1 \times w_1 + L_2 \times w_2 + L_3 \times w_3 \ \ldots)/F$

where:

$L_1 = 81.33'$ (length of perimeter at west elevation)

$w_1 = 22.33'$

$L_2 = 751.67'$ (length of perimeter with widths greater than 30 feet)

$w_2 = 30'$

$F = 833'$

Calculation:

$W = (81.33' \times 22.33' + 751.67' \times 30')/833'$

$W = (1,816 \text{ sq. ft.} + 22,550.1 \text{ sq. ft.})/833'$

$W = 24,366.1 \text{ sq. ft.}/833'$

$W = 29.25'$

Using the revised value of 29.25 ft. for *W*, the calculation for the revised frontage increase can be accomplished:

IBC Equation 5-5: $I_f = [F/P - 0.25]W/30$

where:

$F = 833'$

$P = 833'$

$W = 29.25'$

Calculation:

$I_f = [833'/833' - 0.25]29.25'/30$

$I_f = [1 - 0.25]0.975$

$I_f = [0.75]0.975$

$I_f = 0.73$, which is less than 0.75 used in Step 7. Therefore, allowable areas and building areas will need to be reevaluated to determine if the building still remains within the allowable area.

Calculate the allowable area for each occupancy group using IBC Equation 5-3:

Group A-2:

$A_a = 11,500$ sq. ft. + (11,500 sq. ft. × 0.73)

$A_a = 11,500$ sq. ft. + 8,395 sq. ft.

$A_a = 19,895$ sq. ft.

Group R-2:

$A_a = 12,000$ sq. ft. + (12,000 sq. ft. × 0.73)

$A_a = 12,000$ sq. ft. + 8,760 sq. ft.

$A_a = 20,760$ sq. ft.

Group S-2:

$A_a = 21,000$ sq. ft. + (21,000 sq. ft. × 0.73)

$A_a = 21,000$ sq. ft. + 15,330 sq. ft.

$A_a = 36,330$ sq. ft.

Calculate the ratios of designed floor area to allowable area for each story.

Basement: Group S-2: 17,879 sq. ft. ÷ 36,330 sq. ft. = 0.49

1st Story: Group A-2: 14,793 sq. ft. ÷ 19,895 sq. ft. = 0.74

2nd Story: Group R-2: 14,793 sq. ft. ÷ 20,760 sq. ft. = 0.71

3rd Story: Group R-2: 14,793 sq. ft. ÷ 20,760 sq. ft. = 0.71

4th Story: Group R-2: 14,793 sq. ft. ÷ 20,760 sq. ft. = 0.71

Sum the ratios calculated above for each story.

Basement: $0.49 \leq 1$, therefore, okay

1st Story: $0.74 \leq 1$; therefore, okay

2nd Story: $0.71 \leq 1$; therefore, okay

3rd Story: $0.71 \leq 1$; therefore, okay

4th Story: $0.71 \leq 1$; therefore, okay

The sum of ratios per story is less than 1; therefore, the building so far complies with the code.

Sum the ratios calculated above to determine if the building complies.

The basement is not included, since one basement level can be excluded from the allowable building area:

$0.74 + 0.71 + 0.71 + 0.71 = 2.87 \leq 4$

The sum of ratios for the building is less than 4 (for a four-story building per the exception to IBC Section 506.2.4); therefore, the building still complies with the code.

STEP 15

Identify Locations of Fire-Resistive Construction, Assemblies, and Openings

STEP OVERVIEW

As the design continues to be developed, the design of exterior and interior walls, structural frames, floor systems, and roof systems are defined in regard to their materials and performance. One aspect of performance is *fire resistance*, and this characteristic of a building element is determined first, since it takes precedence over most other aspects of an assembly's characteristics (other than structural). In this step, *fire resistance* requirements are applied to each applicable building element to determine the required *fire-resistance rating* and type of assembly. *Fire resistance* of *exterior walls* is not covered in this step but is covered in Step 16.

15.1 IDENTIFYING FIRE-RESISTIVE ASSEMBLIES AND CONSTRUCTION

In Part I "Types of Fire-Resistive Assemblies and Construction," the various types of fire-resistive assemblies and construction in the IBC were discussed. Additionally, throughout the previous steps, various requirements have mentioned the need for fire-resistive assemblies or construction based on unique circumstances or specific alternatives that the design team may have decided to implement for some reason or another.

The identification of fire-resistive assemblies and construction should follow a logical sequence. Since some requirements may overlap, it is best to identify fire-resistive construction starting with the most restrictive requirements and working toward the least restrictive requirements. Thus, if a wall is required to be a *fire partition* for a *corridor* condition as well as a *fire barrier* for an occupancy separation, then, if following the prescribed logical sequence, it will be identified as a *fire barrier* first to ensure that the most restrictive condition is identified for that wall. The fire-resistive assemblies and construction discussed in this step will be presented in the recommended order.

There are many instances where a building component is required to incorporate fire-resistive assemblies but may also include *exterior walls*, such as an *interior exit stairway* enclosure. Where a building component is required to have a *fire-resistance rating* and the component includes *exterior walls*, only those walls separating the component from the interior of the building are required to comply with the requirements for the applicable *fire-resistance-rated* assembly. *Exterior walls*, on the other hand, need only comply with the *fire resistance* requirements for *exterior walls* per Step 16.

15.1.1 FIRE WALLS

As discussed in Part I, *fire walls* completely divide a larger building into two or more smaller buildings, thus allowing the design professional to treat each building created by the *fire wall* as a complete separate *structure*. If a *fire wall* is used, it needs to be clearly marked on the *construction documents*, along with the required *fire-resistance rating* and identification of the *fire-resistance-rated* assembly or assemblies used to comply with that required rating.

The required *fire-resistance rating* for a *fire wall* is based on the occupancy group or groups that are being separated. IBC Table 706.4 lists the occupancy groups and the required ratings. For example, if a Group B occupancy has a *fire wall*, a 3-hour *fire wall* is required. If each side of the *fire wall* has a different occupancy group, then the highest *fire-resistance rating* of the two occupancy groups is required. For example, if one side of a *fire wall* is a Group S-2 occupancy, which requires a 2-hour rating, and the other side is a Group B (3-hour rating per previous example), then a 3-hour rating is required.

Since a *fire wall* literally separates a building into different buildings, the *fire wall* must extend from *exterior wall* to *exterior wall* and from foundation to roof. The main issue when designing with *fire walls* is how to terminate them at *exterior walls* and roofs.

15.1.1.1 Fire Wall Horizontal Continuity

Since a *fire wall* is required to extend from *exterior wall* to *exterior wall*, the termination of a *fire wall* at the *exterior wall* can be a little confusing. The basic requirement in the IBC states that a *fire wall* must extend 18 inches beyond the exterior surface of the *exterior wall*. However, three exceptions are offered that eliminate the wall extension:

1. The *fire wall* may terminate at the interior surface of exterior combustible sheathing or siding, provided the *exterior wall* has a 1-hour *fire-resistance rating* that extends 4 feet on each side of the *fire wall* and any openings within this protected area have a *fire protection rating* of 45 minutes.
2. The *fire wall* may terminate at the interior surface of noncombustible sheathing, siding, or other material, provided the noncombustible material extends at least 4 feet on each side of the *fire wall*.
3. The *fire wall* may terminate at the interior surface of noncombustible sheathing where the building on each side of the *fire wall* is sprinklered in accordance with NFPA 13 or 13R.

The requirement and exceptions described above are applicable to *fire walls* that terminate at *exterior walls* that are 180 degrees or more from each other. However, when *fire walls* intersect *exterior walls* that are less than 180 degrees apart, other requirements come into play. Per IBC Section 706.5.1, there are two options available for working with this type of *exterior wall* condition.

- **Option 1:** This option is a simple method that requires the *exterior walls* within 4 feet on each side of a *fire wall* to be constructed of 1-hour *fire-resistance-rated* construction and any openings within this protected area must have a minimum 45-minute *fire protection rating* (Figure 15.1.1.1-1).
- **Option 2:** This option is a little more complex and involves the application of an imaginary lot line (also called an "assumed lot line") that extends from the termination of the *fire wall* to a point beyond the building or to an actual *lot line* so as to determine *exterior wall* and opening protection per IBC Sections 705.5 and 705.8, respectively (Figures 15.1.1.1-2 and 15.1.1.1-3). Refer to Step 16 for a discussion on exterior opening protection.

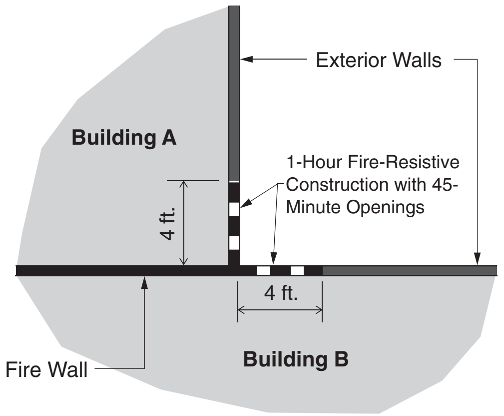


FIGURE 15.1.1.1-1. Termination of a *fire wall* at *exterior walls* less than 180 degrees apart using the Option 1 simple prescriptive method.

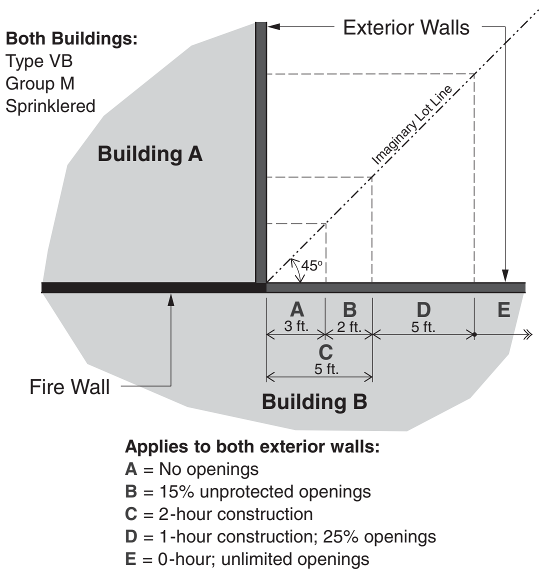


FIGURE 15.1.1.1-2. Example of terminating a *fire wall* at *exterior walls* less than 180 degrees apart using Option 2 *fire separation distance* method.

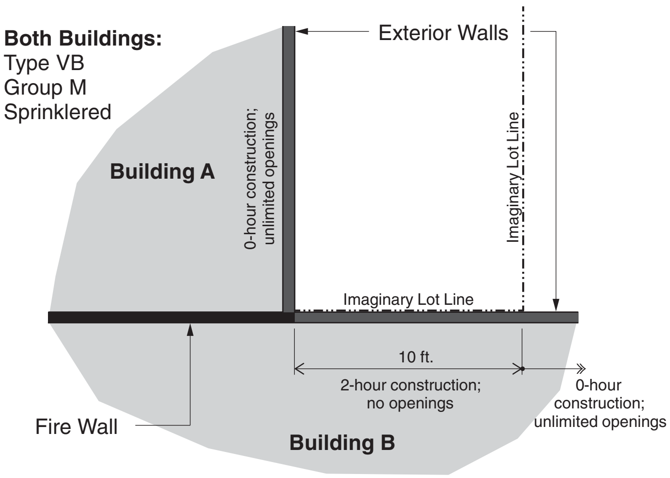


FIGURE 15.1.1.1-3. Another Option 2 example using a different imaginary *lot line* location.

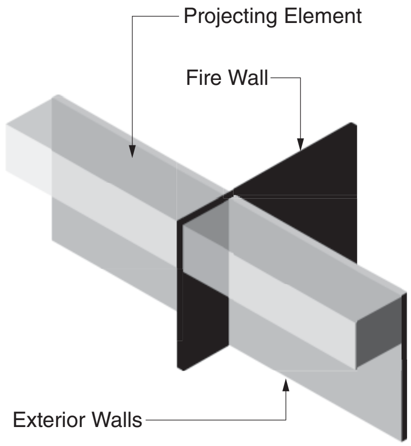


FIGURE 15.1.1.1-4. Requirement for a *fire wall* through a projecting element.

Building elements that project horizontally from the face of an *exterior wall*, such as balconies, roof overhangs, and *canopies*, provide opportunities for fire to circumvent *fire wall* construction. Therefore, the IBC requires that *fire walls* extend to the outer edge of projecting elements when they are within a distance of 4 feet of the *fire wall* (Figure 15.1.1.1-4). Typical of most code requirements, there are exceptions:

1. If the projecting element does not include concealed spaces, the *fire wall* need only comply with the basic requirements for *fire wall* horizontal continuity when the wall behind and below the projecting element is constructed of 1-hour *fire-resistance-rated* construction for a distance equal to the depth of the projecting element on each side of the *fire wall*. Openings within the protected *exterior wall* area must have a minimum *fire protection rating* of 45 minutes (Figure 15.1.1.1-5).
2. If the projecting element is noncombustible and does include concealed spaces, then the installation of a 1-hour *fire-resistance-rated* wall through the concealed space that aligns with the *fire wall* is required. The construction of the projecting element must be of 1-hour fire-resistive construction for a distance equal to the depth of the projecting element on each side of the *fire wall*

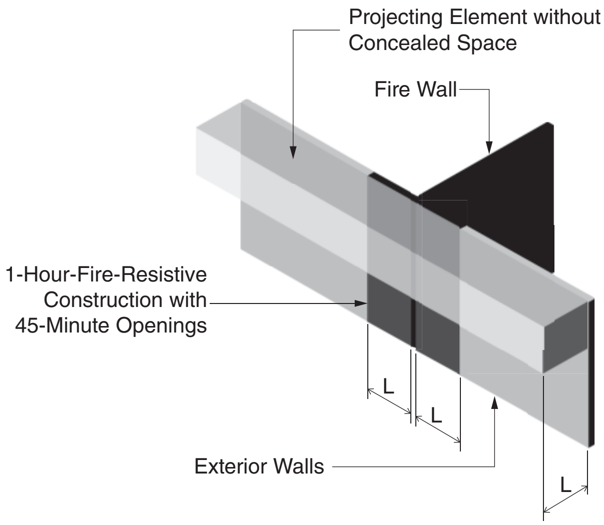


FIGURE 15.1.1.1-5. Requirement for a *fire wall* at a projecting element without concealed space. "L" is the depth of the projecting element.

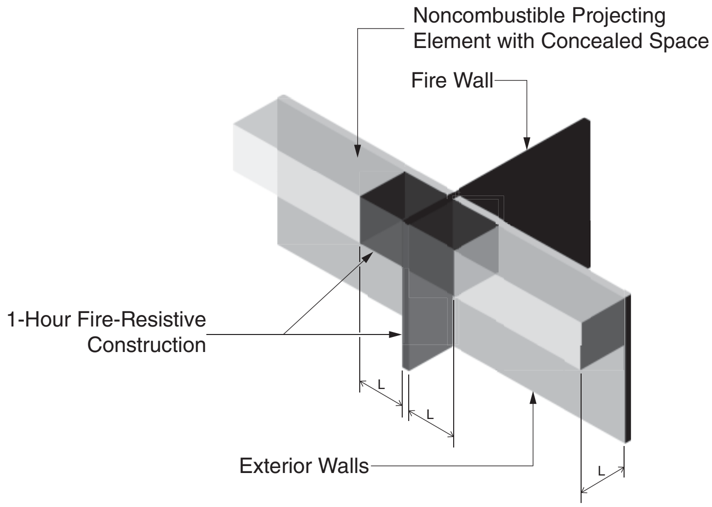


FIGURE 15.1.1.1-6. Requirement for a *fire wall* through a noncombustible projecting element with concealed space. "L" is the depth of the projecting element.

(Figure 15.1.1.1-6). The separation wall below the projecting element may be omitted provided the *exterior wall* below the projecting element is of 1-hour fire-resistive construction for a distance equal to the depth of the projecting element on each side of the *fire wall* (Figure 15.1.1.1-7). Openings within the protected *exterior wall* area must have a minimum *fire protection rating* of 45 minutes.

3. If the projecting element is combustible and does include concealed spaces, then the *fire wall* is only required to extend through the projecting element to the outer edge. The construction of the *exterior wall* below and behind the projecting element must be of 1-hour *fire-resistance-rated* construction for a distance equal to the depth of the projecting element on each side of the *fire wall*. Openings within the protected *exterior wall* area must have a minimum *fire protection rating* of 45 minutes (Figure 15.1.1.1-8).

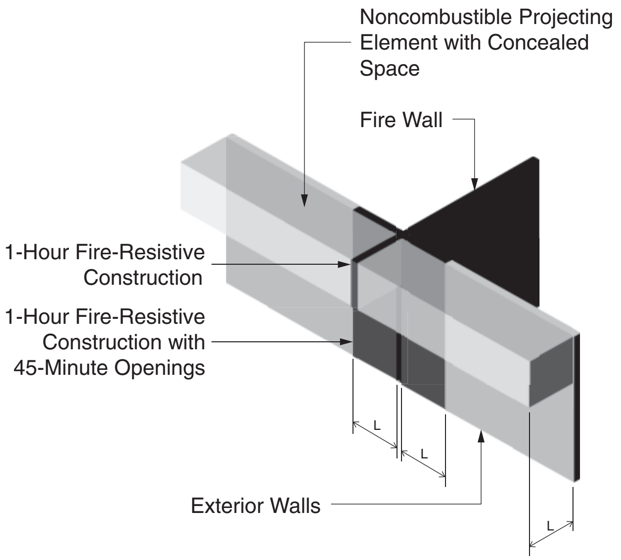


FIGURE 15.1.1.1-7. Alternate requirement for a *fire wall* through a noncombustible projecting element with concealed space. "L" is the depth of the projecting element.

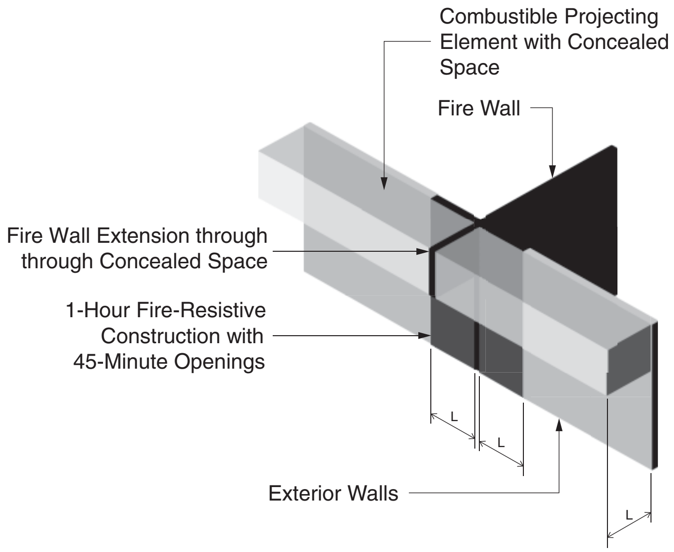


FIGURE 15.1.1.1-8. Requirement for a *fire wall* through a combustible projecting element with concealed space. "L" is the depth of the projecting element.

15.1.1.2 Fire Wall Vertical Continuity

In addition to the horizontal extension of *fire walls* to the *exterior walls*, *fire walls* are also required to extend from the foundation to a point that is 30 inches above the adjacent roof surfaces (Figure 15.1.1.2-1). As with *exterior walls*, the vertical extension of a *fire wall* also has exceptions:

1. *Fire walls* in stepped buildings must extend 30 inches above the lower roof surface, and for 15 feet above the lower roof, the *exterior wall* must be protected with 1-hour *fire-resistance-rated* construction and any openings in the protected area must have a minimum *fire protection rating* of at least 45 minutes (Figure 15.1.1.2-2).

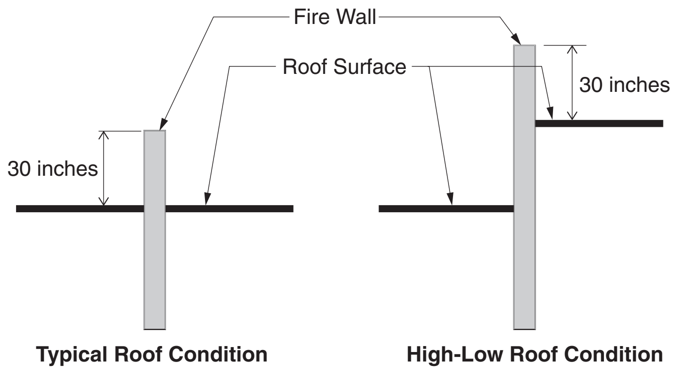


FIGURE 15.1.1.2-1. Vertical extension of *fire wall* through roof.

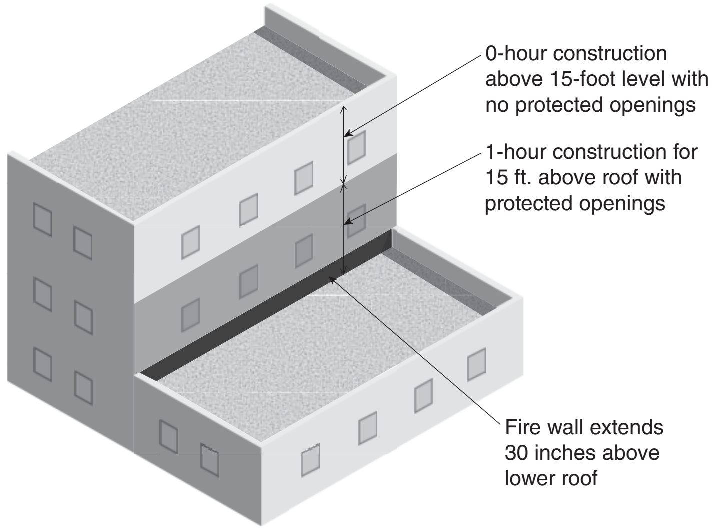


FIGURE 15.1.1.2-2. Exception 1: *fire wall* extension through roof for stepped buildings.

2. *Fire walls* with a 2-hour rating may terminate at the underside of roof sheathing, decks, or slabs, provided the lower roof is constructed of 1-hour *fire-resistance-rated* construction within 4 feet of the *fire wall* and the supporting elements for the roof are protected for the full length with an equal *fire-resistance rating*. Also, no openings are permitted within the 4-foot protected area and the roof must have a Class B *roof covering* (Figure 15.1.1.2-3).
3. *Fire walls* may terminate at the underside of noncombustible roof sheathing, decks, or slabs, provided the building on each side has a Class B *roof covering* and no openings are located within 4 feet of the *fire wall* (Figure 15.1.1.2-4).
4. *Fire walls* in buildings of Type III, IV, and V construction may terminate at the underside of combustible roof sheathing or decks provided the sheathing or deck is constructed of *fire-retardant-treated wood* extending at least 4 feet on each side of the *fire wall* or the sheathing or deck is protected by 5/8-inch-thick Type X gypsum board applied directly to the underside of the sheathing or deck for a distance of 4 feet on each side and supported by 2-inch nominal ledgers. Also, no openings are permitted within 4 feet of the *fire wall* and the roof must be covered by a Class B *roof covering* (Figure 15.1.1.2-5).
5. Buildings permitted to be separated by a 3-hour *horizontal assembly* per IBC Section 510.2 (see Step 7.4) may have the *fire wall* terminate at the horizontal separation and need not extend to the foundation.

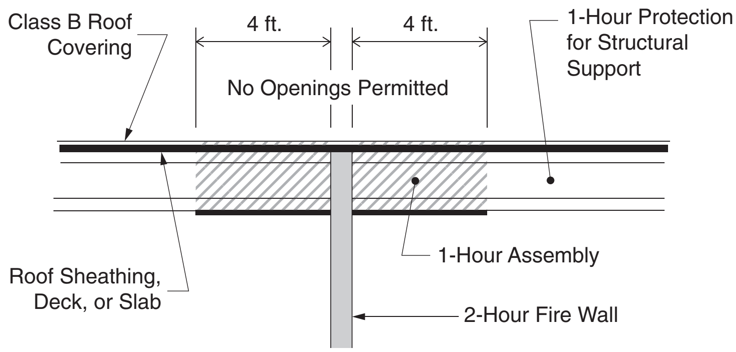


FIGURE 15.1.1.2-3. Exception 2: 2-hour *fire wall* termination at underside of roof.

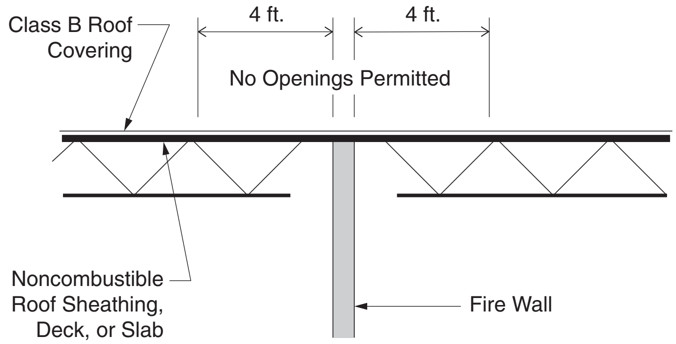


FIGURE 15.1.1.2-4. Exception 3: *fire wall* termination at noncombustible roofs.

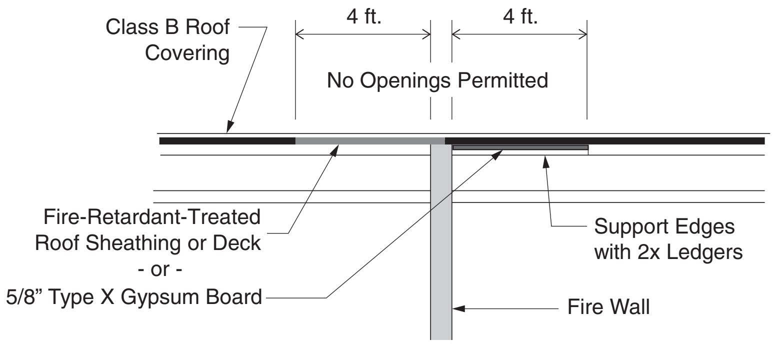


FIGURE 15.1.1.2-5. Exception 4: *fire wall* termination at combustible roofs for Type III, IV, and V construction. Left side shows *fire-retardant-treated wood* option and right side shows gypsum board application method. Either option must be provided on both sides of the *fire wall*.

15.1.2 FIRE BARRIERS

Fire barriers are used is a variety of applications as required by the IBC. Regardless of where or why *fire barriers* are required, the technical requirements for *fire barriers* are the same. Once the *fire walls*, if any, have been identified within the building, the process of identifying the locations of *fire barriers* can begin.

Identifying the locations of *fire barriers* is best performed in the order listed in Table 15.1.2-1. If two or more types of *fire barriers* are required for different reasons, then the *fire-resistance rating* for the most restrictive application will be required.

TABLE 15.1.2-1. Summary of Required *Fire Barrier* Locations and Ratings (Listed in Recommended Order of Identification)

Location		Reference Section	Fire-Resistance Rating
1.	Horizontal Exits	IBC Section 1026.2	2 hours
2.	Interior Exit Stairways and Ramps	IBC Section 1023.2	1 or 2 hours
	Smokeproof Enclosures and Vestibule Separation	IBC Section 909.20.2	2 hours
	Ventilation Systems for Smokeproof Enclosures	IBC Section 909.20.6.1	2 hours
3.	Exit Passageways	IBC Section 1024.3	1 hour
	Extension of Interior Exit Stairway or Ramp	IBC Section 1023.3.1	Equal to stairway or ramp enclosure
	Extension of a Smokeproof Enclosure	IBC Section 1023.11.1	2 hours
	Service Areas in Mall Buildings Off of Exit Passageways	IBC Section 402.8.7	1 hour
4.	Interior Exit Access Stairways and Ramps	IBC Section 1019.3	As for shafts
5.	Shaft Enclosures	IBC Section 713.2	1 or 2 hours
	Access Rooms to Trash and Linen Chutes	IBC Section 713.13.3	1 hour
	Chute Discharge Room	IBC Section713.13.4	Equal to the shaft
	Shafts in High-Rise Buildings Not Greater Than 420 Feet in Building Height	IBC Section 403.2.1.2	1 hour
	Termination Rooms	IBC Section 713.11, Item 2	Equal to the shaft
6.	Fire Areas	IBC Section 901.7	IBC Table 707.3.10
	Fire Areas in Aircraft Hangars	IBC Section 412.4.6.2	1 hour
7.	Separated Occupancies	IBC Section 508.4.4	IBC Table 508.4
8.	Atriums	IBC Section 404.6	1 hour
	Nonsprinklered Areas Adjacent to or Above an Atrium	Exception to IBC Section 404.3	2 hours
9.	Control Areas	IBC Section 414.2.1	IBC Table 414.2.2
10.	Incidental Uses	IBC Section 509.4	IBC Table 509
11.	Special Uses and Occupancies	See Table 15.1.2-2	

15.1.3 SMOKE BARRIERS

The differences between a *smoke barrier* and a 1-hour *fire barrier* or *horizontal assembly* lie in the treatment of the joints, penetrations, and openings to resist the passage of smoke. This is accomplished by prescribing maximum leakage rates for each. For treatment of joints and penetrations, the details are addressed later in the design process in Step 25 during the construction documents phase. At this point in the design, it is only necessary to identify which walls need to be considered *smoke barriers* and not select the specific joint assemblies. Similarly, openings are enhanced with special seals to minimize the passage of smoke. Openings for *smoke barriers* are covered in Step 15.2.

The locations of *smoke barriers* depend on very specific conditions. For a typical building, only one condition will likely apply if any at all. Where both a *smoke barrier* and a *fire barrier* are required, the *fire-resistance rating* shall be the rating as required for the *fire barrier*, but it shall have the maximum leakage as required for a *smoke barrier*. Where horizontal *smoke barriers* are required, they must also comply with the requirements for *horizontal assemblies*. Table 15.1.3-1 provides a summary of locations where *smoke barriers* are required and the applicable IBC reference.

15.1.4 FIRE PARTITIONS

Fire partitions are less restrictive than all other *fire-resistance-rated* wall assemblies; thus, they are near the end of the location process. If a *fire partition* is required where a *fire barrier*, *smoke barrier*, or both have already been identified, then the requirements for *fire barriers* or *smoke barriers* will apply in lieu of the requirements for *fire partitions*. Table 15.1.4-1 summarizes the locations where *fire partitions* are required.

TABLE 15.1.2-2. Summary of *Fire Barrier* Locations and Ratings for Special Uses (Listed Alphabetically)

Location	Reference Section	Fire-Resistance Rating
Aircraft-Related Occupancies		
Heating Equipment in Aircraft Hangars	IBC Section 412.4.4	2 hours
Residential Aircraft Hangar Separation from Dwelling Unit	IBC Section 412.5.1	1 hour
Bleachers and Grandstands with Spaces Underneath	IBC Section 1029.1.1.1	1 hour
Cleaning Establishments	IBC Section 307.1.1, Item 4	1 hour
Combustible Dusts and Grain Processing and Storage		
Grinding Rooms (Area > 3,000 sq. ft.)	IBC Section 426.1.2	4 hours
Grinding Rooms (Area ≤ 3,000 sq. ft.)	IBC Section 426.1.2	2 hours
Tire Rebuilding	IBC Section 426.1.7	1 hour
Elevator Machine Rooms for Buildings > 4 Stories Above Grade Plane	IBC Section 3005.4 and Exception 2	Equal to the hoistway rating
Elevator Machine Rooms Not Abutting Hoistway (Except for Fire Service Access and Occupant Evacuation Elevators)	IBC Section 3005.4, Exception 1	1 hour
Electrical Wiring Spaces		
Critical Operations Power Systems (COPSs) Feeder Circuits and Equipment	NEC Sections 708.10(C) and 708.11 (B)[4]	2 hours
Fire Pump Feeder Circuits	NEC Section 695.6(A)(2)[4]	2 hours
Generator Control Wiring	NEC Section 695.14(F)[4]	2 hours
Emergency Power Source Feeder Circuits and Equipment	NEC Sections 700.10(D)(1) and (2)[4]	2 hours
Electrical Transformer Rooms for Transformers Rated over 112 1/2 kVA	NEC Section 450.21(B)[4]	1 hour
Electrical Transformer Vaults for Transformers Rated over 35,000 volts	NEC Section 450.21(C)[4]	3 hours[1, 2]
Electrical Vaults for Equipment over 600 volts Nominal	NEC Section 110.31(A)(1)[4]	3 hours[2]
Emergency Power Source Rooms		
Battery Storage Rooms[3]	NEC Section 700.12[4]	1 hour
Generators		
Uninterruptible Power Supplies		
Separate Service		
Fuel Cell Systems		
Emergency Power Source Rooms for Critical Operations Power Systems (COPSs)		
Battery Storage Rooms	NEC Section 708.20[4]	2 hours
Generators		
Uninterruptible Power Supplies		
Separate Service		
Fuel Cell Systems		
Fire Pump Rooms	IBC Section 913.2.1	2 hours
Sprinklered Non-High-Rise Buildings	IBC Section 913.2.1, Exception 1	1 hour
Group H-2 Flammable and Combustible Liquid Storage Tank Protection	IBC Section 415.9.1.2	1 hour
Group H-3 and H-4 Occupancies		
Gas Room Separation	IBC Section 415.10.2	1 hour
Highly Toxic Solid and Liquid Storage Separation	IBC Section 415.10.4	1 hour
Group H-5 Occupancies		
Fabrication Area Separation	IBC Section 415.11.1.2	1 hour
HPM and Gas Room Separations (Area > 300 sq. ft.)	IBC Section 415.11.5.1	2 hours
HPM and Gas Room Separations (Area ≤ 300 sq. ft.)	IBC Section 415.11.5.1	1 hour
HPM Supply Piping and Nonmetallic Waste Line Separation from Corridors and Other Occupancies (Except H-5)	IBC Section 415.11.6.4, Item 4	1 hour
Liquid Storage Room Separation (Area > 150 sq. ft.)	IBC Section 415.11.5.2, Item 2	2 hours

(*continued*)

TABLE 15.1.2-2. (*Continued*)

Location	Reference Section	Fire-Resistance Rating
Group H-5 Occupancies (Continued)		
Liquid Storage Room Separation (Area ≤ 150 sq. ft.)	IBC Section 415.11.5.2, Item 2	1 hour
Group H-5 in Unlimited Area Mixed-Occupancy Buildings	Exception to IBC Section 507.9, Item 3	2 hours
Group U Multiple Private Garage Separation	IBC Section 406.3.1	1 hour
High-Rise Buildings		
Telecommunications High-Rise Buildings	IBC Section 403.3, Exception 2	1 hour
Standby or Emergency Power Generator Rooms in High-Rise Buildings	IBC Section 403.4.8.1	2 hours
Open and Covered Mall Buildings		
Anchor Building Separation from Mall Building	IBC Section 402.4.2.2, Exception 1	2 hours
Parking Garage Separation from Covered or Open Mall Buildings	IBC Section 402.4.23	2 hours
Open Parking Garages		
Beneath Groups A, I, B, M, and R	IBC Section 510.7.1	IBC Table 508.4
Separation of Other Occupancies' Means of Egress from Parking Garage		2 hours
Above Group B or M Buildings, Separation of Parking Garage Exits from Building Below	IBC Section 510.8	2 hours
Organic Coating Manufacturing		
Tank Storage Areas	IBC Section 418.4	2 hours
Nitrocellulose Storage	IBC Section 418.5	2 hours
Finished Product Storage	IBC Section 618.6	2 hours
Pedestrian Walkway Connections to Buildings	IBC Section 3104.5.1	2 hours
Smoke Control Removal Control Rooms	IBC Section 910.4.5	1 hour
Spray Rooms for Flammable Finishes	IBC Section 416.2	1 hour
Standby Power Equipment Rooms used for Smoke Control	IBC Section 909.11.1	1 hour
Stages		
Dressing and Appurtenant Room Separation from Stage (Stage Height > 50 feet)	IBC Section 410.5.1	2 hours
Dressing and Appurtenant Room Separation from Stage (Stage Height ≤ 50 feet)	IBC Section 410.5.1	1 hour
Dressing and Appurtenant Room Separation between Each Other	IBC Section 410.5.2	1 hour
Telecommunication Equipment, Power Distribution, or Standby Power Rooms in Telecommunications Buildings	Exception to IBC Section 903.2	1 hour

[1] *Fire-resistance-rated* construction consisting of metal studs and gypsum board is not permitted.
[2] May be reduced to 1-hour rating if vault is protected by an *automatic sprinkler system* or *automatic fire-extinguishing system* using carbon dioxide or halon.
[3] Compare to requirements for battery storage per incidental use requirements. See Table 15.1.2-1.
[4] The NEC does not specifically mention "*fire barriers*" for this type of construction; however, since *fire barriers* require similar opening protection as required by the NEC and the *fire-resistance ratings* can exceed 1 hour, the application of *fire barrier* requirements to these conditions is appropriate.

15.1.5 SMOKE PARTITIONS

Since *smoke partitions* do not require any *fire-resistance rating*, they fall at the end of locating *fire-resistance-rated* wall assemblies. If a wall requires a *fire-resistance rating* per any of the previously covered *fire-resistance-rated* wall assemblies and is also required to comply with the requirements of a *smoke partition*, then the *fire-resistance rating* of the assembly will apply along with the leakage requirements for *smoke partitions*. *Smoke partitions* have very limited use in the IBC and the locations where they are required are provided in Table 15.1.5-1. However, incidental uses that allow *automatic*

TABLE 15.1.3-1. Summary of Required *Smoke Barrier* Locations (Listed Alphabetically)

Location	Reference Section
Ambulatory Care Facility Smoke Compartments	IBC Section 422.3
Areas of Refuge Not Located within Exit Enclosures	IBC Section 1009.6.4
Fire Service Elevator Lobbies	IBC Section 3007.6.2
Group I-1 Condition 2 Smoke Compartments	IBC Section 420.4
Group I-2 Smoke Compartments	IBC Section 407.5
Group I-3 Smoke Compartments	IBC Section 408.6
Occupant Evacuation Elevator Lobbies	IBC Section 3008.6.2
Passive Smoke Control and Smoke Control Systems	IBC Section 909
Atriums	IBC Section 404.5
Windowless Buildings	IBC Section 408.9
Stages (as an option)	IBC Section 410.3.7
Smokeproof Enclosures	IBC Section 1023.11
Smoke-Protected Assembly Seating	IBC Section 1029.6.2.1
Pressurized Elevator Hoistway (as an option)	IBC Section 3006.3
Underground Building Smoke Compartments	IBC Section 405.4.2
Lobbies of Shared Elevators for Underground Building Smoke Compartments	IBC Section 405.4.3

TABLE 15.1.4-1. Summary of Required Locations for *Fire Partitions* (Listed Alphabetically)

Location	Reference Section
Ambulatory Care Facility Separation	IBC Section 422.2
Corridors	IBC Section 1020.1 and IBC Section 708.3, Exception 1
Dwelling Unit and Sleeping Unit Separations	IBC Section 420.2 and IBC Section 708.3, Exception 2
Elevator Lobbies (as an option)[1]	IBC Section 3006.3
Egress Balconies (as required for corridors)	IBC Section 1021.2
Tenant Space Separation in Malls	IBC Section 402.4.2.1
Vestibules as Part of the Exit Discharge	IBC Section 1028.1, Exception 2

[1]Conditions where elevator lobbies may be required are provided in IBC Section 3006.2 and include the following: nonsprinklered buildings, buildings with a Group I-1 Condition 2 occupancy, buildings with a Group I-2 or I-3 occupancy, and elevators with 75-foot-high hoistways in *high-rise buildings* (see Step 21.4.1.3).

TABLE 15.1.5-1. Summary of Required *Smoke Partition* Locations

Location	Reference Section
Atrium Separation Using Glass Walls (as an exception to 1-hour fire barrier)	IBC Section 404.6, Exception 1
Elevator Lobbies (as an option)[1]	IBC Section 3006.3
Group I-2	
Corridors	IBC Section 407.3
Care Suite Separation	IBC Section 407.4.4.2

[1]Conditions where elevator lobbies may be required are provided in IBC Section 3006.2 and include the following: nonsprinklered buildings, buildings with a Group I-1 Condition 2 occupancy, buildings with a Group I-2 or I-3 occupancy, and elevators with 75-foot-high hoistways within *high-rise buildings* (see Step 21.4.1.3).

sprinkler systems in lieu of *fire barriers* are required to have walls that resist the passage of smoke per IBC Section 509.4.2. No performance criteria are given within the section, and therefore the application of a *smoke partition* in this situation would likely be acceptable.

15.1.6 HORIZONTAL ASSEMBLIES

The placement of *horizontal assemblies* near the end of the process for locating fire-resistive construction and assemblies is not to be construed as being of low priority in the location process. In fact, the identification of *fire-resistance-rated horizontal assemblies* is somewhat dependent on the location of *fire-resistance-rated* wall assemblies. Per the requirements for *fire barriers*, *fire partitions*, and *smoke barriers*, the supporting construction of those *fire-resistance-rated* assemblies must have a *fire-resistance rating* equal to the rating of the supported *fire-resistance-rated* assembly. For example, if a second-*story* space requires a 2-hour *fire barrier*, then the floor assembly supporting that *fire barrier* must also have a 2-hour *fire-resistance rating*.

TABLE 15.1.6-1. Summary of Required *Horizontal Assembly* Applications and Ratings (Listed in Recommended Order of Identification)

Application	Reference Section	Fire-Resistance Rating
1. Floor and Roof Construction per Construction Type	IBC Table 602.1	IBC Table 601
2. Fire Barrier Applications	See Tables 15.1.2-1 and 15.1.2-2	
3. Smoke Barrier Applications	See Table 15.1.3-1	
4. Fire Partition Applications	See Table 15.1.4-1	

There are exceptions to the supporting construction requirements:

- **For *Fire Barriers* (IBC Section 707.5.1, Exception 2):** One-hour *fire barriers* for incidental uses within Type IIB, IIIB, and VB buildings.
- **For *Fire Partitions* (IBC Section 708.4):** *Fire partitions* separating tenant spaces in *mall* buildings, *dwelling units*, *sleeping units*, and *corridors* within Type IIB, IIIB, and VB buildings.
- **For *Smoke Barriers* (IBC Section 709.4):** *Smoke barriers* within Type IIB, IIIB, and VB buildings.

Since *horizontal assemblies* serve similar purposes as the wall assemblies previously covered, the order in which they are identified should follow a similar sequence as the walls. Table 15.1.6-1 summarizes the required applications of *horizontal assemblies* in the order in which they should be identified.

15.1.7 PRIMARY STRUCTURAL FRAME AND BEARING WALL STRUCTURE

The *primary structural frame* and *bearing wall structure* of a building may be required to have a *fire-resistance rating* per IBC Table 601. For the *primary structural frame*, this includes, by definition, columns, beams, girders, trusses, and bracing members that provide the overall structural support for the building. For a *bearing wall structure*, this includes a building that uses walls as the primary support for floor and roof construction. It is not uncommon for a building to use both a structural frame and bearing walls. Secondary members, such as floor and roof joists, are considered part of the floor or roof construction they are associated with and are protected as part of that *horizontal assembly* if required.

If a *horizontal assembly* is required to have a *fire-resistance rating*, then the *primary structural frame* and *bearing wall structure* supporting the *horizontal assembly* are also required to have equal or greater protection. Per IBC Table 601, if a *horizontal assembly* is required to be protected based on construction type, then the *fire-resistance rating* for the *primary structural frame* and *bearing wall structure* are always equal to or greater than the *fire-resistance rating* of the *horizontal assembly*. It only becomes an issue when a *horizontal assembly* requires a *fire-resistance rating* that is greater than what is required for the construction type used.

For example, Type IIA construction requires 1-hour *horizontal assemblies* for floors and roofs as well as for the *primary structural frame* and *bearing wall structure*. If a two-story Type IIA building includes a *horizontal exit* on the second story, then the *horizontal exit* must be supported by a 2-hour *horizontal assembly* at the second floor per IBC Section 1026.2. Therefore, since the second-story floor is required to have a 2-hour *fire-resistance rating*, then the *primary structural frame* and *bearing wall structure* supporting that floor are also required to have a 2-hour *fire-resistance rating*.

The identification of the *primary structural frame* and *bearing wall structure* is placed last in the process, since the *fire resistance* of these elements do not require opening, joint, or penetration protection. Thus, if bearing walls serve as other fire-resistive assemblies, then those fire-resistive assembly applications should be identified first. If a *fire-resistance rating* for an assembly is less than the rating required for the bearing wall, then the wall assembly rating will need to be increased; however, the *fire protection ratings* for openings, joints, and penetrations need only comply with the required assembly rating and not the bearing wall rating.

For example, Type IB construction requires a 2-hour rating for interior bearing walls. If one of those walls also serves as a *corridor* wall, which requires a 1-hour *fire partition*, then the wall must have a 2-hour *fire-resistance rating*, but the openings, joints, and penetrations need only have ratings based on the 1-hour *fire partition*.

If a *primary structural frame* member is required to be protected, then it must be individually protected; protection by concealment within a *fire-resistance-rated* wall or behind a *fire-resistance-rated* ceiling membrane only is not permitted. With the exception of columns, individual protection is not required for *primary structural frame* members if they support only two floors or one floor and a roof.

The type of protection may affect the design of concealing construction around the structural member. For example, a column may require several inches of spray-applied fireproofing (depending on the size and shape of the member and the required *fire-resistance rating*), which may require wider construction of metal studs and gypsum board to conceal the column. Gypsum board protection in lieu of the spray-applied fireproofing may reduce the required width to achieve equal protection, but the labor cost may be higher. Another option to minimize the size is the application of a thin intumescent fireproof coating in lieu of a standard spray-applied fireproof coating. Although the system may have a lower installation cost, the material cost may be higher than the other methods. The thin intumescent fireproof coating is desirable if the *primary structural frame* is to remain exposed and protection of the steel is required.

15.2 OPENING PROTECTION

Fire-resistance-rated assemblies have been tested to restrict the spread of fire, but openings, such as doors and windows, within these assemblies introduce points of weakness. Therefore, openings in a *fire-resistance-rated* assembly must afford some protection to maintain a minimum level of *fire resistance* throughout the extent of the assembly. The requirements for openings are found in IBC Chapter 7 in three locations. The first location is IBC Section 705.8 for openings in *exterior walls* (covered in Step 16); the second location is in IBC Section 712 for vertical openings through *horizontal assemblies*; and the third location is IBC Section 716, which is titled "Opening Protectives"—the primary location for opening requirements.

Openings consist of *fire door assemblies* and *fire window assemblies* that allow small "breaches" within a *fire-resistance-rated* assembly. *Fire door assemblies*, because of their ability to be opened, inherently provide limited protection, even though they are required to be self-closing. *Fire window assemblies*, on the other hand, can be either operable or fixed, but, like doors, operable *fire window assemblies* are required to be self-closing. *Fire-rated glazing* used in *fire door assemblies* and *fire window assemblies* can be provided as one of two types: *fire-protection rated* or *fire-resistance rated*.

Fire-resistance-rated glazing is glass that has been tested in window assemblies in accordance with ASTM E 119 or UL 263, which are the same tests that fire-resistive wall assemblies are required to pass. Therefore, fixed *fire window assemblies* that are *fire-resistance rated* are not subject to the limitations for openings

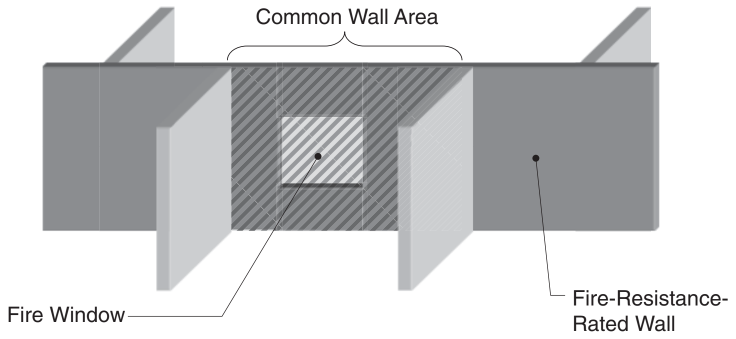


FIGURE 15.2-1. Common wall area between two rooms for determining allowable area of *fire-protection-rated* glazing.

per IBC Section 716; however, they are required to have the same *fire-resistance rating* as the wall in which they are installed. These types of assemblies are sometimes referred to as “transparent walls,” since they are not considered openings.

Fire-protection-rated glazing is glass that has been tested in window assemblies in accordance with NFPA 257 or UL 9. *Fire-protection-rated* glazing does not meet the required radiant heat portion of the ASTM E 119 or UL 263 tests; thus, this type of glazing is limited in allowed area and generally is required to have a fire rating that is less than the wall assembly in which it is installed.

The required fire rating for a *fire door assembly* is dependent on the type and rating of the wall assembly within which it is installed. IBC Table 716.5 lists the various wall assemblies and ratings and the permitted opening ratings. Also included are the required ratings for *fire-rated glazing* installed as a vision panel within the *fire door*. Sidelights and transoms associated with *fire door assemblies* generally require *fire-resistance-rated* glazing. If a *fire door assembly* is installed in an assembly with a *fire-resistance rating* of 1 hour or less and is not part of an *exit* enclosure or *exit access stairway* or *ramp* enclosure, then the glazing in transoms and sidelights is permitted to be of the *fire-protection-rated* type.

The required *fire protection ratings* of *fire window assemblies* are provided in IBC Table 716.6. *Fire window assemblies* with *fire-protection-rated* glazing are only permitted in wall assemblies with *fire-resistance ratings* of 1 hour or less. Additionally, the total area of glazing within a *fire-protection-rated* window assembly cannot exceed 25% of the common wall area between two rooms (Figure 15.2-1). However, as previously stated, assemblies with *fire-resistance-rated* glazing are permitted in wall assemblies with *fire-resistance ratings* greater than 1 hour, provided the glazed assembly has a rating equal to or greater than the wall.

In addition to the limitations provided in IBC Tables 716.5 and 716.6, *horizontal assemblies* and some of the *fire-resistance-rated* wall assemblies have restrictions on openings that are specific to those individual types of assemblies. When identifying openings within *fire-resistance-rated* assemblies, ensure that *fire window assemblies* do not exceed the common wall limitations described previously or the limitations provided in the following list:

- **Fire Walls:** Per IBC Section 706.8, each opening in a *fire wall* is limited to 156 sq. ft., and the aggregate sum of the widths of openings on any floor cannot exceed 25% of the length of the *fire wall*. If the buildings on both sides of the *fire wall* are sprinklered per NFPA 13, then the area limitation of 156 sq. ft. does not apply. *Fire walls* used as party walls on a *lot line* are not allowed to have any openings.

- **Fire Barriers:** Per IBC Section 707.6, each opening in a *fire barrier* is limited to 156 sq. ft., and the aggregate sum of the widths of openings on any floor cannot exceed 25% of the length of the *fire barrier*. The area or the percentage limitations do not apply to door openings into enclosures for *exit* and *exit access stairways* and *ramps* or for door openings from *exit* and *exit access stairways* and *ramps* into *exit passageways*. If the floor areas on both sides of the *fire barrier* are sprinklered per NFPA 13, then the area limitation of 156 sq. ft. does not apply. The 25% limitation does not apply to *fire window assemblies* within *atrium* separation walls.
- **Fire Partitions:** There are no limitations on area or aggregate width for *fire partitions*. However, *fire door assemblies* in *corridors* are required to meet the smoke and draft control requirements of IBC Section 716.5.3.1.
- **Smoke Barriers:** There are no limitations on area or aggregate width for *smoke barriers*. However, *fire door assemblies* in *smoke barriers* are required to meet the smoke and draft control requirements of IBC Section 716.5.3.1.
- **Smoke Partitions:** There are no limitations on area or aggregate width for *smoke partitions*, and there are no requirements for *fire protection ratings*. However, door assemblies in *smoke partitions* are required to meet the smoke and draft control requirements of IBC Section 710.5.2.2, and windows must resist the passage of smoke or be automatic closing upon detection of smoke per IBC Section 710.5.1.
- **Horizontal Assemblies:** There are no limitations on area of openings within *horizontal assemblies*. IBC Section 712 covers multiple variations of vertical openings through *horizontal assemblies*. When an assembly is provided, such as a *floor fire door assembly* or access door, the assembly shall be properly tested in the horizontal position. *Skylights* in *fire-resistance-rated* roof construction are not required to be protected, unless *fire-resistance-rated* roof construction is required per IBC Section 705.8.6, Exception 1. However, the roof structure that may be exposed by a *skylight* opening must be sufficiently protected.

EXAMPLE PROJECT—STEP 15

Since the building is classified as Type VA construction, the bearing walls and structural frame are required to be of 1-hour fire-resistance-rated construction; however, openings within these walls are not required to be protected. Other wall, floor, and roof assemblies are required to have a fire-resistance rating based on requirements for the individual assembly types per IBC Chapter 7. In this project, fire barriers, fire partitions, smoke partitions, and horizontal assemblies are required. Described below are the types of fire-resistance-rated assemblies required by the IBC.

The illustrations below incorporate a modified diamond symbol method recommended in CSI's *Uniform Drawing System*, which is a part of the NIST *National CAD Standard*. Each diamond represents 1 hour of a fire-resistance rating; thus, two diamonds represent a 2-hour fire-resistance-rated wall. A half of a diamond represents a 30-minute fire-resistance-rated wall. Next to each diamond set are letter designations that represent the various types of fire-resistance-rated assemblies:

FP = Fire Partition
FB = Fire Barrier
FW = Fire Wall
SB = Smoke Barrier
HA = Horizontal Assembly

FIRE-RESISTANT-RATED WALL ASSEMBLIES

Basement Story (Example Project Figure 15-1)

The basement will only require 2-hour fire barriers at each of the stairways, at the elevator hoistway shaft, and at the elevator machine room per IBC Section 3005.4. Since the machine room abuts the hoistway, the reductions allowed by the exceptions to IBC Section 3005.4 are not applicable.

First Story (Example Project Figure 15-2)

Since the nonseparated occupancies method has been used for the first story, no fire barriers are required for occupancy separation. However, 2-hour fire barriers are required for the stairways, elevator hoistway shaft, and trash room. The trash room is considered a chute discharge room and must have a rating equal to the shafts.

The manager's apartment is a dwelling unit that is required to be separated from other portions of the building with 1-hour fire partitions. IBC Table 1020.1 requires corridors serving Group R occupancies to have fire partitions with a fire-resistance rating of 30 minutes when serving an occupant load of more than 10. The corridor does serve more than 10 occupants; however, since the manager's apartment has a means of egress directly to the exterior and only one means of egress is required, the corridor technically is not serving the Group R, thus the corridor requires no rating. The door into the hallway is a door for convenience and is not considered to be part of the means of egress. The other occupancy groups within the first story are also not required to have rated corridors since the building is sprinklered throughout.

The mechanical room is considered an incidental use, as determined in Step 3, and requires protection per IBC Table 509. Since the building is sprinklered, the 1-hour separation by fire barriers is not required. However, per IBC Section 509.4.2, the walls must be capable of resisting the passage of smoke. The requirement does not specifically mention smoke partitions, but a smoke partition would satisfy the requirement in this case. Therefore, smoke partitions will be used.

Residential Floors— Stories 2 through 4 (Example Project Figure 15-3)

The stairways, elevator hoistway shaft, and trash chute shafts are required to have 2-hour fire barriers. The trash chute access room is required to be separated from other areas of the building with a 1-hour fire barrier. Since most of the walls of the trash chute access room adjoin other areas requiring 2-hour fire barriers, the only wall requiring the 1-hour rating is the wall separating the trash chute access room from the corridor.

Dwelling units are required to be separated from each other and from other areas of the building with 1-hour fire partitions. The corridors, since they serve an occupant load of 10 or greater, must have at least 30-minute fire partitions.

HORIZONTAL ASSEMBLIES (EXAMPLE PROJECT FIGURE 15-4)

The use of Type VA construction requires that floor and roof assemblies be of 1-hour construction. Thus, all floor assemblies and the roof must be of 1-hour construction, minimum.

Since the building is sprinklered throughout with a NFPA 13R system and the first story is required to be separated from the stories above per the requirements for separated occupancies, then the nonsprinklered values of IBC Table 508.4 are applicable. Therefore, a 2-hour horizontal assembly must be provided at the floor assembly between the first and second stories. Because of this 2-hour rating, the construction supporting the horizontal assembly must also be of 2-hour construction. Thus, the floor system between the parking garage and the first story, which supports the wood framing above, must also have a 2-hour rating, as well as the concrete structural frame for the basement. The stairway enclosure at the first story is slightly larger than the enclosure above, so the portion of floor between the first and second stories must also comply with the exit enclosure requirements.

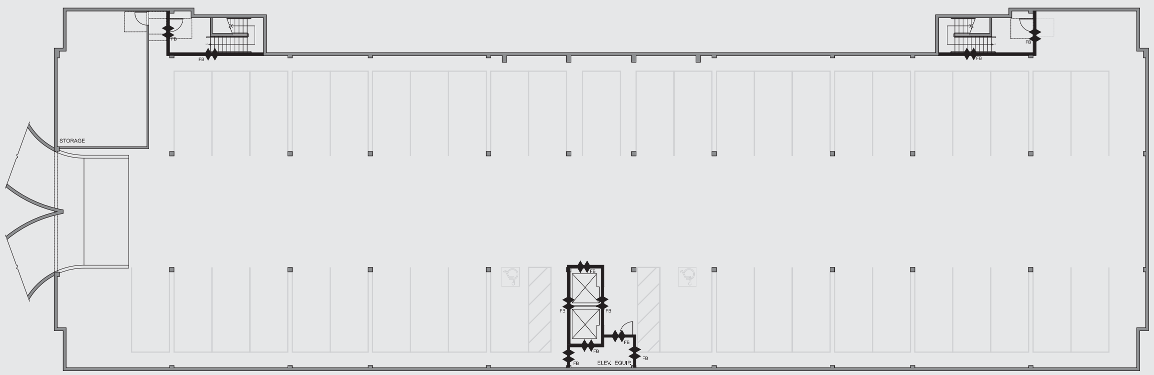
The dwelling units are required to be separated from each other and from other areas of the building with 1-hour horizontal assemblies, which has already been accomplished by the 1-hour rating required based on construction type.

OPENING PROTECTION

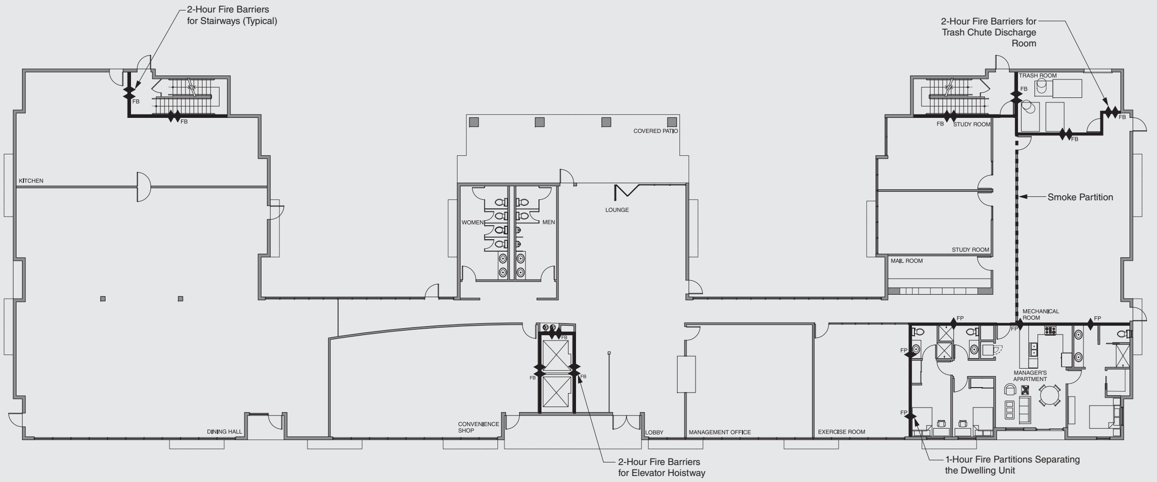
Doors into stairways, trash chute discharge room, and elevator equipment room are required to have a 1 1/2-hour rating since they are located within 2-hour fire barriers per IBC Table 716.5. Glazing within these doors is limited to 100 sq. in. No sidelights or transoms are provided, so fire-resistance-rated glazing is not required.

Doors that open into trash chute access rooms are located within 1-hour fire barriers; thus they will require 3/4-hour opening protection. Glazing is permitted up to the size tested.

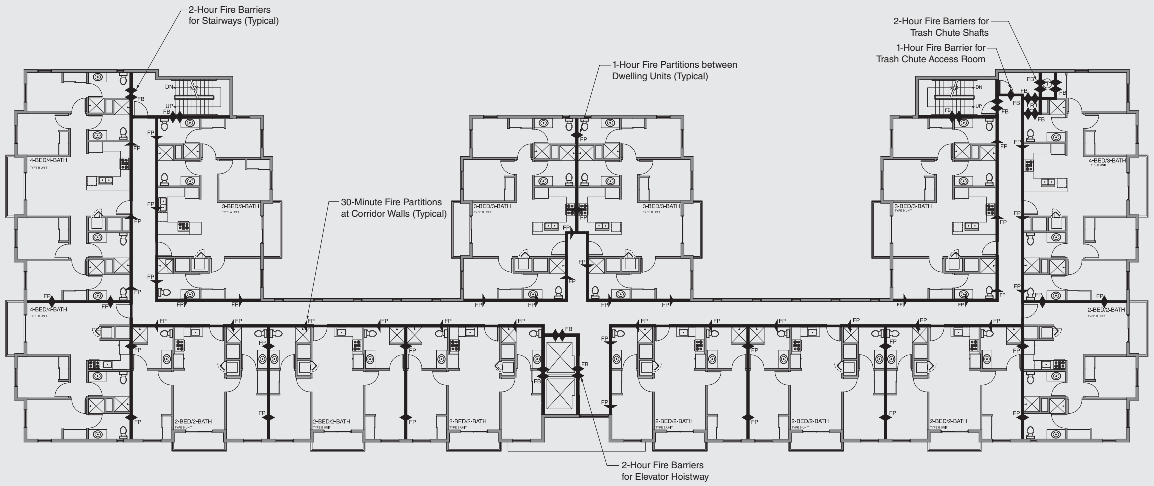
Doors between dwelling units and corridors are required to have 20-minute ratings per IBC Table 716.5.



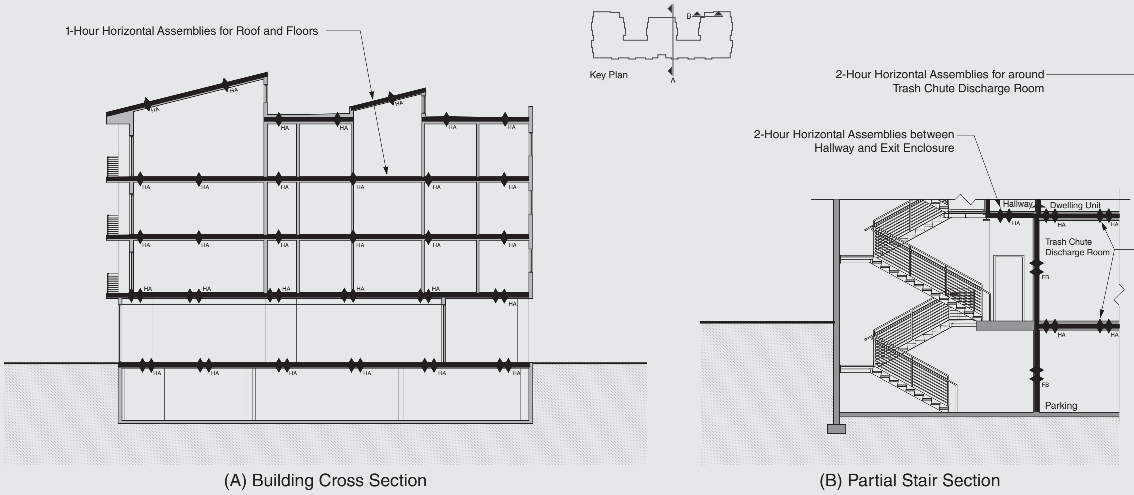
EXAMPLE PROJECT FIGURE 15-1. The basement story with fire-resistance-rated assemblies identified.



EXAMPLE PROJECT FIGURE 15-2. The first story with fire-resistance-rated assemblies identified.



EXAMPLE PROJECT FIGURE 15-3. The residential stories with fire-resistance-rated assemblies identified.



EXAMPLE PROJECT FIGURE 15-4. Horizontal assembly locations. (A) Overall building section with horizontal assemblies identified. (B) Partial stair section showing location of horizontal assemblies.

STEP 16

Develop Exterior Wall and Exposed Floor Assemblies

STEP OVERVIEW

The first and foremost consideration for *exterior walls* is the determination of the required fire-resistance and exterior opening protection. There are other factors that are fire-related to *exterior walls*, including fire propagation and the use of combustible materials for *exterior wall coverings*—both of which are covered in this step. Additionally, *exterior walls*, which include *basement* walls, separate the interior from the exterior and must have a minimum level of thermal performance and must also prevent air leakage and water intrusion. Some exposed floor assemblies perform similar to walls thermally and must be considered as part of the *building thermal envelope* and are included here when applicable. Lastly, the materials used as *exterior wall coverings* must comply with minimum requirements.

16.1 EXTERIOR WALL FIRE RESISTANCE AND OPENING PROTECTION

As discussed in Part I "Types of Fire-Resistive Assemblies and Construction," IBC Tables 601 and 602 provide the requirements for *exterior wall* fire resistance. If a wall is not required to have a *fire-resistance rating* per IBC Table 601, it still may need to have a *fire-resistance rating* based on *fire separation distance* per IBC Table 602. Per the IBC definition, the *fire separation distance* of an *exterior wall* is measured at 90 degrees from the *exterior wall* to one of three lines: (1) the closest interior *lot line*, (2) the centerline of a street, alley, or other *public way*, or (3) an imaginary line between two buildings on the same *lot*. In addition to an *exterior wall's fire separation distance*, the application of IBC Table 602 also depends on a building's construction type and occupancy group. Furthermore, openings in *exterior walls* may also be required to

Applying the Building Code: Step-by-Step Guidance for Design and Building Professionals. Ronald L. Geren, FCSI, AIA

be protected. Example 16-A applies the *fire resistance* and opening protection requirements discussed in this step.

IBC Section 705 provides specific requirements for *exterior walls*. If an *exterior wall* has a *fire separation distance* greater than 10 feet, then the *exterior wall* assembly only needs to be tested for fire exposure from the inside; however, if the *exterior wall* has a *fire separation distance* that is 10 feet or less, then the *exterior wall* must be tested for fire exposure from both sides. Some tested assemblies provided by the resources offered in Part I are specifically designed for *exterior walls* with only an interior exposure. For those types of assemblies, the exposure side of the wall is indicated.

Openings in *exterior walls* may be required to be protected and are based on *fire separation distance*, the installation of a sprinkler system, and the area of the openings. IBC Table 705.8 is used to determine if openings are required to be protected or not. Two exceptions to the requirements for opening protection are provided in IBC Section 705.8.1:

1. The first *story above grade plane* may have unlimited unprotected openings if the *exterior wall* faces a street and has a *fire separation distance* greater than 15 feet or the *exterior wall* faces unused space that is on the same *lot* or dedicated for public use and is 30 feet or more with access from a posted fire lane.
2. Buildings that are not required to have *fire-resistance ratings* for exterior bearing walls, exterior nonbearing walls, and structural frames are permitted to have unlimited unprotected openings. This means that this exception only applies to buildings of Type IIB and VB construction with *fire separation distances* of 10 feet or greater per IBC Table 602.

IBC Table 705.8 establishes three degrees of opening protection:

- **Unprotected, Nonsprinklered (UP, NS):** This degree applies to openings within buildings that are not sprinklered throughout per NFPA 13 and the openings do not have a *fire protection rating* per IBC Section 716.5 for *fire doors* and shutters and IBC Section 716.6 for fire windows.
- **Unprotected, Sprinklered (UP, S):** This degree applies to openings within buildings that are sprinklered throughout per NFPA 13, but the openings do not have a *fire protection rating* per IBC Section 716.5 for *fire doors* and shutters, and IBC Section 716.6 for fire windows.
- **Protected (P):** This degree applies to openings within buildings that have a *fire protection rating* per IBC Section 716.5 for *fire doors* and shutters and IBC Section 716.6 for fire windows. For *exterior walls* with a required rating of 1 hour, the required opening protection is $^3/_4$-hour. For *exterior walls* with a required rating over 1 hour, the required opening protection is $1\,^1/_2$-hour; however, the sidelights and transoms associated with door openings are required to have a *fire-resistance rating* equal to or greater than the rating of the *exterior wall* and, thus, are excluded from the opening area.

The percentages provided in IBC Table 705.8 apply to the wall area per *story*. Thus, if an *exterior wall* of a multistory building is permitted 25% unprotected openings and the area of the wall at each *story* is 200 sq. ft. (measured from floor surface to floor surface and, for the top *story*, from floor surface to top of ceiling joists or roof rafters), then each *story* is permitted to have 50 sq. ft. of unprotected openings. As with any IBC table, review the footnotes for exceptions.

Even though it appears that all openings are required to be either protected or unprotected, the IBC allows a mixture of protected and unprotected openings in the same wall area. However, when using a mixture of protected and unprotected openings, the application of the percentages from the table cannot be used directly for each type of opening. In accordance with IBC Section 705.8.4, the sum of the ratios for actual areas to allowable areas for each opening type cannot exceed 1. IBC Equation 7-2 is used to calculate the sum of the ratios. Example 16-A includes an example of using the mixed opening calculation.

EXAMPLE 16-A: APPLICATION OF IBC TABLES 601, 602, AND 705.8 TO A BUILDING.

Given: Type VA nonsprinklered two-story building with a Group F-1 occupancy having the fire separation distances indicated in Figure 16-A-1.

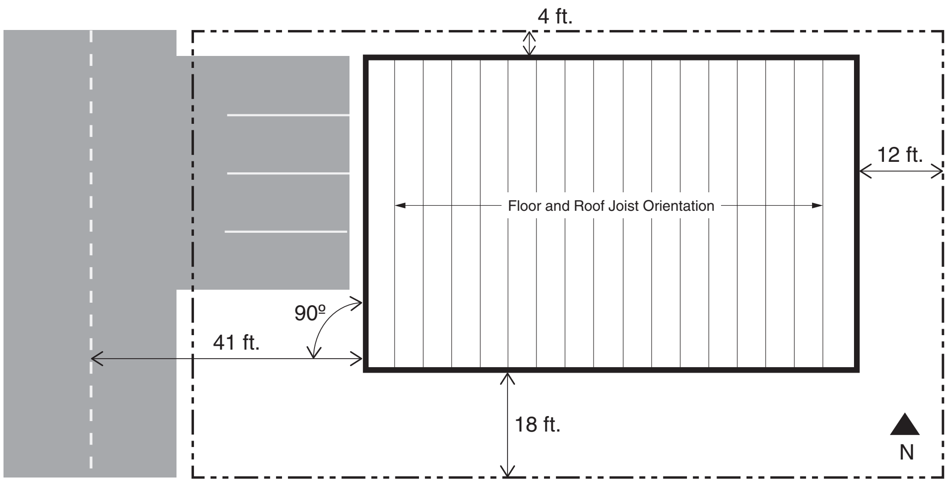


FIGURE 16-A-1. Fire separation distances for given building.

Step 1: Determine if exterior bearing walls are required to have a fire-resistance rating per IBC Table 601.

Per IBC Table 601, a building of Type VA construction is required to have 1-hour fire-resistance-rated exterior bearing walls. Thus, the north and south exterior walls, which are supporting the floor and roof loads of the given building, are required to have a 1-hour fire-resistance rating.

Step 2: Determine if exterior walls, bearing or nonbearing, are required to have a fire-resistance rating based on fire separation distance per IBC Table 602.

- **North Wall:** With a 4-foot fire separation distance, IBC Table 602 requires a 2-hour rating for Group F-1 occupancies for all construction types. Even though this wall is required a 1-hour rating per IBC Table 601, the 2-hour rating per IBC Table 602 will take precedence.
- **East Wall:** With a 12-foot fire separation distance, IBC Table 602 requires a 1-hour rating.
- **South Wall:** With an 18-foot fire separation distance, IBC Table 602 requires a 1-hour rating, which does not change the rating as required per IBC Table 601.
- **West Wall:** With a 41-foot fire separation distance, IBC Table 602 does not require a fire-resistance rating; thus, it can remain a non-fire-resistance-rated wall.

Step 3: Determine if the fire-resistance-rated exterior walls are required to be protected from an exposure on both sides of the wall or only on the interior side per IBC Section 705.5.

- **North Wall:** The fire separation distance for this wall is less than or equal to 10 feet; therefore, it must be protected from fire exposure on the exterior and interior sides of the wall.
- **East and South Walls:** Both of these walls have fire separation distances that are greater than 10 feet; therefore, they only need to be protected from fire exposure on the interior side of the wall.

Step 4: Determine required opening protection per IBC Table 705.8.

Since the building is nonsprinklered, only the unprotected, nonsprinklered (UP, NS) and protected (P) percentages may be used.

- **North Wall:** 4-foot fire separation distance.
  - UP, NS: Not permitted
  - P: 15%
- **East Wall:** 12 -foot fire separation distance.
  - UP, NS: 15%
  - P: 45%
- **South Wall:** 18-foot fire separation distance.
  - UP, NS: 25%
  - P: 75%
- **West Wall:** 41-foot fire separation distance.
  - UP, NS: No limit
  - P: No limit

Step 5: Apply opening percentages to proposed openings to determine compliance.

For purposes of this example, only the openings for the south wall will be evaluated for compliance. Figure 16-A-2 illustrates the proposed elevation for the south elevation.

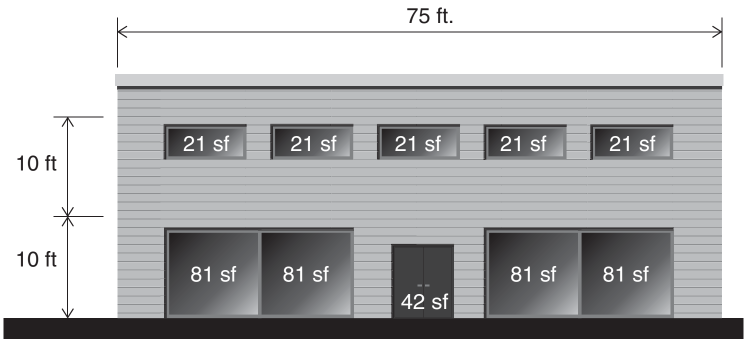


FIGURE 16-A-2. South elevation for building with proposed openings.

- Wall Area per Story: 10 ft. × 75 ft. = 750 sq. ft.
- 1st-Story Opening Area:

  Calculate the Actual Area of Openings:

  (81 sq. ft. × 4 each) + 42 sq. ft. = 366 sq. ft.

  Calculate the Percentage Opening Area to Wall Area of Story:

  (366 sq. ft. ÷ 750 sq. ft.) × 100 = 49%

  The 49% of actual opening area exceeds the 25% area permitted for unprotected, nonsprinklered (UP, NS) openings but is less than the 75% area permitted for protected (P) openings. Therefore, the openings at the first floor are required to be protected. Since the south wall is only required to have a 1-hour fire-resistance rating, the required fire protection ratings for the openings are $^3/_4$-hour.
- 2nd-Story Opening Area:

  Calculate the Actual Area of Openings:

  21 sq. ft. × 5 each = 105 sq. ft.

Calculate the Percentage Opening Area to Wall Area of Story:

(105 sq. ft. ÷ 750 sq. ft.) × 100 = 14%

The 14% of actual opening area is less than the 25% area permitted for unprotected, nonsprinklered (UP, NS) openings. Therefore, the openings at the second story are permitted to be unprotected.

Step 6: Review options available if the outcome is not satisfactory and make adjustments to the building design as necessary.

- If unprotected openings are desired for a building, there are five options that can be considered. These five options are applied to the exterior wall in this example as follows:
  1. *Sprinkler Building*: Per IBC Table 705.8, this would allow 75% of unprotected openings, which is greater than the 49% of actual opening area. Adding a NFPA 13 sprinkler system will add cost to the project but may offer cost reductions in other areas of code compliance.
  2. *Reduce Area of Openings*: If the actual total area of the openings is reduced to 25% or less of the wall area, then unprotected openings would be permitted. This will obviously have an effect on the design of the building's elevation but will allow unprotected openings.
  3. *Relocate Building on Site to Increase Fire Separation Distance*: In order to increase the allowable percentage, the wall for the building in the example will need to have a fire separation distance of not less than 25 feet. This would require adding 7 feet to the south wall fire separation distance. The building can be moved north 4 feet; however, the building area will still need to be reduced or the building shape changed in order to gain the remaining 3-foot difference. If the building location and/or shape is changed, then Steps 1 through 6 of this example will need to be completed again to determine if any of the exterior walls have changes in fire resistance or opening protection.
  4. *Provide a Mix of Protected and Unprotected Openings*: Some of the openings on the first story can be installed as unprotected openings.
  5. *Install Glazed Assemblies Tested per ASTM E 119 or UL 263*: Although not specifically mentioned as an exception in IBC Section 705.8, the use of these assemblies, as discussed in Step 15.2, affords protection that is equal to the adjacent wall, and thus are not considered openings. However, IBC Section 705.8.2 references specific sections in IBC Section 716 that bypass the provision in IBC Section 716.2, which exempts glazing tested per ASTM E 119 or UL 263 from the requirements of Section 716. Using this option may cause the design team to encounter resistance from the building department.
- Each of the options must be evaluated for its effect on the project budget, building design, or both. For purposes of this example, it is assumed that Option 4 provides the best alternative for the project. To implement this option, the door will be considered as unprotected and the glazed openings will remain protected.
- Option 4 requires using IBC Equation 7-2:

$$(A_p/a_p) + (A_u/a_u) \leq 1$$

where:

A_p = Actual area of protected openings

a_p = Allowable area of protected openings

A_u = Actual area of unprotected openings

a_u = Allowable area of unprotected openings

A_p = 81 sq. ft. × 4 each = 324 sq. ft.

a_p = 750 sq. ft. × 0.75 (i.e., 75% protected opening allowable area) = 562.5 sq. ft.
A_u = 42 sq. ft.
a_u = 750 sq. ft. × 0.25 (i.e., 25% unprotected opening allowable area) = 187.5 sq. ft.
(324 sq. ft./562.5 sq. ft.) + (42 sq. ft./187.5 sq. ft.) ≤ 1
0.576 + 0.224 ≤ 1
0.8 ≤ 1; therefore, this mix of protected and unprotected openings is acceptable

16.2 PROJECTIONS

Projections are not specifically defined in the IBC, but IBC Section 705.2 describes projections as "[c]ornices, eave overhangs, exterior balconies and similar projections extending beyond the exterior wall." Excluded from this list but mentioned within this section are exterior egress balconies (see Step 10.2.6) and *exterior exit stairways* and *ramps* (see Step 10.3.4), which have special requirements in their respective sections of the IBC. Since the *fire-resistance rating* of *exterior walls* is based on *fire separation distance*, any building element extending beyond the *exterior wall* places it even closer to the line used to determine *fire separation distance*, thus giving it greater exposure to a fire than the *exterior wall*. Therefore, it is important to ensure that projections do not extend too far and are constructed of appropriate materials for the applicable construction type.

IBC Table 705.2 provides an easy-to-understand method of determining the minimum distance a projection must be from the line used to determine *fire separation distance*. If two or more buildings on a lot are considered as one building (see Step 7.1), then the requirements would not apply to projections on walls between the buildings.

For buildings of Type I or II construction, projections are required to be of noncombustible materials, except for combustible materials complying with IBC Sections 1406.3 and 1406.4. Buildings of Type III, IV, or V construction may have projections constructed of any *approved* materials. If a combustible projection is 5 feet or less of the line used to determine *fire separation distance*, then the projection must be constructed to comply with one of the following:

- Provide a minimum 1-hour *fire-resistance rating*.
- Be of Type IV construction.
- Be constructed using *fire-retardant-treated wood*.
- Comply with IBC Section 1406.3.

The exception to the previous requirements for combustible projections applies only to Type VB buildings with Group R-3 or U occupancies with a *fire separation distance* of 5 feet or greater.

16.3 THERMAL PERFORMANCE

An *exterior wall* is more than just a physical barrier between the interior and exterior of a building—it must also provide thermal resistance to keep heat outside in building environments that require cooling, and it must also keep the heat inside in building environments that require heating. To achieve these basic performance criteria, the *exterior wall envelope* must incorporate insulating materials that restrict the flow of heat through the wall assembly. These thermal performance requirements indirectly affect occupant comfort by allowing environmental control systems to perform in the most energy-efficient manner possible. Although this step addresses *exterior walls*, the thermal performance may also apply to interior walls that separate *conditioned space (IECC)* from unconditioned space. Additionally, *basement* walls by IECC definition are considered *exterior walls* (*IECC*).

Requirements for the building envelope thermal performance are provided in IECC Section C402 for *commercial buildings* and Section R402 for *residential buildings*. As a reminder, the IECC defines *residential buildings* as one- and two-family *dwellings*, *townhouses*, and any Group R-2, R-3, or R-4 building having three *stories* or less above grade—all other residential-type buildings are considered *commercial buildings*. For *commercial buildings*, IECC Section C401.2 allows three paths for complying with the requirements of the IECC. The first path is complying with ASHRAE/IESNA/ANSI 90.1, which allows a little more flexibility. The second path is complying with the prescriptive requirements of the IECC. The third path, which allows the greatest flexibility for the design team, requires minimal application of the IECC; however, it does require that the overall energy performance of the building be 85% or less of the standard design for a building of a similar type. The requirements discussed here are based on the second path.

16.3.1 COMMERCIAL THERMAL PERFORMANCE

For *exterior walls* (referred to as "opaque portions" of the building envelope in the IECC), the insulation requirements of IECC Section C402.2.3 will apply.

The IECC offers three methods for determining compliance with the thermal performance of the building envelope. The tables used by the three methods categorize walls into two major categories: above grade and below grade. *Exterior walls* that are supported by foundation walls may have slabs-on-grade that either are contiguous with the foundation wall or abut the foundation wall, thereby creating a path for heat loss. Similarly, exposed floor systems that extend beyond *exterior walls* or support *exterior walls* or separate *conditioned space* from nonconditioned space can create paths for heat loss, too. Therefore, the thermal requirements for slabs-on-grade and floors are considered along with the *exterior walls*.

Above-grade walls are further subcategorized into the following:

- **Mass:** Mass walls are considered those weighing not less than 35 psf of wall surface area, weighing not less than 25 psf of wall surface area where the weight of the material does not exceed 120 pcf, having a heat capacity exceeding 7 Btu/sq. ft. × °F, or having a heat capacity exceeding 5 Btu/sq. ft. × °F where the weight of the material does not exceed 120 pcf. ASHRAE/IESNA/ANSI 90.1 Appendix A describes a mass wall as being either concrete or masonry (brick and concrete masonry unit). However, stone and adobe walls, which are a form of masonry, as well as rammed earth would also likely be considered a mass wall.
- **Metal Building:** A metal building is not clearly defined by the IECC, but the intent is for this subcategory to cover the standard preengineered metal building systems that typically consist of insulated or noninsulated structural metal panels attached to a metal framing system. For buildings using noninsulated metal panels, the insulation used commonly consists of flexible blankets secured to the wall system with either an attached or separate facing material.
- **Metal Framed:** This subcategory includes buildings using metal-stud framing for the *exterior walls*, whether the walls are loadbearing or not. The cavities between the studs are frequently filled with insulation. Since metal studs create a thermal bridge from one side of the stud to the other, IECC requires that metal-framed walls include *continuous insulation* (*IECC*) on the exterior side of the metal framing.
- **Wood Framed and Other:** Wood-stud framing and other wall assemblies that do not qualify for classification in any other subcategory shall comply with the requirements for this subcategory. Like metal-framed walls, wood-framed walls will have some thermal bridging, but, because wood has greater thermal resistance than metal, the required *continuous insulation* values are not as restrictive.

Below-grade walls are defined as walls associated with a *basement* or are 85% or more below grade and are at the perimeter of the building. If walls extend below grade, the values for *continuous insulation* must also extend to 10 feet below grade or to the lowest level of condition space, whichever is less.

Slabs-on-grade are concrete floor systems cast directly on the grade. Heat loss through the edge of the slab-on-grade can be minimized by the installation of perimeter insulation. Slabs with *radiant heating systems (IECC)* must comply with the values for heated slabs. IECC Table C402.1.3 provides two values: the minimum required *R-value (IECC)* for the perimeter insulation and the distance to which the insulation must extend. IECC Section C402.2.5 provides prescriptive requirements for various perimeter insulation installations. Where insulation is installed vertically against the foundation wall, the insulation must extend from the top of the slab to the distance prescribed or the top of the footing, whichever is less. Slabs-on-grade located more than 24 inches below the adjacent exterior grade are not required to have perimeter insulation.

Floors are considered either mass or joist/framing and are considered a part of the building thermal envelope when they are exposed to the exterior or are used to separate *conditioned space* from nonconditioned space, such as *basements* or crawl spaces.

Fenestration is covered in IECC Section C402.4 for the *building thermal envelope (IECC)*. For vertical *fenestration (IECC)* (e.g., windows, *curtain walls (IECC)*, *storefront (IECC)*, but excluding *opaque doors (IECC)* and spandrel panels), IECC Section C402.4.1 limits the maximum area to 30% of the gross wall area above grade. IECC Section C402.4.2 allows buildings in Climate Zones 1 through 4 to have a maximum *fenestration* area of 40% if all of the requirements listed are provided, including *daylight responsive controls (IECC)*, which adjust artificial light levels based on the amount of daylight within a space. IECC Table C402.2 provides the maximum *U-factor (IECC)* and *solar heat gain coefficient (IECC)*, or *SHGC*, permitted for vertical *fenestration* based on a building's *climate zone*. The *SHGC* values are determined according to a building's orientation and window projection factor (*PF*).

- **Orientation** is determined based on elevations facing either north (*N*) or south/east/west (*SEW*). To be considered a north orientation, the fenestration must be within 45 degrees of true north. In the Southern Hemisphere, the north and south orientations are reversed. Any building that is located south of 23.5 degrees latitude are required to use the *SEW* orientation for all elevations, which only applies to the state of Hawaii and all of the U.S. territories listed in the IECC.
- **The projection factor** is calculated in accordance with IECC Equation 4-5 and is the result of dividing the distance a shading element (e.g., roof eave, *awning*, overhang, etc.) projects from the vertical surface of the glazing by the vertical distance between the bottom of the glazing and the shading element.

16.3.1.1 R-Value Method (IECC Section C402.1.3)

This method prescribes the minimum *R-value* of the insulation installed within the wall assembly per IECC Table C402.1.3 based on the *climate zone* determined in Step 2.7. This method applies only to the R-value of the insulating materials and not the entire wall assembly. The "Group R" column of IECC Table C402.1.3 is applied to walls that enclose buildings, or portions of a building, with Group R occupancies and are not regulated by the IECC residential requirements. The "All other" column of the table applies to walls not enclosing Group R buildings or portions of buildings with Group R occupancies. Doors that are opaque (i.e., not glazed) use the door values; glazed doors must comply with the values for *entrance doors (IECC)* per IECC Table C402.4.

16.3.1.2 U-Factor, C-Factor, and F-Factor Method (IECC Section C402.1.4)

This method is similar to the *R-value* method; however, this method uses the values in IECC Table C402.1.4 for complete assemblies. The "Group R" and "All other" columns are used as described for the *R-value* method. For *exterior walls*, the complete assemblies, including air films, must have a *U-factor* equal to or less than the value in the table for the respective *climate zone* as determined in Step 2.7. For walls below grade, *C-factor (IECC)* values of the table are used. If the building has slabs-on-grade, then the *F-factor (IECC)* values in the table apply to those slabs-on-grade where the edge areas are exposed around the perimeter of the building. *F-factors* can be obtained from a few sources, including ASHRAE/IESNA/ANSI 90.1 Appendix A. Doors that are opaque (i.e., not glazed) use the door values; glazed doors must comply with the values for *entrance doors* per IECC Table C402.4.

16.3.1.3 Component Performance Alternative Method (IECC Section C402.1.5)

This method compares the proposed values for the building envelope components to the prescribed values. If the sum of the differences is zero or less per IECC Equation 4-2, then the building is considered to be in compliance. The method utilizes the *U-factors*, *C-factors*, and *F-factors* from IECC Table C402.1.4 as well as the prescriptive values for *fenestration* from IECC Section C402.4. The area limits on *fenestration* do not apply. What this method does is allow designers to use assemblies that do not comply with the prescriptive requirements in some areas as long as other areas perform much better than what is prescribed; thus, the maximum sum of zero is required.

16.3.2 RESIDENTIAL THERMAL PERFORMANCE

The thermal performance requirements for *residential buildings* are less restrictive than those for *commercial buildings*. However, similar to *commercial building* requirements, the IECC also provides designers with three methods for complying with thermal performance requirements for *residential buildings*.

Fenestration in *exterior walls* is addressed in IECC Table R402.1.2 and provides only the assembly *U-factor* and *SHGC*. Per IECC Section R402.3, a weighted average of all *fenestration U-factors* is permitted. This can be accomplished by determining the sum of each *fenestration U-factor* multiplied by the area and dividing it by the total *fenestration* area. If the result is equal to or less than the value in IECC Table R402.1.2, then the building is considered compliant. Per IECC Sections R402.3.3 and R402.3.4, up to 15 sq. ft. for glazed *fenestration* and up to 24 sq. ft. of *opaque doors* are permitted to be exempted from the *U-factor* requirements. However, they are not exempt if the *U-factor* alternative or the total UA alternative methods are used as described below. The *SHGC* per IECC Table R402.1.2 is required regardless of the method utilized.

16.3.2.1 R-Value Computation Method (IECC Section R402.1.3)

This method requires that the total *R-value* of all insulating materials within the *exterior walls* comply with the minimum values indicated in IECC Table R402.1.2. Materials such as gypsum board and plywood sheathing cannot be considered in determining the total *R-value* of the *exterior wall*. Insulated sheathing, however, may be used, provided the manufacturer's published *R-value* is reduced by R-0.6. Similar to the table for *commercial buildings*, IECC Table R402.1.2 provides *R-values* for a variety of *exterior wall* assembly types, including wood-framed walls, mass walls, *basement* walls, and crawl spaces. Also, similar to slabs-on-grade for *commercial buildings*, slabs-on-grade for *residential buildings* are included in the *exterior wall* requirements due to their connection with exterior foundation walls that support *exterior walls*.

Wood-framed walls include walls constructed of wood studs. Depending on the *climate zone*, IECC Table R402.1.2 requires either insulation within the cavities formed by the studs or a combination of cavity insulation between studs and *continuous insulation* on the exterior side of the framed wall. The latter is shown in the format of two numbers separated by a plus sign ("+"), where the first number is the cavity insulation *R-value* and the second number is the *continuous insulation R-value*. In Climate Zones 1 and 2, only cavity insulation is required. In Climate Zones 3, 4, and 5, either cavity insulation or the combination is required. In Climate Zones 6, 7, and 8, only the combination is permitted; however, two combinations are provided.

Metal-framed walls, although not included in IECC Table R402.1.2, are permitted in lieu of wood-framed walls. Since metal-framed walls are less resistant to heat flow than wood-framed walls, the insulation requirements must be modified. The *R-values* for wood-framed walls are converted to the respective *R-values* indicated in IECC Table R402.2.6. For example, if IECC Table R402.1.2 allows an R-13 for wood-framed walls, then one of the combinations in the "R-13" row of IECC Table R402.2.6 for either metal studs at 16 inches on center or 24 inches on center must be utilized.

Mass walls, per IECC Section R402.2.5, include concrete masonry units (CMUs), brick (except for veneer, unless used as a part of a masonry cavity wall), concrete, insulated concrete forms (ICFs), adobe, compressed block, rammed earth, or solid timber or logs. Other walls with a heat capacity of 6 Btu/sq. ft. × °F will also be considered mass walls. The *R-values* in IECC Table R402.1.2 are provided in pairs separated by a slash ("/"). The first number is used when all of the insulation is located on the exterior side of the mass wall. The second number is used when 50% or more of the insulation is located on the interior side of the mass wall.

Basement walls can be constructed of any combination of materials permitted by the IBC for *basement* construction. Climate Zones 1 and 2 do not require any insulation for *basement* walls. The remaining *climate zones*, on the other hand, do require insulation. Similar to the values for mass walls, the values for *basement* walls that require insulation are also provided in pairs separated by a slash ("/"). The first value applies to insulation installed on either the interior or exterior side of the *basement* wall. The second value applies to insulation installed only within the cavities of framed walls. For Climate Zones Marine 4, 5, 6, 7, and 8, footnote "c" of ICC Table R402.1.2 allows a combination of cavity insulation and *continuous insulation*.

Slabs-on-grade in *residential buildings*, like those in *commercial buildings*, are required to have perimeter insulation in all *climate zones*, except for Climate Zones 1, 2, and 3. The minimum *R-values* in IECC Table R402.1.2 also include the minimum distance the perimeter insulation must extend. However, unlike slabs for *commercial buildings*, there is no distinction between heated and unheated slabs. IECC Section R402.2.10 provides prescriptive requirements for location of the perimeter insulation and exempts slabs that are 12 inches or more below the adjacent exterior grade from the perimeter insulation requirements.

Floors in *residential buildings*, similar to *commercial buildings*, may separate *conditioned space* from nonconditioned space, or from the exterior, similar to exterior walls.

Crawl space walls are permitted to be insulated in lieu of insulating the floor directly above the crawl space if the crawl space is not vented to the exterior. When provided insulation, crawl spaces have requirements that are identical to those for *basement* walls. Per IECC Section R402.2.11, crawl space insulation must extend from the floor sheathing to the grade and then an additional 24 inches, either horizontally on grade or vertically below grade. The exposed earth in the crawl space must be covered by a Class I vapor retarder and sealed at all edges and joints.

16.3.2.2 U-Factor Alternative Method (IECC Section R402.1.4)

In lieu of the *R-values* per IECC Table R402.1.2, the *U-factors* per IECC Table R402.1.4 may be used for the same assemblies as described above for the *R-value* computation method. The assembly *U-factor* can consider all components within the assembly, including air films. The only assembly not included in IECC

Table 402.1.4 are slabs-on-grade, which will still require compliance with IECC Table 402.1.2. Additionally, since a total *U-factor* for the assembly is considered, both wood- and metal-framed walls are included in the column for framed walls.

16.3.2.3 Total UA Alternative Method (IECC Section R402.1.5)

This method is a more simplistic version of the component performance alternative method for *commercial buildings*. The UA, which is the sum of *U-factors* for each assembly multiplied by the area of each assembly, must be equal to or less than the UA using the *U-factors* from IECC Table R402.1.4 multiplied by the same assembly areas. This method includes all building envelope surfaces, including the roof (see Step 17).

16.4 AIR AND WATER MANAGEMENT

Even if the design of the *exterior wall envelope* conforms to the thermal performance requirements of the IECC, the actual performance of the *exterior wall envelope* may likely be reduced if air and water management is not considered. Air leakage and *infiltration (IECC)* through the envelope will create a heat loss or heat gain situation, depending on the region where a building is located. Further, if liquid water is allowed to penetrate the wall assembly or water vapor is allowed to condense within the wall assembly, then water-susceptible insulation will lose its overall effectiveness when it becomes wet.

16.4.1 AIR MANAGEMENT

Within the past decade, *air barrier (IECC)* systems have increasingly been introduced to the construction industry. An *air barrier* system consists of tested assemblies, which may include an *air barrier* membrane, construction materials with known performance, and the joint systems between these materials. Since the IECC is divided between *commercial* and *residential buildings*, the requirements for *air barriers* between the two types are different.

Air barriers should not be confused with vapor barriers or, more correctly, vapor retarders. Some *air barriers* are vapor permeable and some are not. If a vapor retarder is required (see Step 16.4.2), then the *air barrier* selected should be vapor permeable to avoid a double-vapor-retarder condition. Some products are marketed as air/vapor barriers, so a single product can satisfy both requirements. The location of the *air barrier* is not regulated by the IBC, so its location can be where it is most advantageous for the project; however, if an air/vapor barrier is used, then the location of the barrier material is dependent upon hygrothermal analysis of the wall assembly.

As mechanical systems within a building operate, they create an internal pressure that will cause air to leak through the building envelope where cracks and joints are not properly sealed. This leakage increases the load on the mechanical system, which will cause energy consumption to increase. Additionally, moisture-laden air can create other problems if that moisture vapor carried by the air is allowed to condense within the wall system. Therefore, *air barrier* systems are installed to prevent this air leakage.

Per IECC Section C402.5, a *commercial building* is required to have its thermal envelope tested per ASTM E 779 for air leakage. The only exceptions to this requirement are buildings located within Climate Zone 2B. The maximum leakage rate is 0.40 cfm/sq. ft. at a pressure differential of 0.3 inch w.g. (water gauge) This mandatory requirement is performance based and does not specify specific materials. However, IECC Section C402.5.1.2 provides *air barrier* compliance options, which do provide more direction in the way of individual material performance. The basic material performance criterion is to have an air permeability rating of not greater than 0.004 cfm/sq. ft. at a pressure differential of 0.3 inch w.g.

For residential construction the requirements are less stringent. IECC Section R402.4.1.2 requires that *residential buildings* be tested per ASTM E 779 or ASTM E 1827. For Climate Zones 1 and 2, up to five air changes per hour are permitted at a pressure differential of 0.2 inch w.g. For Climate Zones 3 through 8, the number of air changes is limited to three at the same pressure differential. The residential portion of the IECC does not provide any minimum performance requirements for materials used in an *air barrier* system.

16.4.2 WATER MANAGEMENT

Water management in an *exterior wall* assembly comes in three forms: (1) moisture vapor transmission through materials; (2) liquid water through cracks and joints; and (3) moisture vapor carried with air through leakage in the wall assembly. The third form is addressed using an *air barrier* discussed in Step 16.4.1. The first and second forms are addressed below. *Basement* walls have similar requirements to *exterior walls* above grade, but the control of water takes on a slightly different form depending on the groundwater conditions of the *site*.

16.4.2.1 Above-Grade Exterior Walls

For liquid water, IBC Section 1403.2 provides the minimum performance requirement for weather protection by stating that *exterior walls* "shall be designed and constructed in such a manner as to prevent the accumulation of water within the wall assembly … and a means for draining water that enters the assembly to the exterior." The only exceptions to this requirement are assemblies that have been tested in accordance with ASTM E 331, concrete and masonry walls designed in accordance with their respective chapters in the IBC, and *exterior insulation and finish systems* (*EIFSs*) *with drainage*.

For veneers, metal panel systems, and other *exterior wall coverings*, a *water-resistive barrier* is required between the *exterior wall covering* and the substrate, such as studs or sheathing. IBC Section 1404.2 establishes one layer of No. 15 felt complying with ASTM D 226 for Type 1 felt as the prescriptive *water-resistive barrier*. The IBC section also allows "other *approved* materials," so the designer can utilize many of the other materials that are on the market for such an application. In some cases, the *water-resistive barrier* could also perform as an *air barrier* as discussed in Step 16.4.1.

To address moisture vapor transmission, the concept is to prevent moisture in the gaseous state from passing through building materials until it reaches a point where the dew temperature is reached and the moisture vapor condenses (i.e., returns to liquid form) within the wall assembly.

The IBC identifies three *vapor retarder classes* based on the vapor permeability, or "perm" rating, in Chapter 2 definitions. Per IBC Section 1405.3, Class I and II vapor retarders are not permitted on the interior side of framed walls in Climate Zones 1 and 2, and a Class I vapor retarder is not permitted on the interior side of framed walls in Climate Zones 3 and 4. However, a Class I or II vapor retarder is required on the interior side of framed walls in Climate Zones 5, 6, 7, 8, and Marine 4. A Class III vapor retarder is permitted in Climate Zones Marine 4, 5, 6, 7, and 8, in accordance with IBC Table 1405.3.2. A Class III vapor retarder must be installed on the interior side of framed walls when foam plastic sheathing is used on the exterior side and the perm rating of the sheathing is less than 1. IBC Section 1405.3.3 provides some prescriptive materials for each type of vapor retarder class.

Where *exterior walls* also become parapets, the tops of the walls must be provided with coping that is of noncombustible and weatherproof materials. The coping must extend the full width of the walls. The coping requirements apply to parapets of nonexterior walls as well.

16.4.2.2 Basement Walls

As a requirement of IBC Section 1803, the building *site* shall have a geotechnical investigation performed to provide information for the design team to prepare the *construction documents*. This report is typically furnished by the owner and is prepared by a registered professional under the laws of the state where the building is located. Where a floor will be located below the finished exterior grade adjacent to the foundation, the report from this investigation shall include, in part, the location of the groundwater table if groundwater was encountered.

If the groundwater table is below the floor of an enclosed *basement* (i.e., no hydrostatic pressure), then the walls of the *basement* must be dampproofed per IBC Section 1805.2.2. The dampproofing material must be applied to the exterior side of the *basement* wall and extend from the top of the footing to grade level. Dampproofing materials must comply with the requirements of this section; waterproofing materials may be used in lieu of dampproofing materials. Per IBC Section 1805.4, a subsoil drainage system is required around the foundation perimeter.

If the groundwater table is determined to be above the *basement* floor level (i.e., existence of hydrostatic pressure), then the *basement* walls must be waterproofed per IBC Section 1805.3.2. The waterproofing must extend from the bottom of the wall to a point not less than 12 inches above the maximum groundwater table elevation. The remaining portion of the *basement* wall to the grade level must be either dampproofed or waterproofed. If a subsoil drainage system is designed in accordance with IBC Section 1805.1.3, then the *basement* walls can be dampproofed per IBC Section 1805.2.

When a *basement* is determined to be a *story above grade plane* and the floor of the *basement* is below the finished grade adjacent to the *basement* wall for 25% or more of the perimeter, then the walls are required to be dampproofed and a foundation drain shall be installed per IBC Section 1805.4.2 for the perimeter of the floor area that is located below the adjacent finished grade.

16.5 EXTERIOR WALL MATERIALS

Materials used within *exterior wall envelopes* must comply with IBC Section 1404. This section provides little in the way of direct prescriptive requirements. Rather, it references other sections of the IBC or ASTM standards for material-specific provisions.

Materials used for *exterior wall coverings* and their minimum installation requirements must comply with the provisions of IBC Section 1405. Materials covered within this section include the following:

- **Wood Veneers:** Board siding, hardboard siding, exterior plywood siding, and other wood-based exterior panels.
- **Anchored Masonry Veneer:** Masonry materials not covered by other requirements in this section and attached to a back-up system using metal anchors.
- **Stone Veneer:** Stone attached to a back-up system using metal anchors.
- **Slab-Type Veneer:** Stone or precast panels attached to a back-up system using metal anchors.
- **Terra Cotta:** Fired-clay or other ceramic products attached to a back-up system using metal anchors.
- **Adhered Masonry Veneer:** Masonry materials attached to a back-up system using mortar or some other adhesive material.
- **Vinyl Siding:** Manufactured polymer siding formed to look like wood siding.
- **Cement Plaster:** Three- or two-coat plaster systems applied over lath or solid backing. Also called "stucco."

- **Fiber-Cement Siding:** Cement-based panels with glass-fiber reinforcing attached to support framing using screw or nail fasteners.
- **Polypropylene Siding:** Similar to vinyl siding but uses polypropylene plastic in lieu of polyvinyl chloride (PVC).

Other materials that are included but rarely used include metal veneer and glass veneer. The requirements in this section are very descriptive and may include installations that are no longer used. Installation instructions by manufacturers may require methods contrary to the methods prescribed in the IBC. In these cases, IBC Section 104.11 for alternate materials, designs, and methods may be utilized; however, this will likely require approval by the *building official*. This section also includes IBC Table 1405.2, which provides the minimum thicknesses for a variety of *exterior wall covering* materials.

In addition to the materials in IBC Section 1405, other sections are included in IBC Chapter 14 for unique materials that require special attention. The materials and the sections that address them include the following:

- *Metal composite materials (MCMs)* (IBC Section 1407):
- *Exterior insulation and finish systems (EIFSs)* (IBC Section 1408):
- *High-pressure decorative exterior-grade compact laminates (HPLs)* (IBC Section 1409):

Basement wall materials are generally very limited, especially if the *basement* walls are a part of a building's foundation system. Wood walls are permitted in Type III, IV, and V construction only and must be designed and constructed in accordance with AWC/ANSI PWF. When used, wood foundations can only be used where hydrostatic pressure is not present. Otherwise, per IBC Section 1805.3.2, *basement* walls must be either concrete or masonry.

16.6 FIRE PROPAGATION

As discussed in Step 16.3, energy codes are requiring higher performance from building envelopes, and the best method to improve thermal performance is providing *continuous insulation*. *Continuous insulation* interrupts the thermal bridging created by common exterior wall construction. When *exterior insulation and finish systems (EIFSs)* were introduced in the 1970s, they were the only foam plastic insulations used in this manner. When the codes caught up with the new technology in the 1980s and developed testing standards, *EIFS* manufacturers immediately sought testing for their systems. However, with few manufacturers and a limited number of common substrates, it was easier to test most, if not all, of the typical *EIFS* assemblies at the time.

Even with the code demanding greater thermal performance, large continuous vertical planes of combustible material, like foam insulation, installed within an *exterior wall* assembly will allow a fire to spread quickly horizontally and vertically to other areas of a building. Due to this fire propagation potential, the code requires that wall assemblies that integrate combustible plastics (per IBC Section 2603.5.5) and combustible *water-resistive barriers* (per IBC Section 1403.5) be tested in accordance with NFPA 285.

Even though the standard's scope applies to non-load-bearing walls as its title implies, the IBC's requirements for testing does not differentiate between load-bearing and non-load-bearing walls—all wall assemblies with combustible materials (with some exceptions) are required to be tested. The IBC includes five provisions where NFPA 285 testing is specifically required for *exterior wall* applications:

- **IBC Section 1403.5:** For combustible *water-resistive barriers* in buildings over 40 feet in height of Type I, II, III, or IV construction.

- **IBC Section 1407.10.4:** For *metal composite materials (MCMs)* used on buildings of Type I, II, III, and IV construction. IBC Section 1407.11 provides alternate conditions that do not require compliance with NFPA 285, such as using *MCM* not higher than 40 feet and having a *fire separation distance* of more than 5 feet. If the *fire separation distance* is 5 feet or less, then only 10% of the wall area can include *MCM*.
- **IBC Section 1409.10.4:** For *high-pressure decorative exterior-grade compact laminate (HPL) exterior wall coverings* used on buildings of Type I, II, III, and IV construction. IBC Section 1409.11 provides alternate conditions that do not require compliance with NFPA 285, such as using *HPL* not higher than 40 feet and having a *fire separation distance* of more than 5 feet. If the *fire separation distance* is 5 feet or less, then only 10% of the wall area can include *HPL*.
- **IBC Section 2603.5.5:** *Exterior walls* of buildings of Type I, II, III, and IV construction of any height incorporating foam plastic insulation, except for one-story sprinklered buildings with sheet metal covering the foam plastic in accordance with IBC Section 2603.4.1.4.
- **IBC Section 2612.5:** For fiberglass-reinforced polymer (FRP) *exterior wall coverings*. This section references IBC Section 2603.5, which means NFPA 285 is required for Type I, II, III, and IV buildings that are more than two stories and higher. However, this section does offer two exceptions that would not require NFPA 285 testing.

Noticeably missing in the list of requirements above are *EIFSs*. That is because *EIFSs* were not directly addressed in the IBC until the 2009 edition. Prior to the 2009 IBC, *EIFSs* were regulated by the foam plastic insulation requirements of IBC Chapter 26. In the 2009 IBC, *EIFSs* were directly incorporated into the code in IBC Section 1408, which requires compliance with ASTM E 2586. Since ASTM E 2586 requires *EIFSs* to pass NFPA 285, IBC Section 1408 essentially supplants the foam insulation requirements of IBC Chapter 26 for *EIFSs*.

It is important to stress that the NFPA 285 test is an assembly test and not a material component test. With the constant introduction of new *exterior wall coverings*, the implementation of ***rainscreen systems***, and the increasing requirements for improved thermal performance, the building exterior envelope suddenly became a very complex assembly with thousands of possible combinations, thereby making it cost-prohibitive for a manufacturer to test every probable wall assembly. If an assembly can be found that has passed the NFPA 285 test, then the assembly must be designed and built exactly as it was tested. Therefore, the designer must use all of the proprietary products that are indicated in the tested assembly—any changes, regardless of how minor, will require a new test.

DEFINITION

Rainscreen System

An exterior wall covering system that is separated from a water-resistive substrate by an air space that allows drainage.

With this wide variety of potential *exterior wall* assemblies to choose from, the design professional must now consider one of the following options to remain compliant with the building code:

1. Design a building using Type V construction.
2. Design a sprinklered building with only one *story above grade plane* and protect the foam plastic insulation with sheet metal.
3. Design an *exterior wall* assembly that has no combustible materials.
4. Design a building using *MCM* and *HPL* that are more than 5 feet from the *lot line* and less than 40 feet in height and include no foam insulation or combustible *water-resistive barrier*.

5. Select a tested wall assembly from the few assemblies that are available. .
6. Design a wall assembly and have it tested.

Some of the options mentioned above may not be immediately available to the design professional due to a building's design program (i.e., size and type of spaces required), available site area, or project budget. For example, designing a 100,000-sq.-ft. office building on a tight urban site will likely eliminate the first two options. The third option, although achievable, will require some additional research time on part of the design team; however, to obtain equal energy performance using noncombustible materials (e.g., mineral wool insulation) will require thicker wall assemblies that may pose some design challenges. The fourth option is probable, but the use of foam plastic insulation or combustible *water-resistive barriers* (both are common with these *exterior wall coverings*) may require testing anyway. Resorting to the fifth option will limit the number of material and assembly options on a designer's palette. Lastly, the project budget may eliminate the sixth option, since project-specific testing can be very expensive.

EXAMPLE PROJECT—STEP 16

EXTERIOR WALL FIRE RESISTANCE

Example Project Figure 16-1 shows the fire separation distances between the nearest exterior walls and lot lines of adjacent lots or centerlines of streets and alleys. These distances are not exactly the same as the distances used for open spaces for the frontage increase calculated in Step 7.

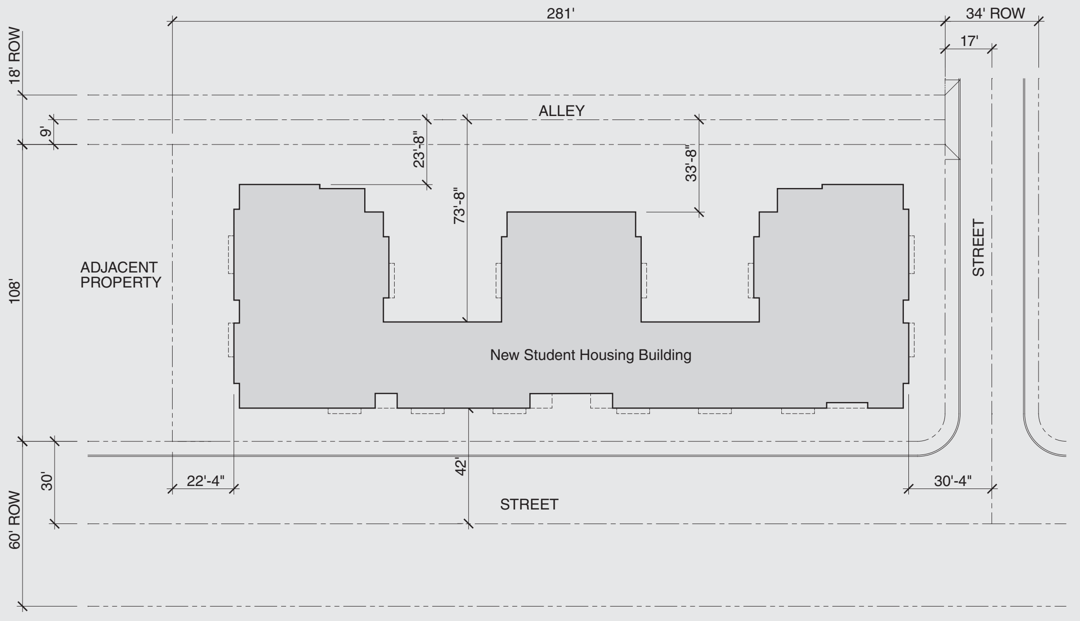
Using IBC Table 602, fire separation distances of 30 feet and greater do not require any fire resistance rating for exterior bearing walls. For occupancy Groups A, B, M, R, and S, 1-hour construction is required for exterior bearing walls. However, IBC Table 601 requires 1-hour construction for Type VA construction, regardless of fire separation distance. Therefore, all exterior bearing walls are required to have a 1-hour rating. At the first floor and basement, exterior bearing walls are supporting 2-hour horizontal assemblies, so construction of these walls are also required to be of 2-hour construction.

The exterior walls of the courts that face each other are not considered, since the definition of fire separation distance does not apply to distances between walls of the same building.

Since all exterior walls have fire separation distances of more than 10 feet, the exterior walls are only required to be protected from an interior exposure per IBC Section 705.5. To comply with the fire resistance requirement, the type of exterior materials must be considered. An EIFS and steel wall panels are proposed (see "Exterior Wall Materials" below). Many ICC-ES evaluation reports allow the use of an EIFS on exterior load-bearing walls provided that the EIFS is installed on the surface of an assembly listed in IBC Table 721.1(2) and the exterior wall has a fire separation distance of more than 10 feet. For this project, UL U348 and UL349 for 1- and 2-hour exterior walls, respectively, are provided with interior exposure only. The 2-hour assembly is for the 1st story, which supports the 2-hour horizontal assembly. The UL assemblies allow any exterior wall covering approved by the building official, so it will be assumed that an EIFS complying with the code and metal wall panels are acceptable. For the 1-hour exterior wall, UL U356 specifically provides for an EIFS on the exterior.

EXTERIOR OPENING PROTECTION (NFPA 13R)

Similar to exterior wall fire resistance, the requirements for exterior opening protection are based on the same fire separation distances. IBC Table 705.8 indicates that fire separation distances of



EXAMPLE PROJECT FIGURE 16-1. Building site plan with fire separation distances indicated to nearest exterior walls.

30 feet or greater are permitted unlimited area of unprotected openings, and thus the south, east, and north elevations (at the courts and center wing only) exceed 30 feet, so unlimited openings are permitted.

The west and north elevations (east and west wings) have separation distances less than 30 feet, so they will be limited, since the use of a NFPA 13R sprinkler system does not allow the use of the sprinklered values. These elevations have fire separation distances from “20 to less than 25” feet per IBC Table 705.8. Therefore, unprotected openings on these elevations are limited to 45%.

For the areas of limited unprotected openings, the area of openings is less than the 45% allowed. The table below outlines the opening areas.

Exterior Opening Analysis

Location	Exterior Wall Area	45% of Exterior Wall Area	Opening Area	Within Allowable?
1st Story, North Elevation, West Wing	352.8 sf	158.8 sf	21 sf	Yes
1st Story, North Elevation, East Wing	352.8 sf	158.8 sf	69 sf	Yes
1st Story, West Elevation, West Wing	976.8 sf	439.6 sf	21 sf	Yes
2nd through 4th Stories (each), North Elevation, West and East Wings	583.3 sf	262.5 sf	76.5 sf	Yes
2nd through 4th Stories (each), West Elevation of West Wing	813.3 sf	366 sf	180 sf.	Yes

THERMAL PERFORMANCE

As indicated in Step 2, the climate zone for the project is 4A. Since this building will have more than three stories, the residential requirements of the IECC are not applicable. The R-value method will be used for this project since it is the most common and allows typical construction methods.

Exterior Walls

The exterior walls are predominately wood-framed construction, which will require the use of the “Wood framed and other” category of IECC Table C402.1.3 under “Walls, above grade.” For the stories with the apartments, the “Group R” column is used from the Climate Zone 4 columns, and the first story will use the “All other” column. However, the requirements for both conditions are identical, so separate consideration is not necessary.

Based on the IECC table, exterior walls are required to have either R-13 in the stud framing with R-3.8 of continuous insulation or R-20 within the stud framing. R-21 fiberglass blanket insulation is available for 2 × 6 stud framing, so the latter option will be used.

Exposed Floors

The exterior walls of the basement parking are not required to comply with the building thermal envelope requirements per IECC C402.1.1, provided that the first-story floor assembly separating the first story from the basement parking complies with the requirements for the building thermal envelope. Thus, per IECC Table C402.1.3, the floor assembly must have R-10 of continuous insulation or R-30 within the framing. Because of the spans in the basement and the limitation of ceiling height, posttensioned concrete will be used for the floor system. This will be considered a “Mass” floor and must have the continuous insulation option. A spray-applied cellulose insulation is considered with 3 inches of insulation providing a little over the required R-10.

Further, there are some instances where the floor system is exposed to the exterior. This occurs over the exterior lobby, dining hall entrances, the recessed patio area of the manager's apartment, and, more prominently, over the covered patio; some balconies are included, as well, where they extend over occupied space located in the first story below. Since the floor system uses wood joists, R-30 insulation is required per IECC Table C402.1.3 per the "Joist/framing" value. To achieve R-30, loose-fill insulation for the full depth of the floor joists will be necessary. Further, since loose-fill insulation does not have a vapor retarder, a separate vapor retarder sheet needs to be installed. And finally, since this is required to be a 2-hour horizontal assembly, a tested floor design that allows loose-fill insulation will be required, similar to UL Assembly L577. This assembly requires two layers of 5/8-inch gypsum board applied to resilient channels over a third layer of 5/8-inch gypsum board on joists spaced at not more than 24 inches on center.

Fenestration

The IECC limits vertical fenestration to 30% of the gross above-grade wall area. The exterior wall area of the building is 37,467 sq. ft. Therefore, the fenestration area cannot exceed 30% of that area, or 11,240 sq. ft. The fenestration on the first story is 2,677 sq. ft. and, on the residential floors, each has 1,489 sq. ft. This provides a total of 6,970 sq. ft., which is less than the maximum of 11,437 sq. ft.

The required U-factor for glazed fenestration is 0.38 for fixed fenestration, 0.45 for operable fenestration (folding storefront in lounge and single hung windows in dwelling units), and 0.77 for storefront entrances.

The solar heat gain coefficient (SHGC) will vary depending on orientation and the projection factor per IECC Table C402.4. The projection factor will also vary depending on the location of the glazing and the type of protection. The table below summarizes the projection factors based on IECC Equation 4-5.

Summary of Projection Factors and SHGCs for Building Fenestration Using IECC Equation 4-5 and Table C402.4

Location	A	B	PF	Orientation	SHGC
Sliding Glass Doors at Balconies	4 ft.	9 ft.	0.44	SEW	0.48
Entrances to Dining Hall, Store, and Lobby	5.25 ft.	11 ft.	0.48	SEW	0.48
Entrance and Folding Doors between Lounge and Covered Patio	15 ft.	11 ft.	1.36	N	0.64
Sliding Glass Door and Window at Manager's Apartment Patio	2 ft.	11 ft.	0.18	SEW	0.40
All Other Glazing	0 ft.	0 ft.	0	SEW	0.40
				N	0.53

AIR AND WATER MANAGEMENT

In accordance with IECC Section C402.5.1, an air barrier is required within the building thermal envelope. Gypsum board is a suitable air barrier, so special detailing and care will be necessary at joints and penetrations to prevent air leakage.

A vapor retarder is required for Climate Zone 4. Per IBC Section 1405.3.1, a Class I or II vapor retarder is required on the exterior side of framed walls. Kraft-faced fiberglass blanket (i.e., batt) insulation is permitted per IBC Section 1405.3.3. Additionally, a water-resistive barrier is required on the exterior side of the framed wall.

EXTERIOR WALL MATERIALS

To keep costs as low as possible, an EIFS will be used predominately as an exterior material. The system will be a drainage system complying with ASTM E 2570, which is required on Group R-2 buildings of Type V construction per IBC Section 1408.4.1. The drainage system will comply with the requirements for a water-resistive barrier.

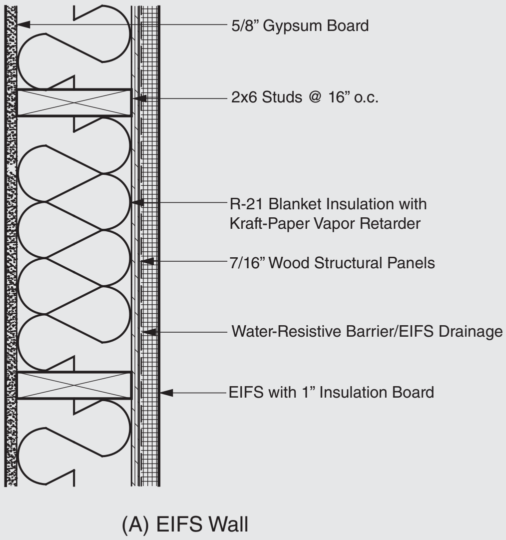
To add variety in materials, a flush metal panel system will be used in selective locations of the building elevations. The steel panel system will not be a metal composite material (MCM). The IBC does not provide any requirements for steel wall panels; thus, the panels need only comply with the performance requirements of IBC Section 1403. A water-resistive barrier is also required behind the metal panels. Some manufacturers of EIFS drainage systems provide drainage materials that can also be used behind other exterior wall coverings to provide a continuous membrane around the entire building. This project will assume such a material will be used.

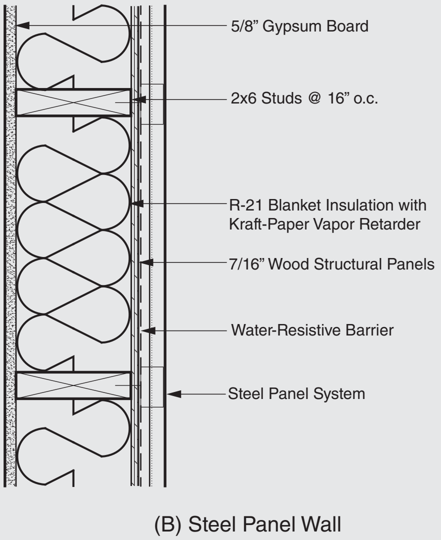
FIRE PROPAGATION

The proposed EIFS will be tested per NFPA 285 as a part of the requirements integrated in ASTM E 2570 (for EIFS with drainage) even though Type V buildings are not required to comply with the requirements for NFPA 285 testing.

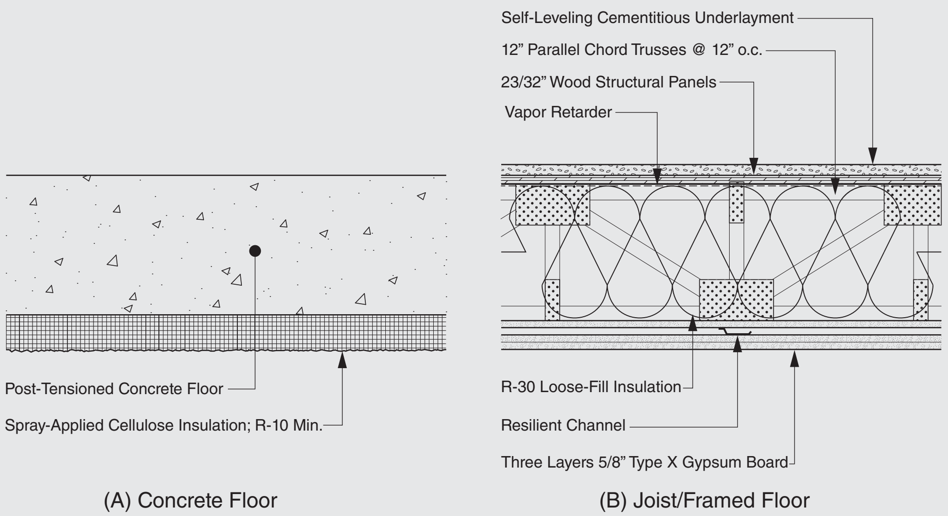
PROPOSED ASSEMBLIES

Based on the decisions made during this step, the two types of wall assemblies proposed are indicated in Example Project Figure 16-2. For the locations where floor systems are part of the building thermal envelope, the proposed assemblies are indicated in Example Project Figure 16-3.





EXAMPLE PROJECT FIGURE 16-2. Plan views of exterior wall assemblies. (A) Wall with EIFS. (B) Wall with steel panels.



EXAMPLE PROJECT FIGURE 16-3. Floor assemblies that are part of the building thermal envelope. (A) Posttensioned concrete slab between basement parking and first story. (B) Exposed exterior floor assemblies at second-story locations.

STEP 17

Develop Roof Assemblies

STEP OVERVIEW

Similar to *exterior walls*, *roof assemblies* have thermal, air, moisture, structural, and fire-resistance performance requirements that must be considered. The building code also addresses minimum material requirements, which may have an impact on the type of system selected for a particular application.

17.1 ROOF ASSEMBLY PERFORMANCE

Roof assemblies, like their *exterior wall* counterparts, have a requirement to provide weather protection. However, the water management of a *roof assembly* is much different than that of *exterior walls*. There are two basic types of roofing assemblies: low slope and steep slope. The National Roofing Contractors Association (NRCA; www.nrca.net) defines a low-slope roof as one with a slope of 3:12 or less; any roof with a slope greater than 3:12 is considered a steep-slope roof. However, the IBC typically refers to roofs with slopes of 2:12 or less as low-slope roofs, since the IBC definition for a *steep slope* roof is one that is greater than 2:12.

Although the IBC and IPC both use the phrase "where roof drains are required," those two codes never explicitly state where roof drains are required. Logically, roof drains should be provided where the flow of rainwater along the roof surface would be impeded by parapets or walls or where opposing roof surfaces converge to a valley or low point that has no means of draining. Secondary, or emergency overflow, drains or *scuppers* are required per IBC Sections 1503.4.1 and 1503.4.2 where the roof perimeter will entrap water should the primary drains become blocked.

Flashing is required at locations specified in IBC Section 1503.2.1, which include roof and wall intersections, at gutters, at changes of roof slope or direction, and around roof openings and penetrations.

Additionally, to ensure proper drainage, crickets and saddles are required at roof penetrations that are greater than 30 inches wide. The only exception to this requirement is *skylights* that comply with IBC Section 2405.5.

17.1.1 FIRE CLASSIFICATION AND RESISTANCE

Roof assemblies and *roof coverings* are required to be tested and classified per ASTM E 108. If the *roof covering* is fabricated of *fire-retardant-treated wood*, then the material must be tested per ASTM D 2898. The minimum classification of *roof coverings* is determined using IBC Table 1505.1 and is based on the building's construction type determined in Step 4.

Class A *roof coverings* are tested for severe fire exposure and are permitted in buildings of all construction types. Although many Class A *roof coverings* are available, the IBC does not require a Class A *roof covering* for any construction type. The IBC includes several materials that are considered Class A *roof coverings* and do not require the testing. These materials include the following:

- Brick or masonry coverings
- Exposed concrete *roof decks*
- Metal shingles and sheets (e.g., copper, zinc, stainless steel, and steel)
- Clay or concrete tiles
- Slate shingles

Class B *roof coverings* are considered to be effective against moderate fire exposure, and Class C *roof coverings* are effective against light fire exposure. *Roof coverings* that are not classified as Class A, B, or C are considered "nonclassified."

In Step 15, the *fire-resistance rating* of the roof construction was identified and must comply with the requirements for *horizontal assemblies*. However, there are other instances in the IBC where portions of the roof construction may be required to have a *fire-resistance rating* based on other conditions without conforming to the full requirements for *horizontal assemblies*. These conditions include the following:

- IBC Section 705.8.6, Exception 1: Protection of roof in lieu of protected openings for building on same *lot*.
- IBC Section 706.6, Exception 2: Termination of 2-hour *fire walls*.
- IBC Section 706.6.1, Exception: Termination of *fire walls* for stepped buildings.

17.1.2 WIND RESISTANCE

Wind resistance is primarily a structural concern for the *roof deck* and the loads are generally determined by the structural engineer. However, in addition to the deck, the *roof assembly* must also be capable of resisting the same uplift loads. The type of material selected for the *roof covering*, as well as any insulation installed above the *roof deck*, will need to comply with IBC Section 1504.1. If the *roof covering* proposed is clay or concrete tiles, the tiles are required to resist overturning, which may require adhesive to hold the tiles in place.

Nonballasted roofing systems, including metal panel roofing systems, are required to be tested in accordance with one of the test standards indicated. Ballasted roofs which use stones, pavers, or both over the roofing membrane are required to comply with SPRI/ANSI RP-4. Stone ballast consists of either 1 $^{1}/_{2}$-inch or 2 $^{1}/_{2}$-inch smooth river stone. Pavers are usually fabricated of concrete weighing 18 to 22 lb./sq. ft.

Whether roofing systems are ballasted or not, stone aggregate is not permitted on roofing systems used in areas designated as a *hurricane-prone region*. Aggregate is also not permitted on any building where the mean roof height exceeds the height indicated in IBC Table 1504.8. The table is read by finding the nominal design speed applicable to the building *site* and moving across to the column for the applicable exposure per IBC Section 1609.4.3. The nominal design wind speed (V_{asd}) can be determined by finding the ultimate design wind speed (V_{ult}) per IBC Figure 1609.3(1), 1609.3(2), or 1609.3(3), as applicable, based on the building's *risk category* per IBC Table 1604.5. The ultimate design wind speed can be converted to the nominal design wind speed using either IBC Table 1609.3.1 or IBC Equation 16-33.

17.1.3 THERMAL PERFORMANCE

Many of the same methods in the IECC used for *exterior walls* also apply to *roof assemblies*. Thermal performance criteria for *commercial building* roofs are permitted to use the same three methods described for *exterior walls* (see Step 16.2.1). The thermal performance criteria for *residential building* roofs also use the same three methods used for *residential building exterior walls*; however, the requirements for *residential buildings* are more simplified.

17.1.3.1 Commercial Buildings

For the *R-value* method, use IECC Table C402.1.3, which is based on different roof construction types and the *climate zones*. The table identifies three types of roof construction: roofs with the insulation above the deck, metal buildings, and *attics* and other *roof assemblies*.

The "**Insulation entirely above the roof deck**" category is commonly associated with low-slope roofing systems and is similar to the *continuous insulation* systems for *exterior walls*. The *R-value* in IECC Table C402.1.3 is only for the insulation installed above the deck. When using the *U-factor* method, IECC Table C420.1.4 is the source of maximum *U-factors*. If the component performance method is used, then the *U-factors* are included with the wall assemblies in determining the UA value for IECC Equation 4-2.

The "**Metal buildings**" category, as it relates to *roof assemblies*, is a little more refined than it is for *exterior walls*. IECC Table C402.1.3, through footnote "a," references ASHRAE/IESNA/ANSI 90.1 Appendix A for commentary on the type of assembly system provided in the table, which is a liner system (LS). This system consists of a layer of insulation draped over the purlins and is compressed when the metal roof panels are attached. To use the *R-value* method, insulated spacer blocks are required between the roof panels and the purlins to reduce the thermal bridging at the points where the insulation is compressed. Otherwise, footnote "b" of IECC Table C402.1.3 requires that the *U-factor* method be used per IECC Table C402.1.4, which also allows the use of the component performance method. Below the purlins, a continuous membrane (i.e., the liner) is attached and uncompressed, unfaced insulation is installed above the membrane between the purlins. The first *R-value* in the paired numbers is for insulation over the purlins and the second *R-value* is for the insulation between the purlins above the liner.

The "**Attic and other**" category primarily includes assemblies with insulation installed below the *roof deck*—usually above the ceiling to allow *attics* to be ventilated. The IECC does not address ventilation of *attics* in *commercial buildings*; therefore, *attic* ventilation must comply with the provisions in IBC Section 1203.2. Assemblies assigned to this category can utilize the *R-value* method, the *U-factor* method, or the component performance method.

The *attic* ventilation requirement of the IBC has frustrated designers for many years. When buildings have *roof assemblies* that are *steep sloped*, the ventilation requirements make perfect sense. However, when low-slope roofing is used and the perimeter of the roof is enclosed by parapet walls, there is no practical means for ventilating *attics* or enclosed rafter spaces. The 2015 IBC includes new provisions that cover these low-slope roof conditions (although it does not specifically restrict the requirement to low-slope roofs). The new provisions, which are located in IBC Section 1203.3, have existed in the IRC for several editions but have not, until now, been applicable to buildings designed under the IBC. The provisions allow unvented *attic* and enclosed rafter assemblies provided all the conditions listed are met. The two main concerns addressed by the conditions are to prevent a double-vapor-retarder condition and to minimize condensation on the interior side of the *roof deck*.

The first condition requires that unvented *attic* spaces be completely within the *building thermal envelope*. This means that space above the ceiling must be included within the *conditioned space*, thus placing the insulation directly against the *roof deck* (see Figure 17.1.3.1-1).

To prevent the double-vapor-retarder condition, the second condition prohibits the installation of a Class I vapor retarder on the ceiling side of the *attic* or rafters. Roof membranes, especially the single-ply types, have relatively low perm ratings, so if another low-perm vapor retarder is installed at the ceiling side of the *attic* or rafters, there is no means for the space between the two membranes to dry out if moisture is trapped.

The third condition only applies to roofs with wood shingles or shakes, thus requiring the *roof assembly* to be a *steep-sloped* roof per IBC criteria (see Step 17.3). The shingles or shakes must be separated from the required *underlayment* by not less than a $^1/_4$-inch airspace. The airspace is created by installing battens with an eave-to-ridge orientation to allow the free flow of any water. Horizontal battens are then attached perpendicular to the first battens at a spacing necessary for the attachment of the shingles or shakes.

The fourth condition applies only to Climate Zones 5, 6, 7, and 8. If insulation is air impermeable, then the insulation must comply with the requirements for a Class II vapor retarder or have a coating or covering that is a Class II vapor retarder to prevent condensation on the underside of the *roof deck*. If the covering in the latter option is used, then it must be in direct contact with the insulation.

For all *climate zones*, insulation in other locations must be installed using one of the four methods described in the fifth condition. Similar to the fourth condition, this condition prevents the condensation of moisture on the underside of the *roof deck*. Figure 17.1.3.1-2 illustrates the four alternative insulation locations described within this condition.

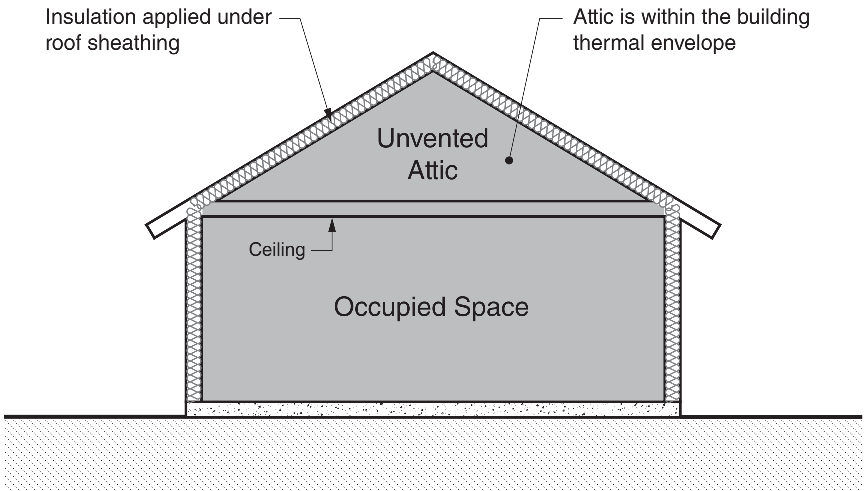


FIGURE 17.1.3.1-1. Location of insulation per the first condition of IBC Section 1203.3 making the *attic* part of the *conditioned space*.

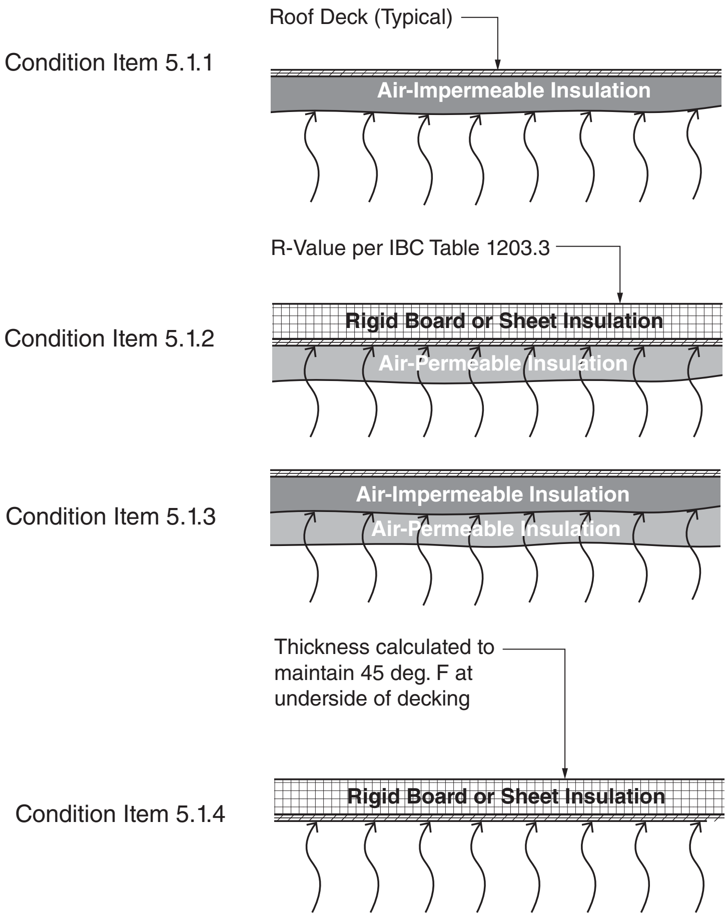


FIGURE 17.1.3.1-2. Alternative locations for insulation in an unvented *attic* or enclosed rafter space per the fifth condition of IBC Section 1203.3.

17.1.3.2 Residential Buildings

Roof thermal performance in *residential buildings* also aligns with the same methods used for wall construction in *residential buildings*. The IECC tables for residential roofing construction are very limited in the type of construction for the roof. In fact, the table only lists insulation for ceilings and does not address the roof as part of the *building thermal envelope*. This is indicative of typical residential construction where the thermal envelope stops at the ceiling and any space above is considered unconditioned *attic* space—the tables do not address the installation of insulation above the *roof deck*.

The *R-value* computation method requires R-30 to R-49 above the ceilings based on *climate zone*. Where R-38 is required, the *R-value* may be reduced to R-30 if uncompressed insulation is allowed to extend into the eaves over the *exterior wall* top plates. A similar reduction is allowed where R-49 is required permitting the use of R-38 insulation instead. These reductions are not permitted when the *U-factor* alternative method is used. As stated in Step 16.2.2.3 for *exterior walls*, the total UA alternative method requires that the ceiling *U-factor* be considered along with the rest of the *building thermal envelope*.

When *skylights* are present, they are considered based solely on their *U-factors* and are not included with the roof/ceiling construction when complying with the requirements per the *R-value* computation method. Similarly, when the *U-factor* alternative method is used, requirements for *skylights* are still considered independent of the roof/ceiling construction. However, the use of the total UA alternative method requires the consideration of all *building thermal envelope* component *U-factors*, including those for *skylights*.

17.2 ROOF OPENINGS AND PENETRATIONS

Openings and penetrations in roof construction are treated much differently than openings and penetrations in *exterior walls*. The most obvious difference is the lack of fire-resistance-rating requirements for roof openings and penetrations. Closely related to *fire-resistance ratings* are the requirements for combustibility for roof openings that include plastic materials. Additionally, *sloped glazing* and *skylights* are required to comply with requirements regarding structural loading, glass types, and general performance.

There are several conditions where openings in the roof construction are not permitted, whether the openings are protected or not. These conditions involve exceptions to other requirements of the IBC and are associated with *fire walls* and *fire-resistance-rated exterior walls*.

In buildings that are separated by a *fire wall*, no openings are permitted within 4 feet of the *fire wall* if the *fire wall* terminates at the underside of the roof sheathing per IBC Section 706.6, Exceptions 2, 3, and 4. Where a *fire wall* separates buildings of different roof elevations, openings in the lower roof are not permitted within 10 feet of the *fire wall* if the *fire wall* terminates at the underside of the roof sheathing per the exception to IBC Section 706.6.1.

When an *exterior wall* requires a 1-hour *fire-resistance rating* and parapets are not provided per IBC Section 705.11, Exception 4, then openings are not permitted within 5 feet of the *fire-resistance-rated exterior wall* for Group R and U occupancies. This distance is increased to 10 feet for all other occupancy groups.

17.2.1 FIRE RESISTANCE

Roof assemblies are *horizontal assemblies* per IBC definition. Therefore, IBC Section 712 provides the requirements for openings in roof construction. IBC Section 712.1.15, although titled "Skylights," actually applies to any opening in a *fire-resistance-rated* roof as stated in the first sentence. Where a roof is required to have a *fire-resistance rating*, *skylights* and other openings are permitted to be unprotected, provided the fire resistance of the roof structure is not compromised by the roof opening. Therefore, if a *fire-resistance-rated* roof depends on the ceiling membrane to provide the protection, the sides of the roof opening must provide the same level of fire resistance (Figure 17.2-1).

The only instance where a protected opening may be required is the condition as stated in IBC Section 712.1.15. Unprotected openings are not permitted in a *fire-resistance-rated* roof as required by IBC Section 705.8.6, Exception 1. This exception requires a 1-hour *fire-resistance-rated* roof for the lower roof of a building when two or more buildings are on the same *lot* and the buildings are closer than 30 feet to each other. However, the IBC does not address *fire-resistance ratings* for openings where they are required to be protected by this exception. *Floor fire door assemblies* are required to have a rating equal to or greater than that required for the floor *horizontal assembly*; therefore, it is logical to assume that *fire protection ratings* for openings in roof construction must be equal to or greater than the *fire-resistance rating* for the roof construction.

17.2.2 SKYLIGHTS

The requirements for *skylights* are threefold. There are requirements for the thermal performance, which are addressed in Step 17.1.3. Then there are requirements for the fabrication of the assemblies themselves per IBC Section 2405. Finally, there are requirements for their application as a daylighting feature per the IECC.

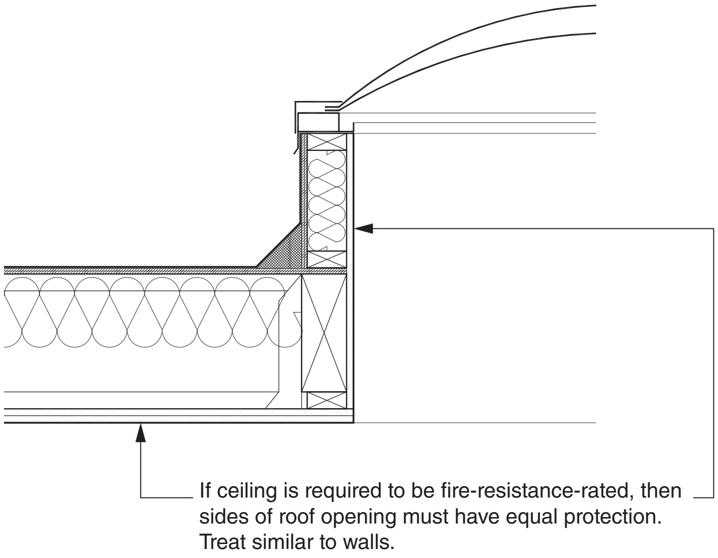


FIGURE 17.2-1. Protection of roof structure where a *fire-resistance-rated* roof is required and ceiling provides the required *fire-resistance rating*.

Skylight assemblies can be classified into two types: *sloped glazing* and *unit skylights*. *Sloped glazing* is typically site- or shop-fabricated assemblies that use a framing structure that is then glazed. They are very similar to glazed curtain wall systems but have enhanced water management capabilities. *Sloped glazing*, from the IBC perspective, includes assemblies used as a roofing system, wall system, or manufactured metal-framed *skylights* used to cover openings in a roof. The requirements for *sloped glazing* used as *skylights* are the same for *sloped glazing* used as a roof or wall assembly. *Sloped glazing* is covered in Step 24.3.

Unit skylights are typically smaller that metal-framed *skylights* and are manufactured and tested as complete assemblies. Glazing used in *unit skylights* must also comply with the same requirements for glazing in *sloped glazing* assemblies.

Skylights and *sloped glazing* assemblies that utilize plastic glazing must comply with the combustibility requirements of IBC Section 2610. The aggregate area of plastic *skylights* within a room or space is limited according to the class of plastic used. Therefore, a designer will need to know the plastic used and ensure that the proper plastic class is specified. For Class CC1 plastic materials, the aggregate area shall not exceed $33\,^1/_3$% of the floor area, whereas Class CC2 plastic materials are limited to 25% of the floor area. These limitations may be increased 100% where the building is sprinklered throughout per NFPA 13 or the building is equipped with heat and smoke vents per IBC Section 910. Additionally, the maximum area of plastic glazing within a *skylight* is limited to 100 sq. ft.; however, if the building is sprinklered throughout per NFPA 13 or heat and smoke vents are installed per IBC Section 910, then there is no limitation on the area of a single *skylight*.

Some heat and smoke vents, as well as some roof hatches, are available with plastic glazing in the vent or hatch doors. If these are provided, then they are also considered *skylights* and must be included in the area limitations stated above.

17.2.3 ROOF HATCHES

If a roof access hatch is provided in the building, then a *guard* adjacent to the hatch may be required. Per IBC Section 1015.7, a *guard* is required when the roof access hatch is located within 10 feet of the roof edge or open side of a walking surface when the roof edge or walking surface is located more than 30 inches above the floor, roof, or grade below. The *guard* is not required per the exception to this section when fall protection anchorage is provided in accordance with ASSE/ANSI Z 359.1.

17.3 ROOFTOP STRUCTURES AND EQUIPMENT

IBC Section 1510 covers the requirements for *penthouses*, tanks, cooling towers, spires, domes, cupolas, *mechanical equipment screens*, *photovoltaic panels*, and other structures, such as flagpoles, dormers, and bulkheads. Most of the requirements for these elements address the materials for their construction, so detailing of these structures should conform to the material requirements of this section.

Other requirements address height and area issues. For *penthouses*, the area is limited to no more than one-third the area of the supporting *roof deck*. The use of a *penthouse* is limited to the protection of mechanical or electrical equipment, tanks, or vertical *shaft* openings in the roof, such as elevator hoistways and mechanical *shafts*. It is important to note that *penthouses* are not considered stories and are not included in determining the total *building area*. The height of *penthouses* is limited to 18 feet, unless the building is of Type I construction, in which case the height is not limited. The height, where limited, may be increased to 28 feet if enclosing an elevator to the roof or rooftop tanks. Cooling towers are limited to one-third of the supporting *roof deck*. *Mechanical equipment screens* are limited to 18 feet in height.

If mechanical equipment is located on the roof, then a *guard* adjacent to the equipment may be required. Per IBC Section 1015.6, a *guard* is required when the equipment is located within 10 feet of the roof edge or open side of a walking surface when the roof edge or walking surface is located more than 30 inches above the floor, roof, or grade below. The *guard* is not required per the exception to this section when fall protection anchorage is provided in accordance with the ASSE/ANSI Z 359.1.

17.4 ROOF CONSTRUCTION MATERIALS

The materials used in roof construction are covered in multiple areas. For the structural frame, the requirements are based on the building's construction type. The *roof deck* material must also be consistent with the building's construction type but must also be an acceptable material for the required *fire-resistance rating*, as determined by Step 15.1.6. The type of material used for a *roof deck* may also be dependent on the type of *roof covering* proposed.

17.4.1 ROOF COVERINGS

IBC Section 1507.1 requires that *roof coverings* comply with the requirements of IBC Section 1507 and the manufacturer's installation instructions. Therefore, the manufacturer's installation instructions should be consulted and compared to the requirements of this IBC Section. Where there are differences, the manufacturer's instructions should be followed to ensure that the roof warranty is not voided. The IBC provides prescriptive requirements for the *roof coverings* listed below. Also included for each *roof covering* are basic requirements for *roof decks*, slope, *underlayment*, and flashings, which should be reviewed for roof detailing.

- **Asphalt Shingles:** Shingles manufactured using glass-fiber or organic felts that are either coated or saturated with hot asphalt. They are typically coated with mineral granules.
- **Clay and Concrete Tiles:** Molded or extruded tiles that are available in a variety of shapes and sizes.
- **Metal Roof Panels:** Manufactured or site-formed metal panels of aluminum, aluminum-zinc alloy coated steel, copper, galvanized steel, lead, zinc, stainless steel, or terne-coated stainless steel. The panels may be standing seam, batten seam, horizontal seam (Bermuda style), or lap seam.
- **Metal Roof Shingles:** Shingles formed into individual shingles that may be fabricated to look like other materials.
- **Mineral-Surfaced Roll Roofing:** Manufactured similar to asphalt shingles but provided in wide rolls.
- **Slate Shingles:** Individual shingles of slate rock.
- **Wood Shingles:** Individual shingles fabricated from cedar that are sawn on both faces and tapered.
- **Wood Shakes:** Shakes are similar to wood shingles but are usually thicker and have a split face, usually on the exposed side only.
- **Built-Up Roofing:** Layers of glass fiber or organic felts bonded together with hot bitumen.
- **Modified Bitumen Roofing:** Layers of glass fiber or organic felts bonded together with hot bitumen that has been modified with polymers to give it a more plastic- or rubber-like characteristic.
- **Thermoset Single-Ply Roofing:** Roofing membranes that are applied in a single layer and consist of thermoset materials, such as EPDM (ethylene propylene diene monomer) and CSPE (chlorosulfonate polyethylene).
- **Thermoplastic Single-Ply Roofing:** Roofing membranes that are applied in a single layer and consist of thermoplastic materials, such as PVC (polyvinyl chloride), TPO (thermoplastic polyolefin), and KEE (ketone ethylene ester).
- **Sprayed Polyurethane Foam Roofing:** Roofing that combines foam insulation and waterproof membrane in a single application. The foam is protected from ultraviolet degradation with a liquid-applied roof coating.
- **Liquid-Applied Roofing:** Roofing materials that include elastomeric waterproofing and coatings of emulsified asphalt, acrylic, silicone, and polyurethane.
- **Vegetative Roofs, Roof Gardens, and Landscaped Roofs:** Roof systems that may include a roofing membrane listed above and covered with soil and plant materials.
- **Photovoltaic Shingles:** Shingles that integrate solar cells to provide electrical power that can be converted into building use.

In addition to the material requirements listed above, the IECC requires that the *roof coverings* used in low-slope roofing systems in Climate Zones 1, 2, and 3 have minimum solar reflectance and thermal emittance properties. Solar reflectance is the ability of the material to reflect solar radiation and thermal emittance is the ability of the material to radiate energy away from itself, or, in other words, it does not absorb heat. Solar reflectance is directly affected by the color of the *roof covering*, where lighter colors have greater reflectivity than darker colors. Thermal emittance, on the other hand, is more dependent on the type of material. Metal roofing materials generally will have a low emittance; thus, they are more likely to retain heat, whereas single-ply roofing membranes will have a very high emittance.

As required by IECC Table C402.3, *roof coverings* for *commercial buildings* must have a three-year aged solar reflectance of 0.55 and a three-year aged thermal emittance of 0.75. There are no requirements for *roof coverings* on *residential buildings*. As an alternative to the two values, the IECC table also allows *roof coverings* with a three-year aged solar reflectance index (SRI) of 66. The SRI is calculated using the solar reflectance and thermal emittance values of a *roof covering*. Manufacturers of *roof coverings* may provide the solar reflectance and thermal emittance values or only the SRI.

17.4.2 UNDERLAYMENTS

Underlayments are sheet materials that are required for *roof coverings* that are not used in a low-slope condition, such as shingles, shakes, tiles, some types of metal panels, and roll roofing. The *underlayment* provides a secondary barrier should water make it past the primary barrier provided by the *roof covering*. Typical *underlayment* materials include asphalt-saturated organic felts and polymer-modified bituminous sheets. The polymer-modified bituminous sheets are self-adhering with some having resistance to high temperatures suitable for use underneath metal panels.

In some regions of the country where there is a potential for ice to build up at the eaves of a roof, polymer-modified bituminous sheets are required as ice barriers at these ice-susceptible locations. The application of the ice barrier must extend from the edge of the roof to a point that is 24 inches on the interior side of the *exterior wall* line. As snow melts from radiant heat produced by a building's interior, the water flows to a roof eave where there is no heat and the water refreezes, creating icicles and a dam that prevents subsequent water from reaching the eave. The water that is subsequently blocked can reach the *underlayment* through the gaps and joints within the *roof covering*.

17.4.3 INSULATION

Insulation, when installed above the *roof deck* as required by the IECC per Step 17.1.3.1, is permitted by IBC Section 1508 provided that the insulation is covered by an *approved roof covering*. There are several insulation types prescribed by the IBC and they are listed in IBC Table 1508.2 along with the reference standard for each insulation material.

Insulation manufactured using foam plastics are required to comply with the requirements of IBC Section 2603. This section establishes minimum surface burning characteristics for foam insulation as well as requirements for thermal barriers between the interior of the building and the roof insulation under certain conditions. Insulation manufactured using cellulosic fiberboard must comply with IBC Section 2303.1.6, which identifies the reference standard for minimum material properties.

17.4.4 FLASHINGS

The IBC, surprisingly, does not have prescriptive requirements for flashings for all *roof coverings* included in the code. Where flashings are prescribed, it is generally for *steep slope* roofing systems consisting of shingles, shakes, and tiles. The requirements for flashings are provided within each section for the applicable *roof covering* materials and are limited to valleys, drip edges, base flashing, and cap flashing (i.e., counterflashing). Materials for flashings are limited to those that are considered corrosion-resistant; therefore, galvanized steel, copper, lead, and stainless steel are generally considered acceptable materials. Although specifically applicable to flashing for asphalt shingles, IBC Table 1507.2.9.2 has a complete list of what is considered a corrosion-resistant metal, along with the applicable thickness, gage, or weight.

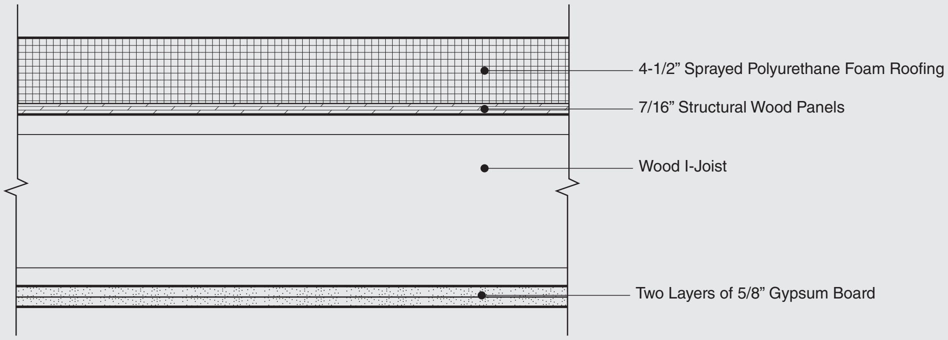
EXAMPLE PROJECT—STEP 17

The design of the building currently utilizes two types of roof systems. The first system is a low-slope system using sprayed-in-place polyurethane foam with a liquid protective membrane. The second system is a steep-sloped standing seam metal roof.

The roof assemblies are required to be 1-hour horizontal assemblies, since the type of construction requires it. Therefore, Item Number 26-1.1 per IBC Table 721.1(3) is an acceptable roof system for the low-sloped roof where the insulation is located entirely above the deck. For the steep-sloped roofing, Item Number 30-1.1 per IBC Table 721.1(3) should be used since it allows fiberglass insulation within the assembly.

LOW-SLOPED ROOFING

Sprayed polyurethane foam (SPF) systems can provide the minimum R-30 required by IECC Table C402.1.3 using a 4-$1/2$-inch-thick insulation layer (Example Project Figure 17-1). But using this system requires that Condition 5.1.4 per IBC Section 1203.3 be met. Per this condition, the interior face of the roof sheathing must be maintained at or above 45°F based on an interior temperature of 68°F and an exterior temperature using an average of the three coldest months within the region. For this example, it is assumed that the average temperature for the three coldest months is 26°F.



EXAMPLE PROJECT FIGURE 17-1. Roof assembly for low-slope sprayed polyurethane foam.

Using standard calculations for temperature drop, the inside surface of the sheathing will only drop to 65.2°F. To calculate the temperature, use the following:

$$\text{Temp. drop} = T_i - \Delta T(R_{max}/R_{tot})$$

where:

T_i = Indoor temperature (68°F per Condition 5.1.4)

ΔT = Temperature differential (T_i is 3-month average)

R_{max} = Accumulative R-value to the point being measured

R_{tot} = Total R-value of assembly

$\Delta T = 68°\text{F} - 26°\text{F} = 42°\text{F}$
R_{tot} = 33.52, based on the following R-values:
- Interior Air Film: R-0.61
- Two Layers of $5/8$" Gypsum Board: R-1.12
- Air Cavity: R-1
- $1/2$-inch Plywood Sheathing: R-0.62
- Spray Foam Insulation: R-30
- Outside Air Film: R-0.17

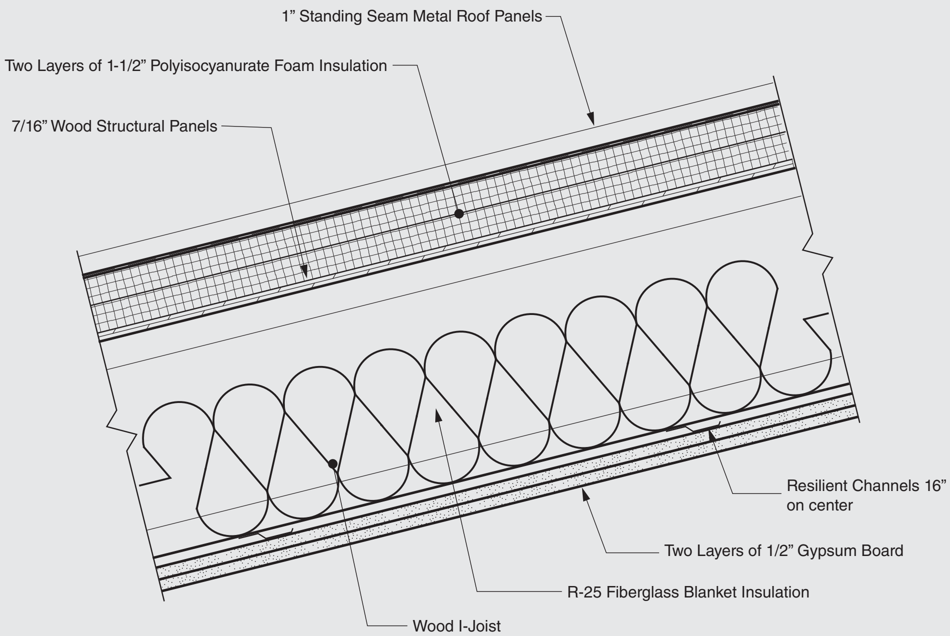
R_{max} = 2.17, sum of R-values for interior air film, gypsum board, and air cavity
Temp. drop = 68°F − 42°F(2.73/33.52)
Temp. drop = 64.6°F

The slope of the foam roofing must be 1/4 inch per foot per IBC Section 1507.14.1. Since polyurethane foam is a foam plastic, it must comply with the requirements of IBC Chapter 26. With the double layer of gypsum board at the ceiling for the 1-hour horizontal assembly, the thermal barrier requirements of IBC Chapter 26 are met, even though Item 2 of IBC Section 2603.4.1.5 would not have required a thermal barrier, since many SPF manufacturers provide Class A roofing tested per UL 1256.

SPF roofing is considered self-flashing, so metal flashing is not required at the parapets or at penetrations. Additionally, no underlayment is required.

STEEP-SLOPED ROOFING

The metal roofing will be installed with split insulation in accordance with Condition 5.1.2 per IBC Section 1203.3. The insulation above the roof deck will be two layers of 1 1/2-inch-thick polyisocyanurate insulation board to achieve the minimum R-15 required above the roof deck per IBC Table 1203.3 (as referenced by the condition). Installed below the deck will be 8 inches of fiberglass blanket insulation (R-value of 25) to provide a total R-value of 40 to comply with the minimum R-38 requirement of IECC Table C402.1.3 under "Attic and other" (Example Project Figure 17-2).



EXAMPLE PROJECT FIGURE 17-2. Roof assembly for steep-slope standing seam metal roofing.

The slope of the standing seam metal roof is only required to be 1/4 inch per foot per IBC Section 1507.4.2, so using a slope of 3 inches per foot is well above the required minimum. Per IBC Section 1507.2.8, the slope of the metal roofing will require an underlayment consisting of two layers.

ROOF OPENINGS

The only roof opening proposed is a roof hatch accessed by a ladder in the west stairway. Since the roof assembly requires a fire-resistance rating, the sides of the opening penetration must provide equal protection for the structural joists.

ROOFTOP STRUCTURES

There are no rooftop structures on this project.

STEP 18

Select Finishes

STEP OVERVIEW

Interior finishes are typically investigated for use on a project during this phase of design. Many clients want to see a "color board" of selected finishes, so initial finish selections are made and added to a preliminary finish schedule. The materials selected, however, must comply with minimum surface-burning and sanitation performance criteria.

18.1 INTRODUCTION TO FINISHES

The IBC sets minimum requirements for materials applied as finish materials to walls, ceilings, and floors. The IBC even establishes requirements for decorations and *trim* such as curtains, draperies, and other materials suspended from walls and ceilings. The IBC defines an *interior wall and ceiling finish* as the exposed *interior surfaces* of a building. As a part of that definition, it provides several examples in addition to the standard finishes, including movable walls and partitions, toilet compartments, and any material used for acoustic correction and *fire resistance*. Furthermore, the IBC defines an *interior floor finish* as the interior exposed floor surface and includes the riser and tread surfaces of *stairs*.

However, any *interior wall and ceiling finish* that has a thickness less than 0.036 inches (i.e., 36 mils) and is applied directly to a substrate is exempt from the finish requirements of the IBC. This allows materials like paint and wallpaper to be applied without complying with the requirements of the IBC. Other thin materials, such as vinyl wall coverings, may or may not be exempt. Manufacturer product data for vinyl wall coverings typically do not provide the thickness of the material—just the weight in ounces. Therefore, the manufacturer may need to be contacted if the intent is to exempt a vinyl wall covering.

The minimum requirements for finishes are found in IBC Chapter 8 and are typically based on nationally recognized standards such as those developed by ASTM, UL, and NFPA. The IBC categorizes finish requirements into three groups: (1) *interior wall and ceiling finishes*, (2) *interior floor finishes*, and

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(3) *decorative materials* and *trim*. Elevator finishes, which are regulated by ASME/ANSI A17.1 and not the IBC, are also included in this step. There are other areas of the IBC that also affect *interior finishes*, including ceramic tile, gypsum board, plaster, and stone veneer, but these are detailed requirements addressed in Step 27.

18.2 INTERIOR WALL AND CEILING FINISHES

The primary concerns with many *interior wall and ceiling finishes* include the potential combustibility of a finish material and the quantity of smoke produced during the combustion of a finish material. In addition to those requirements, there are requirements for sanitation in toilet facilities and the prevention of water damage and mold in wet areas.

18.2.1 FLAME AND SMOKE PERFORMANCE

Two approaches to address flame and smoke performance for standard *interior wall and ceiling finishes* are provided in IBC Section 803.1. The first approach is testing the finish material for flame spread and smoke development using ASTM E 84 or UL 723. The IBC establishes a classification of finish materials in IBC Section 803.1.1, using both the *flame spread index* and *smoke-developed index*, which are the results of these test methods. These classes are identified as A, B, or C, with A being the best rating. IBC Table 803.11 identifies minimum finish classifications for finish materials based on occupancy group, type of building component (i.e., *exits*, *corridors*, rooms, etc.), and whether or not the building has fire protection (sprinklered and nonsprinklered).

The second approach is testing the finish material per NFPA 286 and comparing the results to the minimum performance requirements of IBC Section 803.1.2.1.

Textile and expanded vinyl wall and ceiling finishes pose additional hazards that require further control. Textiles include fabrics, carpet, and other similar materials. For textile and expanded vinyl wall coverings, IBC Section 803.5 permits any material to comply with one of three methods:

- The material is tested per NFPA 286 and has met the minimum performance requirements as stated in IBC Section 803.1.2.
- The material is tested per NFPA 265 as required by IBC Section 803.1.3. This test method is commonly referred to as the “Room/Corner Test.” The results shall comply with the minimum performance requirements of IBC Section 803.1.3.1.
- The material has a Class A rating per ASTM E 84 or UL 723 and is protected by a NFPA 13 or 13R sprinkler system as required by IBC Section 803.1.4.

Similarly, textile and expanded vinyl ceiling coverings are given options, but only two: compliance with NFPA 265 per IBC Section 803.1.2 or the Class A rating per ASTM E 84 or UL 723.

Other specialized wall and ceiling finishes are also required to comply with some of the same requirements as for other wall and ceiling finishes but are specifically mentioned in the IBC. Products that use high-density polyethylene (HDPE) and polypropylene (PP) are required to be tested per NFPA 286 and meet the minimum performance requirements of IBC Section 803.1.2.1. Site-fabricated stretch systems, which are fabrics stretched over a plastic or wood frame and may include insulation material between the frames and behind the fabric, are required to comply with either ASTM E 84 or UL 723 per IBC Section 803.1.1 or with NFPA 286 per IBC Section 803.1.2.

For walls and ceilings identified to have a *fire-resistance rating* per Step 15 or are required to be noncombustible based on construction type per Step 4, the finishes that are applied to these assemblies need to comply with the additional requirements of IBC Section 803.13. If finish materials are set out from the wall or ceiling with furring strips no deeper than 1 3/4 inches, then the cavities between the furring must be filled with inorganic or noncombustible material, a Class A material, or be *fireblocked* at a maximum of 8 feet in every direction per IBC Section 718.2. If the finish material is set out greater than 1 3/4 inches, then Class A finish materials must be used to fill the cavity.

18.2.2 SANITATION

IBC Section 1210.2.2 provides finish requirements for walls and partitions in toilet facilities of buildings other than *dwelling units*, *sleeping units*, and other nonpublic toilet facilities with only one water closet. The section requires a nonabsorbent surface within 2 feet of water closets and urinals, as well as service sinks, and must extend to a height not less than 4 feet above the floor surface. The nonabsorbent surface must be hard and smooth and cannot be overcome by the effects of water.

Likewise, per IBC Section 1210.2.3, showers, whether as a separate compartment or as part of a bathtub, must have nonabsorbent surfaces on all sides that extend to a height of not less than 72 inches above the drain.

For areas that involve food handling and preparation, local health regulations may require specific finishes that are nonabsorbent. Materials installed per health department regulations must still comply with building code requirements.

18.2.3 MOISTURE AND MOLD RESISTANCE

Where tile is installed to comply with the requirements covered in Step 18.2.2, the material used as a substrate to the tile must also have resistance to the common effects of water on a material, such as deterioration and mold growth.

For tile installed on shower and bathtub walls or exposed panel surfaces of shower ceilings, the material must comply with the material types and standards listed in IBC Table 2509.2. Essentially, the material must be either a gypsum-based board with a moisture-resistant fiberglass facing or a cementitious panel with fiberglass reinforcing. Gypsum board walls behind water closets in toilet compartments that are to be covered with tile must be of the water-resistant type or one of the materials permitted for showers and bathtubs. Regular gypsum board is permitted as a substrate for tile in all other locations.

18.3 INTERIOR FLOOR FINISHES

Interior floor finishes in the IBC have some requirements that are similar to those of walls and ceilings, but they are much less restrictive. Moisture and mold resistance is not addressed for floor systems, but sanitation remains a concern. One issue of floor finishes that is not applicable to walls and ceilings is the concern for slip resistance.

18.3.1 FLAME AND SMOKE PERFORMANCE

Combustible *interior floor finishes* have a history of not contributing to the early development of a fire. Furthermore, *interior floor finishes* contribute little to a fire until the fire is fully involved; thus, regulation of smoke development is deemed unnecessary. For those reasons, IBC Section 804.1 exempts traditional floor finishes that are not manufactured of fibers from the requirements of IBC Section 804. As examples of traditional floor finishes, the IBC lists wood, vinyl, linoleum, terrazzo, and other resilient floor coverings. Therefore, floor finishes such as carpeting must comply with the requirements of IBC Section 804.

The federal government regulates carpet through 16 CFR 1630. This standard, known as the "Pill Test," is similar to ASTM D 2859. Both of these standards are considered the minimum performance requirements for all carpeting in the IBC regardless of where the carpeting is installed. Carpeting installed on walls must also comply with the requirements for wall finishes per Step 18.2.

Floor coverings subject to the requirements of IBC Section 804 could become involved in a fire when a space reaches or is close to reaching flashover. Thus, floor finishes could, under certain conditions, propagate flames just on the basis of radiant heat, gases, and flames from an adjacent space through an opening such as a door. For *stairway* and *ramp* enclosures (*exit* and *exit access*), *exit passageways*, and *corridors*, this is of great concern. To control such an occurrence, floor finishes in these spaces must be tested for critical radiant flux in accordance with NFPA 253. The higher the critical radiant flux, the more the material will resist flame propagation. Per NFPA 253, Class I materials have a critical radiant flux of greater than 0.45 W/cm^2, while Class II materials are greater than 0.22 W/ cm^2.

Class I materials are required in Group I-1, I-2, and I-3 occupancies, and Class II in all other occupancy groups except Group F, which only requires compliance with Consumer Product Safety Commission (CPSC) 16 CFR Part 1630 or ASTM D 2859. If a building is sprinklered throughout with a NFPA 13 or 13R system, then Class II materials can be provided where Class I materials are required, and where Class II materials are required, compliance with CPSC 16 CFR Part 1630 or ASTM D 2859 is all that is required.

18.3.2 SANITATION

For sanitation requirements, IBC Section 1210.2.1 covers the requirements for floors and base. Like the requirements for walls, the floors of toilet facilities in buildings, excluding toilet facilities within *dwelling units*, are required to have a hard, smooth, nonabsorbent surface. This surface must extend upward onto the walls to form a base that has a height not less than 4 inches.

In food handling and preparation areas, floors will have to comply with local health regulations similar to wall and ceiling finishes.

18.3.3 SLIP RESISTANCE

IBC Section 1003.4 requires a slip-resistant surface for *means of egress* components. Additionally, ICC/ANSI A117.1 Section 302.1 also requires a slip-resistant floor surface for *accessible routes*. Neither of these defines or describes what is considered "slip resistant." Therefore, enforcement of these requirements is based on subjective interpretations. The former ADAAG maintained within its Appendix Notes that a static coefficient of friction (SCOF) of 0.6 was recommended for *accessible routes* and 0.8 for *ramps*. OSHA recommends a minimum SCOF of 0.5 but adds that that is not an absolute value, since other surfaces under different conditions may require a higher value.

Many manufacturers provide one of two types of slip-resistance values for their products: the SCOF previously mentioned and the dynamic coefficient of friction (DCOF). The difference between the two is that the "static" type applies to movement from a stopped position, while the "dynamic" type applies to movement already in motion. In other words, the SCOF would replicate a person standing still who begins walking and DCOF would replicate a person already in a walking motion.

There are differing viewpoints as to what minimum SCOF or DCOF values are considered slip resistant. There are so many variables (and possible testing methods) involved, including the type of walking surface, the type of sole for the shoes, the size of a person, and the walking style of a person. Additionally, a surface that is heavily traveled may have a different value as it is worn down. Therefore, without any further guidance from the IBC, the design professional is left to make the determination of what is considered "slip resistant."

18.3.4 FIRMNESS AND STABILITY

Another characteristic of *interior floor finishes* that must be considered for accessibility is the firmness and stability. Carpet is specifically addressed in ICC/ANSI A117.1 Section 302.2. Carpet cannot have a pile greater than $^{1}/_{2}$ inch in height. Carpet pile must be level loop, textured loop, level cut pile, or a level combination of cut and uncut piles.

Other resilient floor materials may be unsuitable for accessibility. Spongy rubber sports flooring may compress too much for operating a wheelchair or may cause a tripping hazard for others with mobility impairment. Although no objective criteria are provided, surfaces that show footprints for several seconds after walking on them would likely not be considered firm.

Stability, like firmness, is not well-defined, so common sense will have to prevail. Stability generally means the finish will not move when walked or rolled over and does not curl at the edges or wrinkle. Many walk-off mats at building entrances would not be considered stable surfaces. Recessed mats or low-profile mats with sufficient gripping capability, on the other hand, are acceptable.

18.4 ELEVATOR FINISHES

The IBC states that *interior finishes* for enclosed spaces must be of Class C or Class B materials, depending on whether the space is sprinklered or not. However, that is not a decision that needs to be determined, since ASME/ANSI A17.1 requires finishes to be of Class B materials when tested in accordance with ASTM E 84 or UL 723.

If carpet or fabric (napped, tufted, woven, or looped) is used on elevator car walls, the material must be tested using the method specified in ASME/ANSI A17.1 Section 8.3.7. The material shall not have a burn length greater than 8 inches, the flame shall extinguish within 15 seconds after removal of the flame source, and drippings shall not burn for more than 5 seconds. Floor coverings, underlayments, and adhesives must have a critical radiant flux of not less than 0.45 W/cm^2 when tested in accordance with ASTM E 648, which is similar to Class II materials tested using NFPA 253. *Handrails* are permitted, but not required, inside elevator cars.

18.5 DECORATIONS AND TRIM

The IBC provides definitions for *decorative materials* and *trim*, and the prescriptive requirements are provided in IBC Section 806. If materials are noncombustible, then there is no limitation on the quantity of *decorative materials* and *trim*. However, if they are combustible, then the quantity of combustible *decorative materials* and *trim* is limited to 10% of the wall or ceiling surfaces to which they are attached. Exempted from the 10% limitation are *handrails* and *guards*. The 10% limitation may be increased under the following conditions:

- Group A auditoriums may have the maximum area increased to 75% when the building is sprinklered throughout with a NFPA 13 system.
- Group R-2 *dormitories* may have the maximum area increased to 50% when the building is sprinklered throughout with a NFPA 13 system.
- Group B and M occupancies may have unlimited area of combustible fabric partitions when they are suspended from the ceiling and not supported by the floor and they comply with NFPA 701.

Curtains, draperies, and other hanging fabrics must be tested per NFPA 701 or meet the maximum results indicated in IBC Section 806.4 when tested per NFPA 289.

Combustible *trim* consisting of materials other than foam plastic must be of Class C materials. Foam plastic interior *trim* must comply with IBC Section 2604. The *flame spread index* of foam plastic interior *trim* is limited to 75 as tested per ASTM E 84 or UL 723, but the *smoke-developed index* is not limited. If the *trim* has been tested per NFPA 286, then compliance with the *flame spread index* is not required. The maximum thickness of foam plastic interior *trim* is $^1/_2$ inch and the minimum density is 20 pcf.

Also addressed in IBC Section 806 are base materials and pyroxylin plastic. Pyroxylin plastic, once used for imitation leather, is rarely used; thus, the requirement is largely irrelevant. Base materials, typically associated with floor systems, are materials applied to the walls at the floor level. The IBC refers to these materials as *interior floor-wall base* and are commonly fabricated of wood, tile, vinyl, and rubber. Combustible *interior floor-wall base* must be Class II as tested per NFPA 253. If the *interior floor finish* is required to be Class I, then the *interior floor-wall base* must also be Class I.

EXAMPLE PROJECT—STEP 18

PROPOSED FINISHES

The finishes selected may be directed by the owner based on durability and cost. If provided finishes by the owner, the architect must review the selected materials for compliance with code requirements.

Floor Finishes

Floors within the dwelling units will be limited to carpet in bedrooms and living areas and ceramic tile in kitchens and bathrooms. In the hallways of the residential-only stories, carpeting will be installed.

For the public areas on the first story, carpeting will be provided in the dining hall, study rooms, lounge, and management office. Ceramic tile will be installed in the restrooms and quarry tile in the dining hall kitchen. Vinyl composition tile (VCT) will be installed on the floors in the hallways, lobby, mail room, and convenience shop. Sheet rubber sport flooring will be installed in the exercise room. Within stairways and the trash and mechanical rooms, sealed exposed concrete floors will be provided. In the elevators, large porcelain tiles will be installed.

Rubber base will be used where VCT and carpeting are installed. Tiled areas will have tile base matching the floor tile.

Wall Finishes

In public restrooms, ceramic tile will be installed as required by IBC Section 1210.2.2. In the dining hall kitchen, fiberglass-reinforced plastic (FRP) panels will be provided to allow easy cleaning. In the elevators, stainless steel wall panels are proposed. All other areas within the building, including all dwelling units, will be painted gypsum board.

Ceiling Finishes

Throughout the first story, acoustical panel ceilings will be installed in all areas except for the dining hall kitchen, restrooms, trash room, and mechanical room. The dining hall kitchen, restrooms, trash room, and mechanical room will have painted gypsum board ceilings.

In the dwelling units, all ceilings are painted gypsum board. The elevators will have luminous ceilings that are standard with most elevator manufacturers.

FLAME AND SMOKE PERFORMANCE

Since the building is sprinklered with a NFPA 13R system, IBC Table 803.11 allows the use of the sprinklered values. Therefore, since the first story is a nonseparated Group A-2 occupancy, the wall and ceiling finishes must have a Class B rating for corridors and stairways. All other walls and ceilings are permitted to have a Class C rating.

Within the residential stories and the parking garage, all walls and ceilings are permitted to have a Class C rating. Since the stair enclosure on the east side also serves the Group A-2 on the first story, this stairway must have Class B wall and ceiling finishes.

Where suspended acoustical panel ceilings are installed, the floor system must still provide the required 1-hour rating. A rated suspended acoustical panel ceiling system may be installed, but this will require all diffusers, grilles, and lighting to be treated as penetrations. Since the first story has a higher floor-to-floor height, a gypsum board fire-resistant ceiling membrane can be applied directly to the bottom of the joists. This will allow the suspended acoustical panel ceilings to be installed below the gypsum board and still have enough room for light fixtures, plumbing, and HVAC ductwork without penetrating the fire-resistant ceiling membrane. However, compliance with IBC Section 803.13.2 is now required, which includes either a Class A rating for the ceiling or the installation of sprinklers on both sides of the suspended ceiling system. It is likely that the installation of a Class A suspended acoustical panel system would be the least expensive option, since many manufacturers provide Class A suspended acoustical panel ceiling systems.

With the exception of the carpeting, all floor finishes are considered traditional and are not required to comply with the provisions of IBC Section 804. The carpeting, on the other hand, will need to have been tested using the “Pill Test” only. Without the sprinkler system, the carpeting would have been required to comply with Class II materials for minimum critical radiant flux; however, the exception to IBC Section 804.4.2 allows the sprinkler system to reduce that requirement to only provide the pill test.

SANITATION

The public restrooms are required to comply with the sanitation requirements for floors and walls. The dining hall kitchen area is not regulated by the IBC, but local health regulations will likely require nonabsorbent surfaces for the floors, walls, and ceilings. The quarry tile and FRP panels will definitely comply with these common requirements. For the ceiling, which is proposed to be painted gypsum board, the application of a gloss paint will usually be sufficient.

SLIP RESISTANCE

Since carpeting will definitely be considered slip resistant, the areas of concern for slip resistance will be the quarry tile in the dining hall kitchen, ceramic tile in the public restrooms and dwelling unit bathrooms and kitchens, and, finally, VCT in the public areas on the first story. Ceramic tile manufacturers may offer DCOFs for their products using a standard adopted by the Tile Council of North America (TCNA, www.tcnatile.com).

VCT products may be difficult to obtain COF values, either static or dynamic, and the test methods they used. Rubber sports flooring typically has a very high COF.

FIRMNESS AND STABILITY

All selected materials are stable, since they are adhered to the floor substrate. The rubber sports flooring and carpet must comply with the requirement for firmness.

ELEVATOR FINISHES

The proposed finishes are typical finishes provided by elevator manufacturers in their standard packages and comply with the minimum Class B ratings. Floor finishes in the elevators, which will be porcelain tile, will definitely comply with the minimum critical radiant flux requirements of AMSE/ANSI A17.1.

STEP 19

CHECK EGRESS WIDTHS

STEP OVERVIEW

Although egress widths have been preliminarily determined using minimum widths and rules of thumb, the actual widths must have the capacity to handle the actual number of occupants. With wall thicknesses refined, actual clear dimensions can now be measured and adjustments made before *construction documents* are prepared.

19.1 CALCULATION OF MINIMUM EGRESS WIDTH

The calculation of the width of the *means of egress* system begins with the *occupant loads* that were determined in Step 8. The process of calculating the required width is best done when starting from the macroelements of the building to the microelements. For example, the *occupant load* of a *story* is used to determine the required *exit* widths for that *story*. Next, the *corridor* widths are determined based on the sum of *occupant loads* for all spaces for which the *corridors* serve. Finally, the egress widths for *exit* or *exit access doorways* from each space are sized based on the *occupant loads* they serve. (For clarity, this step will use "egress doors," which will apply to either *exit access doorways* or *exit* doorways.)

The calculation of egress width is established in IBC Section 1005. *Stairway* widths are calculated at 0.3 inch per occupant, while other egress component widths (i.e., doors, *ramps*, *corridors*, *exit passageways*, exterior egress balconies, and *egress courts*) are calculated at 0.2 inch per occupant. The egress width may be reduced in all occupancy groups, except for Groups H and I-2, when a NFPA 13 or 13R system is installed throughout the building and an *emergency voice/alarm communications* system is installed. *Stairway* widths may be reduced to 0.2 inch per an occupant and other egress component widths may be reduced to 0.15 inch per occupant.

For facilities with interior *smoke-protected assembly seating*, the calculation of egress width can be as provided in IBC Section 1029.6.2. The egress width factors for stepped *aisles* in IBC Table 1029.6.2 may be used for *exit access stairways* and *exit stairways*, and the factors for level and ramped *aisles* may be

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used for other components. Facilities with outdoor *smoke-protected assembly seating* may use the same factors in IBC Table 1029.6.2 or use 0.08 inch per occupant for *stairways* and 0.06 inch per occupant for other egress components.

The minimum width or capacity cannot be diminished along the egress path of travel per IBC Section 1005.4. However, IBC Section 1005.7 does permit encroachments into the required widths under the following circumstances:

- Doors, when in their fully opened positions, cannot project more than 7 inches into the required egress width. Door hardware is not included if it is located between 34 and 48 inches above the finished floor (Figure 19.1-1).
- Doors, in any position, cannot reduce the required egress width by more than 50% (Figure 19.1-1).
- *Handrails* are permitted to project into the required egress width by 4 1/2 inches on each side per IBC Section 1014.8. However, the clear width between *handrails* for *ramps* on an *accessible route* cannot be less than 36 inches (Figure 19.1-2).
- *Trim* and other decorative features may project into the required egress width by not more than 1 1/2 inches.
- Protruding objects not more than 4 inches deep can encroach on the required egress width provided the lowest edge is more than 27 inches above the floor surface per IBC Section 1003.3.

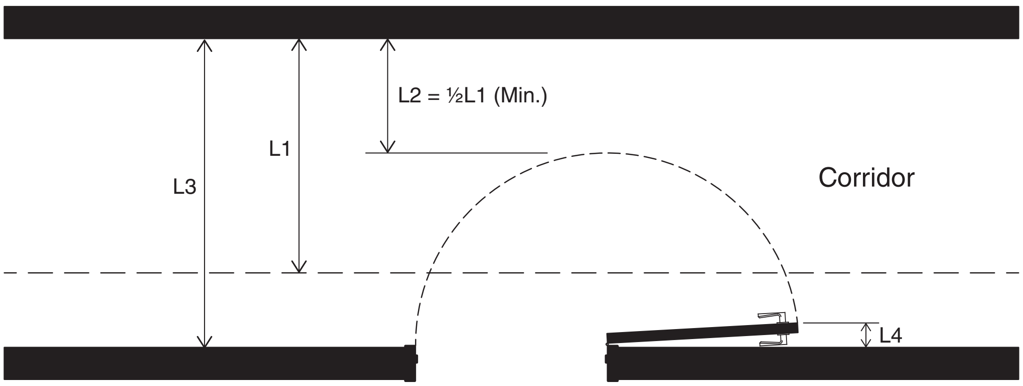
Although *handrails* are discussed in detail in Step 23.1.3, the identification of *handrails* at this phase of design should be shown on the drawings. IBC Section 1011.11 requires that *handrails* be provided on each side of a *stairway*. There are four exceptions provided, but most of these only apply to *dwelling units* and *sleeping units* within Group R-2 and R-3 occupancies and decks and patios. One troublesome *handrail* application is the requirement for intermediate *handrails*. IBC Section 1014.9 states that all portions of the minimum width or capacity be within 30 inches of a *handrail*. Therefore, if the required width of the

L1 = Required Width based on default width required by the IBC (See Table 10.6-1 in Step 10) or width determined by calculation based on occupant load, whichever is larger.

L2 = Minimum width between door swing and building element.

L3 = Minimum width required to ensure that egress path is not reduced by more than 50% by door swing.

L4 = 7 inches maximum if within required width L2.



Example 1:

L1 = 44 inches (default width required for corridors)
L2 = ½L1 = 22 inches
L3 = 58 inches if door is 36 inches wide (22" + 36" = 58")
L4 is irrelevant since it is outside of the required width

Example 2:

L1 = 72 inches (based on occupant load)
L2 = ½L1 = 36 inches
L3 = 72 inches if door is 36 inches wide
L4 = 7 inches

FIGURE 19.1-1. Door encroachment into the required egress width.

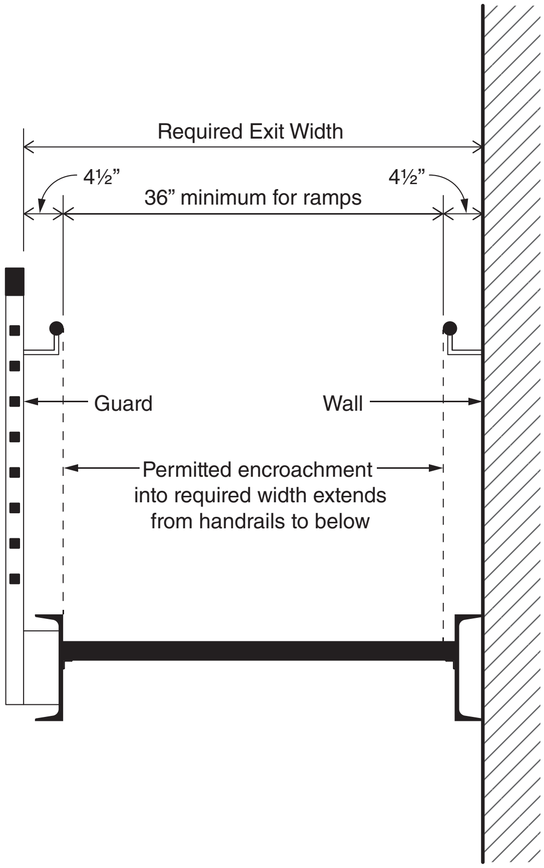


FIGURE 19.1-2. *Handrail* encroachment into required *stairway* and *ramp* width.

stairways is greater than 60 inches clear between *handrails*, then an intermediate *handrail* is required. If the *stairway* is much wider than what is required, such as a monumental *stairway*, then the *handrails* must be located along the most direct path.

The IBC often uses both "width" and "capacity" when referring to the ability of a *means of egress* system to handle the design *occupant load*, but each has distinct meanings, although neither is defined in IBC Chapter 2. IBC Section 1005.2 states that "width" is provided in inches (or millimeters) and applies to the minimum dimension required for an egress component. IBC Section 1005.3, on the other hand, addresses egress "capacity," which is also provided in inches (or millimeters) and applies to the width required based on *occupant load*.

Therefore, if the required egress capacity is less than the required width for an egress component, then the minimum width of the egress component must be used. For example, a *corridor* in a nonsprinklered office building serves an *occupant load* of 180. At the factor of 0.2 inch per occupant, the required egress capacity for the *corridor* is 36 inches (180 occupants × 0.2 inch/occupant = 36 inches). However, since the *occupant load* is greater than 50, a minimum *corridor* width of 44 inches is required per IBC Table 1020.2 (see Step 10.2.5). Therefore, even though the calculated capacity is 36 inches, a 44-inch-wide (or wider) *corridor* must be provided.

Conversely, if the *occupant load* demands an egress capacity that is greater than the required width of the component, then the width of the component cannot be less than the required capacity. For example, if the *corridor* in the same nonsprinklered office building serves an *occupant load* of 350, then the required width of the *corridor* must be 70 inches (350 occupants × 0.2 inch/occupant = 70 inches). Since 70 inches is greater than the minimum *corridor* width of 44 inches, the *corridor* must be designed at 70 inches.

19.1.1 EXIT WIDTH FROM BUILDINGS

The point of egress from the building is considered the *exit discharge*, as discussed in Step 10.4. The width and capacity for the *exit discharge* largely depend on where the *exit discharge* occurs. At the exterior of the building, the pathway from the building to the *public way* must accommodate the combined egress capacity for which the pathway serves. There is no prescribed minimum width similar to other egress components, except for the *egress court* (see Step 10.4.1), so the minimum width is calculated by multiplying the *occupant load* by the "other egress component" factor.

If the *exit discharge* egresses through areas on the *level of exit discharge* or a vestibule, no more than 50% of the required egress width or capacity is permitted to egress through those types of areas. Therefore, even if the number of *exits* discharging through these areas is less than 50% of the total number of *exits* (see Step 10.4), the width and capacity are also limited to 50% and must be calculated to ensure that the 50% threshold is not exceeded.

19.1.2 EXIT WIDTH FROM STORIES

As recommended in Step 8.3, the *occupant loads* that were determined should be delineated by *story*. For the *level of exit discharge*, there may be spaces that have *exits* directly to the exterior. If those are the only *exits* from those spaces or the spaces are permitted a single egress doorway per IBC Table 1006.2.1, then the *occupant loads* of those spaces may be excluded from the main *exits* from the building. The remaining *occupant load* will be used to size the main *exits* from the building (Figure 19.1.2-1).

For stories above and below the *level of exit discharge*, the *means of egress* must include *stairs*, *ramps*, or both to reach the *level of exit discharge*. If the *stairs* are required to be enclosed, then the doorway capacity into the *stairway* enclosure will be calculated using the factor for other egress components and the *stairway* capacity will be calculated using the factor for *stairways*.

IBC Section 1005.5 requires that the required capacity be distributed among the required *means of egress* so that the loss of any one *means of egress* will not reduce the required width or capacity by more than 50%. Hence, if a *story* is required to have only two *exits* or access to two *exits*, then each must be sized to handle not less than 50% of the *occupant load*. If three *exits* or access to three *exits* is required and if

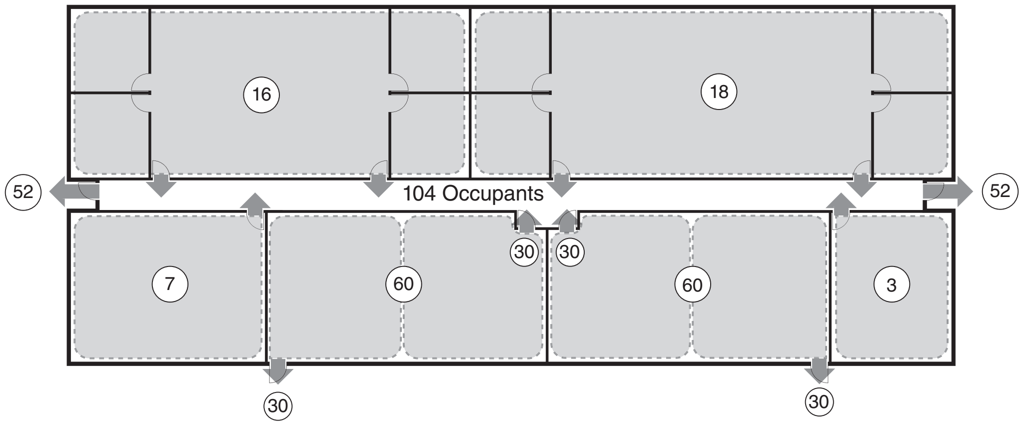


FIGURE 19.1.2-1. This floor plan has a couple of spaces that have *exits* directly to the exterior, which are sized for those *occupant loads*. The *occupant load* of the remaining building spaces will be used to size the *means of egress* serving those spaces.

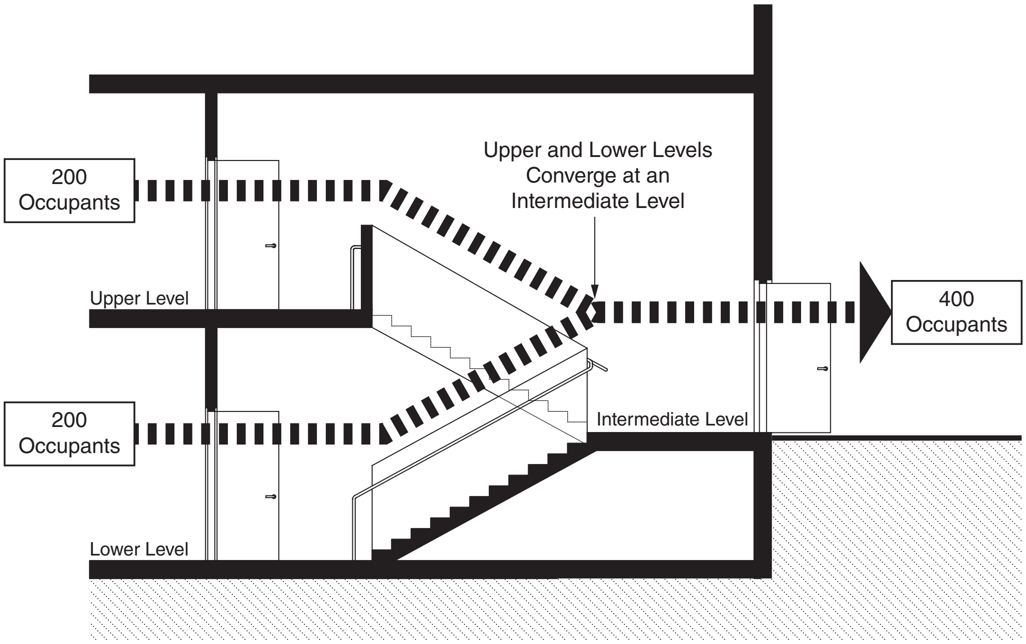


FIGURE 19.1.2-2. Convergence occurs when an upper floor level and a lower floor level meet at an intermediate level to exit. The egress width at the intermediate level must be the total of the two *occupant loads* converging.

one of those becomes unusable, the aggregate capacity of the remaining two must be at least 50% of the total required capacity.

If the *means of egress* from an upper *story* and another from a lower *story* converge at an intermediate level or *story*, then the egress path to the *exit discharge* on that intermediate level or *story* must be based on the combined *occupant loads* of the two converging stories per IBC Section 1005.6. For example, if a floor level and the floor level next above meet at an intermediate level to exit the building, then it is assumed that as the upper floor level occupants come down the *stairs* they will meet the occupants coming up the *stairs* from the floor level below at nearly the same time. The egress door at the intermediate level must be sized for the combined *occupant loads* of those two floor levels (Figure 19.1.2-2).

If the intermediate level is another floor level, such as the first *story* of a building, and the *basement* and second *story* converge at the first *story*, then the door out of the *stairway* at the first *story* must be sized based on the combined *occupant loads* of the *basement* and the second *story* or the *occupant load* from the first *story*, whichever is greater (Figure 19.1.2-3). If there is more than one *story* below the *level of exit discharge* and more than one *story* above the *level of exit discharge*, then the process must be repeated for each paired floor levels to determine which has the greatest *occupant load* to determine the minimum capacity of the shared egress pathway on the intermediate level.

19.1.3 EXIT WIDTH FOR CORRIDORS

The capacity of a *corridor* is based on the sum of all *occupant loads* identified to egress into the *corridor*. Although not clearly described in the requirements of IBC Section 1020.2, the entire interconnected *corridor* system between *exits* must be sized for the entire *occupant load* used by the *corridor* system. However, if the corridor leads to two different exits, then the width can be based on one half of the occupant load served, assuming one half will go in one direction and the remaining half in the other direction. Figure 19.1.3-1 shows how *occupant loads* are used to determine the capacity of the *corridor* system.

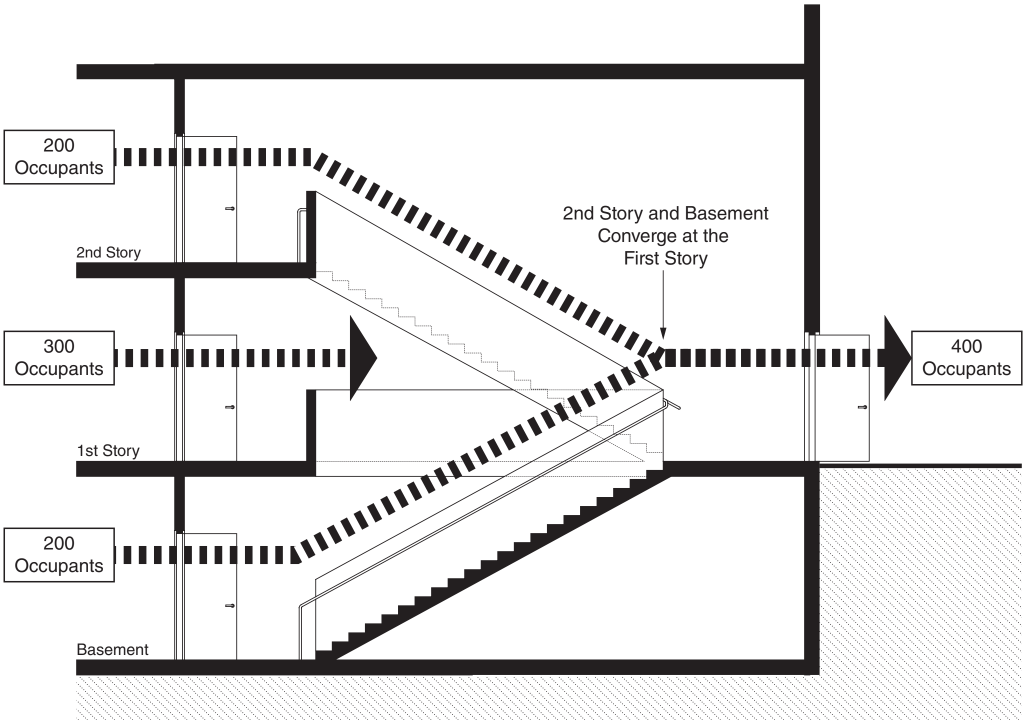


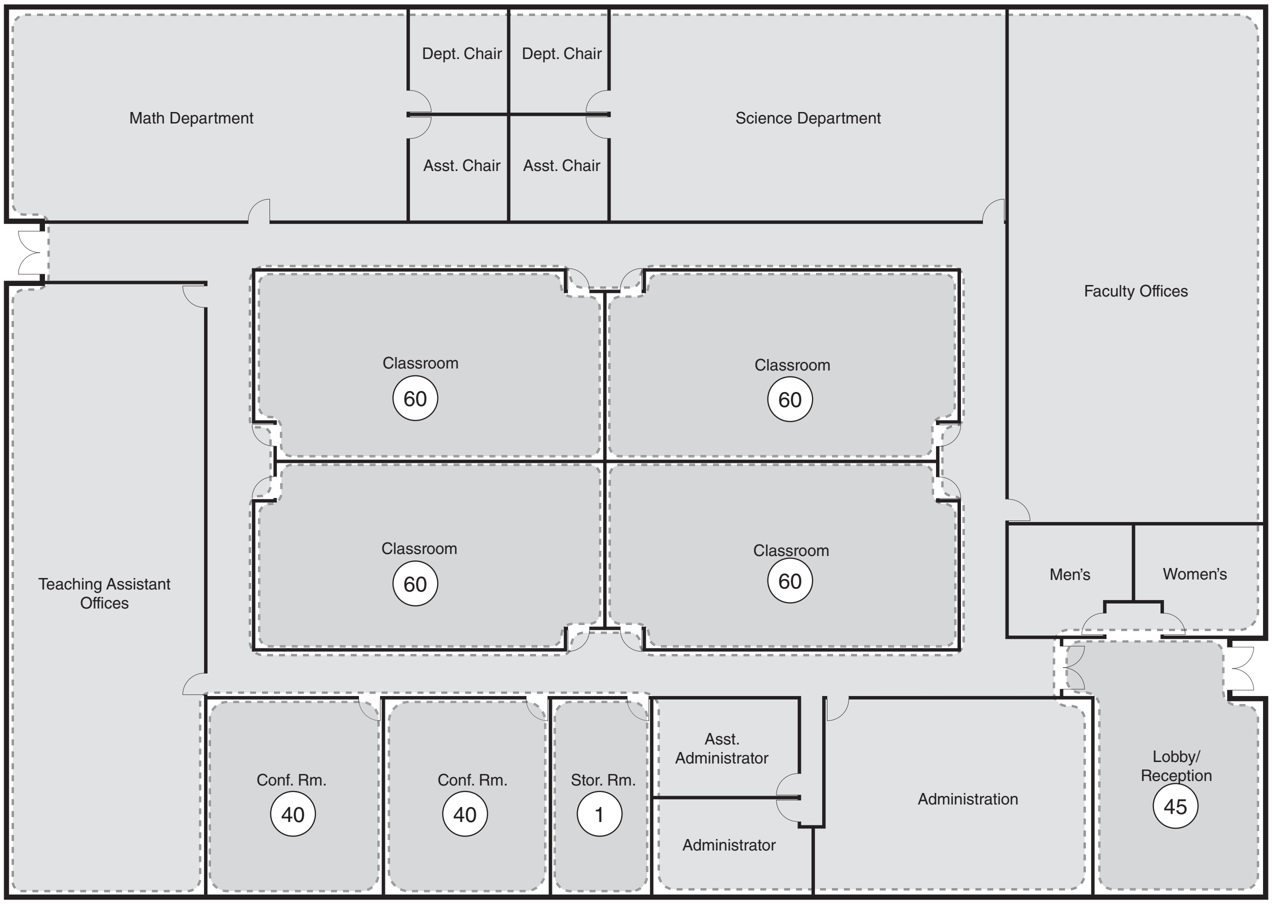
FIGURE 19.1.2-3. Convergence also occurs when an upper *story* and a lower *story* converge at an intermediate *story*.

19.1.4 EXIT WIDTH FROM SPACES

The doorways that lead from spaces to other spaces, *corridors*, or *exits* are sized according to the *occupant loads* they serve. If a space requires two or more egress doors, then all required egress doors should be utilized when distributing the *occupant load*. For example, if a space has an *occupant load* of 600, which requires three egress doors, then the *occupant load* should be distributed among all three doors. There is no requirement that the *occupant load* must be evenly distributed among all the required doors; however, as required for stories, the minimum width or capacity must be distributed among the required egress doors so that the loss of any one door will not reduce the required width or capacity by more than 50% per IBC Section 1005.5.

In assembly spaces with more than 300 occupants, IBC Section 1029.2 requires that a main *exit* be provided that has a capacity of not less than 50% of the *occupant load*. The main *exit* was addressed in Step 9.2.2, but this step is to ensure that the capacity of the main *exit* is appropriately sized. This really does not become an issue unless more than two egress doors are provided because of the 50% loss requirement per IBC Section 1005.5. Since the requirement applies to a space and the building in which the space is located, the main egress pathway out of a space to the main *exit* of the building must maintain the required 50% capacity plus the capacity of all other *means of egress* leading to the *exit*. For example, if a theater has an outer lobby, then the doors of the lobby to the exterior must be sized for 50% of the theater occupants plus all other areas that egress through the lobby. As stated in Step 9.2.2, a main *exit* is not required when the building has no well-defined main *exit*, such as sports arenas where exits are provided around the perimeter of the building. Therefore, the capacity of all the *exits* distributed around the building must be 100% of the required capacity.

If a space egresses through another space, called an "intervening space," then the capacity of the egress doors from the intervening space into a *corridor*, *exit*, or other intervening space must be based on the combined *occupant loads* of both spaces (Figure 19.1.4-1).



Occupant loads are shown in circles.

* Classrooms use "Classroom area" factor under "Educational" for the net floor areas
* Conference Rooms and Lobby/Reception use use the "Unconcentrated" factor under "Assembly without fixed seats" for the net floor areas
* Storage Room uses the "Accessory storage areas, mechanical equipment room" factor for the gross floor area

Lighter shaded areas use the "Business Areas" factor for the gross floor area for a total occupant load of 130.

Total occupant load used by the corridor system is 496. If the building is sprinklered but has no emergency voice/alarm communication system then the required width for the corridor is 49.6 inches: $496/2 \times 0.2$ in./occupant = 49.6 inches

FIGURE 19.1.3-1. Determining the capacity of a *corridor* system based on the *occupant loads* it serves.

19.2 CALCULATION OF AISLE AND AISLE ACCESSWAY WIDTHS

For *aisles* in other than assembly spaces, the minimum widths are fixed, as stated in Step 10.2.3, and are not adjusted based on *occupant load* or length. In assembly spaces, *aisles* also have minimum widths but are modified based on *occupant load*. *Aisle accessways* in assembly spaces also have minimum widths but are modified based on the length of the *aisle accessway* (see Step 10.2.3).

The width and capacity of *aisles* are determined in the same manner that other egress components are calculated; however, the *occupant load* used to size an *aisle* is based on the *aisle's* "catchment area" per

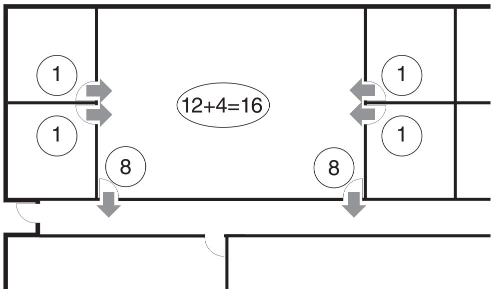


FIGURE 19.1.4-1. Egress width for intervening spaces. The four smaller spaces, each with an occupant load of 1, egress through the larger intervening space, which has an occupant load of 12. The four occupants of the smaller spaces must be added to the 12 occupants of the larger space.

IBC Section 1029.9.2. A catchment area is the proportional seating area assigned to a portion of the *aisle*. The catchment areas are assigned based on a balanced use of the *means of egress* system for the assembly space by distributing the number of occupants proportionally to the egress capacity of each component. Example 19-A illustrates how catchment areas are used and how the *occupant loads* are distributed among the multiple egress doors in an assembly space.

EXAMPLE 19-A: USE OF CATCHMENT AREAS IN DETERMINING EGRESS WIDTH IN ASSEMBLY USES

Given: A theater with seating for 680 occupants arranged as shown in Figure 19-A-1. The aisles are level. The theater is sprinklered as required by IBC Section 903.2.1.1 with a NFPA 13 system and is provided with an emergency voice/alarm communications system.

Step 1: Determine required egress width and capacity.

Since the occupant load is greater than 500, per IBC Table 1006.2.1.1 three exit or exit access doorways are required.

The required egress capacity is calculated as follows:

$$680 \text{ occupants} \times 0.15 \text{ inch/occupant} = 102 \text{ inches}$$

The required width is 32 inches per exit and three exits are required; therefore, the required width is 96 inches. The required width is less than the required capacity, so the capacity will be used.

Since this space is provided with a main exit, the main exit must provide 50% of the required width or capacity per IBC Section 1029.2. One-half of the capacity is 51 inches (102 inches × 0.50 = 51 inches) and one-half of the required width is 48 inches (96 inches × 0.50 = 48 inches). Therefore, the main exit must provide a minimum width of 51 inches, since it is the greater of the two.

Per IBC Section 1010.1.1, the maximum leaf of a door is 48 inches; thus, a door with a 48-inch-wide leaf will not provide a 51-inch clear width, so a minimum of two doors with 32 inches clear each will need to be provided. The other two doors will remain at the minimum clear width of 32 inches each.

Step 2: Divide the assembly seating area into catchment areas based on a balanced occupant load distributed among the required exit or exit access doorways.

Since the main exit must have a capacity of $^1/_2$, divide the seating area so that the back half of the theater will use the main exit and the front half will be split, 25% each, between the two front egress doors.

It is assumed that, for each row of seating, half of the occupants will go to their left and the other half will go to their right. This division line completes the arrangement of the catchment areas (Figure 19-A-2).

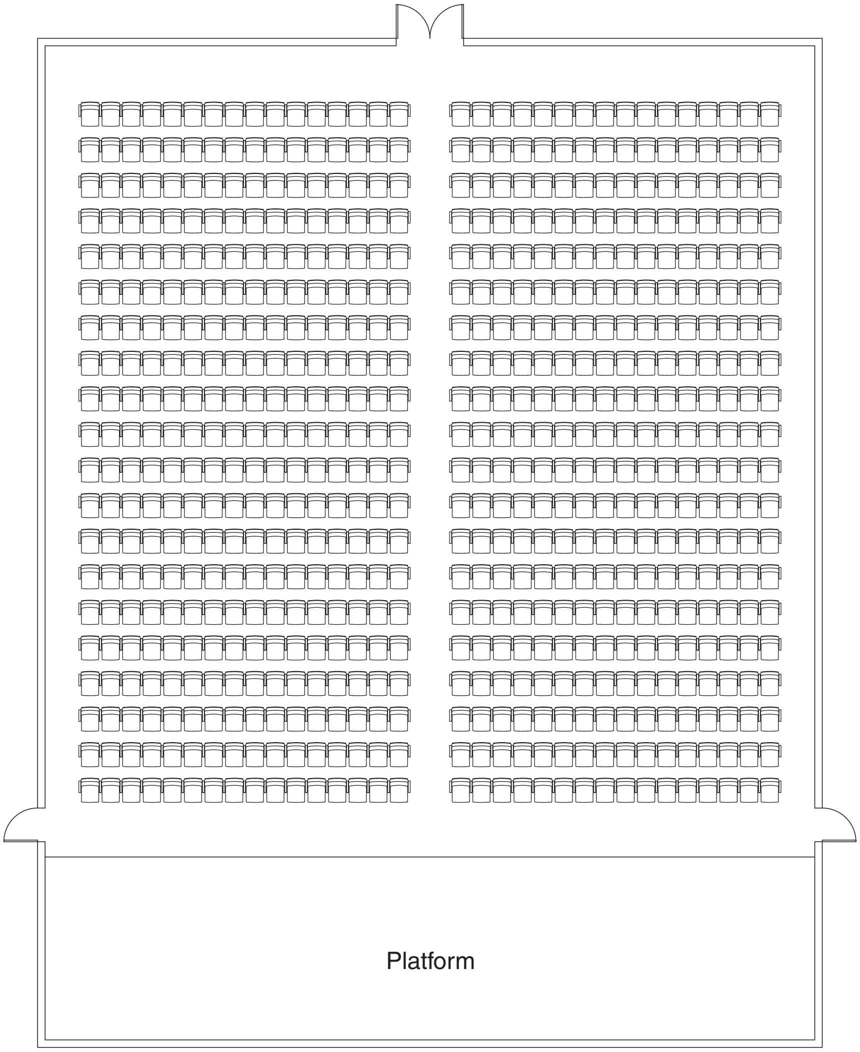


FIGURE 19-A-1. Floor plan of theater.

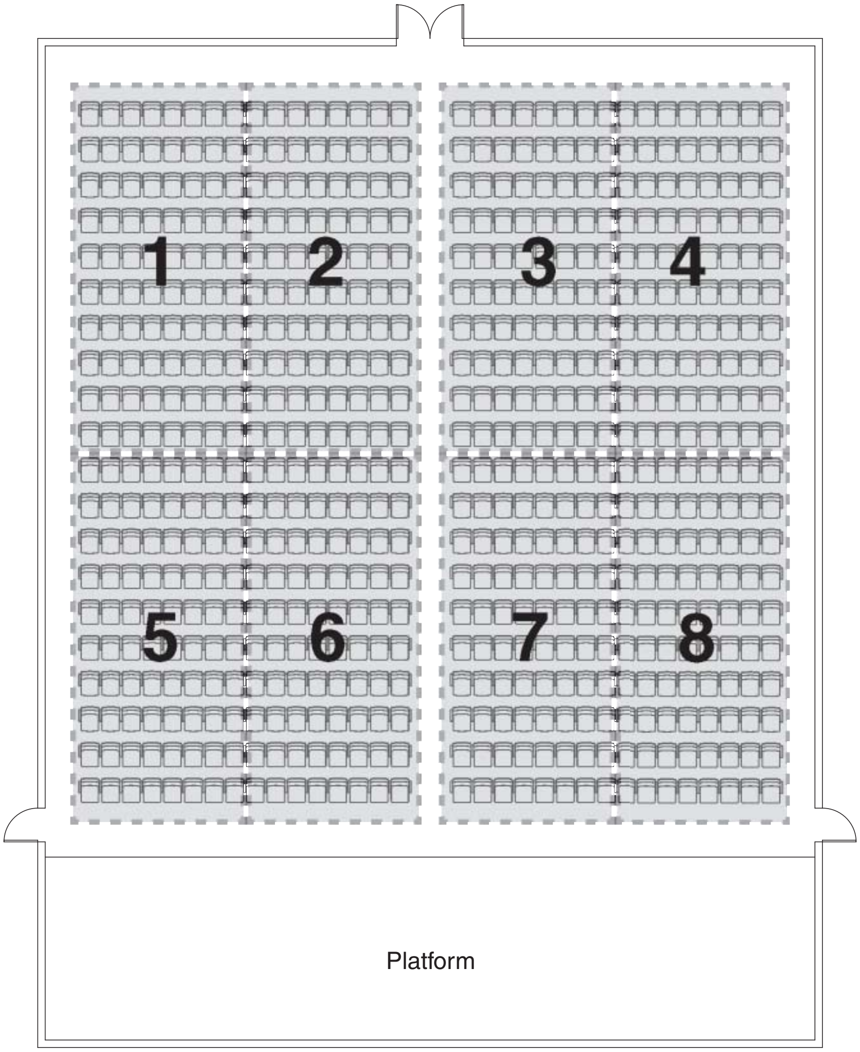


FIGURE 19-A-2. The theater seating with the catchment areas identified.

Step 3: Total the occupant load for each catchment area and size the aisle widths and capacities based on those occupant loads.

Each catchment area has an occupant load of 80. For the side aisles (i.e., catchment areas 1, 4, 5, and 8), the occupant load used to size those portions of the aisles will be the occupant load of each catchment area. For the catchment areas along the center aisle, the occupant load to size those portions of the aisle will be the sum of the two catchment areas across from each other on the aisle (i.e., catchment areas 2 and 3 and 6 and 7). Therefore, using the egress factor for other egress components, the calculation to determine the required capacities is as follows:

$$\text{Side Aisles: } 80 \text{ occupants} \times 0.15 \text{ inch/occupant} = 12 \text{ inches}$$

$$\text{Center Aisle: } 150 \text{ occupants} \times 0.15 \text{ inch/occupant} = 24 \text{ inches}$$

The required capacities are much less than the required minimum widths, which are 36 inches for aisles with seating on one side and 42 inches for aisles with seating on both sides. Therefore, the minimum widths must be used (Figure 19-A-3).

For the aisle behind the back row of seating, the minimum width or capacity of the egress path cannot be diminished; there the 36-inch minimum must be maintained. For the aisles located in front of the first row of seating leading to the egress doors, the required minimum width is not as clearly defined. Therefore, the widths for seating on one side (i.e., 36 inches) can be used, since the center aisle splits at this point and each side of that aisle is now supporting an occupant load for seating only on one side.

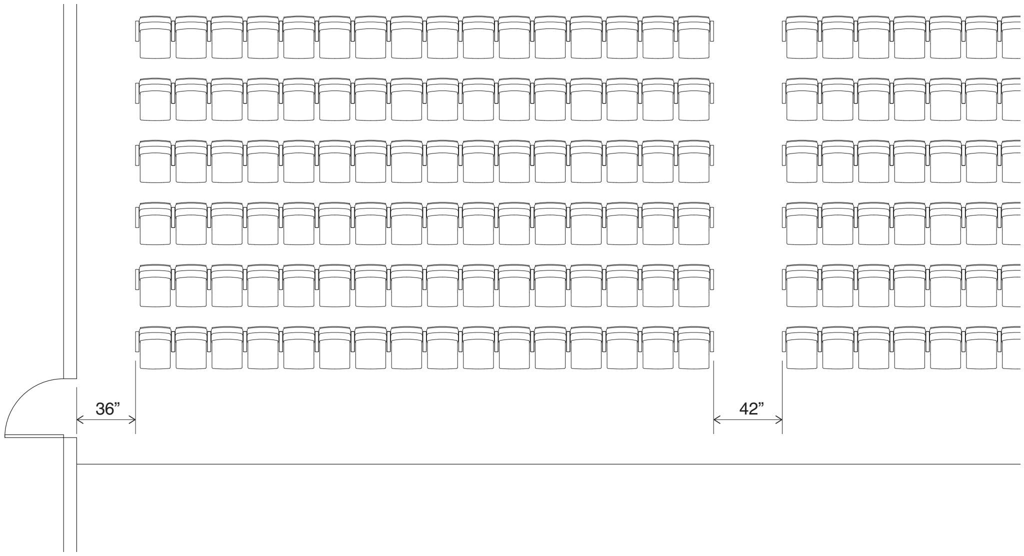


FIGURE 19-A-3. Minimum aisle width dimensions.

EXAMPLE PROJECT—STEP 19

The egress calculated is based on the revised occupant load determined in Step 14. The lower factors for egress sizing may be utilized since a NFPA 13R system is installed, but the installation of an emergency voice/alarm communications system would be required. It is assumed that the designed egress width will exceed the minimum required so the larger factors will be used, thus avoiding the added cost of an emergency voice/alarm communications system.

EGRESS WIDTH FROM STORIES

Stairways

$$\text{Basement: } 87 \text{ occupants} \times 0.30 \text{ inch/occupant} = 26.1\text{-inch capacity}$$

$$\text{2nd through 4th Stories: } 73 \text{ occupants} \times 0.30 \text{ inch/occupant} = 21.9\text{-inch capacity}$$

The minimum width for stairways is 44 inches; therefore, the minimum width will be provided in both stairways providing a total of 88 inches of minimum required width.

Other Egress Components

For the stories requiring egress through the stairways, the doors into the stairways must comply with the width requirements based on other egress components. On the residential stories, the dwelling units have a corridor connecting the stairways, which are also considered within this category. Since all spaces on these levels use the stairway doors and corridors, the minimum widths are calculated as follows:

$$\text{Basement: } 87 \text{ occupants} \times 0.20 \text{ inch/occupant} = 17.4\text{-inch capacity}$$

$$\text{2nd through 4th Stories: } 73 \text{ occupants} \times 0.20 \text{ inch/occupant} = 14.6 \text{ inches}$$

The minimum width of doorways is 32 inches and the minimum width of corridors is 44 inches. Both minimum widths exceed the calculated capacities for the basement and second-, third-, and fourth-story doors and corridors; thus, the minimum widths will have to be met. The current design uses 36-inch-wide doors (33-inch clear width) and 60-inch-wide corridors, so the minimum requirements have been exceeded.

The first story is a different situation since many spaces have exits directly to the exterior. However, as a whole, the total number of exits on the first story must provide the following minimum egress capacity:

$$\text{1st Story: } 377 \text{ occupants} \times 0.20 \text{ inch/occupant} = 75.4\text{-inch capacity}$$

The first story has a sufficient number of doors that exceed the required minimum widths, and adequate width is provided in the design for the occupant load within each space. The 60-inch-wide corridor, however, does not provide sufficient width, but the corridor does not serve all occupants within the story.

As shown in Example Project Figure 19-1, all of the occupants for the dining hall kitchen, dining hall, convenience shop, lounge, mechanical room, manager's apartment, and trash room (via the mechanical room) have access to the minimum number of egress doors from their respective spaces without having to egress through the corridor. Therefore, the corridor is only required to serve a total of 78 occupants (i.e., circulation space, management office, exercise room, mail room, and the two study rooms). At this occupant load, the calculated capacity will be as shown below:

$$\text{1st} - \text{Story Corridor/Door Capacity: } 78 \text{ occupants} \times 0.20 \text{ inch/occupant} = 15.6\text{-inch capacity}$$

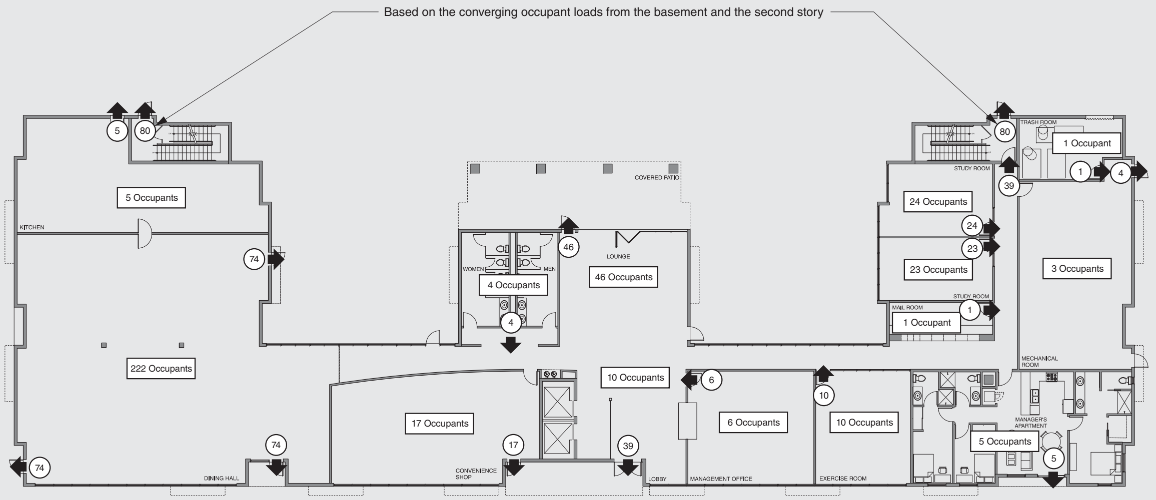
The calculated capacity is less than the minimum width of 44 inches required for corridors; therefore, the 60-inch-wide corridor provided complies with the code. Additionally, the exit doors available (the main entrance double doors, the east stairway door, and the door west of the restrooms) provide a total of 135 inches of clear width, which is more than the minimum width of 64 inches (i.e., two 32-inch clear-width doors).

EGRESS FROM SPACES

The only space requiring further consideration is the dining hall, since its occupant load is 222. The calculated minimum capacity for the dining hall is as follows:

$$\text{Dining Hall: } 222 \text{ occupants} \times 0.20 \text{ inch/occupant} = 44.4\text{-inch capacity}$$

Since two means of egress are required, the capacity of each door must be 22.2 inches. The proposed floor plan provides three doors directly from the space to the exterior, each with a clear width of 33 inches for a total width of 99 inches—more than enough capacity.



EXAMPLE PROJECT FIGURE 19-1. Occupant load egress for the first story.

CONVERGENCE

The basement level occupant loads and the second-story occupant loads will converge within the two stairways at the first story. This will require the doors from the exit enclosure to the exterior to have the minimum capacity or exit based on the sum of the occupant loads converging at that point. A total of 87 occupants is egressing from the basement and 73 occupants from the second story, which provides a total occupant load of 160, leaving the building at the exterior doors at the stairways. Each stairway will need to be sized for 80 occupants:

$$\text{Stairway Exterior Door: } 80 \text{ occupants} \times 0.20 \text{ inch/occupant} = 16\text{-inch capacity}$$

The capacity of each door is less than the minimum required width of 32 inches so each door must provide the 32-inch clear width. The current design uses 36-inch-wide doors, so the clear width provided at each door is 33 inches.

AISLES AND AISLE ACCESSWAYS

Aisles and aisle accessways will be relevant to this project for the dining hall and convenience shop. The location of tables and chairs in the dining hall and display cases in the convenience shop must comply with the minimum widths indicated in Step 10.2.3. Some building departments will require a furniture layout to show that proper widths can be provided.

However, for this project, these spaces are designed as shell space. The tenants who lease the space to provide those services will be required to submit construction documents for their respective tenant improvement projects.

STEP 20

Check Accessibility Requirements

STEP OVERVIEW

The details of accessibility compliance are reviewed and integrated during this step. Built-in *elements* are checked for reach requirements, *accessible* assembly seating is checked for lines of sight, and plumbing fixtures and accessories are checked for proper location and space clearances. Other details include integration of special requirements for *dwelling* and *sleeping units* and recreational facilities.

20.1 REACH AND CLEARANCE DETAIL REQUIREMENTS

As the design of a building develops, attention to detail in regard to accessibility must be given. Certain building *elements* must be sized and located to ensure they can be used by the disabled. Lack of early consideration in the design process may require modifications that could adversely affect a project's design aesthetic.

The use of architectural cabinets, countertops, service counters, checkout aisles, and tables require that they be designed so that persons with disabilities can utilize them without added difficulty. ICC/ANSI A117.1 Chapter 9 provides the requirements for built-in furnishings and *elements*. These requirements are based, in part, on the requirements of ICC/ANSI A117.1 Section 308 for obstructed reach. Obstructed reach involves the limitations of a person extending over an obstruction, such as a counter or cabinet, to grab or touch an object on the far side. These obstructions may be limited in depth depending on the required elevation of reach—the higher a person must reach, the narrower the depth.

The heights of surfaces are also limited, but the actual dimensions differ relative to the purpose of the surface. Work surfaces and dining surfaces must be between 28 and 34 inches per ICC/ANSI A117.1

Section 902. Sales and service counters are permitted to be 36 inches high per ICC/ANSI A117.1 Section 904, but if the counter is less than 36 inches, then the entire counter must be at that lower height. Also in the same section, checkout aisles are permitted to be higher at 38 inches above the floor surface, while food service lines are restricted to a height between 28 and 34 inches.

Where a forward approach is necessary or desired, clearance under the surface must be provided. Therefore, below lavatories and some surfaces and counters, knee and toe clearances are required per ICC/ANSI A117.1 Section 306. Regarding knee clearance, a height of 27 inches is required under the surface. If the 27-inch clearance is not provided for the full depth of the surface, then sufficient toe clearance is required. A minimum 9-inch height is required above the floor surface at a depth that is no more than 6 inches. See ICC/ANSI A117.1 Figures 306.2 and 306.3 for illustrations of the knee and toe clearance requirements.

All *elements* that are required to be *accessible* must be provided with a 30-inch-wide by 48-inch-long clear floor space. The clear floor space may include the knee and toe clearance previously described; however, the clear floor space cannot extend more than 25 inches under a surface *element*. Turning spaces complying with ICC/ANSI A117.1 Section 304 are required in many locations and are identified in ICC/ANSI A117.1. Turning spaces can be either a 60-inch-diameter circle or a 60-inch-square T-shape with 12-inch by 24-inch notches at the bottom of the T-shape. The turning space may overlap with required clear floor spaces and clearances at fixtures and doors. Table 20.1-1 provides a listing of *elements* and conditions that require a turning space.

20.2 ACCESSIBLE ASSEMBLY SEATING (IBC SECTION 1108.2 AND ICC/ANSI A117.1 SECTION 802)

In spaces used for assembly purposes, whether classified as Group A occupancies or not, the spaces must provide equal accessibility for disabled persons. The primary concern is areas where fixed seating is provided, performance areas, and seating within dining and drinking areas.

TABLE 20.1-1. Conditions Where a Turning Space Is Required

Condition	ICC/ANSI A117.1 Reference
Passing space created by intersecting spaces permitted to be a T-shape turning space	Section 403.5.2
Two doors in a series (excludes doors in Accessible units per Section 1002.5, Exception 3, Type A units per Section 1003.5, Exception 3)	Section 404.2.5
Change in direction on a ramp	Section 405.7.4
Ramp landings with adjacent lockable doors	Section 405.7.5
Optional elevator car dimensions	Table 407.4.1
Toilet and bathing rooms	Section 603.2.1
Saunas and steam rooms	Section 612.3
Dressing and fitting rooms	Section 803.2
Holding and housing cells	Section 806.2.1
Courtrooms	Section 807.2
All rooms served by an accessible route in an Accessible unit (excludes toilet rooms and bathrooms not required to comply with Section 1002.11.2 and pantries and closets not deeper than 48 inches)	Section 1002.3.2
All rooms served by an accessible route in a Type A unit (excludes toilet rooms and bathrooms not required to comply with Section 1003.11.2 and pantries and closets not deeper than 48 inches)	Section 1003.3.2
Load and unload areas of amusement rides	Section 1102.3
Fishing piers and platforms	Section 1105.5
Option for play areas with less than 1,000 sq. ft. and using the reduced width for an accessible route	Section 1108.4.1.4.1, Exception 1
Play components	Section 1108.4.3.1
Shooting facilities	Section 1110.1

For performance areas, the focus is on *accessible routes* per Step 13.3. Between the performance area and the assembly seating area, an *accessible route* is required where a *circulation path* exists between the performance area and assembly seating area; if no *circulation path* is provided, then the *accessible route* is not required. However, an *accessible route* is required between the performance area and ancillary areas used by performers.

Similar to performance areas, the main focus for dining and drinking areas is on the *accessible route* per Step 13.3. All floor areas, whether located inside or outside, are required to be *accessible*, but some situations are afforded exceptions. A *mezzanine* for a dining and drinking area is not required to be *accessible* if it provides less than 25% of the area for dining and drinking. Tiered dining areas in sports facilities must have *accessible routes* to at least 25% of the dining area, provided that all *accessible* seating is on an *accessible route* and is provided the same services.

In assembly seating where fixed seating is installed, *wheelchair spaces* are required to be distributed throughout the seating area. A *wheelchair space* per ICC/ANSI A117.1 Sections 802.3 and 802.4 is an unobstructed area that is 36 inches wide by 48 inches long. If multiple *wheelchair spaces* are provided, then the width of each space can be reduced to 33 inches. If *wheelchair spaces* can only be approached from the side, then the length of the space is required to be 60 inches. *Wheelchair spaces* cannot overlap the required *aisle* widths per Step 10.2.3.

The number of *wheelchair spaces* required depends on the number of seats within the seating area per IBC Table 1108.2.2.1. Seating areas to be considered include boxes and suites and not just the public seating areas. IBC Section 1108.2.4 specifies that all luxury boxes, club boxes, and suites be provided with *wheelchair spaces*. In other boxes, *wheelchair spaces* are required to be provided in not less than 20% of the boxes. Each *wheelchair space* provided shall be paired with a companion seat. Companion seats, per ICC/ANSI A117.1 Section 802.7.2, shall be aligned shoulder to shoulder with the associated *wheelchair space*.

As previously mentioned, *wheelchair spaces* are required to be dispersed across all types of seating locations, including boxes and suites. In the general seating areas, *wheelchair spaces* are required on the main seating level as well as on one of every two additional floor or *mezzanine* levels when *multilevel assembly seating* areas are provided. Exceptions to these requirements include the following:

- *Wheelchair spaces* are permitted to be located only on the main level seating area for worship services where no more than 25% of the seating capacity is located on a level other than the main level.
- *Wheelchair spaces* are permitted only on the main level seating area where the total seating capacity does not exceed 300 and no more than 25% of the capacity is located on a level other than the main level.
- *Wheelchair spaces* are not required in team or player seating areas of sports facilities.

In accordance with ICC/ANSI A117.1 Section 802.10.2, the locations of *wheelchair spaces* are required to be dispersed at a variety of distances from the performance area, except for bleachers, movie theaters with 300 seats or less, or other assembly spaces with 300 seats or less where all *wheelchair spaces* are located within the front half of the seating rows. *Wheelchair spaces* shall also be dispersed horizontally to provide a variety of options. Additionally, ICC/ANSI A117.1 Section 802.10.3 requires that *wheelchair spaces* be dispersed among distinct areas that have different amenities.

In addition to *wheelchair spaces*, at least 5% of the *aisle* seating spaces, but not less than one, shall be designated *aisle* seats for persons with disabilities. The *aisle* seats shall be those located closest to the *accessible routes*. These are not *wheelchair spaces* but fixed seating that can be used by mobility-impaired persons using a walker or cane.

Also needing consideration at this phase of design are the sightlines for *wheelchair spaces*. This may require adjustment of floor elevations where the *wheelchair spaces* are located. When spectators are seated, the line of sight shall be either over the heads or over the shoulders and between the heads of those seated in the row immediately in front of the *wheelchair spaces* per ICC/ANSI A117.1 Section 802.9.1. For standing spectators, ICC/ANSI A117.1 Section 802.9.2 requires a *wheelchair space* be located within 12 inches of the chair back in the row in front of the *wheelchair space*. The height of the *wheelchair space location (ICC/ANSI)* shall be in accordance with ICC/ANSI A117.1 Table 802.9.2.2. The height is based on the spacing of rows and is measured from the floor surface of the row immediately in front of the *wheelchair space location*.

20.3 KITCHENS (IBC SECTION 1109.4 AND ICC/ANSI A117.1 SECTION 804)

The scoping requirements in the IBC for kitchens and kitchenettes are very minimal, requiring only that when they are provided within *accessible* spaces they, too, need to be *accessible*. For *dwelling units* and *sleeping units*, the requirements are associated with the requirements for *Accessible units*, *Type A units*, and *Type B units*. For space planning purposes, the configuration of kitchens will dictate how much space a kitchen will require. ICC/ANSI A117.1 provides requirements for two types of kitchen configurations: pass-through and U-shaped.

Pass-through kitchens are required to be open at both ends of the kitchen. The width between the cabinets on opposite sides, or between the cabinets on one side and a wall on the other, is required to be 40 inches. U-shaped kitchens are enclosed on three sides, whether or not all sides include cabinets. Clearance between opposing cabinets or walls is 60 inches.

A clear floor space of 48 inches by 30 inches is required for each appliance and the sink. At least one work surface is required if the kitchen includes a cooktop or conventional range. The work surface shall provide a minimum 30-inch width for a forward approach with the clear space extending 17 to 25 inches under the work surface for knee and toe clearance. For pass-through kitchens that cannot provide a 60-inch-diameter turning space, the clear space below the work surface shall be 36 inches wide to accommodate a T-shaped turning space.

- Kitchen sinks must provide clear space for a forward approach with 17 to 25 inches located under the sink for knee and toe clearance. If a sink has multiple bowls, the knee and toe clearance under the sink is only required for one of the bowls.
- The clear space for a dishwasher shall be positioned next to the dishwasher door. When the door is opened, the door shall not encroach on the clear space for the dishwasher or the sink.
- Ovens are required to have a clear space situated so that the oven door does not encroach on the clear space. If the door is side hinged, a work surface must be provided on the latch side of the oven. If the door is bottom hinged, a work surface must be provided on one of the sides of the oven.
- Cooktops can have either a forward or parallel approach. If a forward approach is provided, then the clear space shall extend 17 to 25 inches under the cooktop. For a parallel approach, the clear space shall be centered on the cooktop.
- The clear space for a refrigerator/freezer shall be offset 24 inches between the centerline of the appliance and the centerline of the clear space.

20.4 DWELLING AND SLEEPING UNITS (ICC/ANSI A117.1 CHAPTER 10)

During Step 13.4 in the schematic design, *accessible* units were addressed to make sure the location, number, and general size of the units were considered early in the design process. Now, in design development, the details of those *accessible* units must be applied to ensure that the size of units can sufficiently accommodate the minimum widths and clear spaces for bathrooms and kitchens.

20.4.1 TOILET AND BATHING FACILITIES IN DWELLING AND SLEEPING UNITS

Toilet and bathing facilities for *dwelling units* and *sleeping units* have slightly different requirements than those described in Step 13.5.1. As previously mentioned, *dwelling units* and *sleeping units* are required to meet the requirements for *Accessible units*, *Type A units*, or *Type B units*, as applicable for the type of occupancy group (see Table 13.4-1). The requirements discussed below do not cover all of the accessibility issues related to toilet and bathing facility design; only those affecting space configuration are addressed at this phase.

- **Accessible Units (ICC/ANSI A117.1 Section 1002.11):** At least one toilet and bathing facility is required to comply with the requirements described in Step 13.5.1; all other toilet and bathing facilities provided must provide reinforcement for grab bars and shower seats if *Type B units* are required in the structure. Grab bar reinforcement is required at water closets, bathtubs, and showers. The *accessible* toilet and bathing facility must include a lavatory, water closet, and a shower or bathtub. All fixtures must be located within the same area so that travel through other areas of the unit is not required between fixtures.
- **Type A Units (ICC/ANSI A117.1 Section 1003.11):** At least one toilet and bathing facility is required to comply with the requirements described in Step 13.5.1; all other toilet and bathing facilities provided must provide reinforcement for grab bars and shower seats. Grab bar reinforcement is required at water closets, bathtubs, and showers. Exceptions to the requirements discussed in Step 13.5.1 include the following:
  - A lavatory, not more than 24 inches in depth, is permitted within the clear space of the water closet. The side edge of the lavatory must be located no closer than 18 inches to the centerline of the water closet.
  - Standard roll-in showers are permitted to have lavatories, countertops, or cabinets at one end of the clear space provided the counter or cabinets can be removed and the floors and walls are finished.
- **Type B Units (ICC/ANSI A117.1 Section 1004.11):** Fixtures on floor levels that are not required to be *accessible* do not need to comply with the requirements for toilet and bathing facilities. Toilet and bathing facilities provided on *accessible* floors must include reinforcement for grab bars and shower seats. Grab bar reinforcement is required at water closets, bathtubs, and showers. Where a side wall is not provided for a water closet to allow the installation of a future grab bar, reinforcement for swing-up grab bars are permitted. Two options are provided regarding toilet and bathing facilities in *Type B units*:
- **Option A (ICC/ANSI A117.1 Section 1004.11.3.1):** All toilet and bathing areas must provide the following:
  - A lavatory with a 48-inch by 30-inch clear space centered on the lavatory for a parallel approach.
  - A water closet with a clear space measuring 48 inches wide from the side with a clearance of 16 to 18 inches and 56 inches deep from the rear wall. If the water closet has a forward approach, the clear space depth shall be 66 inches from the rear wall. A vanity not more than 24 inches in depth from the rear wall is permitted within the water closet clear space, provided the remaining clear space is at least 33 inches wide. See ICC/ANSI A117.1 Figure 1004.11.3.1.2.

- A bathtub, where provided, shall have a 60-inch-long by 30-inch-wide clear space for a parallel approach, or a 60-inch-long by 48-inch-wide clear space for a forward approach. A lavatory is permitted within the clear space for a parallel approach; however, a 48-inch by 30-inch clear space must be provided in front of the bathtub. A lavatory and a water closet are permitted within the clear space for a forward approach. See ICC/ANSI A117.1 Figures 1004.11.3.1.3.1 and 1004.11.3.1.3.2.
- A shower, where provided as the only bathing fixture, shall be at minimum a transfer-type compartment as described in Step 13.5.1.

- **Option B (ICC/ANS A117.1 Section 1004.11.3.2):** Only one toilet and bathing facility is required and all fixtures must be located within the same area so that travel through other areas of the unit is not required between fixtures. The toilet and bathing facility must provide fixtures as required for Option A with the following exception:
  - A bathtub, where provided, must have a 48-inch-long by 30-inch-wide clear space located at the control end of the bathtub with the long dimension parallel to the bathtub. No other fixture, cabinet, or counter is permitted within this clear space. See ICC/ANSI A117.1 Figure 1004.11.3.2.3.1.

20.4.2 KITCHENS IN DWELLING AND SLEEPING UNITS

The requirements for kitchens in *dwelling units* and *sleeping units* follow the basic requirements described in Step 13.7. However, some unit types will have slight modifications to the basic requirements.

- **Accessible Units (ICC/ANSI A117.1 Section 1002.12):** The kitchen or kitchenette in an *Accessible unit* shall comply with the requirements as described in Step 13.7.
- **Type A Units (ICC/ANSI A117.1 Section 1003.12):** Cabinets are permitted under the required work surface and sink, provided the cabinet can be removed and the floor and wall surfaces are finished.
- **Type B Units (ICC/ANSI A117.1 Section 1004.12):** A parallel approach is permitted at the sink with the required clear space centered on the sink. Work surfaces are not required.

20.5 RECREATIONAL FACILITIES

ICC/ANSI A117.1 Chapter 11 covers recreational facilities that include *amusement rides (ICC/ANSI)*, boating facilities, exercise machines and equipment, fishing piers and platforms, golf and miniature golf facilities, play areas, *swimming pools*, wading pools, hot tubs and spas, and shooting facilities. Of these, *swimming pools*, wading pools, hot tubs, and spas are addressed in detail in this step. Where a project includes other covered recreational facilities, review the requirements of the applicable sections in ICC/ANSI A117.1.

Swimming pools are required to have at least two *accessible* means of entering the *swimming pool*. Means of entry that are acceptable include pool lifts, sloped or ramped entries, transfer walls, transfer systems, and *stairs* that comply with specific requirements. If the *swimming pool* has less than 300 linear feet of pool wall, then only one means of *accessible* entry is required. Wading pools only require one entry that shall be sloped. Hot tubs and spas also only require one *accessible* entry but are permitted to use a lift, transfer wall, or transfer system.

- **Pool lifts**, where provided, must be located where the depth does not exceed 48 inches, unless the entire pool has a depth greater than 48 inches. The design of the pool lift must comply with the requirements of ICC/ANSI A117.1 Section 1109.2. Beyond the equipment requirements imposed on manufacturers of lifts, the only other requirement for pool lifts applicable to the building design is the required clear deck space per ICC/ANSI A117.1 Section 1109.2.3. The clear space must be located adjacent to the seat position on the side opposite of the pool edge. The centerline of the pool lift seat cannot be closer than 16 inches from the pool's edge. The clear space is required to be 36 inches by 48 inches and located parallel to the seat with one edge located 12 inches from the back of the seat.

- **Sloped entries** must comply with the requirements for *accessible routes*, which must be modified as stated in ICC/ANSI A117.1 Section 1109.3. In *swimming pools*, the sloped entry must go a depth of 24 inches and a maximum of 30 inches below the water level, whereas sloped entries for wading pools must extend to the deepest portion of the pool. *Handrails* are required on both sides with a minimum clear width of 33 inches and a maximum clear width of 38 inches. *Handrail* extensions are not required. Sloped entries for wading pools are not required to have *handrails*.
- **Transfer walls** provide a means of entering the pool by transferring from a wheelchair to a wall, then to the water per ICC/ANSI A117.1 Section 1109.4. The deck is lowered at the wall to a depth that is 16 to 19 inches below the top of the wall. The transfer wall shall have a width of 12 to 16 inches and a minimum of 60 inches long. A grab bar is required at the center of the 60-inch dimension. Two grab bars are permitted, but they must have a 24-inch minimum clearance between them and must also be centered on the wall. A clear deck space of 60 inches by 60 inches is required to be centered on the transfer wall length.
- **Transfer systems**, per ICC/ANSI A117.1 Section 1109.5, consist of a series of steps that start at a height between 16 and 19 inches above the deck and extend to a depth of at least 18 inches below the water level. The riser of each step cannot exceed 8 inches and the treads must be between 14 and 17 inches. The topmost step is the transfer area and it must have a depth not less than 19 inches. Each step shall be provided with an individual grab bar or the entire transfer system is provided with a single continuous grab bar. The clear width of the transfer system shall be 24 inches between the edge and the grab bars. A clear deck space of 60 inches by 60 inches centered on the transfer system is required.
- **Pool stairs**, per ICC/ANSI A117.1 Section 1109.6, shall comply with the requirements for *stairways* of ICC/ANSI A117.1 Section 504. The treads must be a minimum of 11 inches; however, the risers are not required to conform to the 4- to 7-inch dimension as long as the riser height is uniform. *Handrails* are required on each side with a clear width of 20 to 24 inches. *Handrail* extensions are not required.

EXAMPLE PROJECT—STEP 20

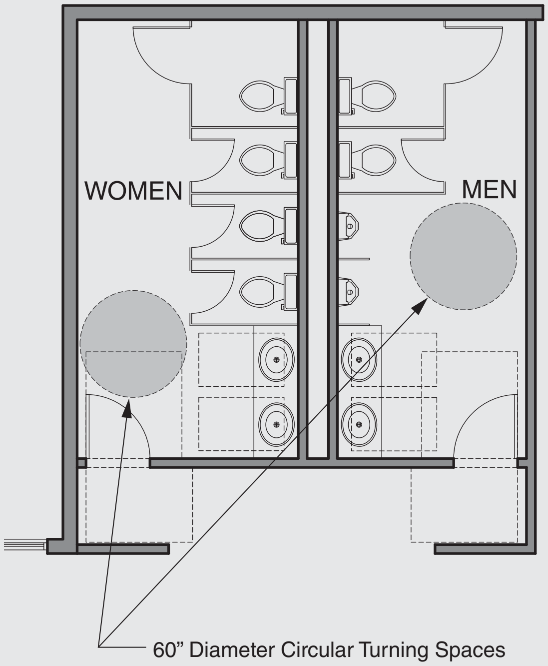
REACH AND CLEARANCE DETAIL REQUIREMENTS

For this project, the reach requirements apply to appliances, drinking fountains, lavatory counters and faucets, transaction counters, and mailboxes. Since all of the appliances for this project are within dwelling units, they will be addressed below under that heading.

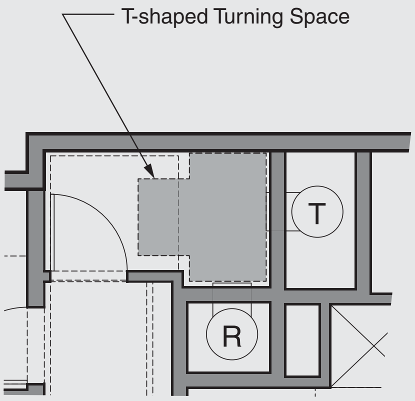
The public restrooms are required to be provided with turning spaces, so 60-inch-diameter turning spaces are provided (Example Project Figure 20-1). Although not required to have a turning space, the trash rooms on each of the residential floors are provided with a turning space because it makes sense. A circular turning space is not feasible, so a T-shaped turning space complying with ICC/ANSI A117.1 Section 304.3.2 is provided instead (Example Project Figure 20-2).

Lavatory counters within the public restrooms must provide the toe and knee clearance per ICC/ANSI A117.1 Section 306. Faucets mounted on those lavatories must be within the obstructed high forward reach, since the counters are 24 inches wide.

The drinking fountains selected must comply with ICC/ANSI A117.1 Section 602. Since two drinking fountains are required (Step 11), one will be provided at the 36-inch maximum height and the second one will be provided at a height between 38 and 43 inches.



EXAMPLE PROJECT FIGURE 20-1. Circular turning spaces in the public restrooms.



EXAMPLE PROJECT FIGURE 20-2. T-shaped turning space in trash rooms on residential floors.

At the management office, a transaction counter is provided for service. This counter is required to be located no more than 36 inches above the floor surface.

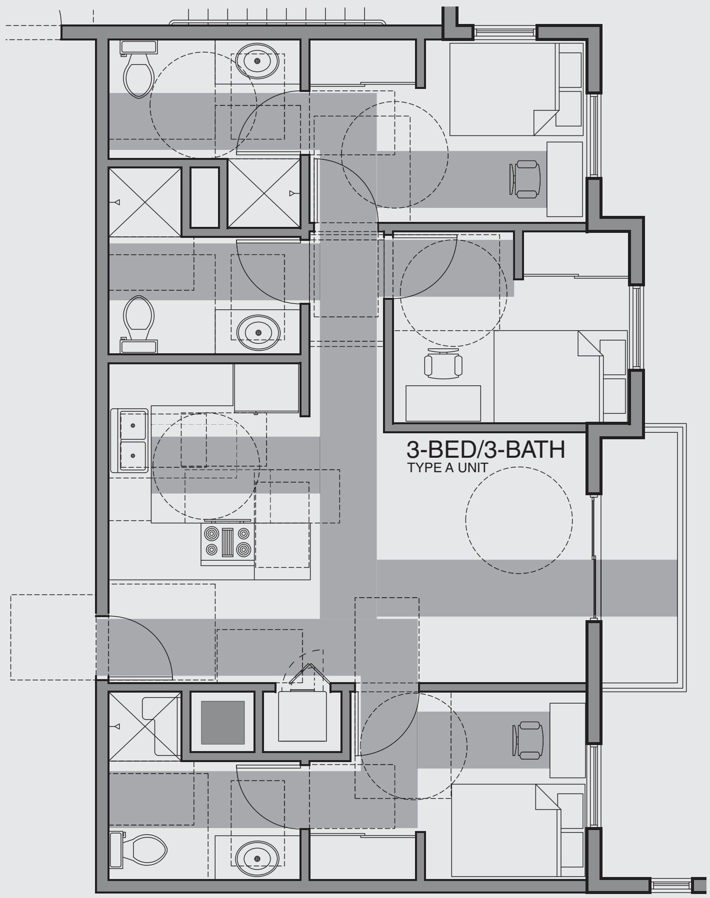
Finally, the mailboxes must be within one of the reach requirements provided in ICC/ANSI A117.1 Section 308. The current design allows each box to be accessed from either an unobstructed side or forward reach with no box lower than 15 inches above the floor and no box higher than 48 inches above the floor.

DWELLING UNITS

As determined in Step 13, one apartment is required to comply with the requirements for Type A units. A three-bedroom unit was selected to be designed as a Type A unit and all remaining units are designed as Type B units.

Type A Unit

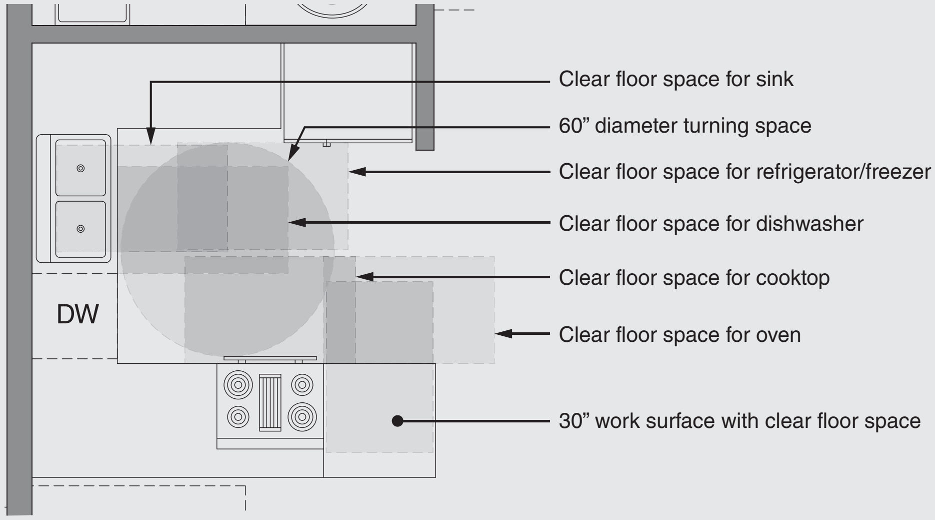
The Type A unit (Example Project Figure 20-3) has all spaces located on an accessible route and each space, with the exception of two bathrooms, has 60-inch diameter turning spaces. The other two bathrooms comply with ICC/ANSI A117.1 Section 1003.3.2, Exception 1, by providing a 30-inch by 48-inch clear floor space beyond the swing of the bathroom door. The clear floor spaces for the showers in these bathrooms meet the requirement. Further, all doorways within the Type A unit have the minimum 32-inch clear width. The balcony is not required to include a turning radius nor is it required to have maneuvering clearances per ICC/ANSI A117.1 Section 1003.5 Exception 6, but an accessible route is provided to the balcony and the width of the sliding door provides a 32-inch clear width. The threshold will need to be a maximum of 3/4 inches high with beveled edges at a 1:2 slope.



EXAMPLE PROJECT FIGURE 20-3. Type A accessible unit with 32-inch-wide accessible route indicated. All turning spaces and all clear floor spaces are located on the accessible route.

Appliances within the Type A unit are provided with clear floor spaces in accordance with the requirements for each type of appliance. The washer and dryer have a clear floor space with its centerline located within 24 inches of the appliance centerline based on the requirements for stackable front loading machines. All controls are within the reach requirements.

The kitchen design is a standard U-shaped configuration (Example Project Figure 20-4). Because of this arrangement with cabinets on all three sides, a 60-inch clear width is provided between the cabinets on one side and the refrigerator/freezer on the other side, which also allows a 60-inch-diameter turning space within the kitchen area.

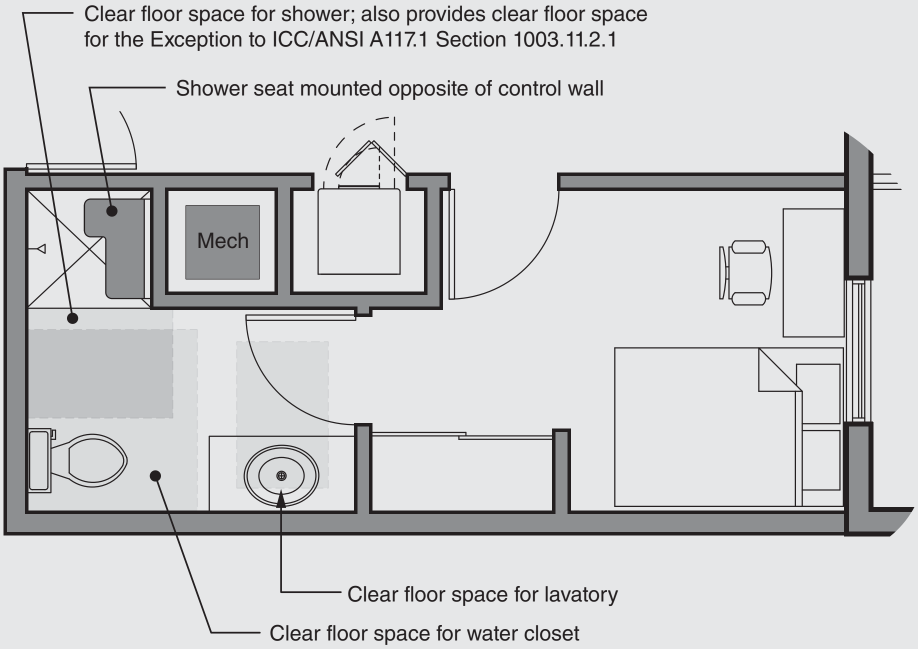


EXAMPLE PROJECT FIGURE 20-4. Kitchen layout for the Type A unit with each clear floor space identified.

The appliances within the kitchen have operable parts that are within the reach requirements, except that the stove cannot have controls that require reaching over burners. Since the cooktop and oven are combined in the same appliance, each function must have its own clear floor space. For the cooktop, the clear floor space is centered on the appliance, whereas the clear floor space for the oven is off to the side of the appliance so it is not obstructed by the oven door. Similarly, the door of the dishwasher cannot overlap the clear floor space of the dishwasher or the adjacent sink. The refrigerator/freezer has a clear floor space with a centerline that is within 24 inches of the centerline of the refrigerator/freezer.

Other areas within the kitchen, such as the sink and counters, comply with the requirements for Type A units. All counter heights are at 34 inches even though only a 30-inch-wide work surface is required at the 34-inch height. However, the work surface is required to be used from a forward approach, so knee and toe clearance is provided underneath the 30-inch-wide work surface only. ICC/ANSI A117.1 does not indicate where the work surface is to be located within the kitchen, so for this project it is located adjacent to the cooktop/oven. The kitchen sink, like the work surface, is provided with knee and toe clearance as required by ICC/ANSI A117.1.

Regarding the bathrooms, only one is required to comply with the requirements of ICC/ANSI A117.1 Section 1003.11.2 (Example Project Figure 20-5). For this example project, two of the three bathrooms comply with the clear floor space requirements, but only the south bathroom complies with all of the requirements. The other two bathrooms will have reinforcements for future installation of grab bars and shower seats per ICC/ANSI A117.1 Section 1003.11.1.



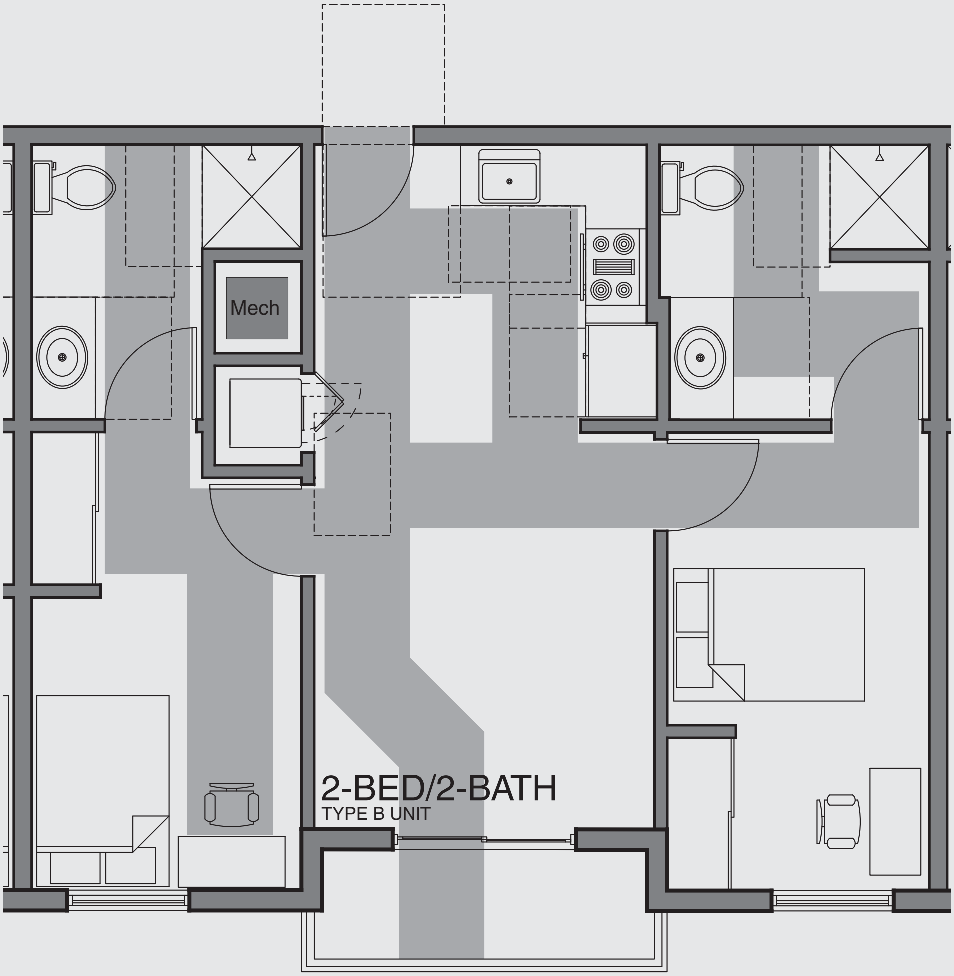
EXAMPLE PROJECT FIGURE 20-5. Bathroom layout for the Type A unit.

The selected bathroom has a lavatory designed for a forward approach with knee and toe clearance. A mirror will be mounted on the wall behind the lavatory with a bottom edge not more than 40 inches above the floor. The water closet is located 17 inches from the wall to the centerline of the water closet, which allows 1 inch of tolerance within the 16- to 18-inch required dimension. A 60-inch-wide by 56-inch-deep clear space is provided around the water closet.

A shower is provided in lieu of a bathtub, so the requirements of ICC/ANSI A117.1 Section 1003.11.2.5.2 are applicable, which requires compliance with Section 608 of the same standard. The shower is designed to be a transfer-type compartment with dimensions exceeding the minimum 36 by 36 inches. A clear floor space of 36 by 48 inches is situated with the long dimension perpendicular from the control wall. A shower seat is mounted on the wall opposite the control wall.

Type B Units

All of the Type B units comply with one or more of the requirements for Type A units (Example Project Figure 20-6). However, because they do not comply fully with the requirements for Type A units, they must be classified as Type B units. Within the Type B units, there is an accessible route that connects all the spaces within the unit and the primary entrance. Doors exceed the minimum 31 3/4-inch clear width and the threshold at the balcony sliding door does not exceed 3/4 inch in height and has beveled edges sloped at 1:2.



EXAMPLE PROJECT FIGURE 20-6. Type B accessible unit with 32-inch-wide assessable route.

At laundry equipment, a parallel approach is shown; however, a forward approach is also feasible at all Type B units. Bathrooms are required to be provided with reinforcements for grab bars and shower seats. In bathrooms where the door swing overlaps a clear floor space for a fixture, a clear floor space is available outside of the door's swing. The clear floor space provided for the shower typically satisfies this requirement.

Fixtures in bathrooms for this project are provided with clearances complying with Option A per ICC/ANSI A117.1 Section 1004.11.3. Lavatories are provided with clear floor spaces configured for a parallel approach and are centered on the lavatory. Water closets are positioned 17 inches from the side wall to allow a 1-inch tolerance. Although a 48-inch-wide by 56-inch-deep clearance is required around a water closet, clearances of 60 inches wide by 56 inches deep are provided. Showers are provided in sizes greater than the minimum 36 inches by 36 inches. Clear floor spaces measuring 30 inches wide by 48 inches long are situated in front of the shower with the long dimension perpendicular to the control wall.

Kitchens are provided in U- and L-shaped configurations. ICC/ANSI A117.1 does not address L-shaped kitchens, but most L-shaped kitchens in the building have rather large open areas on one side, so minimum clearance is not an issue. The corner two-bedroom apartment units have L-shaped kitchens that have a wall on the opposite side. Since this does not meet the description of a U-shaped kitchen (i.e., counters, appliances, or cabinets on three contiguous sides), only a 40-inch clearance is required between cabinets, counters, or appliances and the opposite wall. Clear floor spaces in Type B unit kitchens comply with the requirements for the Type A unit, except that a 30-inch-wide work surface with knee and toe clearances is not required, and neither are knee and toe clearances required for the sink. The sink, however, must have a clear floor space for a parallel approach.

RECREATIONAL FACILITIES

The swimming pool and the exercise room are the only recreational facilities provided for this project. The exercise room is only required to comply with being on an accessible route—the exercise equipment provided does not have to comply with the accessibility requirements of ICC/ANSI A117.1.

The swimming pool has a linear wall length of 144 feet 5 inches, so only one accessible means of entry is required. For this project, a transfer wall designed per ICC/ANSI A117.1 Section 1109.4 is provided along the east and south sides of the pool. The pool walls are 18 inches high and have a depth of 16 inches.

STEP 21

Integrate Special Requirements

STEP OVERVIEW

The IBC includes many requirements that are occupancy specific or are of a minor nature that a complete separate step for each is not necessary. Special requirements include those applicable to special uses and occupancies determined in Step 6, sound transmission requirements for residential occupancies, *emergency escape and rescue openings*, elevators and escalators, flood-resistant design, and special construction elements, such as membrane structures, pedestrian walkways, *awnings*, and *canopies*.

21.1 SPECIAL USES AND OCCUPANCIES

Step 6 covered a number of special uses and occupancies identified in IBC Chapter 4. At this phase of design, and based on the selections made in Step 6, we review the detailed requirement for each special use or occupancy applicable to the project. Many special requirements for special uses and occupancies have been addressed in other steps, such as *fire resistance* and *means of egress*. Table 21.1-1 summarizes the more notable requirements for the special uses and occupancies that have additional requirements not covered elsewhere.

21.2 SOUND TRANSMISSION

There are two types of sound transmission addressed in the IBC. The first type is airborne sound, which is sound that radiates through the air. Examples of airborne sound are people talking and music playing. The second type is structure-borne sound, which is sound that is transmitted in the form of vibration

Applying the Building Code: Step-by-Step Guidance for Design and Building Professionals. Ronald L. Geren, FCSI, AIA

TABLE 21.1-1. Summary of Requirements for Special Uses and Occupancies

Special Use or Occupancy Requirement	IBC Section Reference
Covered Mall and Open Mall Buildings	
Children's play structures	402.6.3
Plastic signage	402.6.4
Security door and grille requirements	402.8.8
High-Rise Buildings	
Structural integrity of interior exit stairways and elevator hoistway enclosures for buildings over 420 feet in height	403.2.3
Minimum bond strength of sprayed fire-resistant materials	403.2.4
Atriums	
Class B finishes	404.8
Motor-Vehicle-Related Occupancies	
Separation of private garages from dwelling units	406.3.4.1
Vehicle barriers for public parking garages when the height between a parking space or driving lane is 1 foot or greater above the ground or surface below	406.4.3
Slope of vehicle ramps in public parking garages limited to a maximum of 1:15	406.4.4
Vestibules between public parking garages and rooms containing fuel-fired appliances	406.4.7
Concrete or other approved material for fueling pad	406.7.1
Canopy requirements for fuel-dispensing facilities	406.7.2
Mechanical ventilation for repair garages	406.8.2
Floor surfaces for repair garages	406.8.3
Group I-2	
Care suite requirements	407.4.4
Refuge area sizing in smoke compartments	407.5.1
Secured yards for safe dispersal areas	407.9
Group I-3	
Means of egress special requirements, including guard tower doors, spiral stairways, ship ladders, exit discharge, sallyports, and interior exit stairways and ramps,	408.3
Refuge area sizing in smoke compartments	408.6.2
Subdivision of housing areas	408.8
Stages, Platforms, and Technical Production Areas	
Stage construction	410.3.1
Galleries, gridirons, and catwalks	410.3.2
Exterior stage doors	410.3.3
Stage proscenium wall	410.3.4
Stage proscenium curtain	410.3.5
Stage ventilation	410.3.7
Platform construction	410.4
Means of egress	410.6
Special Amusement Buildings	
Exit marking	411.7
Class A finishes	411.8
Aircraft-Related Occupancies	
Two-hour exterior walls for hangars with fire separation distance less than 30 feet	412.4.1
Floors to be sloped to drain	412.4.3
Two means of egress from residential aircraft hangars	412.5.2
Groups H-1, H-2, H-3, H-4, and H-5	
Group H-2 flammable and combustible liquid leakage containment	415.9.1.4
Liquid-tight and noncombustible floors for Groups H-3 and H-4	415.10.3
Service corridors for Group H-5	415.11.3
Liquid-tight and noncombustible floors for Group H-5 HPM rooms	415.11.5.3
Application of Flammable Finishes	
Surfaces of spray rooms	416.2.1
Surfaces of spraying spaces	416.3.1
Groups I-1, R-1, R-2, R-3, and R-4	
Refuge area sizing in smoke compartments for Group I-1, Condition 2	420.4.1
Ambulatory Care Facilities	
Refuge area sizing in smoke compartments	422.3.2

and reradiated at another point. Examples of structure-borne sound would be tapping on one end of a length of pipe and hearing it at the other end or walking on a floor and hearing the footsteps in the space below.

21.2.1 AIRBORNE SOUND TRANSMISSION

For airborne sound, the IBC requires that applicable walls, partitions and floor/ceiling assemblies have a sound transmission class (STC) of 50 when tested in a laboratory using ASTM E 90. An STC is a single number that represents the effectiveness of materials or construction in retarding the transmission of airborne sound. At STC 50, loud speech may be audible but not understood. Like *fire-resistance ratings*, many standard wall and floor/ceiling assemblies have documented STC ratings.

For wood and metal construction, the Gypsum Association has a number of assemblies with STC ratings in GA-600. For masonry, NCMA TEK 13-1A provides some common masonry assemblies with tested STC ratings.

To be accepted by most building departments, assemblies incorporated into a project must be designed and installed according to the tested assembly. To ensure the wall meets the required rating, any penetrations or openings need to be "sealed, lined, insulated, or otherwise treated" to prevent sound leakage. Leaks may occur at outlet boxes, pipe penetrations, and ductwork. The exception to this is *dwelling* entrance doors. They do not have to meet the STC requirements, but they must fit tight to the frame and sill.

If a project has a unique situation which has not been tested in the laboratory, the IBC does permit the use of a field test to ensure sound transmission requirements are met. The field method tests the assembly "as installed." Fortunately, the IBC permits a reduction in the required STC to 45 since it lacks the benefits of a controlled laboratory test.

21.2.2 STRUCTURE-BORNE SOUND TRANSMISSION

For structure-borne sound, the IBC requires floor/ceiling assemblies to have an impact insulation class (IIC) of 50 when tested in accordance with ASTM E 492. The IIC measures the level of resistance to transmission of noises through floors and ceilings generated by impact sounds, such as footsteps and movement of objects.

Finding IIC ratings is not easy. Many manufacturers of products that reduce structure-borne sound transmission only provide a delta IIC per ASTM E 2179. This test method compares the difference between two tests using a concrete floor, one test with and one test without the tested product. To determine the IIC of an entire assembly, the IIC of the base assembly must be known, which still does not solve the problem of finding assemblies with IIC ratings. If an assembly's base IIC rating can be determined, adding carpet and pad will significantly increase the IIC rating. In a technical bulletin published by the Carpet and Rug Institute (CRI; www.carpet-rug.org), adding carpet alone can increase the IIC almost 60%, while adding carpet and a pad can more than double the IIC rating.

One possible source that may be of assistance is a document titled "Catalog of STC and IIC Ratings for Wall and Floor/Ceiling Assemblies" by Russell B. Dupree published by the Office of Noise Control in the California Department of Health Services. This document is somewhat outdated (it was published in 1980), but it can be used to determine base IICs for common assemblies. Once a base IIC is known, then the base IIC can be modified by adding the 'Delta IIC' (also shown as 'ΔIIC') of the products selected to obtain the overall IIC of the complete floor/ceiling assembly.

The IBC also permits the use of field testing to determine the IIC of an installed floor/ceiling assembly. Like the STC, the rating is reduced to 45 due to the imperfect nature of field conditions.

21.3 EMERGENCY ESCAPE AND RESCUE

In Groups R-2 and R-3, other *means of egress* are required from *basements* and sleeping rooms below the fourth *story above grade plane* as a secondary means of exiting a building. A "sleeping room," although not formally defined, is a room in which sleeping is its intended purpose, and it should not be confused with *sleeping units*, which are defined by the IBC. These secondary egress points, called *emergency escape and rescue openings*, are provided as a means of escaping from a building should the primary *means of egress* be blocked. Another purpose is to provide access for firefighters into the building to allow the rescue of occupants who may be unconscious or otherwise unable to escape on their own. The requirements for *emergency escape and rescue openings* are located in IBC Section 1030.

Although it may seem that all sleeping rooms below the fourth *story* are required to have *emergency escape and rescue openings*, the IBC only requires them when required by IBC Tables 1006.3.2(1) or 1006.3.2(2). These tables apply to buildings with *stories* that have only one *exit* or access to one *exit*, and per footnote "a" in each table, *emergency escape and rescue openings* are required as one of the conditions that must be provided to allow one *exit* or access to one *exit* from a *story*. Therefore, if each *story* has at least two *means of egress*, then *emergency escape and rescue openings* are not required.

One *emergency escape and rescue opening* from each sleeping room and *basement* shall provide direct access to the exterior that is a *public way* or a *yard* or *court* that has direct access to a *public way*. If a *basement* has sleeping rooms, each sleeping room must have an *emergency escape and rescue opening*, but other areas of the *basement* are not required to have the opening. The following exceptions do not require *emergency escape and rescue openings*:

- *Basements* that have ceilings less than 80 inches in height
- Sleeping rooms that have *exit* or *exit access doorways* that open directly to a *public way* or to a *yard*, *court*, or egress balcony that leads to a *public way*
- *Basements* that have 200 sq. ft. or less of floor area and do not have any *habitable spaces*

Bars, grilles, grates, and similar security devices installed over *emergency escape and rescue openings* must also comply with the same minimum area and dimensions for the openings. The security devices must be operable or removable from the inside without keys or tools or by excessive force.

21.3.1 MINIMUM SIZE OF OPENINGS

In order to be effective, *emergency escape and rescue openings* must have a minimum size that will allow occupants to escape and firefighters to enter through them. Each opening is required to have a minimum clear area of 5.7 sq. ft., except that openings that open to grade level are only required to have a clear area of 5 sq. ft. Clear area means the unobstructed area between the frame and operational sashes when in the open position.

In addition to the clear area, an *emergency escape and rescue opening* must also have a minimum clear height and width. The height must not be less than 24 inches and the width cannot be less than 20 inches. Although these are minimum dimensions, an *emergency escape and rescue opening* cannot be fabricated to the minimum dimensions and still meet the minimum clear area. Thus, one or both dimensions will have to exceed the minimum dimensions. The bottom of the clear opening cannot be located higher than 44 inches above the floor. See Figure 21.3-1 for an illustration of the requirements.

21.3.2 WINDOW WELLS FOR BELOW-GRADE OPENINGS

When *emergency escape and rescue openings* have a sill located below the finished grade elevation, a window well in accordance with IBC Section 1030.5 is required. The window well must have a horizontal

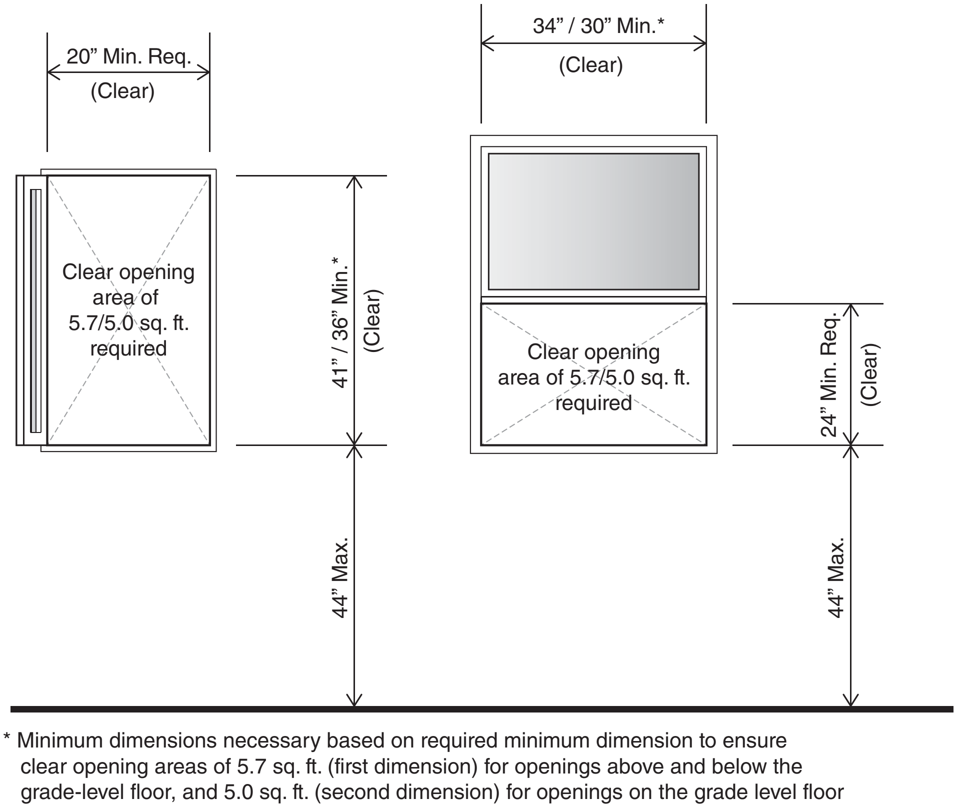


FIGURE 21.3-1. *Emergency escape and rescue opening* minimum size requirements.

projected area of 9 sq. ft. and a minimum dimension of 36 inches; thus, a window well that is 3 feet by 3 feet is the minimum size required. The size and shape of the window well must allow the operation of the opening and any security device to their fully opened positions. If the well has a depth greater than 44 inches, then a permanently installed ladder or set of steps complying with the requirements of IBC Section 1030.5.2 must be provided.

21.4 ELEVATORS AND CONVEYING SYSTEMS

IBC Chapter 30 establishes the primary criteria for elevators and other conveying systems. Most of the chapter is dedicated to elevators, which includes dumbwaiters, but IBC Section 3004 does address other conveying systems, such as escalators, moving walks, conveyors, and hoists. Not included in IBC Chapter 30 but considered a conveying system nonetheless and included in this step are platform lifts mentioned as part of an *accessible route* (see Step 13.3.1) and as an *accessible means of egress* (see Step 10.5.5).

21.4.1 GENERAL ELEVATOR REQUIREMENTS

Although IBC Chapter 30 provides many requirements for elevators, there are other sections of the IBC that supplement the primary criteria with special provisions, such as requirements for *accessible means of egress*, elevator lobbies, and *shaft enclosures* for hoistways. ASME/ANSI A17.1 provides most of the requirements for the elevator equipment, but it also establishes some basic requirements for the hoist-way and machine rooms that are expanded further in the IBC.

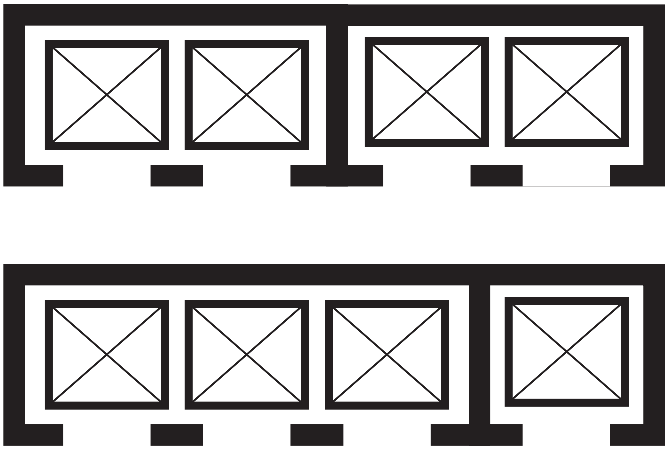


FIGURE 21.4.1-1. Allowable combinations for four elevators.

With a couple of exceptions, neither the IBC nor ASME/ANSI A17.1 dictates the number of elevators that must be provided in a building—any number of elevators may be provided at the discretion of the designer or as the owner's budget will allow. The first exception is in IBC Section 1009.2.1, which requires at least one elevator be provided as one of the required *accessible means of egress* if an *accessible story* is located four or more *stories* above or below the *level of exit discharge* as addressed in Step 10.5.2. The second exception is in IBC Section 403.6, which requires at least two elevators be designated as fire service access elevators in buildings with occupied floors greater than 120 feet above the lowest level of fire department vehicle access.

If multiple elevators are provided in a building, IBC Section 3002.2 requires that the number of cars within a single hoistway enclosure be limited to no more than four. However, if four or more elevator cars serve all or the same stories, then the elevators must be located in a minimum of two hoistway enclosures. Thus, if four elevator cars are provided, then they must be located in two hoistways in a 2–2 or 1–3 combination (Figure 21.4.1-1). If six elevator cars and two hoistways are provided, then the only combinations permitted would be 3–3 or 2–4 (Figure 21.4.1-2). A 1–5 combination would not be permitted, since no more than four cars are allowed in a single hoistway.

Elevator car size is also regulated by the IBC and by ICC/ANSI A117.1. In IBC Section 3002.4, if an elevator is provided in a building that has four or more *stories* above or below the *grade plane*, then at least one elevator shall be sized to accommodate an ambulance stretcher that is 24 inches wide by 84 inches long with corners having radii of 5 inches or more. ICC/ANSI A117.1 Table 407.4.1 provides the minimum inside dimensions for elevator cars based on the location of the door opening. Existing elevator cars are exempt from the size criteria in the table provided they have clear dimensions of 36 inches wide and 54 inches deep and a clear floor area of 16 sq. ft.

Other considerations that go into planning and design for elevators are machine rooms, elevator lobbies, pits and clearances, and car finishes. Machine rooms are regulated by both the IBC and ASME/ANSI A17.1. Requirements for elevator lobbies are only located in the IBC, while pits and clearances are only regulated by ASME/ANSI A17.1. Regarding elevator car finishes, the IBC is not very specific but will likely consider elevators as enclosed spaces per IBC Table 803.11. On the other hand, ASME/ANSI A17.1 provides specific criteria for car finishes that may supersede IBC criteria (see Step 18.4).

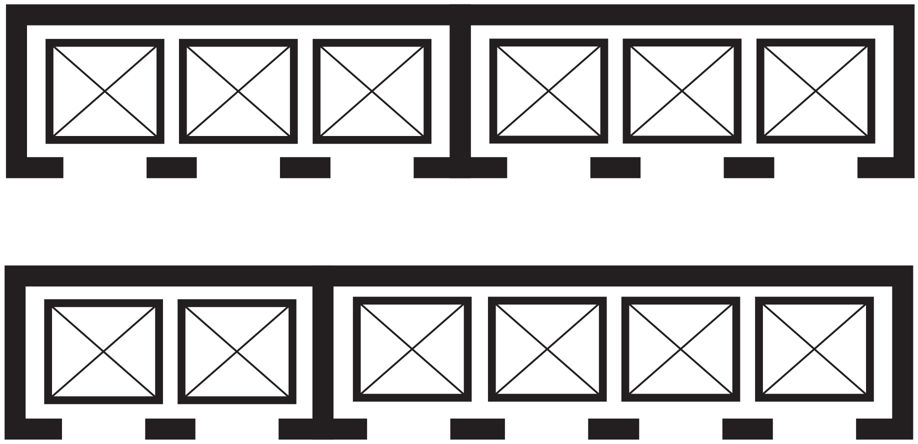


FIGURE 21.4.1-2. Allowable combinations for six elevators.

21.4.1.1 Pits and Clearances

Criteria for pits and clearances in hoistways are separated between electric and hydraulic elevators in ASME/ANSI A17.1 Parts 2 and 3, respectively. Typically, most of the requirements are in Part 2 and referenced by Part 3, except where specifically modified for hydraulic elevators. For both types of elevators, the pit depth is based on the required equipment plus the minimum bottom car clearance of 24 inches when the elevator rests on fully compressed buffers or bumpers. For top clearances, the requirements are basically the same, except the dimensions will likely vary between electric elevators (either ***counterweighted*** or ***uncounterweighted***) and hydraulic elevators. Therefore, for design purposes, consult manufacturers' design criteria for the types of elevators under consideration.

DEFINITIONS

Counterweighted Elevator

Elevators that use ropes with weights to help offset the weight of the elevator car for ease in moving the car.

Uncounterweighted Elevator

Elevators that are identified by ASME/ANSI A17.1 as screw column elevators and rack-and-pinion elevators that do not require counterweights.

21.4.1.2 Machine Rooms

ASME/ANSI A17.1 provides the majority of the technical requirements for machine rooms and spaces but defers *fire resistance* requirements to the building code. The minimum clear headroom in a machine room per ASME/ANSI A17.1 is 84 inches. If *fire resistance* of the machine room is not required by the IBC (see Step 15.1.2), ASME/ANSI A17.1 requires that machine rooms be constructed of noncombustible materials to a minimum height of 79 inches.

Regarding access to machine rooms, the IBC simply states an *approved* means of access must be provided; thus, the detailed criteria in ASME/ANSI A17.1 will establish the minimum requirements for the means of access. If a machine room is elevated above the floor or roof surface, then a permanent and noncombustible set of *stairs* or a ladder, along with a landing at the top, is required to reach the machine room door. The landing must be sized to allow the full swing of the door plus 24 inches if the door swings outward or 29 1/2 inches if the door swings inward. Although ASME/ANSI A17.1 allows doors to machine rooms to have a width of 29 1/2 inches, the IBC requires a minimum clear width of 32 inches.

If access to a machine room will be across a roof, a *stairway* with a swing door shall be provided to the roof from the floor below—roof access hatches with ladders are not permitted. If the roof slopes more than 15 degrees or the roof does not have a minimum 42-inch-high parapet or *guard* around the roof or passageway to the machine room, then a walkway must be provided. The walkway must be 24 inches wide with railings 42 inches high consisting of a top rail, an intermediate rail or solid panel, and 4-inch-high toe-boards.

21.4.1.3 Elevator Lobbies and Hoistway Opening Protection

Hoistway opening protection, of which elevator lobbies are considered a part, is considered as additional protection for the hoistway openings. Doors at hoistway openings are rated for 1 1/2 hours, but they do not provide smoke and draft control capabilities. According to IBC Section 3006.2, hoistway opening protection is required on each floor where an elevator hoistway connects three or more *stories*, the hoistway is enclosed within a *shaft enclosure*, and any one of the following conditions apply:

- The building is not sprinklered per NFPA 13 or 13R.
- The building is or contains a Group I-1, Condition 2 occupancy.
- The building is or contains a Group I-2 or Group I-3 occupancy.
- The building is a high rise and the elevator hoistway is more than 75 feet in height, measured from the lowest floor served (includes *basement* levels) to the highest floor served by the hoistway.

Hoistway opening protection is not required for elevators that only serve *open parking garages* or where the openings open to the exterior. Additionally, hoistway protection is not required at the *level of exit discharge* provided the entire *level of exit discharge* is sprinklered per NFPA 13.

The methods permitted for protecting hoistway openings are prescribed in IBC Section 3006.3, and they include the following:

- Elevator lobbies separated from other areas of the building using *fire partitions* and protected openings as required for *corridors* (see Step 15.1.4)
- Elevator lobbies separated from other areas of the building using *smoke partitions* and smoke and draft control openings when the building is sprinklered throughout per NFPA 13 or 13R
- Additional doors over each hoistway opening that comply with the smoke and draft control requirements of IBC Section 716.5.3.1
- Pressurizing the elevator hoistway in accordance with IBC Section 909.21

21.4.2 FIRE SERVICE ACCESS ELEVATORS (IBC SECTION 3007)

Buildings with an occupied floor more than 120 feet above the lowest level of fire department vehicle access must provide two elevators designated as fire service access elevators. Elevators used for fire service access are required to be identified by a pictorial symbol representing a firefighter's helmet that shall be mounted on the face of a hoistway door frame that is perpendicular to the hoistway door.

Fire service access elevators must have access to a fire service access elevator lobby on each floor, except at the *level of exit discharge*. Each lobby shall have direct access to an *interior exit stairway* or have a protected path to an *interior exit stairway* with a *fire-resistance rating* equal to the elevator lobby. *Stairways* accessed by a fire service access elevator lobby shall be provided with a Class I standpipe. If a fire service access elevator has two entrances to a floor, the second entrance is permitted to have access to a standard elevator lobby as described earlier. Fire service access elevator lobbies must be enclosed with *smoke barriers* (see Step 15.1.3). The size of a fire service access elevator lobby must be a minimum 150 sq. ft. in floor area with no dimension less than 8 feet.

Other unique criteria apply to fire service access elevators. For example, sprinklers are not permitted in machine rooms, machine spaces, and hoistways of fire service access elevators, and water from sprinklers outside the fire service access elevator shall be prevented by *approved* means from entering the fire service access elevator hoistway. Fire service access elevators and associated equipment shall be supplied by normal and *standby power*. Wires and cables from outside the fire service access elevator that provide power, communications, fire detection, and control signals for the elevator must be protected by construction having a *fire-resistance rating* of not less than 2 hours.

21.4.3 OCCUPANT EVACUATION ELEVATORS (IBC SECTION 3008)

The use of occupant evacuation elevators is voluntary, but, if provided, all public passenger elevators must comply with the provisions. Other elevators, such as service or freight elevators, may be used for occupant evacuation but must also comply with the requirements. Additionally, in *high-rise buildings* greater than 420 feet in height, elevators complying with the requirements for occupant evacuation may be used in lieu of the required additional *stairway*. For the most part, occupant evacuation elevators must comply with the same requirements for fire service access elevators in regard to the fire sprinkler prohibition, prevention of outside sprinkler water from entering the hoistway, and protection of wires and cables.

Elevator lobbies serving occupant evacuation elevators have requirements identical to fire service access elevator lobbies, such as *smoke barrier* enclosure construction (except at the *level of exit discharge*), doorways, and access to an *interior exit stairway*; however, occupant evacuation elevator lobbies have additional provisions. Doors, in addition to the fire-resistive requirements, must also have vision panels consisting of *fire-protection-rated* glazing and be automatic closing by fire alarm signal if kept open by magnetic or other hold-open devices. The size of the occupant evacuation elevator lobby shall be a minimum of 3 sq. ft. per occupant based on not less than 25% of the floor *occupant load* served by the lobby. Furthermore, a 30- by 48-inch *wheelchair space* is required for every 50 occupants of the *occupant load* of the floor area served by the lobby. The lobby shall also be provided with two-way communication identical to that required for *areas of refuge*.

Occupant evacuation elevators shall be identified as such on all floors with an *approved* sign located adjacent to each call station. Lobbies serving occupant evacuation elevators must provide a status indicator that shows by green illumination that elevators are available for occupant evacuation when elevators are in normal service and the fire alarm system has indicated an alarm. If the elevators have been switched to emergency recall service by the fire department, the status indicator should show by red illumination that elevators are not available for evacuation and that *stairs* should be used. At all other times, no illumination or message should be indicated.

21.4.4 CONVEYING SYSTEMS OTHER THAN ELEVATORS

As previously mentioned, conveying systems beyond elevators include escalators, moving walks, conveyors, hoists, and platform lifts. For these other conveying systems, the IBC provides very little in the way of requirements. Most of the requirements for these systems are covered within the reference standards identified by the IBC. Personnel and material hoists are not addressed since they have very few requirements established by the IBC that impact building design.

The requirements for escalators and moving walks are covered almost entirely in ASME/ANSI A17.1. Escalators and moving walks, per the limited IBC requirements, are required to be of noncombustible and fire-retardant materials. ASME/ANSI A17.1 limits the slope of an escalator to 30 degrees from the horizontal. The width of an escalator at the steps is limited to a minimum of 22 inches and a maximum of 40 inches. However, IBC Section 3004.2.2 requires escalators to have a minimum width of 32 inches when escalators are used for below-grade transportation stations.

Per ASME/ANSI A17.1, moving walks are limited to a 3% slope at entry and exit points for the first and last 36 inches of the moving walk equipment. Between the entry and the exit, the slope may be increased up to 12%. The minimum width is 22 inches and the maximum width can be 40 inches, 60 inches, or unlimited based on the speed and slope of the moving walk. At a maximum speed of 90 ft./min. and a maximum 4% slope, the width is unlimited. Speeds up to 140 ft./min. and at the same maximum slope are limited to a maximum width of 60 inches. All other speeds and slopes are limited to a maximum width of 40 inches.

Conveyors are required to comply with ASME/ANSI B20.1, but the standard does not address any building or fire-related issues. The only requirements prescribed by IBC Section 3004.3 is that conveyors connecting floors are required to be enclosed with *shaft enclosures* and automatic power shut-off to equipment in emergency situations.

Platform lifts are required to comply with AMSE/ANSI A18.1 per IBC Section 1109.8 in regards to accessibility. Although the IBC mentions platform lifts, it is ICC/ANSI A117.1 Section 410 that provides most of the requirements other than ASME/ANSI A18.1. The maximum travel distance for a vertical platform lift within an enclosure or partial enclosure is 168 inches. Vertical platform lifts that have no enclosures are limited to 60 inches of travel distance. Inclined platform lifts are limited to an incline of 45 degrees and have no restriction on travel distance. IBC Section 1011.2, Exception 3, states that if inclined lifts or chairlifts are used in Group R-3 or within dwelling units of Group R-2, they must leave at least 20 inches of clear passage.

21.5 FLOOD-RESISTANT DESIGN

Essentially, there are four significant locations where flood-resistant design is addressed in the IBC: Chapters 8 and 14 for flood-resistant materials, Chapter 14 for protection of utilities from wave action, Chapter 16 for flood loads, and Appendix G for flood-resistant construction. As mentioned in Part I, IBC Appendix G is not applicable unless specifically adopted by the jurisdiction.

Flood loads on structural elements below the *Design Flood Elevation (DFE)* (see Step 2.8) are determined according to ASCE 7, which includes calculations for such conditions as hydrostatic loads, hydrodynamic loads (moving water), wave impact loads, and debris impact loads. The structural engineer will then design building elements according to ASCE 24 to withstand the applied loads. But, in addition to withstanding loads, ASCE 24 also establishes criteria for floodproofing buildings. Floodproofing consists of a variety of methods that make a building resistant to flood damage, including passive measures such as reducing the building's contact with floodwaters (*dry floodproofing*) or reducing the extent of damage from contact with floodwaters (***wet floodproofing***). The latter term, although not used by ASCE 24 or the IBC, is, by default, the method used by these documents when not describing *dry floodproofing*.

Definition

Wet Floodproofing

Permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding by allowing flood waters to enter the structure.

Source: Technical Bulletin 7-93, "Wet Floodproofing Requirements," Federal Emergency and Management Agency (FEMA).

Of the two methods, only ***wet floodproofing*** is permitted for all types of flood hazards; the use of *dry floodproofing* is limited to nonresidential structures in "A" zones (i.e., areas subject to 100-year flood elevations), and is not permitted in any structure in "V" zones (i.e., coastal areas subject to 100-year flood elevations with wave-induced hazards). Additionally, ***wet floodproofing*** is limited to where it may be used. Generally, the floor elevation of the lowest floor must be at or above the *DFE*, thereby making it unnecessary to ***wet floodproof*** a structure. However, enclosed areas used solely for parking, building access, and limited storage, plus attached garages, may be ***wet floodproofed***. Other structures may be allowed to be ***wet floodproofed***, but only through a variance.

Dry floodproofing involves the use of special sealants, coatings, and specialized equipment and components (*i.e*. flood shields, panels, gates, and backflow valves) to virtually eliminate the entrance of water into the structure. Unlike ***wet floodproofing***, *dry floodproofing* requires the structure to resist hydrostatic pressure since floodwaters are not equalized on both sides of a wall. Vertical buoyant forces must be addressed, too, especially for small, lightweight structures, which could literally float out of the ground. In accordance with the IBC, if *dry floodproofing* is used, the *construction documents* must clearly indicate that the *dry floodproofing* complies with ASCE 24.

21.6 SPECIAL CONSTRUCTION

Detailed requirements associated with special construction identified in Step 6.26 should be considered at this phase of design. For membrane structures, the design is further refined. *Air-inflated structures* and *air-supported structures* are required to have auxiliary inflation systems if the structures are larger than 1,500 sq. ft. If an auxiliary inflation system is required, then *standby power* is also required.

Pedestrian walkways and tunnels also require additional detailing. Tunnels, which are located below grade, are simple structures that are designed much like *basements* and the only unique characteristic is the connections to the buildings they join. Pedestrian walkways also have connections to buildings that require consideration. Additionally, since pedestrian walkways are located at or above grade, then they may have openings or be completely or partially enclosed.

Per IBC Section 3104.10, where tunnels connect to buildings, the walls between the buildings and the tunnel are required to be of 2-hour *fire-resistance-rated* construction with openings protected per IBC Table 716.5. However, IBC Table 716.5 does not list tunnel connections and IBC Section 3104.10 does not specify a specific type of *fire-resistance-rated* assembly. Therefore, since tunnels are not considered parts of a building, the connection technically becomes an *exterior wall* that would require *fire doors* with a $1\,{}^1/_2$-hour *fire protection rating*.

Pedestrian walkways require separation from the buildings they connect by 2-hour *fire barriers* in accordance with IBC Section 3104.5.1. The *fire barriers* are required to be supported by construction having an equal or greater *fire-resistance rating*. Openings in the *fire barrier* will need to have a 1 $^1/_2$-hour *fire protection rating*. For a distance of 10 feet around the pedestrian walkway connection, the *exterior walls* are required to be of 2-hour *fire-resistance-rated* construction. Openings within the 10-foot area are required to have a $^3/_4$-hour *fire protection rating*. Although not specifically marked as exceptions, there are three alternate methods to the *fire-resistance-rated* separation:

- IBC Section 3104.5.2 requires that the buildings are separated by distance of more than 10 feet and the pedestrian walkway and connected buildings are protected throughout with a sprinkler system per NFPA 13. The roof of the pedestrian walkway cannot be higher than 55 feet above grade and cannot connect any *story* higher than the fifth *story above grade plane* of each building. The wall separating a pedestrian walkway from a building must be either capable of preventing the passage of smoke or a glass wall assembly protected by a sprinkler system per NFPA 13.
- IBC Section 3014.5.3 requires that the connected buildings be separated by a distance of more than 10 feet and the sides of the pedestrian walkway be not less than 50% open and distributed evenly along the length of the pedestrian walkway. The roof of the pedestrian walkway cannot be higher than 40 feet above grade and cannot connect any *story* higher than the third *story above grade plane* of each building. The height can be increased to 55 feet and the fifth *story above grade plane* if the pedestrian walkway is sprinklered throughout per NFPA 13.
- IBC Section 3014.5.4 does not require the 2-hour separation if the *exterior walls* where buildings are connected are required to have a *fire-resistance rating* of greater than 3 hours per IBC Section 705. To utilize this provision, the pedestrian walkway must be sprinklered throughout per NFPA 13. The roof of the pedestrian walkway cannot be higher than 55 feet above grade and cannot connect any *story* higher than the fifth *story above grade plane* of each building.

Pedestrian walkways located over a public right-of-way will need approval by the jurisdiction. Per IBC Section 3202.3.4, the minimum clearance between the grade and the lowest part of the pedestrian walkway is 15 feet.

EXAMPLE PROJECT—STEP 21

Special requirements applicable to the example project include sound transmission and elevators. Emergency escape and rescue openings at the first, second, and third stories are not required, since each story has access to two exits. Additionally, compliance with floodplain requirements is not necessary since the site has been identified in Step 2 as not located within a Special Flood Hazard Area.

SOUND TRANSMISSION

Requirements for sound transmission apply to all residential units, including the manager's apartment on the first story. The walls are required to have a STC of 50 and the floor/ceiling assemblies are required to have a STC of 50 and an IIC of 50.

Walls between dwelling units and between dwelling units and other areas of the building are required to be either 1-hour or 30-minute fire partitions as determined in Step 15. Therefore, these walls must also perform as barriers to sound transmission. Using the GA-600 *Fire Resistance Design Manual*, a generic assembly complying with both fire-resistance and sound transmission requirements can be obtained.

GA File Number WP 3243 provides a 1-hour partition with a tested STC of 50 to 54, thus complying with the requirements of the IBC. At the corridors where 30-minute partitions are required, the same assembly will be used, since GA-600 does not provide any 30-minute assemblies. The partition uses 2-by-4 wood studs at 24 inches on center with one layer of $^{5}/_{8}$-inch-thick Type X gypsum board on each side. On one side the gypsum board is attached to resilient channels spaced 16 inches on center at right angles to the studs. The cavities of the wall are filled with fiberglass insulation.

Although a floor assembly was selected in Step 15 where the floor is exposed, the required insulation is unnecessary between the dwelling units. At floor/ceiling assemblies, GA File No. FC 5241 provides the required 1-hour horizontal assembly. However, the GA assembly indicates a STC of 45 to 49 and an IIC of 40 without any finishes applied. The assembly also indicates an IIC of 68 with a carpet and pad as indicated by the "C & P"; however, it does not indicate an increase in the STC. This assembly is very similar to GA File No. FC 5111, which indicates that a STC of 50 to 54 is provided when a 40-oz. carpet is installed over a $^{1}/_{4}$-inch foam pad. Therefore, GA File No. FC 5111 will be used with a base IIC of 40 without finishes.

In areas where ceramic tile is proposed, the carpet will not be there to increase the STC. Insulation may be added to the assembly, but the general explanatory notes in GA-600 state that up to 16 $^{3}/_{4}$ inches of fiberglass insulation may be added, provided that an additional layer of $^{1}/_{2}$-inch Type X gypsum board is applied. The insulation plus the added gypsum board will increase the STC by about 12 to 14; thus, the total assembly would be about 57 to 63, providing a sufficient safety factor. For the IIC, many manufacturers provide acoustical underlayments that have a Delta IIC of 21. With base IIC of 40, adding a delta of 21 to the assembly will provide an assembly with an overall IIC rating of approximately 61, which is another comfortable safety factor. The construction documents should specify that a field test be performed on a mock-up to confirm the STC and IIC performance.

At the 2-hour floor/ceiling assembly, the IIC rating is only required over the manager's apartment. For this area, an Evaluation Services Report (ESR) published by the International Code Council Evaluation Services is referenced. ESR-1153 provides a 2-hour assembly with an STC of 50 and an IIC of 64 with carpet and pad. This construction is similar to GA File No. FC 5111, except for an added layer of gypsum board and the installation of blanket insulation, which would logically only increase the IIC rather than reduce it; therefore, the Delta IIC of 21 for underlayments at ceramic tile flooring should still provide an IIC that exceeds the code minimum.

ELEVATORS

Since the building has four stories above the grade plane, one of the elevator cars must be sized to accommodate an ambulance stretcher. The two elevators indicated are capable of accommodating an ambulance stretcher. The size of the elevator hoistway, pits, and machine room should be based on requirements provided by the selected manufacturer. If no manufacturer is selected, then the requirements can be based on the most restrictive requirements of all the acceptable manufacturers.

A hydraulic elevator is proposed for the building, so the machine room is not required to be located on the roof. Therefore it is located in the basement.

Hoistway openings are not required to be protected since the building is sprinklered throughout with a NFPA 13R system.

PART IV

Construction Documents

The construction documents phase begins when the owner approves the design development documents and gives the design professional authorization to proceed to the next phase. During the construction documents phase, the design professional will incorporate any changes made during the review of the design development documents and proceed to finalize the design and prepare the drawings and specifications that will be used for plan review by the AHJ and pricing by one or more contractors. The documents at this phase must *completely* describe and show the character of the building.

At the start of preparing *construction documents*, the application of the building code should be fairly complete. Since the construction documents phase adds much greater detail to the drawings and specifications, the more narrowly focused requirements of the building and other codes must be applied.

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STEP 22

Confirm Steps 14 through 21

STEP OVERVIEW

Comparable to the schematic design phase, the design development phase will also go through a review process. It is to be expected that changes will be made as a result of comments from the review process. Therefore, before proceeding with preparing the *construction documents*, any changes required to be made after the review of the design development documents must be looked at closely to determine if their implementation would affect any code decisions made since the schematic design phase.

22.1 REVIEW OF CHANGES

During this step, each proposed change should be looked at to determine its impact on the code application to the project. The changes that could occur could affect decisions made as far back as the schematic design phase. Therefore, one of the steps that must be reviewed at this phase is Step 14. Instead of repeating requirements from Step 14, this step will only address the steps covered during the design development phase.

Similar to Step 14, every change does not need to be looked at closely and evaluated for its impact. Changes should be reviewed if they include one or more of the following items (some of the items are repeated from Step 14 because they have an impact on subsequent steps during design development):

- Change in function and/or size of one or more spaces
- Change in space arrangement (i.e., floor plan changes)
- Change in building structural materials
- Change in location on *site*
- Change in wall and *roof assemblies*
- Change in *interior finish* materials

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22.2 CHANGES IN FUNCTION AND/OR SIZE OF SPACES

As mentioned in Step 14, a change in a function or size of a space can impact the occupancy group classification. Many *fire-resistance-rated* assemblies have their ratings based on occupancy group. Additionally, these types of changes may affect the *means of egress* system, which is also further refined during design development.

If a change in this area occurs, the following design development steps will need to be reevaluated (see Step 14 for schematic design steps affected by this type of change):

Step 15: If occupancy group classifications change and the project is based on the separated method for mixed occupancies (Step 5), then the *fire-resistance ratings* for the *fire barriers* used as occupancy separations may need to change. Similarly, if *fire walls* are used or *fire barriers* are used for creating *fire areas*, then those *fire-resistance ratings* may also need to be changed, since they are based on occupancy groups.

Step 19: If an occupancy group changes to an occupancy group that is new to the project, then the finishes currently selected may need to be revised to comply with the minimum requirements of the new occupancy group.

Step 20: If a space is modified, then the clearances and clear spaces previously determined may now be encroached by building construction, other building *elements* (*ICC/ANSI*), or other clear spaces that cannot overlap.

Step 21: Some special requirements are based on the occupancy group or function of a space. Verify that the special requirements discussed in this step are not affected.

22.3 CHANGES IN SPACE ARRANGEMENT

Changes of this type are not any different than those discussed at the beginning of the design development phase. Therefore, the reasons that trigger changes of this type will not be repeated here—refer to Step 14.

If a change in this area occurs, the following design development steps will need to be reevaluated (see Step 14 for schematic design steps affected by this type of change):

Step 15: If the floor plan has been altered, then the location of *fire-resistance-rated* assemblies may have been relocated as well.

Step 19: Any space rearrangement may have altered the egress pathways (Step 10). If that is the case, then the altered egress pathways will need to be checked to see if the new widths are not less than the required minimum widths.

Step 20: The relocation of spaces may affect the *accessible route* established in Step 13. If the *accessible route* is altered, then some building features may need to be verified to ensure that some of the specific requirements for accessibility have not been breached.

Step 21: If special requirements covered in this step apply to the project, then any space relocations should be checked to see if any of the requirements covered in this step need to be readdressed.

22.4 CHANGES IN BUILDING STRUCTURAL MATERIALS

If changing the materials for the structural system forces a change in the construction type of the building (Step 4), then steps covered during the design development phase may be affected. Some building code requirements covered in Steps 15 through 18 are based on construction type, so a review of those decisions will be necessary to see if the new construction type will alter any of those decisions.

If a change in this area occurs, the following design development steps will need to be reevaluated (see Step 14 for schematic design steps affected by this type of change):

Step 15: There are some exceptions that allow a reduction in *fire-resistance ratings* for some construction types. For example, *fire walls* in Type II and V buildings may be reduced by 1 hour for certain occupancy groups.

Step 16: Combustible *exterior wall coverings* are limited in Type I, II, III, and IV construction. If the construction type changes from Type V to any of those other types, an evaluation of the selected exterior materials will be required to see if they need to be changed or minimized.

Step 17: The classification of *roof coverings* is based on a building's construction type. If the construction type is changed, the *roof covering* material may need to be changed to the minimum required classification.

Step 18: *Interior finishes* are minimally affected by building construction type, but some combustible floor finishes are regulated in Type I and II construction.

22.5 CHANGES IN LOCATION ON SITE

As discussed in Step 14, the relocation of a building on a *site* will have little impact on the application of the building code, except when the building is relocated close to a *lot line* or another building on the same property. During design development, the only elements that will be influenced by a building's location on the *site* are the *exterior walls* and exterior openings. The closer the building is to the *lot lines*, the greater the *fire-resistance rating*—the further away from the *lot*, the lower the rating and possibly no required rating.

If a change in this area occurs, the following design development steps will need to be reevaluated (see Step 14 for schematic design steps affected by this type of change):

Step 16: The *exterior walls*, if they are not required to have a *fire-resistance rating*, may now be required to have a rating, or if they had a rating, the rating may have to be increased or be required to be tested for exposure on both sides of the wall. Check *fire separation distances*; for two or more buildings on the same property and considered as separate buildings, the assumed *lot line* may have to be relocated. Additionally, the exterior openings will need to be evaluated for protection requirements. Based on the fire-resistance requirements of the *exterior walls*, the *exterior wall covering* materials may need to be changed to conform to the selected tested assemblies.

22.6 CHANGES IN WALL AND ROOF ASSEMBLIES

Changes in materials for *exterior walls* and roofs are not an infrequent occurrence. As the exterior aesthetic of the building is further developed, the materials proposed for the *exterior walls* and roofs are often changed or their use is increased or decreased in areas.

If a change in this area occurs, the following design development steps will need to be reevaluated (see Step 14 for schematic design steps affected by this type of change):

Step 16: An *exterior wall* material may or may not be permitted if some of the *exterior walls* are required to have a *fire-resistance rating*. Materials selected must conform to tested assemblies. Whether or not the *exterior walls* require a *fire-resistance rating*, the materials used on and in the *exterior wall* assemblies must meet certain prescriptive requirements. If the materials change, the assemblies will need to be evaluated for their compliance with those requirements. If an energy code is adopted by the jurisdiction, the *exterior walls* are required to comply with minimum energy performance requirements. Verify that the new assemblies still conform to the minimum performance requirements.

Step 17: Like *exterior walls*, the roof materials are also required to meet certain prescriptive requirements. If changes are made in materials, verify compliance with the requirements.

22.7 CHANGES IN INTERIOR FINISH MATERIALS

Interior finishes are probably more often modified than exterior materials—they seem to always be in a constant state of change. Although *interior finishes* are identified in the design development phase, some finishes may not be selected until the construction documents phase. If this is the case, then this step will need to be revisited.

If a change in this area occurs, the following design development steps will need to be reevaluated (see Step 14 for schematic design steps affected by this type of change):

Step 18: New or changed finishes will need to comply with the minimum performance requirements.

Step 21: If the project is a residential project that requires minimum sound transmission performance, the floor surfaces will need to be evaluated for impact insulation class (IIC) performance.

EXAMPLE PROJECT—STEP 22

No changes have been made that affect previous steps.

STEP 23

Integrate Egress Details

STEP OVERVIEW

It is not sufficient to indicate on the *construction documents* that there are *stairs* and that they have *handrails* and *guards*. The *construction documents* must show in detail how they are designed so that compliance with the minute requirements of the building code are represented.

23.1 STAIRS, RAMPS, HANDRAILS, AND GUARDS

The more generic requirements for *stairs*, *ramps*, *handrails*, and *guards* have been discussed in previous steps during the earlier phases of design. However, in the construction documents phase, the more specific code requirements for these elements must be integrated into the design of these elements.

23.1.1 STAIRS (IBC SECTION 1011)

The width of *stairs* has been addressed in regard to egress travel, but there are other dimensional aspects of *stairs* that must be considered. The first is the clear height, or headroom, of *stairways* per IBC Section 1011.3. Although the minimum ceiling height is 7 feet 6 inches, the headroom of *stairways* needs only to allow a minimum dimension of 80 inches. The measurement must be taken vertically from a line connecting the *nosings* of the *stairs* to the ceiling or construction above.

The other dimensional aspects of *stairs* are the risers and treads per IBC Section 1011.5. The maximum riser height is 7 inches and the minimum riser height is 4 inches. However, the riser dimensions cannot vary within this range per a *flight* of *stairs* but can change between flights within a single *stairway*. The tolerance for riser uniformity within a *flight* of *stairs* is 3/8 inch. For treads, the minimum dimension is 11 inches with no specified maximum dimension. However, like risers, the treads are required to have a

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uniform dimension within a *flight* of *stairs* that does not exceed $^3/_8$ inch. The measurement of a tread is the horizontal distance from the *nosing* of the tread to the *nosing* of the tread next above.

The *nosing* and profile of risers also have restrictions within the IBC. The maximum projection of a tread *nosing* is 1 $^1/_4$ inches. Risers may be straight or sloped. If sloped, they cannot angle more than 30 degrees from the vertical. If the *stairways* are used as an *accessible means of egress* per Step 10.5.1, then the risers must be solid with no openings. Otherwise open risers are permitted provided a 4-inch-diameter sphere cannot pass through the openings. *Stairs* in Groups I-3, F, H, and S that are not usable by the public may have open risers with no restrictions on the opening size.

Spiral stairways and *stairways* with *winder* treads have special dimensional requirements that are specific to those types of *stairs*. *Winder* tread requirements, which apply to both *spiral stairways* and curved *stairways*, are provided in several locations within the IBC. IBC Section 1011.4 establishes the walkline where measurements for tread depth and uniformity are determined. IBC Section 1011.5.2 states that the *winder* tread depth is 11 inches at the walkline but not less than 10 inches within the clear width of the *stairway*. This dimensional criterion, however, does not apply to *spiral stairways* by exception. Specific tread requirements for *spiral stairways* are provided in IBC Section 1011.10.

23.1.2 RAMPS (IBC SECTION 1012)

The most significant design features of *ramps* have already been covered in Step 13.3.1 for *accessible routes*, almost all of which are replicated in IBC Section 1012. What is not covered in those earlier phases are the details for edge protection. These requirements are covered in both IBC Section 1012.10 and ICC/ANSI A117.1 Section 405.9. Edge protection is required on both sides of a *ramp* and at *ramp* landings and are intended to prevent users of the *ramp* from slipping off the edge.

The standard means of providing edge protection is through the use of curbs that have a minimum height of 4 inches. Other methods prescribed include barriers or rails that prevent the passage of a 4-inch-diameter sphere between the *ramp* or landing surface and the barrier or rail. In lieu of a vertical element, the surface of the *ramp* or landing may extend a distance of 12 inches beyond the interior face of the *handrail*.

Three exceptions to the edge protection requirements are provided in the IBC and four exceptions are provided in ICC/ANSI A117.1. The three exceptions in the IBC are identical to three of the exceptions in ICC/ANSI A117.1. The first exception exempts *ramps* with flared sides, such as *curb ramps*. The second exception, which is a logical deduction, does not require edge protection where the *ramp* or landing adjoins another *ramp* run. The third exception allows a $^1/_2$-inch drop within a 10-inch extension from the edge of a *ramp* or landing. The fourth exception, which is only in ICC/ANSI A1171.1, applies to ramped *aisles* serving adjacent seats or *aisle accessways*.

23.1.3 HANDRAILS (IBC SECTION 1014)

Handrails are both building code and accessibility concerns; thus, the requirements for *handrails* are located in both documents. The building code requirements are located in IBC Section 1014 and the accessibility requirements are located in ICC/ANSI A117.1 Section 505. Fortunately, the requirements in both locations are nearly identical and any notable differences are mentioned below. ICC/ANSI A117.1 provides illustrations that show how many of these requirements are interpreted.

Handrail height must be between 34 and 38 inches measured vertically above a line connecting the *nosings* of the *stairs*. It is important to note that this dimension is above the finished surface of the *ramp* or *stairway*. Therefore, it is best not to design the *handrails* at the lowest possible height within the permitted range. Locating the *handrail* at least 1 inch above the lowest dimension permitted (i.e., 35 inches) will ensure compliance regardless of construction tolerances and proposed or future floor finishes. The clearance between a *handrail* and an adjacent wall or surface must be not less than 1 1/2 inches.

Circular *handrails* must have a diameter that is a minimum of 1 1/4 inches and a maximum of 2 inches. Noncircular *handrails* must have a profile shape that has a perimeter of 4 to 6 1/4 inches. The maximum cross-sectional dimension is 2 1/4 and the minimum is 1 inch. For noncircular *handrails* that have a perimeter exceeding 6 1/4 inches, the shape profile must comply with the detailed requirements of IBC Section 1014.3.2. ICC/ANSI A117.1 does not recognize *handrails* with a perimeter exceeding 6 1/4 inches; thus, they cannot be used on an *accessible route*.

Handrails must be continuous without interruptions. There are exceptions for *dwelling units*, *handrails* for slopes that do not exceed 1:20, and *handrails* used for stepped and ramped *aisles*. Brackets and balusters that do not extend beyond the sides of the *handrail* are not considered interruptions. ICC/ANSI A117.1 considers brackets and balusters obstructions but permits them for up to 20% of the *handrail* length.

At the terminations of *handrails*, the *handrail* must either return to a wall, a *guard*, or the walking surface. *Handrails* must extend 12 inches horizontally beyond the top riser of a *flight* of *stairs* or at the end of a *ramp* run. At the bottom of *stairs*, the *handrail* must continue the slope for one tread depth. At the bottom of *ramps*, the *handrail* must extend horizontally for 12 inches, similar to that at the top of the *ramp*.

23.1.4 GUARDS (IBC SECTION 1015)

Guards, per IBC Section 1015, are required when a walking surface is situated more than 30 inches vertically above the floor or grade below at a point that is 36 inches or less from the edge of the elevated surface. Walking surfaces, as stated in the IBC, include *mezzanines*, equipment platforms, *aisles*, *stairs*, *ramps*, and landings. The locations where *guards* are not required include loading docks, *stages*, *platforms*, vehicle service pits, and assembly seating cross *aisles*.

Guards may be constructed of a variety of materials, such as metal tubing and piping, metal cabling, wood, or glass. If using metal tubing or piping, it should be pointed out that these are not identical. Dimensions for metal tubing are generally for the outside diameter, whereas piping dimensions are for the inside diameter; thus, a 1 1/2-inch-diameter pipe will have a larger outside dimension than a 1 1/2-inch-diameter tube. Glass guards, whether structural or used as infill, are discussed in Step 24.

The minimum height of *guards* is 42 inches measured vertically from the adjacent walking surface, a line connecting the *nosings* of *stairs*, or from the surface of a *ramp*. Openings within a *guard* must be sized in accordance with IBC Section 1015.4, which is summarized in Table 23.1.4-1. *Guards* must be provided for rooftop mechanical equipment and roof hatch openings that are within 10 feet of the roof edge and the grade or surface below is 30 inches or more below the roof surface with the equipment. *Guards* must extend 30 inches laterally beyond the end of the equipment or hatch. *Guards* are not required if fall arrest/restraint anchorage is provided per the exceptions to IBC Sections 1015.6 and 1015.7 for mechanical equipment and roof hatches, respectively.

23.2 UNENCLOSED EXIT ACCESS STAIRWAYS AND RAMPS

Exit access stairways and *exit access ramps* that are not required to be enclosed per IBC Section 1019.3 Condition 4 (see Step 10.2.4) must have a draft curtain and closely spaced sprinklers installed per NFPA 13. Per NFPA 13 Section 8.15.4, draft stops ("draft stops" is used by NFPA 13 in lieu of "draft curtain") are required around the *stair* or *ramp* opening and must comply with the following requirements:

- They must be installed directly adjacent to the floor opening.
- They must be at least 18 inches deep, measured vertically.

TABLE 23.1.4-1. Summary of *Guard* Opening Requirements

Guard Application	**Openings Located in Guard** …	**Must Prevent the Passage of a Sphere That Is** …
Ramps and all other level walking surfaces	Between walking surface and 36 inches above surface	4 inches in diameter
Stairs	Between 36 inches above surface and top of guard	$4\frac{3}{8}$ inches in diameter
	From bottom edge of guard to 36 inches above line connecting nosings	4 inches in diameter
	In triangular area between tread, riser, and bottom edge of guard	6 inches in diameter
	Between 36 inches above line connecting nosings and top of guard	$4\frac{3}{8}$ inches in diameter
Elevated walking surfaces at electrical, mechanical, and plumbing equipment	Between walking surface and top of guard	21 inches in diameter
Alternating tread devices, ships ladders		
Nonpublic areas of Groups I-3, F, H, or S		
Roof access hatches within 10 feet of roof edge or open side of walking surface		
Guards at end of aisles in assembly seating areas	Between walking surface and 26 inches above surface	4 inches in diameter
	Between 26 inches above surface and top of guard	8 inches in diameter
Stairs in dwelling units and sleeping units of Groups R-2 and R-3	From bottom edge of guard to top of guard	$4\frac{3}{8}$ inches in diameter
	In triangular area between tread, riser, and bottom edge of guard	6 inches in diameter

- They must be constructed of "noncombustible or limited-combustible material" and shall be designed to remain in place before and during sprinkler operation.

Sprinklers are required to be spaced at 6 feet on center and located 6 to 12 inches from the draft stops on the side away from the floor opening. If sprinklers are located closer than 6 feet on center, then cross baffles are required per NFPA 13 Section 8.6.3.4.2. Baffles are to be of "solid and rigid material" that can withstand sprinkler operation. Baffle size is to be no less than 8 inches long by 6 inches high, but the bottom must extend down to a point that is no less than the sprinkler deflector level.

23.3 LUMINOUS MARKINGS

Luminous markings are required within *interior exit stairways*, *interior exit ramps*, and *exit passageways* in *high-rise buildings* of Group A, B, E, I, M, and R-1 occupancies. The requirements for luminous markings are prescribed in IBC Section 1025. The luminous markings must be either *self-luminous* or *photoluminescent*. *Self-luminous* markings must be powered by means other than commercial power and batteries, such as tritium. *Photoluminescent* markings are more common and use a building's artificial lighting to generate a light source in the absence of powered light. Various egress and building components are required to be marked in accordance with the requirements of the building code section. The requirements are summarized in Table 23.3-1.

TABLE 23.3-1. Summary of Luminous Marking Requirements

Component	What Must Be Marked	Type of Marking
Steps	Horizontal leading edge of each step within 1/2 inch of leading edge and not more than 1/2 inch over leading edge down riser	Solid and continuous stripe; 1- to 2-inch-wide strip[1]
Landings	Leading edge as required for steps	Solid and continuous stripe; 1- to 2-inch-wide strip
	Perimeter demarcation around the landing, including doors, but excluding leading edge of steps and door leading out of exit to exit discharge	Solid stripe; 1- to 2-inch-wide strip with interruptions not exceeding 4 inches[1] Floor Mounted: Placed not more than 4 inches from wall and within 2 inches of stripes for leading edges Wall Mounted: Placed not more than 4 inches above finished floor; at stairs, drop to floor within 2 inches of stripes for leading edges Transitions between Wall- and Floor-Mounted Markings: Connect with stripes installed vertically
Obstacles	Outline of objects at or below 6feet 6 inches in height and more than 4 inches into egress path	Alternating, 45-degree-angled, 2-inch bands of black and luminous material; 1-inch-wide strip
Handrails	Top surface of handrails	Solid and continuous stripe; 1-inch-wide strip[1]
Doors leading out of exit	Face of door at a height not greater than 18 inches	Exit symbol per NFPA 170
	Door hardware	16-inch-square area of door handle or 1-inch-wide minimum strip for full width of panic bar
	Top and sides of door frame; may be located on wall adjacent to frame if frame is too narrow for stripe	Solid and continuous stripe; 1- to 2-inch-wide strip

[1] A 1-inch minimum width not required for stripes listed per UL 1994.

EXAMPLE PROJECT—STEP 23

The example project includes two stairways and one ramp that require detailing. A guard for the roof access hatch is also required.

STAIRWAYS (EXAMPLE PROJECT FIGURE 23-1)

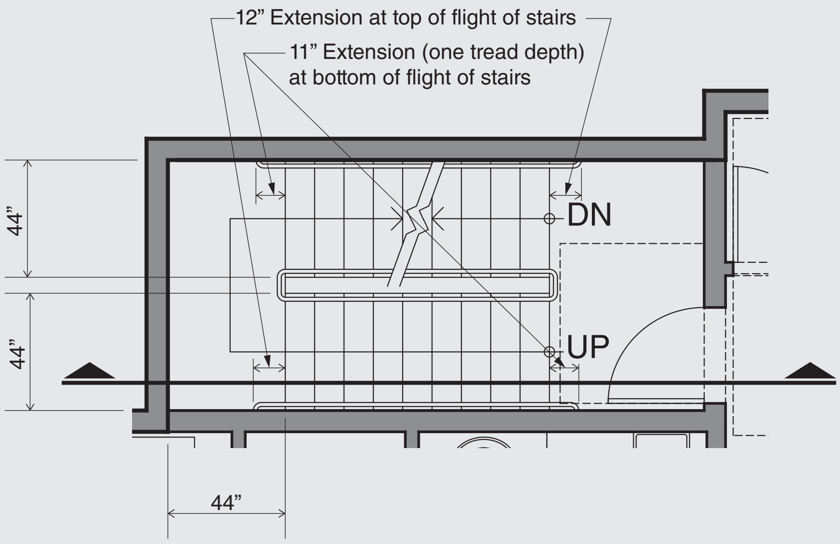
The stairways have a riser height of 6 inches and a tread depth of 11 inches, which complies with the IBC. The stairways are also required to have handrails and guards that need to be detailed.

The handrails are provided on each side of the stairs at a height of 36 inches, which provides 2 inches of tolerance above and below. They do not project more than 4 1/2 inches into the required egress width and provide not less than 1 1/2 inches of clearance between the handrail and the adjacent wall or guard. Extensions are provided at the top and bottom of each flight of stairs and return to the wall or walking surface. The handrails are 1 1/2 inches in diameter, which comply with the graspability requirements.

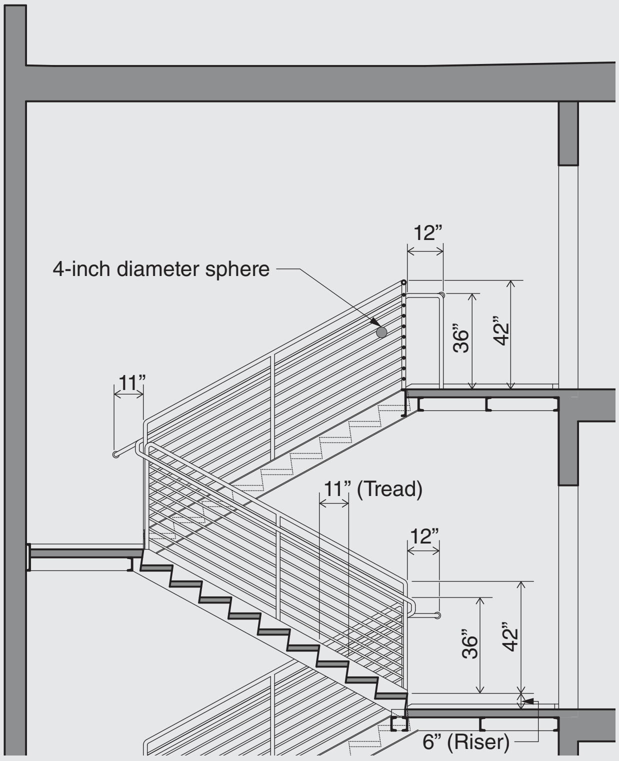
The guards within the center of the stairway have a height of 42 inches and have openings that do not permit the passage of a 4-inch sphere. There are no triangular openings since the stringer channel covers the triangular openings at the treads and risers.

RAMP (EXAMPLE PROJECT FIGURE 23-2)

The ramp to the pool deck is required to have handrails; however, a guard is not required, since the height of the surface below is less than 30 inches. The handrails are required to have extensions at the top and bottom of the ramp run that extend 12 inches. For the required edge protection, the ramp surface is extended a distance of 12 inches per IBC Section 1012.10.2.



(A) PLAN

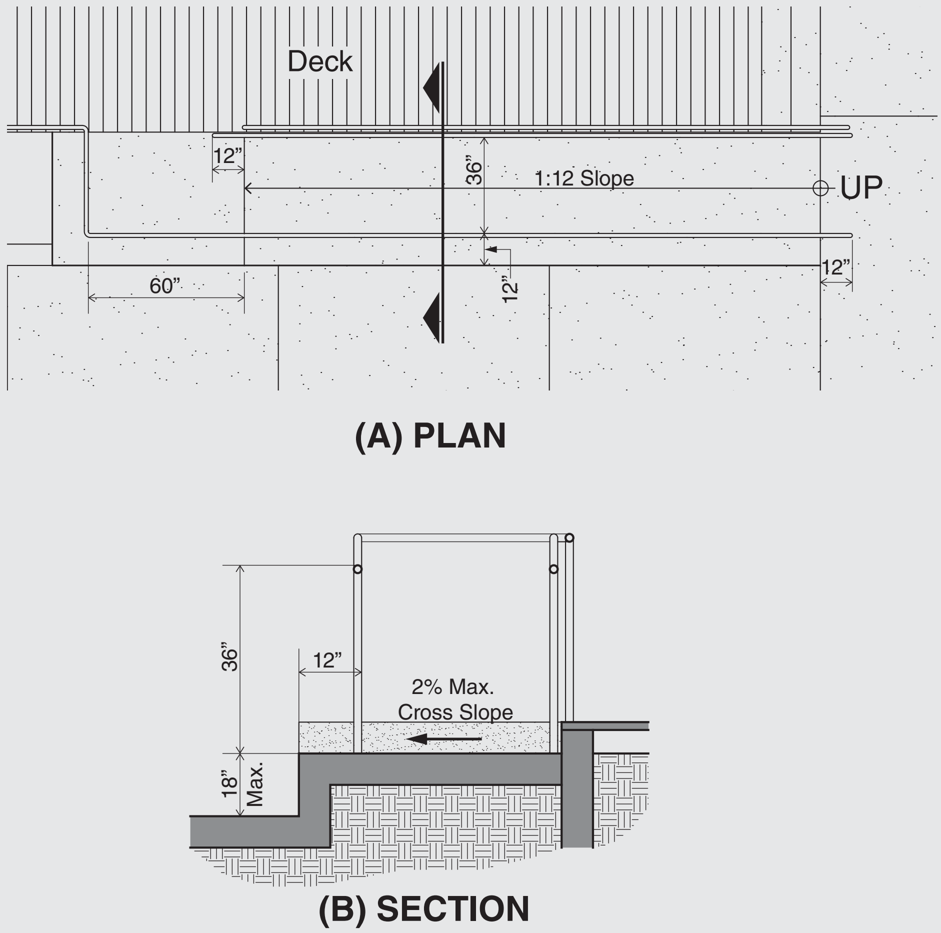


(B) SECTION

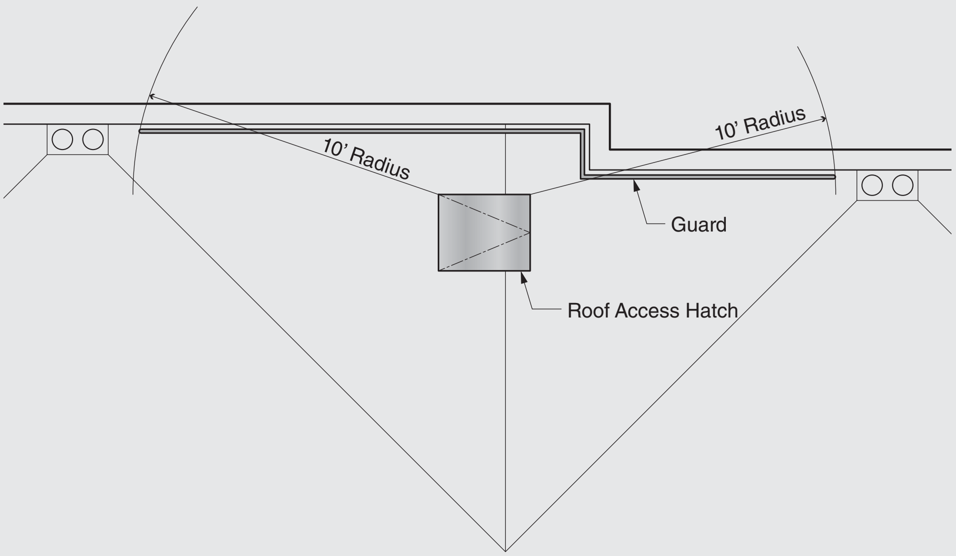
EXAMPLE PROJECT FIGURE 23-1. Stairway details: (A) plan and (B) section.

ROOF ACCESS (EXAMPLE PROJECT FIGURE 23-3)

Since the roof access hatch is located within 10 feet of the roof's edge, a guard is required; however, no specific requirement as to the extent of the guard is provided. The likely interpretation will be that a guard must be provided where the distance at any point to the roof edge is less than 10 feet.



EXAMPLE PROJECT FIGURE 23-2. Ramp details: (A) plan and (B) section.



EXAMPLE PROJECT FIGURE 23-3. Guard at roof access hatch.

STEP 24

IDENTIFY LOCATIONS OF SAFETY GLAZING

STEP OVERVIEW

Glazing is incorporated into building designs to provide views to the exterior and allow natural lighting into the interior. Additionally, interior glass is used to provide a visual connection between spaces. However, large panes of glass require a minimum level of strength to resist bodily impact when installed in certain locations. It is important to know these locations and identify them on the *construction documents*.

24.1 INTRODUCTION TO SAFETY GLAZING

The terms "glass" and "glazing" have similar meanings and are frequently used interchangeably, but they do describe different things. Glass is the material itself, whereas glazing, the noun, refers to any material used as an infill panel, whether it is glass, plastic, or some other material, which is installed in an opening. Glazing, the verb, is defined by the Glass Association of North America (GANA) as the "process of installing an infill material into a prepared opening in windows, door panels, partitions, etc."

The life safety aspect of glass and glazing can be separated into two areas: structural loads and impact loads. Although an impact load is a form of structural load, it is distinguished as a separate category due to its unique application requirements in the IBC. There are two types of impact loads addressed by the IBC: human impact loads and wind-borne debris impact loads. In the IBC, structural loads are used to determine glass thickness, which may be greater or less than what is required for impact loads. Because the determination of glass thickness is a complex process, it should be accomplished by a registered structural engineer. However, this step focuses only on the human impact aspect of glazing, since its application is consistent regardless of building location.

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Glass is required to be provided with a manufacturer's mark indicating glass type and thickness. The marking may be omitted if *approved* by the *building official* and an affidavit from the glazing contractor is provided indicating that the glass conforms to the *construction documents* and the requirements of the IBC. ***Fully tempered glass*** must be permanently marked (e.g., acid or laser etched, sandblasted, ceramic fired, or embossed), except that tempered ***spandrel*** glass may be provided with removable paper labels. Other types of glazing meeting the requirements for safety glazing, such as ***laminated glass*** or plastic glazing, are also required to be marked, but the IBC allows the submission of a certificate, affidavit, or other evidence in lieu of the marking if *approved* by the *building official*.

Definitions

Fully Tempered Glass

Flat or bent glass that has been heat-treated to have either a minimum surface compression of 10,000 psi (69 MPa) or an edge compression not less than 9,700 psi (67 MPa) in accordance with the requirements of ASTM C 1048, kind FT [Fully Tempered] or meet the requirements of ANSI Z97.1 or CPSC 16 CFR 1201. Outside of North America, sometimes called "toughened glass."

Laminated Glass

Two or more lites of glass permanently bonded together with one or more interlayers.

Spandrel

Panel(s) of a wall located between vision areas of windows, which conceal structural columns, floors and shear walls.

Source: Glass Association of North America (GANA), http://www.glasswebsite.com/techcenter/Glossary/index.asp.

24.2 HUMAN IMPACT RESISTANCE

Glazing required to resist human impact needs to comply with the provisions of IBC Section 2406, which requires testing in accordance with Consumer Product Safety Commission (CPSC) 16 CFR 1201. Glazing not located in doors or in wet areas, such as hot tubs, bathtubs, showers, and saunas, may comply with ANSI Z97.1. Both the federal and ANSI standards use similar impact test stands for testing safety glazing.

The basic test involves raising the impactor—a punching bag filled with lead shot weighing 100 pounds—to an established height and releasing it to let it strike the glass. Glass desiring a Category I rating (Class B per ANSI Z97.1) must pass the test when the impactor is raised 18 inches (measured vertically) above the impactor's position at rest. For a Category II rating (Class A per ANSI Z97.1), the impactor is dropped from a height of 48 inches. To qualify as safety glazing, the test specimen must not, at a minimum, develop a hole in which a 4-pound 3-inch solid steel sphere could pass. After the test, the specimen is rotated to the horizontal position and the sphere is placed in the opening. If after one second the sphere has not dropped through, the specimen is deemed to have met the impact criteria.

Category II glazing is permitted in all safety glazing applications; however, Category I glazing is permitted when the exposed surface area of a single pane is 9 sq. ft. or less, except for glazing around wet areas per IBC Section 2406.4.5. Glazing is permitted to be tested by ANSI Z97.1 but must comply with Class A, unless otherwise indicated in IBC Table 2406.2(2) to be Class B. All safety glazing must be identified by a permanent marking that indicates the manufacturer and the safety standard with which it complies plus the information previously mentioned.

The IBC identifies seven specific hazardous locations where safety glazing is required:

Glazing in Doors: IBC Section 2406.4.1 requires that all glass in swinging, sliding, and folding doors, whether the glass is operable or fixed, be safety glazing (Figure 24.2-1). Safety glazing is not required if the glazed opening does not permit the passage of a 3-inch-diameter sphere. Additionally, *decorative glass*, curved glass panels in revolving doors, and glass in commercial refrigerated cabinets are also exempt from the safety glazing requirement.

Glazing Adjacent to Doors: IBC Section 2406.4.2 requires all glazing, fixed or operable, that is within a 24-inch radius of the vertical edges of the door (hinge and latch edges) in a closed position with a bottom exposed edge of glazing that is less than 60 inches above the walking surface be safety glazing (Figure 24.2-1). Exceptions include decorative glass, where an intervening wall or permanent barrier is between the door and glazing (Figure 24.2-2), where access through the door is to a closet 3 feet or less in depth or in walls on the latch side and perpendicular to the door in one- and two-family *dwellings* and R-2 *dwelling units*.

Glazing in Windows: IBC Section 2406.4.3 requires glazing in windows, whether fixed or operable, to be safety glazing when all of the following conditions exist:

- The exposed area of glazing in a single pane is greater than 9 sq. ft.
- The bottom edge of the glazing is less than 18 inches above the floor.
- The top edge of the glazing is greater than 36 inches above the floor.
- A walking surface is located within 36 inches of the glazing measured perpendicular to the glazing surface.

One exception to the requirements is decorative glass. Another exception is when a horizontal rail is installed across the glazing at a height of 34 to 38 inches. The horizontal rail must withstand a horizontal load of 50 plf without contacting the glazing and must be a minimum of $1\frac{1}{2}$ inches in height (Figure 24.2-3). The last exception applies to insulating glass installed

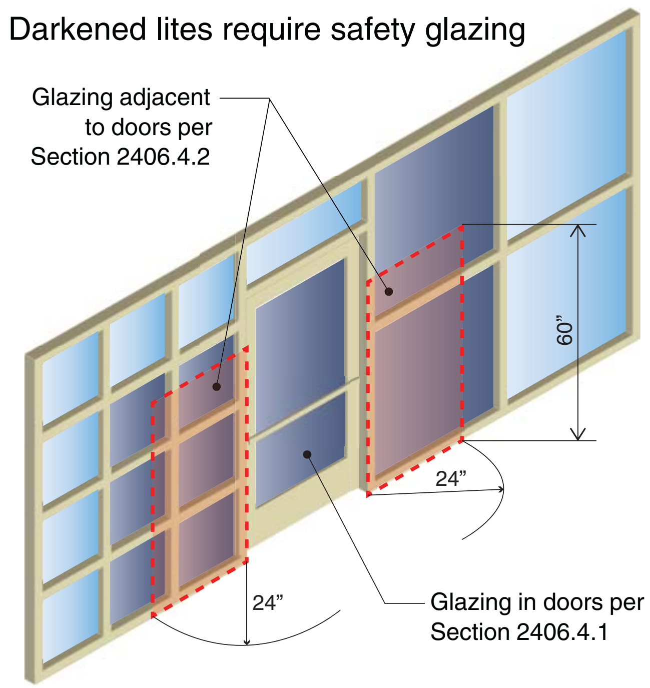

FIGURE 24.2-1. Safety glazing in doors and adjacent to doors.

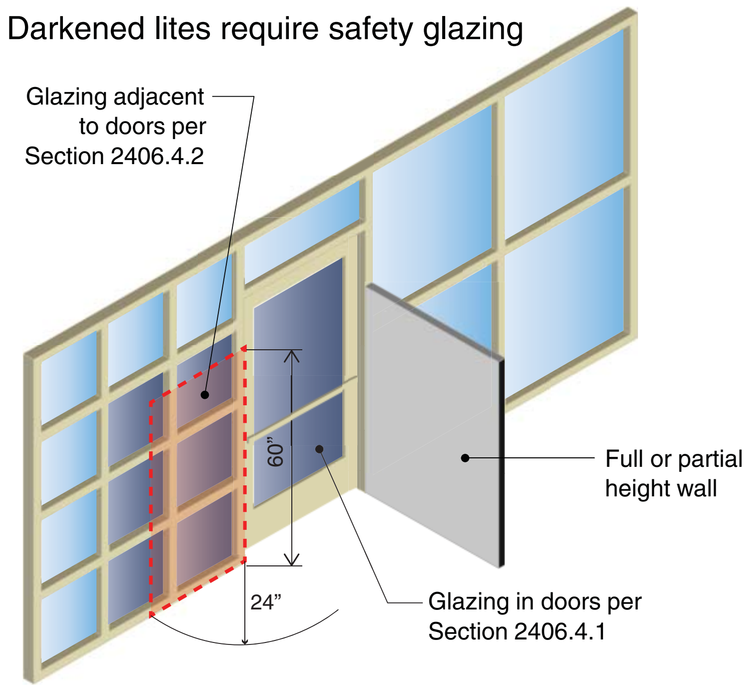

FIGURE 24.2-2. Exception to requirement for safety glazing when partition is between door and adjacent glass.

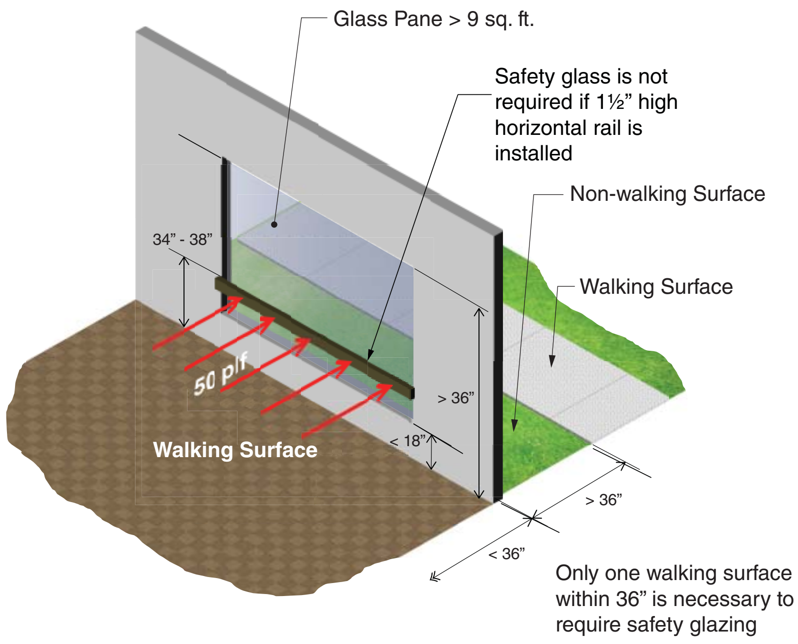

FIGURE 24.2-3. Glazing in windows adjacent to walking surfaces with Exception 2 shown.

25 feet above a walking surface, roof, grade, or other surface with a slope within 45 degrees of horizontal. With this exception, the outboard pane is not required to be safety glazing.

Glazing in Guards and Railings: IBC Section 2406.4.4 requires safety glazing when glazing is used as structural balusters or as infill panels within a railing system of a different material. The requirement is applicable regardless of height above a walking surface. IBC Section 2407 has specific provisions for glazing in *guards* and railings, which require tempered glass or laminated

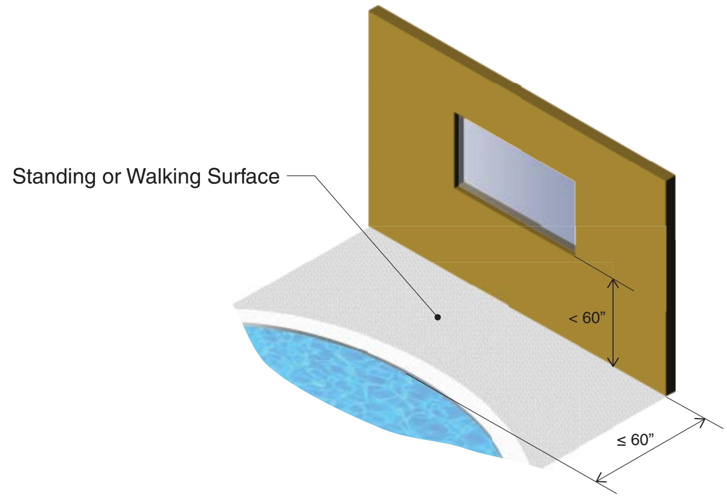

FIGURE 24.2-4. Criteria for safety glazing adjacent to wet areas.

glass fabricated with either tempered or heat-strengthened glass. Glass balusters must have an attached *handrail* or *guard*, unless the baluster is constructed of laminated glass of equal type and thickness, can withstand the loads for *handrails* and *guards* per IBC Section 1607.8, and is *approved* by the *building official*. *Handrails* and *guards* are required to be supported by a minimum of three glazing panels, unless they are designed to be supported by other means.

Glazing in Wet Areas: IBC Section 2406.4.5 requires safety glazing (for a single pane and all panes of multiglazed units) installed as fences, enclosures, or walls near *swimming pools*, hot tubs, spas, whirlpools, saunas, steam rooms, bathtubs, and showers when the bottom edge of the glazing is within 60 inches vertically above any standing or walking surface. The exception to this is that safety glazing is not required if the glazing is located more than 60 inches from the edge of the water when measured horizontally from the face of the glazing (Figure 24.2-4).

Glazing Adjacent to Stairs and Ramps: IBC Section 2406.4.6 requires safety glazing when the bottom edge of the glazing is less than 60 inches above the plane of the walking surface of *stairs*, landings between *flights* of *stairs*, and *ramps*. Safety glazing is not required if the *stairway*, landing, or *ramp* has a *guard* between the walking surface and the glazing, and the glazing is more than 18 inches horizontally from the *guard*. The *guard* must comply with IBC Section 1013 and shall withstand the loads per IBC Section 1607.8. Another exception to the safety glazing requirement is if the glazing is 36 inches or more, measured horizontally, from the walking surface.

Glazing Adjacent to the Bottom Stair Landing: IBC Section 2406.4.7 requires safety glazing at the bottom *stair* landing when the bottom edge of the glazing is less than 36 inches above the landing and within 60 inches of the last tread measured horizontally. The only exception is one similar to that for *stairs* and *ramps* when the glazing is protected by a *guard* complying with IBC Sections 1013 and 1607.8 and the glazing is more than 18 inches from the *guard*.

24.2.1 GLAZING IN ATHLETIC FACILITIES

Due to the higher potential for impact against glazing in athletic facilities, the IBC has established requirements specific to those uses. In racquetball and squash courts, glazing shall be tested per CPSC 16 CFR 1201 or ANSI Z97.1 at a drop height of 48 inches. However, the test method is modified to test an actual installation or an identical assembly, with all the required fixtures and fittings, and the impact point is located at a height of 59 inches above the playing surface. To pass the test, the glazing must remain intact following the impact, and the deflection at the point of impact cannot exceed $1\,^1\!/_2$ inches. In gymnasiums and basketball courts, the glazing must comply with CPSC 16 CFR 1201, Category II, or ANSI Z97.1, Class A.

24.2.2 GLAZING IN ELEVATORS

Glazing is permitted in elevator cars and hoistways per IBC Section 2409 and ASME/ANSI A17.1. When installed in elevator hoistways, glazing shall be laminated safety glass complying with 16 CFR 1201 Category II or ANSI Z97.1 Class A. If the hoistway is required to be *fire-resistance rated*, then the glazing must also comply with IBC Section 716 for opening protectives. Since IBC Section 716 is referenced, glazing tested in accordance with ASTM E 119 or UL 263 may be used in lieu of complying with the limitations of IBC Section 716.

In hoistway doors, glazing shall comply with the same criteria for hoistways, except that ASME/ANSI A17.1 permits wire glass in vision panels without reference to any safety glazing standards; however, the IBC will permit wire glass provided that the glass complies with the safety glazing standards previously mentioned. With the exception of vision panels, glazing in hoistway doors must not be less than 60% of the total visible door surface area; likewise, car doors must have the same minimum area for glazing as viewed from the car side. There is no requirement that glazing, if provided, must be used in both the car and hoistway doors, nor is it required that the areas of glazing in each be equal.

When glazing is installed as part of the elevator car enclosure, ASME/ANSI A17.1 requires laminated safety glazing complying with 16 CFR 1201 and that it be mounted so that the assembly will pass the elevator tests without damage. Additionally, ASME/ANSI A17.1 requires that a *handrail* or other framing be provided if the glazing panels are wider than 12 inches. The IBC further requires that glazing used within an elevator, either as a wall lining or as part of the enclosure, comply with 16 CFR 1201 Category II or ANSI Z97.1 Class A. Since ANSI Z97.1 is not referenced by ASME/ANSI A17.1, then, to comply with both codes, only materials complying with 16 CFR 1201 Category II should be used.

Both the IBC and ASME/ANSI A17.1 allow tempered glass when used as a lining for elevator car walls. If used, tempered glass must be bonded to a coating, sheeting, or film backing to hold fragments in place if broken. The tempered glass cannot be sandblasted, etched, heat treated, painted, or have received any other treatment that would affect the characteristics of the glass. Finally, the IBC requires that tempered glass comply with 16 CFR 1201 Category II or ANSI Z97.1 Class A, which is more specific than the safety glazing requirements specified by ASME/ANSI A17.1.

24.2.3 WIRED GLASS

Not mentioned directly in the IBC but addressed via compliance with current safety glazing standards is the absence of traditional wired glass as safety glazing. For decades, wired glass was exempt from the impact requirements of CPSC 16 CFR 1201 if used in areas where fire-protection and safety glazing was required. With the introduction of specialty fire-resistive and fire-protection glass that can comply with safety glazing standards, the federal standard and the IBC have removed the exceptions, and traditional wired glass is no longer permitted in areas where safety glazing is required. Contrary to popular belief, traditional wired glass is not gone—it has always been permitted where annealed glass is allowed and in *fire window assemblies* where safety glazing is not required. However, wired glass that does comply with safety glazing standards is now available, which typically includes an added film to improve its performance in regard to impact resistance.

24.3 SLOPED GLAZING ASSEMBLIES

Sloped glazing is considered to be any glazed assembly that has a slope of 15 degrees or more from the vertical plane. This includes *sloped glazing* in an interior wall application, *exterior wall* application, or roof application. The requirements for *sloped glazing* is provided in IBC Section 2405.

Glazing materials used in *sloped glazing* assemblies must be laminated glass, wired glass, light-transmitting plastic, ***heat-strengthened glass***, or fully tempered glass. If the glazing includes multiple layers of glass, then each layer can be any material listed. ***Annealed glass*** is permitted, but only in nonpublic greenhouses used for growing plants and where the walking surface below is completely protected from falling glass by permanent means.

DEFINITIONS

Annealed Glass

Any standard float glass that is slowly cooled and is not considered heat strengthened or fully tempered glass.

Heat-Strengthened Glass

Glass that has been heat treated but has an induced surface compression that is much less than that required for fully tempered glass.

Sloped glazing that utilizes fully tempered or heat-strengthened glass in a monolithic system (i.e., single-pane glazing) must have screens installed below the glazing per IBC Section 2405.3. This IBC section provides five exceptions that allow the elimination of the screening. If heat-strengthened, fully tempered, or wired glass is used as the bottom layer of a multiple-layer glazing system, such as insulating glass, then the screening is also required. To avoid using screens or working with one of the exceptions, the easiest approach is to use laminated glass either in a monolithic system or as the inboard pane of an insulated glazing unit.

EXAMPLE PROJECT—STEP 24

Windows within the residential units, including windows with fourth-story clerestories, are not required to be safety glazing since the bottom edge of the glass is located higher than 18 inches above the floor and each pane is less than 9 sq. ft. in area. Glazing in the sliding doors to the balconies is required to be Category II safety glazing per IBC Table 2406.2(1). The glazing within the narrow windows along the corridors on the residential stories is required to be Category II safety glazing per IBC Table 2406.2(1) or Category A safety glazing per IBC Table 2406.2(2), since they meet all the criteria per IBC Section 2406.4.3.

On the first story, all storefront glass is required to be Category II safety glazing, including the entrances, per IBC Sections 2406.4.3 and 2406.4.1, respectively. Glazing within the operable glass wall at the lounge is also required to be Category II safety glazing per IBC Section 2406.4.1.

STEP 25

Detail Firestopping, Fire-Resistant Joints, and Fireproofing

STEP OVERVIEW

Firestopping and fire-resistant joints are critical components of a *fire-resistance-rated* assembly. Just as a wall, floor, or roof system is selected for its fire-resistive performance, so must a firestop system and fire-resistive joint be. Firestopping and fire-resistive joints protect the breaches in a *fire-resistance-rated* assembly to prevent the passage of flame and smoke from one side of the assembly to the other. These breaches come in the form of penetrations into or through a *fire-resistance-rated* assembly, joints between two adjacent *fire-resistance-rated* assemblies, and joints between a *horizontal assembly* and an exterior curtain wall system.

25.1 PENETRATIONS (IBC SECTION 714)

A penetration exists when a building component, such as a pipe, conduit, or beam, breaches either one or both sides of a *fire-resistance-rated assembly* leaving a gap (i.e., *annular space*) that would permit the passage of flame and smoke if not properly sealed. It is not enough to just seal the *annular space* with "stuff"; the materials used must endure the same type of fire exposure that the *fire-resistance-rated* assembly must endure. Otherwise, the overall performance of the required fire-resistive separation will be greatly reduced.

To properly complete this portion of the step, all of the *fire-resistance-rated* assemblies need to be identified on the plans and sections per Step 15. Review structural, mechanical, plumbing, fire protection, and electrical drawings and any other drawings that have distribution systems (e.g., fire alarm, computer

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networking, etc.) to see where distribution lines run. If any pipes, conduits, cable trays, ducts, or structural elements (i.e., beams, joists, and columns) pass through a *fire-resistance-rated* assembly, then they need to be treated as a penetration per IBC Section 714. Ducts with fire, smoke, or combination fire/smoke dampers per IBC Section 717 are not required to be treated as penetrations. Additionally, items penetrating walls required to have a *fire-resistance rating* per IBC Tables 601 and 602 are not required to be treated as penetrations.

Firestop systems use a variety of materials, products, and devices to protect penetrations. The selection of a firestop system is not only for its hourly rating, as explained below, but is also based on the type of item that is penetrating the *fire-resistance-rated* assembly and the type of construction that is being penetrated. For example, a cast-iron pipe going through a *concrete* wall has different protection requirements than a PVC pipe through a *gypsum board* partition.

Sources of tested firestop systems are available through a few third-party testing agencies. The most prominent sources include the following:

- Underwriters Laboratories (UL): http://database.ul.com/cgi-bin/ulweb/LISEXT/1FRAME/Fire ResistanceWizard.html
- FM Global (FMG): http://www.approvalguide.com/CC_host/pages/public/custom/FM/login.cfm
- Intertek Group: https://whdirectory.intertek.com/Pages/DLP_Search.aspx

Penetrations of *fire-resistance-rated* assemblies are categorized into two main types:

- Through Penetration: One in which an item passes completely through the *fire-resistance-rated* assembly. An example of a through penetration would be an electrical conduit that penetrates a *fire barrier* on one side of the barrier and *exits* on the other side of the barrier.
- Membrane Penetration: One in which an item penetrates only one face of a *fire-resistance-rated* assembly. Examples of membrane penetrations include a recessed or semirecessed fire extinguisher cabinet and an electrical wall receptacle box.

25.1.1 PENETRATIONS IN FIRE-RESISTANCE-RATED WALLS (IBC SECTION 714.3)

Through penetrations of *fire-resistance-rated* walls (*fire walls*, *fire barriers*, *smoke barriers*, and *fire partitions*) must be protected with a firestop system or device in accordance with ASTM E 814 or UL 1479. The tested firestop system must have an "F" rating not less than the *fire-resistance rating* of the wall penetrated. An "F" rating is a measurement of the firestop system's ability to prevent the spread of flame (hence, the "F" designation) from the exposed side to the unexposed side of the wall.

The requirements for through penetrations, as those of many other code provisions, have their exceptions:

1. Penetrating pipes of steel, ferrous, or copper materials or steel conduits in *fire-resistance-rated* walls are permitted if the *annular space* is filled with grout or mortar in *masonry* or *concrete* walls. This is only limited to penetrating items having a diameter of 6 inches or less, and the opening through the wall does not have a cross-sectional area that exceeds 144 sq. in.
2. Penetrating items of the same materials mentioned in the exception above are permitted when those penetrations are tested in accordance with the time-temperature conditions of ASTM E 119 or UL 263.

Membrane penetrations are required to conform to the same requirements for through penetrations. However, since a membrane penetration does not completely penetrate the *fire-resistance-rated* wall, they are afforded six exceptions:

1. Steel electrical boxes in assemblies with a rating of up to 2 hours that do not exceed 16 sq. in. (i.e., a typical 4″ by 4″ junction box), provided that the sum of such penetrations does not exceed 100 sq. in. within 100 sq. ft. of wall space. Additionally, electrical boxes on opposite sides of the walls must either be separated by a distance of 24 inches, by a distance not less than the depth of a wall cavity when filled with insulation, by solid *fireblocking*, by listed putty pads, or by other listed materials and methods. The *annular space* cannot exceed 1/8 inch.
2. Electrical boxes of any material that have been tested for use in *fire-resistance-rated* assemblies. The same requirements for separation of boxes on opposite sides apply as stated above, except that wall cavities filled with insulation are not permitted. The *annular space* cannot exceed 1/8 inch.
3. Electrical boxes of any material that have been tested and listed as part of a wall opening protective material for use in a *fire-resistance-rated* assembly.
4. Boxes other than electrical that have the *annular space* protected by a firestop assembly tested per ASTM E 814 or UL 1479.
5. The *annular space* of a fire sprinkler covered by a metal escutcheon plate.
6. Steel electrical boxes in assemblies with ratings up to 2 hours that do not exceed 16 sq. in. (i.e., a typical 4″ by 4″ junction box), provided that the sum of such penetrations does not exceed 100 sq. in. within 100 sq. ft. of wall space and the penetrating items are protected by listed putty pads or other listed materials and methods.

Penetrations in *smoke barriers* are additionally required to have an "L" rating for air leakage (hence, the "L" designation) per UL 1479. The rating cannot exceed 5.0 cfm per square foot of penetration opening or a cumulative of 50 cfm for any 100 sq. ft. of area.

25.1.2 PENETRATIONS IN HORIZONTAL ASSEMBLIES (IBC SECTION 714.4)

During a fire event, the exposure that *horizontal assemblies* (i.e., floors, floor/ceilings, roofs, and roof/ceilings) endure is much harsher than walls. As a fire burns, the heat rises up to the *horizontal assembly*. Therefore, the temperatures at the *horizontal assembly* will be much greater than that at the walls. Because of this level of exposure, firestop systems in *horizontal assemblies* must have a "T" rating in addition to the "F" rating. The "T" rating is a measurement of a firestop system's ability to resist a rise in temperature (hence, the "T" designation) on the unexposed side of the penetrating item. Both the "F" and "T" ratings must be at least 1 hour but not less than the *fire-resistance rating* of the assembly penetrated. There are three exceptions to the required "T" rating:

1. Penetrations within a cavity of a wall
2. Floor penetrations by floor drains, tub drains, and shower drains that are concealed within the *horizontal assembly*
3. Penetrations with a maximum 4 inches in diameter penetrating directly into a metal-enclosed electrical switchgear cabinet

For *horizontal assemblies*, the requirements for through penetrations are very similar to those of walls, but the exceptions vary slightly. In each exception described below, the *annular space* must be filled:

1. Penetrations of a single *fire-resistance-rated* floor assembly subjected to the time-temperature conditions of ASTM E 119 or UL 263. The penetrating items are limited to steel, ferrous, or copper pipes, ducts, or conduits or concrete or masonry items. If an item does not exceed 6 inches in diameter, then it is not limited to a single floor penetration, as long as the total area of penetration openings does not exceed 144 sq. in. in any 100 sq. ft. of floor area.
2. Steel, ferrous, or copper penetrating items are permitted through a single *concrete* floor assembly provided the item does not exceed 6 inches in diameter and the *annular space* is filled for the full

thickness with *concrete*, grout, or mortar. The penetrating item is not limited to a single floor if the total area of openings in each floor does not exceed 144 sq. in.

3. Electrical boxes of any material that have been tested for use in *fire-resistance-rated* assemblies.

Similar to *fire-resistance-rated* walls, membrane penetrations in *horizontal assemblies* must comply with the requirements for through penetrations, and, like the walls, have several exceptions:

1. Steel, ferrous, or copper items, or concrete or masonry items where the *annular space* is protected as for through penetrations. The total area of penetration openings cannot exceed 100 sq. in. in any 100 sq. ft. of ceiling area.
2. Electrical boxes in ceiling membranes of *horizontal assemblies* with ratings up to 2 hours that do not exceed 16 sq. in. (i.e., a typical 4″ by 4″ junction box), provided that the sum of such penetrations does not exceed 100 sq. in. within 100 sq. ft. of wall space. The *annular space* cannot exceed 1/8 inch.
3. Electrical boxes of any material that have been tested and listed as part of an opening protective material for use in *horizontal assemblies*.
4. Electrical boxes of any material that have been tested and listed for use in *fire-resistance-rated* assemblies. The *annular space* cannot exceed 1/8 inch.
5. The *annular space* of a fire sprinkler covered by a metal escutcheon plate.
6. Noncombustible items cast into *concrete* slabs, beams, or joists, which do not penetrate both the top and bottom surfaces of the *concrete* element.
7. Double-top plates of wood frame wall construction, provided that the wall is protected by Type X *gypsum board* on both sides and any items penetrating the double-top plate are protected as required for through penetrations.

Horizontal assemblies that are part of a *smoke barrier* are also required to have the same leakage requirement (i.e., "L" rating) as for vertical *smoke barriers*.

For *horizontal assemblies* that have no required *fire-resistance rating*, penetrations need to comply with one of the following:

- The requirements for *shaft* assemblies
- Noncombustible penetrating items that penetrate not more than five *stories* and have the *annular spaces* filled with a material *approved* for a *through-penetration firestop system*
- Penetrating items of any material that penetrate not more than two *stories* and have the *annular spaces* filled with a material *approved* for a *through-penetration firestop system*

25.2 FIRE-RESISTANT JOINT SYSTEMS (IBC SECTIONS 715)

When a *fire-resistance-rated* assembly abuts another *fire-resistance-rated* assembly, the joint between the two must be treated to provide continuity of the assemblies. Similarly, the gap between exterior curtain walls and *fire-resistance-rated* construction must also be protected.

Like identifying penetration locations, this portion of the step requires that all *fire-resistance-rated* assemblies be identified on the plans and sections per Step 15. Where assemblies come together there may be a need for a *fire-resistant joint system*. Not all intersections of *fire-resistance-rated* assemblies need a special joint assembly in order to be considered protected. For example, intersecting walls constructed of metal or wood studs, covered with *gypsum board*, and taped and finished per the tested assembly at the intersection are not required to have an independently tested joint system. The locations that will likely require a tested joint system are those where assemblies of different construction intersect or where a physical separation is required, whether of similar or different construction, to control thermal, seismic, or other movements of the assemblies.

Joints between *fire-resistance-rated* assemblies are required to be protected with *fire-resistant joint systems* tested in accordance with ASTM E 1966 or UL 2079. However, an exception to IBC Section 715.1 identifies nine locations that are exempt from this requirement:

- Floors within individual *dwelling units*
- Floors where the joints are protected by a *shaft enclosure*
- Floors open to *atriums* and included within the volume protected by smoke control measures
- Floors within *malls*
- Floors and *ramps* of enclosed and *open parking garages*
- *Mezzanine* floors
- Walls not required to have protected openings
- Control joints where the width of the joint does not exceed 5/8 inch and the joint is tested as part of the wall assembly per ASTM E 119 or UL 263

Although *exterior walls* are not considered *fire-resistance-rated* assemblies, they are required to have protected joints per IBC Section 705.9. There is an exception to that IBC section that does not require protected joints when openings, such as windows and doors, are not required to be protected. This is in alignment with one of the excepted locations to IBC Section 715.1 previously listed. Additionally, per the last item of the exception, if the joint was tested as a part of the assembly and does not exceed 5/8 inch in width (e.g., typical masonry joint), then a tested *fire-resistant joint system* is not required.

Exterior curtain walls, because they are set out in front of a building's structural frame, have large gaps between the curtain wall and adjacent walls and floors. Even though the curtain wall may not have a *fire-resistance rating*, these gaps are required to be protected since they provide pathways that circumvent the *fire-resistance-rated* assemblies. Requirements specific to curtain walls are located in IBC Section 715.4.

Floor joints at curtain walls are required to be tested per ASTM E 2307 and are commonly referred to as "perimeter fire containment systems." Most of the systems tested per this standard conform to the vertical separation requirements of IBC Section 705.8.5. However, if the curtain wall vision glass (not to be confused with spandrel glass) extends to the floor line, then the exception allows *approved* materials that can prevent the passage of flame and gases per the ASTM E 119 time-temperature fire conditions. If the floor does not have a *fire-resistance rating*, then the gap is still required to be sealed to retard the passage of flame and gases, but a tested system is not mandated.

Added in the 2015 IBC is the requirement to protect the joint between a *fire barrier* and a curtain wall. A tested assembly is not required, but the IBC does state that an "*approved* material or system" must be used to fill the gap.

Sources of tested *fire-resistant joint systems* are available through a few third-party testing agencies. The most prominent sources include the following:

- Underwriters Laboratories (UL): http://database.ul.com/cgi-bin/ulweb/LISEXT/1FRAME/FireResistanceWizard.html
- Intertek Group: https://whdirectory.intertek.com/Pages/DLP_Search.aspx

25.3 FIREPROOFING

The requirements for fireproofing are not located in a single section within the IBC. Fireproofing can consist of *sprayed fire-resistant materials* (*SFRMs*), *mastic fire-resistant coatings*, *intumescent fire-resistant coatings*, mats, plaster, *gypsum board*, mineral board, or mineral fiber board. The fireproofing materials selected must be part of a tested assembly and be designed and detailed exactly as indicated in the assembly data sheet. Therefore, the IBC offers little in the way of material requirements for fireproofing with the exception of *SFRM*, mastic, and intumescent materials.

SFRMs are addressed in two locations within the IBC: Section 704.13 and Section 1705.14. *Mastic fire-resistant coatings* and *intumescent fire-resistant coatings* are only mentioned briefly in IBC Section 1705.15. Most of the requirements in these sections will be covered within the specifications for the *construction documents*. The drawings should indicate which items must be protected and the required *fire-resistance rating*, since the thickness of coating is relative to the size of the structural member being protected and the required *fire-resistance rating*.

Other materials should be detailed exactly as indicated in the assembly data sheet. For board materials, pay particular attention to the overlapping of materials at the corners. Since many tested assemblies identify specific products, the specifications should only list those products used in the assembly.

25.4 SPECIAL INSPECTIONS (IBC SECTIONS 1705.14, 1705.15, AND 1705.17)

Projects that are *high-rise buildings* (see Step 6) or are assigned in *Risk Category* III or IV per IBC Table 1604.5 are required to have penetration firestops and fire-resistant joints inspected by a special inspector. All *SFRMs*, *mastic fire-resistant coatings*, and *intumescent fire-resistant coatings* are also required to be inspected by *special inspectors*. This issue is not typically addressed on the drawings but should be covered in the project specifications to inform the contractor that penetration firestops and fire-resistant joints will be inspected by an outside inspector.

If *special inspections* are required, to facilitate the process, penetration firestops and fire-resistant joints can be labeled to identify the date of installation, type of system, product, manufacturer, and the contractor that installed the system. Labeling is not required by the IBC, but may be required by a local amendment. If labeling is required or desired, the requirements should be added to the project's specifications.

EXAMPLE PROJECT—STEP 25

PENETRATIONS

Without detailed mechanical, electrical, or plumbing designs, it is difficult to determine what types of penetrations are to be expected on a project. However, it can be assumed that electrical conduit, plumbing, HVAC piping, and fire sprinkler piping will need to pass through walls and horizontal assemblies.

Each dwelling unit has its own air distribution system, so no ductwork on the residential stories will penetrate a fire-resistance-rated assembly. On the first story, no fire-resistance-rated assemblies are required because of the nonseparated occupancies on that story. However, the trash room does have 2-hour fire barriers that will have some penetrations.

Firestop systems selected should be based on metal pipe for water distribution and fire sprinkler systems and plastic pipe for waste and vent systems. It should be anticipated that electrical wiring will be within metallic conduit.

Where electrical outlets and light switches are installed on fire-resistance-rated walls, the boxes need to comply with the requirements for membrane penetrations. Since these walls also have to meet minimum sound transmission performance requirements, putty pads will be installed at these locations to seal the membrane penetrations and to prevent flanking paths for noise.

Using the UL Fire Resistance Directory, the following system categories could be researched to find suitable assemblies:

Penetrations through Framed (C) Floors (F):

- F-C-1000 through 1999: For metallic pipes, conduit or tubing.
- F-C-2000 through 2999: For nonmetallic pipes, conduit or tubing.
- F-C-5000 through 5999: For insulated pipes.
- F-C-8000 through 8999: For groupings of any combination of penetrating items.

Penetrations through Framed (L) Walls (W):

- W-L-1000 through 1999: For metallic pipes, conduit or tubing.
- W-L-2000 through 2999: For nonmetallic pipes, conduit or tubing.
- W-L-5000 through 5999: For insulated pipes.
- W-L-7000 through 7999: For mechanical penetrants, such as ductwork.
- W-L-8000 through 8999: For groupings of any combination of penetrating items.

FIRE-RESISTANT JOINT SYSTEMS

Very few joints will require special treatment for fire resistance. In the basement where fire barriers for the elevator hoistway, elevator machine room, and stairways abut the concrete walls and concrete floor, the joints will need to be treated for fire resistance.

Using the UL Fire Resistance Directory, the walls abutting other walls will need to have assemblies from the category group of WW-S-0000 through 0999, where "WW" refers to wall-to-wall joints, the "S" refers to static joints (i.e., joints that are not intended to move), and the number range refers to joints that are 2 inches or less in width. Where the walls abut the concrete floor above, assemblies from the category group of HW-S-0000 through 0999 should be selected, where "HW" refers to head-of-wall conditions and the other designations remain the same.

At the first through fourth stories, all construction is gypsum board on wood framing, so the joints are treated just like any other joint between gypsum board panels, so no special treatment is required. Where control joints are necessary in long continuous lengths of gypsum board walls, the control joints should be treated as a wall-to-wall joint as described above.

FIREPROOFING

Where steel columns and beams are incorporated into the framing system of the building, the steel must be protected as indicated in Step 15. Steel columns and beams must be individually protected; therefore the gypsum board for ceilings and walls is not sufficient protection. Depending on the size of the steel member and the type of protection proposed, the fireproofing will have varying thicknesses.

For the columns supporting the center wing by the covered patio, the construction will be steel wide flange members protected by SFRM and enclosed by wood stud framing, sheathing, and an EIFS. The UL Fire Resistance Directory provides several assemblies with a 2-hour rating, as determined by supporting the 2-hour horizontal assembly in Step 15. The thicknesses of the various systems range from $^{9}/_{16}$ inch to $^{1}/_{2}$ inch. A single system can be selected or multiple systems can be selected to allow competition among several manufacturers since many UL assemblies are proprietary.

STEP 26

LOCATE PORTABLE FIRE EXTINGUISHERS AND CABINETS

STEP OVERVIEW

Portable fire extinguishers are a fire protection feature often overlooked by design professionals. When a set of *construction documents* does include portable fire extinguishers, the number provided and the locations where they are indicated usually do not meet the requirements of the building and fire codes. The location and number of portable fire extinguishers provided need to be clearly indicated in the *construction documents* to eliminate costly and possibly unsightly field modifications.

26.1 FIRE EXTINGUISHER REQUIREMENTS OVERVIEW (IBC SECTION 906)

Both the IBC and IFC have the same requirements. However, this discussion will only reference the IBC requirements, which are located in IBC Section 906. The IBC requires fire extinguishers in all occupancies except for Group R-3. There is an exception for Group A, B, and E occupancies when quick-response sprinklers are installed throughout the building. The exception, however, does not eliminate portable fire extinguishers entirely; portable fire extinguishers must still be provided in all occupancies (except Group R-3) in the locations listed below:

- Within 30 feet of commercial cooking equipment
- In locations where *combustible liquids* or *flammable liquids* are either used, dispensed, or stored
- On each floor of a building under construction
- Where required by IBC Table 906.1

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- In laboratories, computer rooms, generator rooms, and other locations determined by the *fire code official* (*IFC*) to be special hazards

Referenced by the IBC, NFPA 10 provides requirements regarding the selection, placement, and maintenance of portable fire extinguishers. Most of the standard's content is focused on maintenance, inspection, and testing of portable fire extinguishers. However, many of the requirements in NFPA 10 are included in the text of the IBC.

26.2 SELECTION OF FIRE EXTINGUISHERS

The selection of portable fire extinguishers is based primarily on the type of fire most likely to be encountered in the building. NFPA 10 defines the five fire classes:

Class A: Fires involving ordinary combustible materials, such as wood, cloth, paper, rubber, and most plastics. This is the type of fire that would occur in most building conditions.

Class B: Fires involving flammable and combustible liquids, petroleum-based materials, paints, solvents, alcohols, and flammable gases. This type of fire would likely occur where such materials are used, dispensed, or stored.

Class C: Fires involving energized electrical equipment. In addition to building electrical service equipment, this type of fire could occur with electric equipment, such as computers and copiers.

Class D: Fires involving combustible metals, such as magnesium, titanium, zirconium, sodium, lithium, and potassium.

Class K: Fires in cooking appliances involving combustible cooking materials, such as vegetable or animal oils and fats.

In addition to the fire classifications, spaces are also classified based on their perceived hazard level. The three hazard classifications are determined using the anticipated quantity of Class A and Class B materials. Table 26.2-1 summarizes the classification criteria provided in NFPA 10. The explanatory materials of NFPA 13 Annex A provides a description and common uses for each of the hazard classifications.

Once the fire and hazard classifications are established, the next step is to select the type of extinguisher to use. Portable fire extinguishers use a variety of agents to extinguish fires, but the IBC does not establish requirements for specific agents, while NFPA 10 sets some restrictions. For the most part, the determination of extinguisher type is performance based. Portable fire extinguisher performance ratings are determined by UL/ANSI 711.

Ratings identify the type of fire or fires that a portable fire extinguisher can extinguish and the effectiveness of the extinguisher. For example, a "2-A" rating means that the extinguisher can be used only on Class A fire hazards and the number "2," when multiplied by 1.25, gives the equivalent extinguishing capability in gallons of water—the higher the number, the more effective the extinguisher. The preceding number is used only with Class A and B fire ratings. Portable fire extinguishers can have multiple ratings, such as "3-A:10-B:C," that allow a single extinguisher to handle multiple types of fires.

TABLE 26.2-1. Summary of Hazard Classifications

Hazard Classification	Class A Materials	Class B Materials
Light (Low) Hazard	Normally expected quantities of furnishings	Expected quantities to be less than 1 gal.
Ordinary (Moderate) Hazard	Occasionally contains materials beyond normal anticipated furnishings	Expected quantities to be from 1 to 5 gal.
Extra (High) Hazard	Involve the storage, packaging, handling, or manufacture of materials	Expected quantities to be more than 5 gal.

26.3 DETERMINING NUMBER OF REQUIRED EXTINGUISHERS

A few factors come into play when determining the number of required portable fire extinguishers. These include extinguisher rating, fire classification, hazard classification, and travel distance. IBC Tables 906.3(1) and 906.3(2) use these factors to determine distribution of extinguishers for Class A and B fire hazards, respectively. For example, according to IBC Table 906.3(1), a Class A fire with an ordinary hazard requires at a minimum a 2-A extinguisher with a 75-foot maximum travel distance to reach the extinguisher. If the travel distance exceeds 75 feet, then an additional extinguisher would be required. The travel distance requirement does not apply to Group A-5 occupancies as provided in IBC Section 906.2, Exception 1. Travel distance is measured along the actual path traveled from the most remote location to the extinguisher and not in a direct line; however, NFPA 10 Annex E, which is nonmandatory, shows examples using a 75-foot radius from the extinguisher. The former method conforms to the method used for means of egress with which *building officials* are familiar and will provide a truer travel distance. The latter method, although not required, may be accepted by the *building official*, but could have actual travel distances that exceed the 75-foot maximum.

For Class A fire hazards, IBC Table 906.3(1) sets the maximum areas per unit of "A" and per extinguisher. For an extinguisher in an ordinary hazard, the table allows 1,500 sq. ft. per unit of A; therefore, a 2-A extinguisher is limited to a floor area of 3,000 sq. ft. If the area of the building is 6,000 sq. ft., then an additional 2-A extinguisher or a single 4-A extinguisher must be provided (as long as the travel distance of 75 feet is not exceeded). Additionally, the IBC table limits any extinguisher, regardless of rating or hazard, to a maximum area of 11,250 sq. ft.; thus, a 10-A extinguisher in an ordinary hazard can only cover a 11,250-sq.-ft. area and not 15,000 sq. ft. as determined by calculation.

For Class B fire hazards with a *flammable liquid* or *combustible liquid* depth of not more than $^1/_4$ inch, use IBC Table 906.3(2). For depths greater than $^1/_4$ inch, the IBC refers to NFPA 10, which has specific requirements for liquids of "appreciable depth." According to the IBC table, a Class B fire hazard of ordinary hazard requires either a 10-B extinguisher with a travel distance of 30 feet or a 20-B extinguisher with a travel distance of 50 feet; there are no floor area limitations, since the hazard is based on liquid volume and maximum depth.

For Class C fire hazards, the number of extinguishers can be determined based on Class A or B requirements. Class D fire hazards require that a portable fire extinguisher is placed within a 75-foot travel distance from the hazard. Class K fire hazards are not specifically mentioned in the IBC, but IFC Section 904.12.5 requires that a fire extinguisher be located within a travel distance not exceeding 30 feet from the cooking area. Specific requirements for Class K extinguishers include providing a single 2.5-gallon extinguisher or two 1.5-gallon extinguishers nearby solid fuel cooking appliances, such as wood-burning ovens and stoves. A Class K 1.5-gallon extinguisher is also required for every four deep fat fryers within a commercial kitchen.

26.4 LOCATION AND INSTALLATION OF FIRE EXTINGUISHERS

The IBC and NFPA 10 have nearly identical requirements for the location and installation of portable fire extinguishers. The requirements state that portable fire extinguishers shall be located along normal paths of travel, in conspicuous locations that are readily accessible, and are not obstructed or obscured from view. Although not specifically stated in the IBC or NFPA 10, locating portable fire extinguishers near a building's or space's *exit* or *exit access doorways* provides a logical choice. Where extinguishers have unavoidable partial visual obstruction, signage or other methods of indicating the location shall be provided.

Hand-held portable fire extinguishers must be installed in a hanger or bracket specifically designed or approved for the type of extinguisher or they must be housed in a cabinet. NFPA 10 indicates that wall recesses are also acceptable; however, since wall recesses are not mentioned in the IBC, the *building official* or *fire code official* may not allow them by referencing IBC Section 102.4, which states when "differences occur between provisions of this code and referenced codes and standards, the provisions of this code shall apply."

If portable fire extinguishers are housed in cabinets, the cabinets cannot be locked except in locations subject to vandalism. If locked, cabinets must include a means of accessing the extinguisher in an emergency. In Group I-3 occupancies and in mental health areas of Group I-2 occupancies, portable fire extinguishers may be locked and located in staff locations provided the staff has keys readily accessible. Since some cabinets will partially obscure the extinguisher, those cabinets must be marked to identify the extinguisher location as mentioned earlier.

The mounting heights of portable fire extinguishers are determined based on weight of the extinguishers. Extinguishers weighing 40 pounds or less must be installed so that the top of the extinguisher is no more than 70 inches above the floor. Extinguishers weighing more than 40 pounds must be installed so that the top of the extinguisher is no more than 42 inches above the floor. In no case shall an extinguisher be installed with the bottom of the extinguisher less than 4 inches above the floor. However, when determining installation heights, you also need to consider accessibility requirements.

ICC/ANSI A117.1 limits the unobstructed forward reach and side reach to 48 inches. In some jurisdictions, this measurement is taken from the floor surface to the handle of the extinguisher. Another thing to keep in mind is the projection of the extinguisher or cabinet into the path of travel. ICC/ANSI A117.1 limits projections to 4 inches when the bottom of the projection is greater than 27 inches above the floor surface (Figures 26.4-1 and 26.4-2).

If recessed or semirecessed cabinets are installed in *fire-resistance-rated* wall assemblies, such as *fire walls*, *fire barriers*, *smoke barriers*, and *fire partitions*, the cabinet must have a rating equal to or greater than the wall assembly in which it is installed. Additionally, the penetration must be treated as a membrane penetration as required by IBC Section 714.3.2 and per Step 25.1.1.

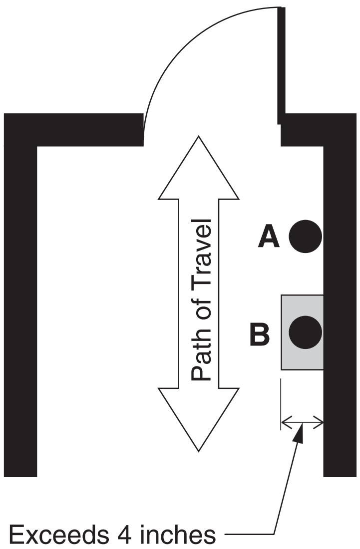


FIGURE 26.4-1. Noncompliant locations if bottom of cabinet or extinguisher is greater than 27 inches above the floor. Both "A" and "B" locations exceed the 4-inch limitation allowed by ICC/ANSI A117.1.

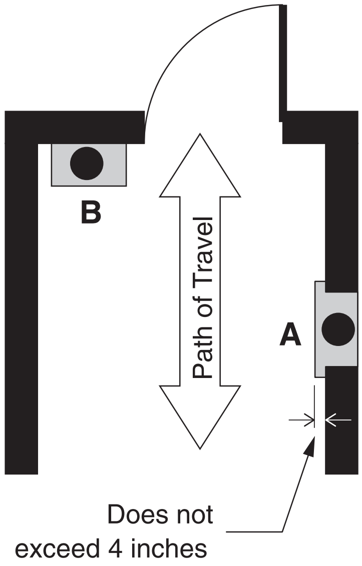


FIGURE 26.4-2. Compliant locations if bottom of cabinet or extinguisher is greater than 27 inches above the floor. A recessed or semirecessed cabinet at location "A" will keep the projection to less than 4 inches. The projection at location "B," whether in a cabinet or on a bracket or hanger, may be acceptable—verify with the *building official* or *fire code official*.

EXAMPLE PROJECT—STEP 26

The building will have varying hazard classifications. The building spaces can be categorized as follows:

- Light Hazard Areas: Apartments (including corridors), dining hall eating area, lounge, management office, study rooms, and exercise room.
- Ordinary Hazard Areas: Dining hall kitchen, convenience shop, mechanical room, trash room, mail room, and parking garage.

In both hazard areas, the minimum size fire extinguisher is a 2-A. For the light hazard areas, the maximum coverage per unit of A is 3,000 sq. ft., and for the ordinary hazard areas, the maximum coverage is 1,500 sq. ft. per unit of A per IBC Table 906.3(1).

At the parking garage, the total area is 17,473 sq. ft. Dividing that by 1,500 sq. ft. per unit of A, 11.6 units of A are required. One 20-A fire extinguisher would be sufficient, but the travel distance would be exceeded, not to mention the difficulty of handling a fire extinguisher of that size. Two options available would be to provide six 2-A or four 3-A extinguishers throughout the parking garage. Each option will provide an extinguisher within the 75-foot travel distance.

However, before deciding which option to use, the possibility of Class B fires from spilled flammable liquids in the parking garage should be considered. Extinguishers for Class B fire hazards require shorter travel distances, so IBC Table 906.3(2) should be consulted to determine the travel distance and extinguisher size for an ordinary hazard area. The table allows either a 10-B or 20-B extinguisher with 30- and 50-foot travel distances, respectively. The 20-B extinguisher will allow greater flexibility in location with the longer travel distance, but more than four extinguishers will be required.

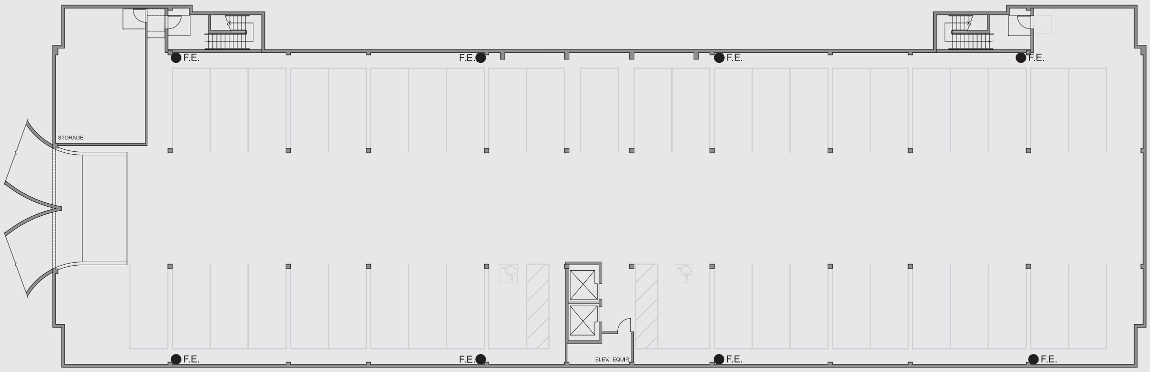
Based on travel distance for Class B fire hazards, eight 2-A:20-B fire extinguishers will be required. The locations can be distributed as shown in Example Project Figure 26-1. They may be mounted on brackets or in cabinets. Where installed on framed walls, a recessed cabinet would work best. On concrete walls, surface-mounted cabinets or brackets would work, too, but the projection could pose a hazard from projecting out too far. Therefore, locating them on either side of a pilaster would provide some warning for individuals with visual impairment.

The light hazard areas on the first story have a total area of 9,816 sq. ft. Dividing that area by 3,000 sq. ft. per unit of A, the total required is 3.3 units of A. The ordinary hazard areas have a total area of 3,355 sq. ft. Dividing that area by 1,500 sq. ft. per unit of A, the total required is 2.2 units of A. For the entire first story, a total of 5.5 units of A are required. Again, travel distance will dictate the quantity of extinguishers even though a single extinguisher would provide enough capacity.

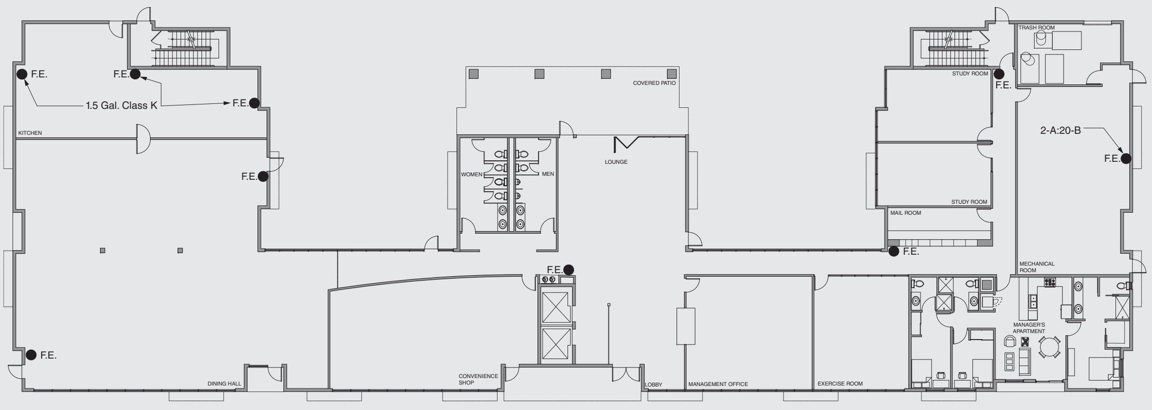
Considering travel distance, a total of six 2-A fire extinguishers (the minimum size) will be provided. Class B fire hazards are not a concern in most of the first-story spaces, so the distribution will be based on a 75-foot travel distance. Most Class A fire extinguishers are also suitable for Class B fire hazards, so 2-A:10-B extinguishers will be used, even though the travel distance for a Class B extinguisher is exceeded. On the other hand, a Class B fire hazard is most likely to occur within the mechanical or trash rooms, so one of the 2-A extinguishers will be rated 20-B and will be located in the mechanical room within a 50-foot travel distance from all points within those spaces.

In the kitchen, three Class K extinguishers are required due to the 30-foot travel distance limitation. Since three extinguishers are required, the 1.5-gallon-type will be used. The number of fryers is unknown, but with two 1.5-gallon Class K extinguishers within reach of all areas of the kitchen, up to 12 fryers can be used within the kitchen, but it is assumed no more than four will be used. Example Project Figure 26-2 shows the locations of fire extinguishers throughout the first story. All extinguishers can be located in recessed or semirecessed cabinets, depending on the depth of the wall.

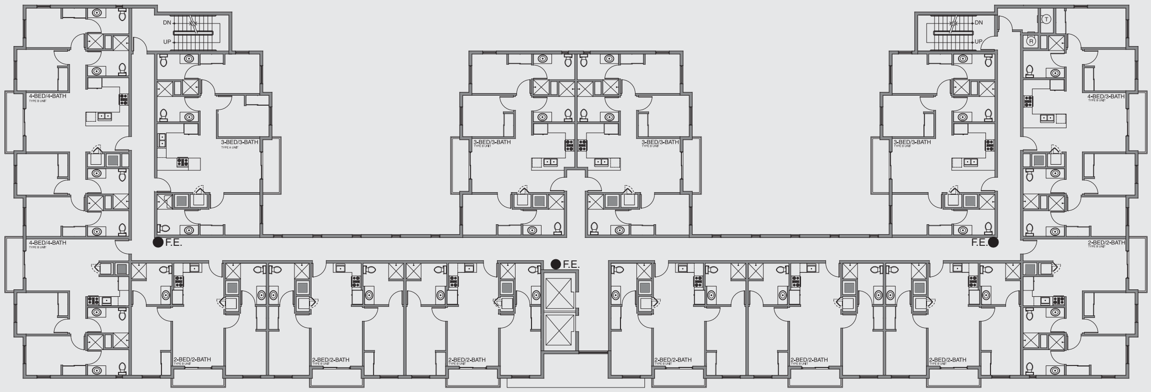
The residential stories have an area of 14,793 sq. ft., which, when divided by 3,000 sq. ft. per unit of A, requires a total of 4.9 units of A. This would require at least three 2-A extinguishers. Class B fire hazards are not a concern, so extinguishers will be distributed using a travel distance of 75 feet. Example Project Figure 26-3 shows the locations of fire extinguishers on each of the residential stories.



EXAMPLE PROJECT FIGURE 26-1. Location of fire extinguishers in the basement parking garage.



EXAMPLE PROJECT FIGURE 26-2. Location of fire extinguishers within the first story.



EXAMPLE PROJECT FIGURE 26-3. Location of fire extinguishers within the residential stories.

STEP 27

Detail Construction Based on Specific Building Materials and Equipment

STEP OVERVIEW

This is a very broad step that covers a multitude of code-related items. As the *construction documents* are being prepared, the detailed requirements associated with the various materials permitted by the IBC must be integrated into the drawings and specifications. Additionally, locations of accessory items and materials need to be shown to provide complete and compliant installations.

27.1 CODE REQUIREMENTS FOR SPECIFIC MATERIALS

The construction material requirements in the IBC are largely structural in nature. Thus, a design team's structural engineer will detail and specify the material aspects of a building design in accordance with the building code. However, there are some materials that have requirements that should be considered for applicability to a project. If determined to be appropriate for the project, the material requirements should be drawn, specified, or both without replicating information in either.

27.1.1 CONCRETE

Nearly all of the requirements for *concrete* construction are structural in nature. However, it will be necessary to show compliance with some requirements on both the structural and architectural drawings,

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and therefore coordination will be necessary. Many of the material requirements mentioned below will also be addressed within the project's specifications.

Concrete slabs on grade are required to have a minimum thickness of 3 1/2 inches per IBC Section 1907.1. Additionally, the installation of a vapor retarder is also required below the slab. The minimum material requirement for this vapor retarder is a 6-mil polyethylene sheet placed between the base course or subgrade and the *concrete* slab. Other products are acceptable provided they are *approved* materials.

Exceptions to the vapor retarder requirement include detached accessory *structures* to Group R-3 occupancies; unheated storage rooms in Group R-3 occupancies that are less than 70 sq. ft. in area; carports attached to Group R-3 occupancies; and driveways, walkways, and patios that are not enclosed and will not be enclosed in the future and where *approved* based on *site* conditions or it is determined that moisture migration will not be detrimental to the building. The last exception should only be used when the proposed floor finish will not be affected by moisture vapor transmission.

If the *concrete* slab is below grade and is subject to hydrostatic pressure (see Step 16.3.2.2 regarding *basement* walls for a discussion on hydrostatic pressure), then the slab will need to be installed with a waterproofing membrane in lieu of a vapor retarder per IBC Section 1805.3.1. This section provides a list of acceptable waterproofing materials as well as the use of other *approved* materials. If hydrostatic pressure is not an issue and the floor is located below the adjacent grade level, then dampproofing per IBC Section 1805.2.1 may be used in lieu of waterproofing. Like the waterproofing section, the dampproofing section also provides a list of acceptable materials, including the provision for the use of other *approved* materials.

27.1.2 MASONRY

Detailing of *masonry* construction may also be shown on both structural and architectural drawings. IBC Chapter 21 addresses multiple *masonry* conditions and applications, most of which are structurally related. Also included in this chapter are requirements for ceramic tile and glass block in addition to standard *masonry* construction. Much of the chapter is devoted to the construction of fireplaces and chimneys, and if used on a project, will likely have to be detailed by the architect instead of the structural engineer.

Single-wythe *masonry*, where used as an *exterior wall* (not as a *veneer*), may require special flashing at the initial course to address the requirement for the prevention of water accumulation within the wall per IBC Section 1403.2. ***Multi-wythe composite masonry*** walls act similarly to single-wythe *masonry* walls, thus, they may also require special flashing at the initial course.

DEFINITIONS

Single-Wythe

A wall with a single vertical section of masonry that has a depth of one masonry unit.

Multi-Wythe

A wall with two or more vertical sections of masonry that has a depth of two or more masonry units.

Composite Masonry

A multi-wythe masonry wall that is bonded together with grout and mortar that functions structurally as a monolithic wall. It may consist of wythes of different masonry materials.

Cavity wall masonry construction is defined in the IBC, but it is not a construction specifically addressed in the IBC. Since a cavity wall involves at least two wythes of *masonry* with a cavity between wythes, it is either considered *anchored masonry veneer* or noncomposite *masonry*. Noncomposite *masonry* involves wythes that are structural but not bonded like composite *masonry*. *Anchored masonry veneer* involves a wythe that does not support a vertical load other than its own weight. The details for noncomposite *masonry* and *anchored masonry veneer* with *masonry* backup are nearly identical—the only difference is the spacing of metal ties.

For *anchored masonry veneer*, the IBC references TMS 402/ACI 530/ASCE 5 and TMS 602/ACI 530.1/ASCE 6 in IBC Section 1405.6. *Anchored masonry veneer* is attached using anchors called ties to a *masonry* backup wall, *concrete* backup wall, or a framed backup wall with sheathing. The type and spacing of anchors will depend on the type of backup wall, type of *veneer*, and expected loads on the *veneer*. This information will likely be provided by the structural engineer.

The width of the cavity between a *veneer* and the backing depends on the type of backing and type of anchor. The minimum width between a *veneer* and its backing is 1 inch, regardless of backing or anchor type. If corrugated metal anchors are used on wood-framed backing, the maximum cavity width is 1 inch; thus, the spacing dimension is an absolute measurement. For all other anchors and backing types, the maximum cavity width is $4\,^1\!/_2$ inches.

For noncomposite *masonry*, there is no specific reference other than the general reference to TMS 402/ACI 530/ASCE 5 in IBC Section 2101.2. Similar to *anchored masonry veneer*, noncomposite *masonry* utilizes metal ties to connect the wythes. Spacing of the metal ties will also be provided by the structural engineer. The maximum width of the cavity is $4\,^1\!/_2$ inches.

Another type of *masonry veneer* is the adhered masonry type, which directly bonds the *veneer* to the backing. *Adhered masonry veneer* is addressed in IBC Section 1405.10. TMS 402/ACI 530/ASCE 5, which is referenced by the IBC, limits the size and weight of *masonry veneer* materials, since it is non-load-bearing and is supported by the backup system. The backup system may include other *masonry* types, such as concrete block, or it may include other construction materials such as *concrete* walls or sheathing over metal or wood stud framing.

27.1.3 STEEL

The IBC provides very little in the form of requirements for steel construction, which are provided in IBC Chapter 22. Similar to other material chapters in the IBC, the primary intent of this chapter is to address the design of *structural steel elements*. For the architect, *structural steel elements* need to be integrated into other building elements, such as wall, floor, and *roof assemblies*. Although not a building code requirement, the architect needs to be aware of structural steel tolerances and to provide sufficient space between *structural steel elements* and the enclosing construction. Where *structural steel elements* are required to be fireproofed, drawings should indicate which elements are to receive the fireproofing and the minimum required rating.

Where architecturally exposed structural steel (AESS) is to be used, the architect should work closely with the structural engineer. A structural steel connection is not always pretty, but it will satisfy the minimum requirements of the building code. Informing the structural engineer that certain connections and members are to be AESS will ensure that drawing details are coordinated so that the design intent regarding aesthetic quality is clearly indicated where required.

Cold-formed steel light-frame construction is also covered in this chapter in IBC Section 2211. This type of construction uses either structural or nonstructural members, such as studs or fabricated joists. This section references several standards published by the AISI (American Iron and Steel Institute, www.steel.org) for the materials, design, and installation of cold-formed steel light-frame construction.

One particular aspect of metal stud framing that must be addressed either on the drawings or in the specifications is the thickness of the metal studs. Although metal studs are nominally classified using a stud gage, the metal stud industry actually uses thicknesses measured in the thousandths of an inch. Another item often overlooked by the architect and directly related to stud thickness is the ability to resist a 5-psf horizontal load per IBC Section 1607.14. What is lacking in the code requirement is the permitted deflection. ASTM C 754 provides tables that indicate the maximum height for a metal stud wall with *gypsum board* on both sides based on stud depth, thickness, spacing, and permitted deflection. The maximum deflection allowed by the standard is *L*/120 (i.e., height of wall divided by 120). The IBC requires metal studs for gypsum construction to comply with ASTM C 754; thus, the minimum loading required by IBC Section 1607.14 is therefore met, since the minimum loading of the ASTM standard is 5 psf. Walls using materials other than *gypsum board* will require some structural analysis to establish that resistance to the minimum horizontal load has been achieved.

27.1.4 WOOD

Wood construction in the IBC, as with all the other materials covered in this step, is concentrated on the structural features of the material. IBC Chapter 23 is dedicated to wood construction, whether it is glued laminated or sawn timber, prefabricated trusses, structural panels (i.e., plywood and oriented strand board [OSB]), logs, or wood stud framing.

Similar to architecturally exposed structural steel, structural wood members that are intended to remain exposed, such as those required for Type IV construction, will need to be coordinated with the structural engineer. Connection design and material quality will be of great concern to the architect, even though utilitarian connections and standard structural quality wood members would be sufficient to comply with the building code.

For wood stud framing, IBC Section 2308 on conventional light-frame construction has been revised significantly with new and updated content, including additional tables and figures. The essential requirements in regard to detailing include the following:

- IBC Section 2308.5.3 requires a 2-inch nominal (1 1/2-inch actual) thickness member for plates and sills. Top plates of bearing and *exterior walls* are required to be of double members, which must overlap at corners and intersections. An exception allows a single top plate when a steel plate complying with the specifications in the exception is provided at the corners and intersections.
- IBC Section 2308.5.4 allows 24-inch on-center spacing for non-load-bearing walls and partitions.
- IBC Section 2308.5.5 requires headers over openings to be constructed of two 2-inch nominal members on edge or a single solid lumber member of equal size. The ends of headers are required to be supported by studs.

Per IBC Section 2309, AWC WFCM (*Wood Frame Construction Manual*) is permitted to be used for *Risk Category* I and II buildings (see IBC Table 1604.5), even though a building may not be a *dwelling unit*. AWC WFCM provides the designer with several illustrations showing typical wood construction.

27.1.5 GYPSUM AND PLASTER

In the IBC, *gypsum board* or gypsum wallboard is mentioned numerous times—primarily in regard to fire-resistive construction—but the basic requirements for *gypsum board*, regardless of where *gypsum board* is mentioned, are located in IBC Chapter 25. Also included in the same section are requirements for gypsum plaster and cement plaster, also called "stucco."

IBC Section 2506 requires that *gypsum board* materials comply with the material standards in IBC Table 2506.2. For standard *gypsum board* products, the table lists ASTM C 1396, which includes various types of common gypsum-based products. Additionally, IBC Table 2506.2 also lists other specialty gypsum-based products, such as glass mat gypsum panels and fiber-reinforced gypsum panels. The construction specifications should establish the material requirements for *gypsum board*, but the drawings will need to indicate where it is used. Although detailing of *gypsum board* installations is the same regardless of the specific type, the drawings should clearly annotate which type of *gypsum board* is used and the required thickness.

Details for *fire-resistance-rated* construction and assemblies on the drawings must conform to the construction as specified in the data sheet for the tested assembly. Where layers of *gypsum board* are required, each layer must be shown and annotated on the drawings. Assemblies complying with IBC Section 403.2.3 for structural integrity (see Step 21.1) may also require layered systems to provide the required impact classification.

For plaster systems, the specifications will provide the material and installation requirements, but the drawings will need to identify where plaster finishes are used and the type of plaster. The IBC provides two types of systems: *gypsum plaster* and *cement plaster*.

Gypsum plaster systems, per IBC Section 2511, is required to be a minimum three-coat system over metal or wire lath. Two-coat systems are permitted over solid substrates, except that a one-coat system is permitted when used as a *gypsum veneer plaster* system and is *approved*. *Gypsum plaster* surfaces are required to comply with ASTM C 842, which provides the thicknesses required for various types of substrates. Over metal lath, vertical *concrete*, and *masonry units*, the required thickness is $^5/_8$ inch; for other plaster bases, a thickness of $^1/_2$ inch is required.

Cement plaster systems are installed as either three- or two-coat systems depending on the substrate. A three-coat system is required over a metal lath substrate but is optional over a solid plaster base, such as *masonry units* or *concrete*. A two-coat system is the minimum system required over solid plaster bases. The thickness of each coat is specified in ASTM C 926, a standard which is referenced by IBC Sections 2511 and 2512 for interior and exterior applications, respectively. A three-coat system over metal lath has a required total thickness of $^7/_8$ inch, while three- and two-coat systems over a solid base only require a thickness of $^5/_8$ inch. At *exterior walls*, exterior *cement plaster* is not permitted to extend to grade. IBC Section 2512.1.2 requires a minimum 4-inch space between ground surfaces and the bottom edge of the plaster system. Over paved areas, this gap can be reduced to 2 inches. A weep screed is also required at the bottom of the plaster system to allow any water that accumulates behind the system to drain.

27.2 ACCESSIBILITY DETAILS

The applicable accessibility requirements up to this point in the step-by-step process have generally been broad in scope. However, even after ensuring compliance with the broader requirements of accessibility, whether they are from the ASAD or the ICC/ANSI standard, it is often the noncompliance with the details of *accessible* design that may lead to a complaint or a lawsuit. There are too many detailed requirements within the standards to cover within this step, but the following areas should be closely examined for each building design.

- **Floor Surfaces (ICC/ANSI A117.1 Section 302):** Within *accessible routes* and within spaces required to be *accessible*, the floor surfaces must be conducive to movement by individuals within wheelchairs and walkers. Gratings must be oriented perpendicular to direction of travel and cannot have openings that are greater than $^1/_2$ inch wide. Carpeting cannot have a pile height greater than $^1/_2$ inch and must have a firm cushion or pad or no cushion or pad. Soft cushions or pads make it difficult to use a wheelchair.

- **Changes in Elevation (ICC/ANS A117.1 Section 303):** Similar to floor changes, slight differences in elevation could create restrictions on mobility for some individuals. Slight changes in floor surface elevation, such as those created by different adjacent floor materials, cannot exceed a $^1/_4$ inch in height or $^1/_2$ inch in height if beveled to a 1:2 slope.
- **Operable Parts (ICC/ANSI A117.1 Section 309):** Wall-mounted controls (e.g., light switches, projection screen or roller shade controls, shower controls, etc.) and equipment-mounted controls must be within one of the reach requirements identified in ICC/ANSI A117.1 Section 308.
- **Grab Bar and Toilet Accessory Locations (ICC/ANSI A117.1 Sections 604 and 607):** Back and side grab bars in *accessible* toilet compartments should be identified. The ICC/ANSI standard still requires an 18-inch vertical grab bar that is no longer required by the ASAD. Placement of toilet accessories within toilet compartments needs to comply with the location requirements indicated and cannot interfere with the use of a grab bar and vice versa. *Accessible* bath tubs and showers are also required to have grab bars on back and side walls depending on the configuration of the bath tub or shower.
- **Signage (ICC/ANSI A117.1 Section 703):** Size of text, tactile features (i.e., raised letters and braille), color contrast, and mounting locations must comply with minimum requirements.
- **Built-In Furnishings and Equipment (ICC/ANSI A117.1 Chapter** 9**):** Benches and other custom built-in counters must be fabricated to the dimensions indicated with *operable parts* (*ICC/ANSI*) complying with ICC/ANSI A117.1 Section 309.

EXAMPLE PROJECT—STEP 27

The details within a set of construction drawings and the qualitative information within the specifications will be very explicit in regard to materials used on the project. A full set of drawings and specifications is not provided for this example project, but enough information has been gathered through this step-by-step process to allow the preparation of those documents without the concern of a major building code violation.

MATERIAL DETAILS

Wood framing and concrete construction will be detailed by the structural engineer. Coordination with the structural engineer is required to ensure that none of the fire-resistance or sound transmission requirements are missed.

ACCESSIBILITY DETAILS

All reach and clear floor space requirements have been addressed in previous steps, so this step will only need to address the accessories that must accompany those previously developed accessible features. The grab bars should be shown on floor plans and interior elevations. Where carpeting is adjacent to the VCT, the transition must comply with the requirements for changes in elevation. Required signage at restrooms, elevators, and stairways must be tactile with letters and graphics of size and contrast required. Room signage must also comply with these same requirements.

STEP 28

Prepare Code Information for Construction Documents

STEP OVERVIEW

Documents submitted to the building department need to convey a project's compliance with the building code. Therefore, the *construction documents* must provide all the information necessary for a plans examiner to fully understand the scope of the project and how the design professional has applied the code requirements. Up to this point, if each of the previous steps have been closely followed and code requirements applied appropriately, compliance with the code should be at its best for submission. However, how well the design professional communicates this compliance in the documents may be the difference between a short or long time for the plan review, the difference between a short or long list of corrections, or both.

28.1 SUBMITTAL DOCUMENTS OVERVIEW (IBC SECTION 107 AND IECC SECTION C103)

The IBC defines *construction documents* and establishes the minimum level of required documentation that must be submitted, but the requirements provided are generally vague. Therefore, the quality of the *construction documents* is completely under the control of the design professional.

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The IBC provides five sections that address the minimum requirements for *construction documents*:

- IBC Section 107.2.1 states that the *construction documents* submitted must be dimensioned and provided in printed sets or in electronic media, as *approved* by the *building official*. In this section are the requirements for clarity in the documents and that they show in sufficient detail compliance with the requirements of the code and other applicable laws and ordinances (e.g., zoning).
- IBC Section 107.2.2 addresses fire protection shop drawings. Although not technically a *construction document* prepared by the design professional, shop drawings are submitted to show the contractor's understanding of the project and how specifically the system or system will be installed. In many cases, the contractor has not been selected when the *construction documents* are submitted for plan review, so the documents will show only basic design criteria. The contractor will eventually use the basic design criteria as the basis for designing the complete system and submitting the shop drawings.
- IBC Section 107.2.3 requires that the *construction documents* show in "sufficient detail" how the project complies with the requirements for *means of egress*. This section requires that all components of the *means of egress* system be shown from the *exit access* through the *exit discharge* to the *public way*. The documents are also required to show the number of occupants for all floors, all rooms, and all spaces.
- IBC Section 107.2.4 addresses *exterior wall envelopes* and requires that the documents show details of how joints, flashings, intersections, materials, and other critical building connections are to be constructed or installed. This section also states that the manufacturer's installation instructions be included with the *construction documents*. However, in many cases, such as with public projects, the actual manufacturer of a product is not determined prior to bidding. Therefore, the products specified in the *construction documents* are usually based on common criteria for the types of products proposed.
- IBC Section 107.2.5 requires that a site plan be submitted with the *construction documents* that shows the location of the building or buildings in relation to *site lot lines*. The site plan must also show the proposed grades of the *site* and actual grades of adjacent streets. If the project is located within a *flood hazard area*, then floodways and the *Design Flood Elevation* are required to be shown as well; the project's civil engineer or land surveyor can provide this information as a part of the required property survey.
- IBC Section 107.2.6 requires that structural information be provided in the *construction documents* in accordance with IBC Section 1603. This is information that the structural engineer will be required to include on the documents and includes the following:
  - Floor and *roof live loads*
  - Roof snow loads, if applicable
  - Wind loading information, including design wind speed, *risk category*, wind exposure, and wind pressures
  - Earthquake design information, such as *risk category*, seismic importance factor, *site class*, and *seismic design category*
  - Geotechnical information, which may be included as a part of the project manual
  - Flood design data, if applicable
  - Any special loading conditions. The IBC specifically mentions *photovoltaic panel systems*.

Similarly, the IECC also requires the *construction documents* to show or describe specific information about a building's energy compliance. Many jurisdictions will allow the submission of a report generated by the U.S. Department of Energy's COMcheck™ software. The report may be submitted as a separate document or copied onto drawing sheets. As a minimum, IECC Section C103.2 requires the following information, as applicable:

- Architectural drawings:
  - Insulation types and *R-values*
  - Window, skylight, and glazed door *U-factors* and *solar heat gain coefficients* (*SHGCs*)
  - Area-weighted *U-factors* and *solar heat gain coefficients* (*SHGCs*)
  - Air sealing systems and assemblies
  - *Daylight zone* locations
- Mechanical drawings:
  - Design criteria
  - Equipment types, sizes, and efficiencies
  - Control systems
  - Fan motor sizes and controls
  - Duct sealing
  - Duct and pipe insulation
  - Economizer information
- Electrical drawings: Lighting fixtures, wattages, and controls

Even though the design professional may feel that the *construction documents* adequately convey the required information, the building department may still require additional information if it determines that the information in the documents is insufficient to show compliance with the building code. However, review comments from the building department should not dictate specific methods of achieving compliance. For example, if a review comment states that panic hardware is required on certain doors, the comment should not direct the design professional to add this information to the door schedule. The design professional should have full control of where to place this information; he or she may decide to place the information on the door schedule on the drawings or in a door hardware schedule located in the specifications that is cross-referenced to those doors in the door schedule.

28.2 CODE DATA ON CONSTRUCTION DOCUMENTS

Probably the most time-consuming part of a plan review is finding all the pieces of information in the *construction documents* that support compliance with the building code. Even though the IBC specifies what information is required as described in Step 28.1, it does not specify how that information should be indicated in the drawings and project manual.

The building code establishes requirements which, by their nature, can be addressed in the *construction documents* in the drawings, in the project manual, or more likely both. Drawings are best suited for showing the following:

- Dimensional requirements (e.g., *corridor* widths, parapet heights, foundation depths, *stair* risers and treads)
- Location requirements (e.g., *exits*, fire-resistive construction, safety glazing, fire extinguishers)
- Quantity requirements (e.g., number of *exits*, *building area*, plumbing fixtures, *ventilation* area)

The project manual, on the other hand, is best suited for establishing the following qualitative requirements:

- Material/product characteristics (e.g., conformance to third-party standards, minimum thickness)
- Performance requirements (e.g., opening force for doors, *flame spread*, minimum activation temperature for smoke vents)
- Installation requirements (e.g., fastener spacing and number, conformance to third-party standards, *special inspection* coordination)

Missing from the two lists above is the information that conveys some of the basic building code data, such as the adopted codes, construction type, occupancy groups, and *hazardous materials*, or calculations indicating compliance with allowable height and area, *occupant loads*, and plumbing fixture counts. This information must be provided but could be provided either in the project manual or on the drawings.

28.2.1 BASIC CODE DATA

Whether provided on the drawings or in the project manual, the basic code data provided should be organized in a manner that will help guide the plans examiner through how the building complies with the building code. The format for this information can be at the design professional's discretion. A sample format is provided in Appendix B. Regardless of the format's details, it is recommended that the overall structure should adapt the following recommendations.

General Code Information: This block of information should include, as a minimum, the following:

- List of adopted codes applicable to the project
- Identification of any applicable reference documents, such as approved reports, variances, and code modifications
- The construction type
- Whether a sprinkler system will be installed or not. If one will be installed, the specific type of system should be identified (i.e., NFPA 13, NFPA 13R, or NFPA 13D).
- The presence of a *basement* and the number of *basement* levels
- The storage or use of *hazardous materials*. Indicate number and location of *control areas*.
- The applicable occupancy groups. If the building is a mixed occupancy, identify the method that will be applied (i.e., separated, nonseparated, accessory, or a combination). Applicable incidental uses per IBC Section 509 should also be listed.
- If special requirements or provisions of IBC Chapter 4 and IBC Section 510 apply, those can be identified with a brief description

Special Requirements: This block should include any special information per IBC Chapter 4 that is applicable to the project, such as information on the following (only commonly used requirements are identified below; information for other special requirements can be included):

- Covered and open mall buildings for gross leasable area and perimeter line
- *High-rise buildings* for highest occupied floor height, fire service access elevators, and *fire command center*
- *Atriums*
- *Open parking garages* for open area determination
- *Stages* for stage area and height

Height and Area: This block of information should include, as a minimum, the following:

- Actual floor areas for each *story* and for the entire building
- Actual height in feet and *stories*
- *Grade plane* elevation
- Allowable height in feet and *stories*, including tabular height and any increases. Compare actual heights to allowable height to show compliance.
- Allowable areas, including tabular areas and any increases. Show all calculations. Compare actual floor areas with allowable floor areas to show compliance.

Fire Resistance: This block of information should include, as a minimum, the following:

- Minimum required *fire-resistance ratings* for all construction and assemblies used
- Location of *fire-resistance-rated* assemblies in either tabular or graphic format
- Cross reference to where details or other information about the assemblies are located

Means of Egress: This block of information should include, as a minimum, the following:

- *Occupant loads* for spaces, *stories*, and buildings
- Travel distances in either tabular or graphic format
- *Common paths of egress travel* in either tabular or graphic format
- Calculations for egress width for all components based on *occupant loads*. Compare to actual widths to show compliance.
- Overall diagonals and maximum separation distances of the doorways for areas where at least two *exit* or *exit access doorways* are required

Plumbing Fixtures: This block of information should include, as a minimum, the following:

- Number of occupants for each applicable occupancy group
- Calculations for minimum number of required fixtures. Compare to actual number of fixtures provided.
- Urinal substitution percentage for each restroom

Fire Protection Systems: This block of information should include, as a minimum, the following:

- Fire hazard classifications within the building
- Number and size of fire extinguishers. Show calculations and compare to actual number to show compliance. Identify travel distances to extinguishers in either tabular or graphic format.
- Locations where sprinkler systems are installed if not installed throughout. Provide a cross reference to drawing locations for detailed information.
- Locations and types of alternative *automatic fire-extinguishing systems*, if any. Provide a cross reference to drawing locations for detailed information.
- Locations and *classes of standpipe systems*. Provide a cross reference to drawing locations for detailed information.
- Type and locations of *fire alarm system* provided. Provide a cross reference to drawing locations for detailed information.
- Types of smoke control systems provided. Indicate methods used and provide calculations.
- Calculations for required roof ventilation area for applicable *stages*, if any. Compare to actual ventilation area provided to show compliance.

Accessibility: This block of information should include, as a minimum, the following:

- Parking and passenger loading compliance
- Required number of *dwelling units* and *sleeping units* that are required to be *accessible* by type (i.e., *Accessible units*, *Type A units*, and *Type B units*). Provide actual number of *accessible* units provided.
- Required number of *accessible* assembly seating. Provide actual number of seats provided.

28.2.2 CODE DATA ON DRAWINGS

Although some of the code data prepared by the design professional is provided in written form, much of the code information is best represented in drawing form. Thus, the set of construction drawings will be the construction document that a plans examiner will look to first to find the code information.

The location of code information within a set of construction drawings may be determined by a design firm's office standards, but the industry convention is to locate the information on one or more sheets bound at or near the front of the set of drawings. The *Uniform Drawing System*™ (UDS)* establishes an organizational structure for construction drawings and has identified drawing designators that divide

* The UDS is developed by the Construction Specifications Institute (CSI) and is a component of the *United States National CAD Standard*® (NCS) published by the National Institute of Building Sciences (NIBS).

drawings into subsets generally based on disciplines but also based on common content. Code information would be located in the latter category in the "G—General" sheets.

In addition to the plans examiner, the code information on the drawings could also prove beneficial to design professionals. When the owner decides to construct an addition or some alterations, the code data would give the design professionals for those subsequent projects sufficient information to make informed decisions about the existing building. Although the project manual (see Step 28.2.3) may include the code information, historically it is the set of drawings that a building owner typically retains for his or her records, so the placement of code information on the drawings would almost ensure that the code information is available for use by design professionals on subsequent projects for the building.

28.2.3 CODE DATA IN THE PROJECT MANUAL

By AIA, CSI, and IBC definitions, the *construction documents* include both graphic and written documents prepared to convey the design of a building. This means that the *construction documents* may include, and usually do for most projects, a set of drawings and a project manual. The project manual, organized according to the 50 Divisions per CSI/CSC's MasterFormat®, will include procurement and contracting requirements along with the specifications.

The procurement and contracting requirements probably will not be of interest to the building department, but the specifications, which establish the qualitative requirements of a construction contract, should be reviewed, since much of the material requirements in the IBC are addressed in the specifications. However, in some jurisdictions, the specifications either are not requested for plan review or, in some cases, are considered irrelevant and not reviewed by the building department when they are submitted for plan review.

EXAMPLE PROJECT—STEP 28

Code data information for the completed project is provided in Appendix C.

PART V

Existing Buildings

Existing buildings (IEBC) pose their own unique problems when it comes to applying the building code. Whether approved and constructed under a previously adopted building code or constructed prior to the adoption of a building code in the jurisdiction, *existing buildings* are not required to be upgraded to comply with the currently adopted building code. However, when a building owner wishes to modify an *existing building*, the new work—and possibly the entire building depending on the type and scope of new work—will need to comply with currently adopted codes.

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Types of Work

To be considered an *existing building*, IEBC Section 101.4 requires that it be legally occupied prior to the adoption of the current code. Otherwise, the building must comply with the IBC for new construction. However, if the building was never occupied or used for its intended purpose and the original building permit has not expired, then the building code in effect at the time it was permitted may still be used.

New construction work performed in *existing buildings* can be defined based on the specific type of work performed. The IEBC provides definitions for five types of work performed on *existing buildings*:

- **Repairs:** A *repair* essentially fixes what was previously there. However, new materials must comply with the requirements for new construction, including safety glazing (where required) and materials that do not contain hazardous materials (i.e., lead and asbestos). Structural damage, whether minor or substantial, will also be required to comply with the provisions for new construction in the IBC.
- **Additions:** An *addition*, as its name implies, adds to an *existing building*. The *addition* may be an increase in the *building area*, the number of *stories*, or the *building height* in feet. An increase in the height in feet of a building may occur whether or not floor area or another story is added to the building. If a low-slope roof is changed to a *steep-slope* roof, the height of the building in feet has changed, thereby classifying the building modification as an *addition*, even though nothing else has been modified.
- **Alterations:** An *alteration* is a modification to a building that cannot be classified as either a *repair* or an *addition*. Modifications associated with an *alteration* can be as simple as moving or adding a single doorway to extensive wall relocations and space reconfigurations.
- **Change of Occupancy:** A *change of occupancy* occurs when the new occupancy of an *existing building* is different from the previously approved occupancy. For example, if a former grocery store (Group M Mercantile) is converted into an office complex (Group B Business), then the requirements for a *change of occupancy* would apply.
- **Historic Buildings:** A *historic building* is one that is listed in either a state or national register of historic places, designated by local or state agencies as historic, certified as a contributing resource within a historic district, or determined to be eligible for any type of official historic designation.

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Compliance Methods

OVERVIEW

Prior to the publication of the 2015 IBC, Chapter 34 provided requirements for existing structures. In 2003, the ICC published the first edition of the IEBC. The IEBC was to be used as an alternative to IBC Chapter 34. The IEBC provided a method that was based on work areas and a compliance alternative that replicated the same compliance alternatives in IBC Chapter 34. In the 2006 IEBC, the concept of "compliance methods" was introduced. The prescriptive compliance method in the IEBC was essentially the same requirements in IBC Chapter 34. Thus, in the 2015 edition, it was eventually decided not to have the same requirements in both the IBC and IEBC, so Chapter 34 in the 2015 IBC is now held in reserve.

In IBC Section 101.4.7, the IEBC is referenced as the required code applicable to the *repair*, *addition*, *alteration*, and *change of occupancy* of *existing buildings* as well as for *historic buildings* and buildings that are relocated. In IEBC Section 301.1, work within an *existing building* is required to comply with one of the three compliance methods provided in the IEBC. The choice, as explicitly stated in this IEBC section, is left entirely to the building permit applicant. It is not within the building department's authority to direct an applicant to use a specific compliance method. Therefore, it is incumbent upon the designer to become familiar with each of the compliance methods to determine which one is the most advantageous for the project.

A fourth "compliance method" does exist; however, it is not referred to as a compliance method in the IEBC. This fourth method is actually an exception to IEBC Section 301.1 that allows the application of the building code in effect at the time when the building or portion of the building was originally constructed. In order to use this exception, the work is limited to *alterations* and the *building official* must approve this alternative method. Some structural work, however, may still be subject to the requirements of the current IBC.

IEBC Section 302.2 requires that all work in *existing buildings*, regardless of the compliance method used, must also comply with the requirements of the IECC, IFC, IFGC, IMC, IPC, IPMC, IPSDC, IRC, and NEC. However, whenever there is a conflict between one of those codes and the IEBC, the requirements of the IEBC shall be applied.

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PRESCRIPTIVE COMPLIANCE METHOD

As previously stated, the prescriptive compliance method was born out of the *existing building* requirements published in IBC Chapter 34 in earlier editions. The requirements associated with this compliance method are relatively broad in nature, which seems a bit inconsistent with its name. IEBC Chapter 4 establishes the criteria for the prescriptive compliance method, with individual sections addressing the different types of work. The majority of requirements within this chapter are structural in nature. This is to prevent the collapse of an *existing building* due to the removal or modification of an existing structural element or the overloading on an existing building's structural system with new construction or use that creates a greater load. To simplify the discussions within this compliance method, only the nonstructural requirements will be addressed.

IEBC Section 401.2 addresses materials, whether new or existing. Existing materials that complied with the building code at the time they were installed may remain unless the *building official* has determined that they are unsafe. Materials complying with the current IBC are permitted; however, new materials that are similar to existing materials may be used for *repairs* and *alterations*, provided they do not pose a health, safety, or property hazard.

ADDITIONS

All *additions* must comply with the requirements of the IBC per IEBC Section 402.1. *Alteration* work associated with the *addition*, plus the *addition* itself, shall not make the total building less compliant with the IBC than it was prior to the *addition*. In other words, if the *existing building* or portions thereof were not in compliance with the IBC, then any new work is not necessarily required to correct the noncompliant portions, but the new work cannot make the noncompliance any worse than it already is.

The *addition*, along with the *existing building*, must comply with the height and area requirements of IBC Chapter 5. Therefore, if the area and height (in *stories* and in feet) of the *existing building* plus the area and height of the *addition* do not exceed the allowable areas and heights (with permitted increases) per IBC Chapter 5, then the new addition is acceptable. However, if the combined areas and heights exceed the allowable areas and heights, then some modifications to the design will need to be implemented.

One modification option to consider is the addition of a sprinkler system if one does not already exist. Another option is to consider the *addition* a complete separate building by using a fire wall to separate the it from the *existing building*. This could be complicated if the existing wall does not meet the fire-resistance or structural stability requirements of IBC Section 706. Other options may include making the building a separate building on the same lot and connecting them using a pedestrian walkway complying with IBC Section 3104 or considering the composite building using the separated occupancies method if not initially considered. The separated occupancies option will require an analysis of the existing fire-resistive features of the building. This may lead to the necessity of modifying some existing construction to comply with the current occupancy separation requirements of IBC Table 508.4.

ALTERATIONS

Alteration work follows the principle of anything altered by the work must comply with the IBC for new construction. IEBC Section 403.1 states that existing areas of the building not affected by the *alteration* work are not required to be modified to bring them into compliance with the IBC. However, the *alteration* work cannot cause the *existing building* to be any less conforming to the IBC than it was prior to the *alteration* work.

The IEBC does provide two exceptions that do not require new construction to comply with the requirements of the IBC for new construction. The first exception allows the replacement of existing noncompliant stairs to use the existing rise and run dimensions if the space for the stairway does not allow for the reduced slope required by the IBC. The second exception still requires *handrails* to comply with IBC Section 1011.11, but the *handrail* extensions required by IBC Section 1014.6 are not required if they create a hazardous situation, such as protruding into the required egress widths of adjoining egress pathways.

For *existing buildings* that have existing refuge areas associated with a *horizontal exit* or *smoke compartment* requirements for Groups I-2 and I-3 or ambulatory care facilities, the required capacity of the refuge areas cannot be diminished by the *alteration* work. This does not necessarily mean that the existing capacity must be maintained; it means that if spaces are altered, the required capacity of refuge areas must still be determined based on the requirements of the IBC. For example, if the use of a space changes from an assembly use to a business use, then the *occupant load* will be reduced, thus allowing the refuge capacity to be reduced, but the capacity still must be calculated per the IBC.

REPAIRS

Almost all of the *repairs* section pertains to structural systems. IEBC Section 404.1 states that nondamaged building elements that are required to be modified as a result of the *repair* are not to be considered as *alterations*. Routine maintenance and repair work that does not require a permit per IEBC Section 105.2 is not classified as a *repair* and is not subject to the requirements of this section.

FIRE ESCAPES

Surprisingly, fire escapes are still permitted to be used, but only on existing buildings and only under specific conditions. IEBC Section 405 allows new fire escapes to be used when *exterior exit stairways* cannot be used due to site restrictions. New fire escapes cannot use ladders or be accessed by a window. Fire escapes may only be used for 50% of the required *means of egress* capacity. Where fire escapes are installed, adjacent openings are required to have a *fire protection rating* of $^3/_4$-hour. This section also has additional requirements on size, materials, and locations.

GLASS AND WINDOW REPLACEMENT

In accordance with IEBC Section 406, all new glass and replacement glass in an *existing building* must comply with the requirements of IBC Chapter 24, including replacement of nonsafety glazing with safety glazing where required.

Operable windows within *dwelling units* of Groups R-2 and R-3 must comply with the requirements of IEBC Section 406.2 for opening controls and IEBC Section 406.3 for *emergency escape and rescue openings*, if required. However, the IBC requirements for *emergency escape and rescue openings* regarding size, height from floor, and window wells are not applicable, provided the replacement windows are the manufacturer's largest size for that window opening and the replacement is not associated with a *change of occupancy*.

CHANGE OF OCCUPANCY

The use of the term *change of occupancy* in IEBC Section 407.1 could be a little misleading when considered within the context of building codes. "Occupancy," although not defined by the IBC or any other code, has generally meant the occupant group classification as established by IBC Chapter 3. However, the use of the word "occupancy" within the term *change of occupancy* implies a much broader application, which includes a change of the use of a space, whether or not there is an actual change in the occupancy group classification. This is explicitly stated in IEBC Section 407.1.1 as a "[c]hange in the character of use."

For example, assume a large existing open office area is programmed to be redesigned as multiple classrooms for adult education with each classroom having an *occupant load* of 49. The occupancy of the original open office is Group B, and since each of the new classrooms does not exceed 49 occupants, the area can still remain a Group B per IBC Section 304.1. However, the "use" of the space will change, which dramatically increases the *occupant load* of the area. Therefore, the application of the requirements for *change of occupancy* in this situation is appropriate.

A *change of occupancy* will require compliance with the IBC for the new use or occupant group. The IEBC does provide some flexibility by allowing some deviations from full compliance based on approval by the *building official*. Generally, if a use or occupancy is changing to one of a lesser hazard, then full compliance with the IBC may not be mandatory. The dilemma with that provision is the determination of the relative hazard between one use and another or one occupancy group and another. Essentially, it will be a decision by the *building official*; however, a design professional may be able to develop an opinion on the relative hazard for occupancy groups by reviewing IEBC Tables 1012.4, 1012.5, and 1012.6. Although these tables are used for the *work area* compliance method, they will give some insight as to how the relative hazard may be interpreted by the *building official*. For changes in the use of the space, relative hazard may be determined by *occupant load* (i.e., increase in *occupant load* equals an increase in relative hazard, and vice versa) or the proposed fire load (i.e., combustible materials) within a space.

HISTORIC BUILDINGS

Historic buildings are given a lot of leeway in regard to the application of building code requirements. Because of their historic nature, changing a building to comply with the current code would essentially remove most of the features that make a building historic. Therefore, the *building official* would only require changes to correct a life safety issue per IEBC Section 408.2. If an existing historic structure is located within a *flood hazard area* and is substantially improved, full compliance with the flood-resistant requirements of the IBC is required. Exceptions to the flood-resistance requirements are applicable to registered *historic buildings* and other qualified historic structures as indicated in the three exceptions to IEBC Section 408.3.

OTHER REQUIREMENTS

In addition to the types of work previously covered, the prescriptive compliance method also includes requirements for buildings that are relocated from one site location to another and requirements for implementing changes for *accessibility* that are associated with the other types of work.

Relocated, or moved, structures have only one simple requirement within the prescriptive compliance method in IEBC Section 409: full compliance with the code for new structures. *Historic buildings* that are relocated may be excluded from this requirement; however, since the IEBC does not explicitly provide an exception for *historic buildings*, a code modification may be necessary to minimize the full application of the IBC.

Accessibility upgrades to *existing buildings* are required and the scope of *accessibility* upgrades is dependent on the type of work performed on the *existing building*. IEBC Section 410 provides separate requirements for *change of occupancy*, *additions*, *alterations*, and *historic buildings*. These requirements should be compared to those within the ASAD to see if additional work may be required under the ADA.

WORK AREA COMPLIANCE METHOD

The *work area* compliance method identifies areas of work within an *existing building* based on the type of work performed similar to that of the prescriptive compliance method. However, the *work area* compliance method establishes specific requirements for that type of work that may fall short of full compliance with the IBC.

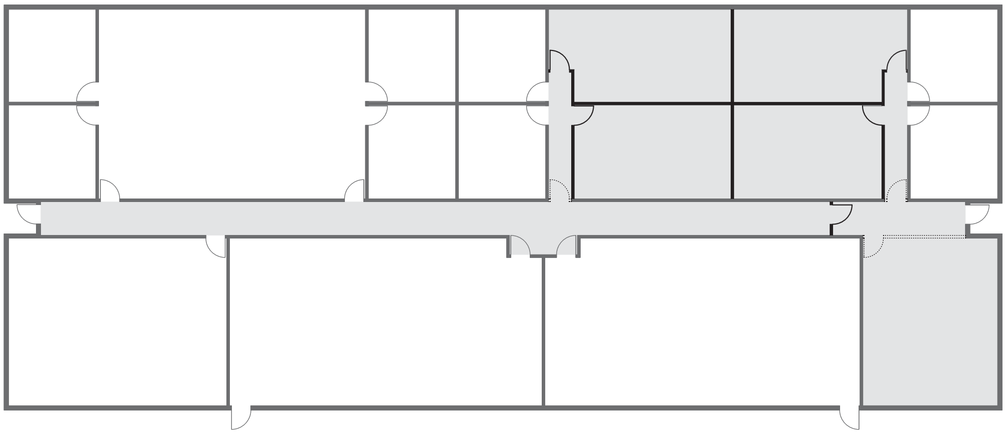
The type of work associated with the *work area* compliance method has some noticeable differences from those of the prescriptive compliance method. Most notable is within the *alteration* category, which includes three levels:

- **Level 1 Alterations:** This level involves the removal, replacement, or covering of existing equipment, materials, and other elements with new equipment, materials, or elements that are used for the same purpose.
- **Level 2 Alterations:** This level involves the rearrangement of space, removal or addition of a door or window, rearrangement or expansion of an existing building system, or addition of new equipment.
- **Level 3 Alterations:** This level involves any *alteration* work where the *work area* exceeds 50% of the *building area*.

If an area is required to comply with a Level 2 or 3 *alteration*, then the requirements for the lower *alteration* levels must also be applied. For example, if a *work area* is classified as a Level 2 *alteration*, then the requirements for Level 1 *alterations* are also applicable to the same *work area*.

As the name implies, the *work area* compliance method is based on defined *work areas*. The *work area* is defined as the portion or portions of the building that have reconfigured spaces. Thus, if the building involves a Level 2 *alteration* with reconfigured spaces, then the aggregate area of those reconfigured spaces is considered the *work area* (Figure 5-1). Per IEBC Section 501.2, the *work area* must be indicated in the *construction documents*.

Since a *work area* only involves reconfigured spaces, areas of the building where only *repairs* or Level 1 *alterations* are proposed are not figured into the *work area*. Level 3 *alteration* requirements will apply when the *work area* exceeds 50% of the *building area*. If an *addition* is part of the proposed work, then the *building area* used in determining the 50% threshold includes both the existing *building area* plus



The existing building is halftone, while the new construction is solid black. Areas that were removed are dashed. The floor area of the building that is shaded is the work area, which consists of all the spaces that have been reconfigured.

FIGURE 5-1. Determination of a *work area* within an existing building.

any area increases created by *additions*. Incidental work in other areas of the building associated with the proposed work is excluded from the *work area* by definition.

The requirements for the *work area* compliance method are spread over several chapters with each chapter being associated with one type of work classification:

- Chapter 5 Classification of Work
- Chapter 6 Repairs
- Chapter 7 Alterations–Level 1
- Chapter 8 Alterations–Level 2
- Chapter 9 Alterations–Level 3
- Chapter 10 Change of Occupancy
- Chapter 11 Additions
- Chapter 12 Historic Buildings
- Chapter 13 Relocated or Moved Buildings

The requirements in each chapter apply to work that is classified by that type. Unlike the prescriptive compliance method, compliance with the requirements of the IBC is only applicable where it is indicated within each of the chapters. With the exception of chapters on *additions*, *historic buildings*, and relocated or moved buildings, each chapter includes sections that are generally consistent from chapter to chapter; however, there are slight variations in each chapter (i.e., some sections are not used while some may have sections unique to that work classification). The most common sections used include the following:

- General
- Special Use and Occupancy
- Building Elements and Materials
- Fire Protection
- Means of Egress
- Accessibility
- Structural
- Electrical
- Mechanical
- Plumbing
- Energy Conservation

The chapters on *additions*, *historic buildings*, and relocated or moved buildings have sections that are unique to those work classifications. IEBC Chapter 11 on *additions* addresses compliance with the height and area requirements of IBC Chapter 5, since an addition may exceed the allowable area or height for a building under the current code. IEBC Chapter 12 on *historic buildings* recognizes that *historic buildings* may undergo new work that falls within one or more of the other work classifications. Therefore, IEBC Chapter 12 provides criteria for *repairs*, *alterations*, and *change of occupancy* that are specifically focused on *historic buildings*. Lastly, IEBC Chapter 13 on relocated or moved buildings has only a couple of sections that are primarily structural in nature.

PERFORMANCE COMPLIANCE METHOD

The last of the three compliance methods is one that has been a part of the IBC in the former Chapter 34 on *existing buildings*. The provisions allow a building of any occupancy, except Groups H, I-1, I-3, and I-4, to be evaluated on 23 areas pertaining to three categories: Fire Safety (FS), Means of Egress (ME), and General Safety (GS). Each evaluation area is assigned a value based on the existing or proposed characteristics of the building. The values are determined either by calculation, from one of the several tables, or by a combination of both. This compliance method requires a comprehensive analysis of the *existing building* which may include a review of original construction drawings (if available) and a physical inspection of the building.

The values are then applied to one or more of the three categories. The values within each category are totaled, and if the sum, or score, is equal to or greater than the calculated, mandatory value for each category, then the building passes. However, if a value falls short of the mandatory value, then improvements to the building will need to be made in order to improve the score. Mandatory values are determined based on the occupancy group per IEBC Table 1401.8.

According to IEBC Section 1401.2, this chapter should only be applicable to buildings that were built before a certain date. It is up to the local jurisdiction adopting the IEBC to determine what will be that cut-off date. The ICC recommends the date used should coincide with the date building codes were first introduced to the jurisdiction. For example, if the jurisdiction decides that the date applicable to this section is January 1, 1928, then any building constructed after that date must use either the prescriptive compliance method or *work area* compliance method or request approval from the *building official* to use the building code in effect at the time of construction per the exception to IEBC Section 301.1.

Applying the Step-by-Step Process to Existing Buildings

Applying the step-by-step process to new work for *existing buildings* is not as straightforward as it is when working with a new building; not all steps are necessary. The steps that may be applicable for one *existing building* project may not be applicable to another *existing building* project. For example, a new building *addition* will require calculation to determine if the *building area* of the *existing building* with the *addition* is within the allowable area, whereas an *alteration* to an *existing building* would not. Thus, the work classification and even the compliance method will influence how the step-by-step method is used.

SCHEMATIC DESIGN

- **Step 1—Determine Applicable Building Code:** This step will be required regardless of what type of work is performed in or on an *existing building*. As a matter of fact, this becomes even more important if a former building code is used per the exception to IEBC Section 301.1.
- **Step 2—Obtain Essential Building Data:** This step will also be required regardless of the type of work performed. Since any new work must conform to the requirements of the IBC, unless stated otherwise, then knowing what materials are existing for the building structural system, if a sprinkler system is installed or not, and the *climate zone* is important. If the new work involves an *addition*, then knowing the number of *stories*, height in feet, and existing *building area* will be necessary for determining compliance with allowable height and area later on.
- **Step 3—Determine Occupancy Group or Groups:** This step requires the identification of existing occupancy groups within a building, whether they are proposed to change or not as part of the new work. If an occupancy group or several groups change, then it should be determined whether or

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not the changes are more or less hazardous than the existing occupancy group or groups. If the new occupancy is more hazardous, then the *change of occupancy* requirements are applicable and the step-by-step process as presented in Part II of this book will apply with little modification. Otherwise, the *construction documents* will need to indicate that the change is to a less hazardous occupancy.

- **Step 4—Determine Construction Type Based on Anticipated Materials:** This step will require some modification since the *existing building* will need to be classified based on its current construction. Prior documentation, such as record drawings, may indicate the construction type based on the code in effect at the time of the original construction or as determined by subsequent work within the *existing building*. If record documents do not provide the information, then a determination will need to be based on an analysis of the drawings, a physical inspection of the building, or both. If no record documents exist, then the determination can only be made through a physical inspection of the building. Regardless of the work classification, the construction type affects the application of some code requirements, such as construction and finish materials and *fire-resistance ratings*.
- **Step 5—Determine How Mixed Uses and Occupancies Will Be Handled:** For *alterations* that do not reconfigure spaces and *repairs*, this step is not applicable. For *alterations* that reconfigure spaces, *additions*, and *changes of occupancy*, then this will be a necessary step. This process may be somewhat predetermined based on the fire-resistance characteristics of the *existing building*; thus, this step may only determine how to handle new work within the building.
- **Step 6—Determine Special Use and Occupancy If Applicable:** This step may only be necessary if the *existing building* or portion of the *existing building* is changing its current use to one that is covered in IBC Chapter 4. Existing special uses and occupancies that are unchanged may remain as they exist, provided they do not create a health or safety hazard.
- **Step 7—Determine Allowable Area and Height:** This step is only required when the *existing building* will have an *addition* or will have a *change of occupancy*.
- **Step 8—Calculate Occupant Load:** For *repairs*, this step is unnecessary, since the *existing building's means of egress* system is not altered. However, *alterations* that reconfigure space, *additions*, and *change of occupancy* will require consideration of this step. *Alterations* may change spaces with different load factors, thus having an impact on the *occupant loads* of the altered spaces as well as the *story*. *Additions* will definitely add occupants to the building. A *change of occupancy* can have an impact on the *occupant load*, even if the occupancy group does not change. A *change of occupancy*, as stated in IEBC Chapter 2 of this part also includes changes in a specific use of a space, which may increase the *occupant load*.
- **Step 9—Establish Points of Egress:** This step is only applicable if Step 8 determines that there is an increase in the *occupant load* or if the existing points of egress are modified by an *alteration* or *addition*. If the *occupant load* decreases, then the existing points of egress will likely be sufficient, unless the points of egress change location due to the new work.
- **Step 10—Check Egress Pathways:** This step should be considered if the existing *means of egress* system is modified in any way. If *occupant loads* increase, then existing pathways, even if they are not programmed to be modified, may require modification to adjust to new capacities (see Step 19).
- **Step 11—Determine Fixture Counts:** If the *occupant loads* increase or a *change of occupancy* changes the occupancy group or groups, then the fixture counts will need to be adjusted. If restrooms or some plumbing fixtures are to be removed, then calculations are required to verify that remaining fixtures will be sufficient.
- **Step 12—Identify Fire Department Access Roads:** This step will only be required if there is an *addition* that will affect the existing fire department access. Relocated or moved buildings will need to be provided with fire department access like that for new buildings.

- **Step 13—Identify Accessible Routes and Requirements:** The ASAD and IEBC establish requirements for *accessibility* for *existing buildings*. It is the goal of the ADA to remove barriers in buildings of public accommodation, even in *existing buildings* where the modifications are technically feasible. If compliance is technically infeasible, then compliance for *accessibility* shall be provided to the greatest extent possible. *Existing buildings* that are proposed to have reconfigured spaces or will have a *change of occupancy* are required to be *accessible* by the accessibility standards, unless identified exceptions apply.

DESIGN DEVELOPMENT

- **Step 14—Confirm Steps 2 through 13:** This step is required whether or not all previous steps are required. Changes are made to a design for an *existing building* just like they are for new buildings, and these changes may affect earlier decisions made.
- **Step 15—Identify Locations of Fire-Resistive Construction, Assemblies, and Openings:** This step is important especially if the new construction requires reconfiguration of spaces, addition of doors and windows, new penetrations in wall, floor, and roof assemblies, and for *additions* that require determination of allowable height and area per Step 7. Existing fire-resistive construction, if required to be maintained as fire resistive, must comply with the current requirements for fire resistance or, if approved, with the requirements of the building code in effect at the time of original construction. There may be situations where an existing fire-resistive assembly is no longer required under the IBC. The construction documents may have to address these situations, especially if evidence of its former fire-resistance function remains (e.g., existing firestopped penetrations, fire-rated doors, etc.), which may be questioned in the field by building inspectors.
- **Step 16—Develop Exterior Wall Assemblies:** This step is only necessary if the *existing building* envelope is affected by new work. *Additions* and *changes of occupancy* will require this step to comply with the IBC and IECC.
- **Step 17—Develop Roof Assemblies:** This step is only necessary if the existing roof assembly is modified or new roofing is added. If only the roof membrane is being replaced, then compliance with IBC Section 1511 for *reroofing (IEBC)* should be reviewed during this step.
- **Step 18—Select Finishes:** This step will likely be used regardless of the work classification. All new finishes will need to comply with the IBC.
- **Step 19—Check Egress Widths:** If the *occupant load* increases per Step 8, the points of egress change per Step 9, the egress pathways change per Step 10, or all three apply, then egress widths should be verified to ensure that the existing or proposed widths are sufficient. If existing widths are not sufficient, then *alteration* work may be necessary to revise the egress width to meet minimum required capacities.
- **Step 20—Check Accessibility Requirements:** For all *alterations*, *additions*, and *changes of occupancy*, the spaces should comply with current *accessibility* requirements. Within the *work area* compliance method, *alterations* that involve reconfiguration of space exclusively for compliance with accessibility standards need only comply with the requirements of Level 1 *alterations*. Thus, the reconfigured spaces are not required to be included in determining the *work area* as previously defined.
- **Step 21—Integrate Special Requirements:** Regardless of work classification, this step should be reviewed to ensure that no special requirements need to be considered. Some work classifications require compliance with flood-resistant design requirements of the IEBC, IBC, or both. *Emergency escape and rescue openings* and sound transmission performance may be required for residential occupancies, especially for *change of occupancy* from another occupancy group.

CONSTRUCTION DOCUMENTS

- **Step 22—Confirm Steps 14 through 21:** This step is required whether or not all previous steps are required. Changes are made to a design for an *existing building* just like they are for new buildings, and these changes may affect earlier decisions made.
- **Step 23—Integrate Egress Details:** If egress components are modified by the new work, new construction must comply with the current requirements of the IBC. There are special exceptions in the IEBC that should be reviewed before applying requirements for new construction.
- **Step 24—Identify Locations of Safety Glazing:** All new glass must comply with the safety glazing requirements of the IBC if located within an identified hazardous location, whether the glass is replacing existing nonsafety glazing or used in new glazed assemblies.
- **Step 25—Detail Firestopping, Fire-Resistive Joints, and Fireproofing:** If penetrations are installed in new fire-resistive assemblies or in existing fire-resistive assemblies that must remain fire resistive, firestopping of the penetrations must comply with the requirements of the IBC. Likewise, fireproofing that is disturbed as a result of the new work must be repaired and new structural steel must be equally protected. New joints between new and existing *fire-resistance-rated* assemblies must be protected as required for new construction per the IBC.
- **Step 26—Locate Portable Fire Extinguishers and Cabinets:** If no extinguishers currently exist in the building, the *fire code official* may mandate their installation under the provisions of the IFC for *existing buildings*. If provided, they must be sized and located as required by the IFC.
- **Step 27—Detail Construction Based on Specific Materials and Equipment:** This step will likely apply to all work classifications, so it should be reviewed for applicability.
- **Step 28—Prepare Code Information for Construction Documents:** This step is required for all work that is required to be submitted for plan review and permit.

PART VI

Code Enforcement

Designing a building to comply with all of the required codes is one thing, but proving it to the agencies responsible for enforcing the codes is another. In Step 28, examples are provided on how to convey that information in a set of submitted documents. However, there is a human, legal, and bureaucratic side to code enforcement that people should be made aware of if they are expected to interface with these authorities.

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Authority Having Jurisdiction

The term "authority having jurisdiction," commonly referred to as "AHJ," is quite nebulous and covers a variety of regulating organizations. People tend to apply the term when the person, office, or agency regulating a specific area is unknown. The term's most common application is in reference to the *building official* and *fire code official* (*IFC*), who are responsible for building code and fire code enforcement, respectively. But the AHJ term (it is closer to a title than a term) encompasses more than just building or fire code compliance. The NFPA, which uses the term throughout its codes and standards, has officially defined it as "the organization, office, or individual responsible for approving equipment, materials, an installation, or a procedure."

The NFPA agrees that the term is broad and in the annexes of its codes and standards explains that "jurisdictions and approval agencies vary, as do their responsibilities." Fortunately, the NFPA annexes also help to narrow the broad term by listing some common AHJs other than building and fire departments, such as labor departments, health departments, insurance companies, governmental agencies, or property owners. Each of these may have developed or adopted standards and codes in addition to those enforced by local building authorities

The word "jurisdiction" is somewhat generic and can be applied at two different levels. The first is the "territorial" application, which means that an official's authority is restricted to a specific territory, such as a city, county, or state. The second is the "limits" application, which means that an official has limits to what the authority covers. In most cases, both applications apply.

The AHJ can be "statutory" or "contractual." The former is fairly straightforward and is what is commonly associated with an AHJ; however, the latter may not be so clearly defined.

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STATUATORY AHJ

A "statutory" AHJ typically includes a federal, state, county, local, or other governmental division that has been given its authority through a law or regulation, such as a local ordinance or state statute. In the context of building regulation, these frequently include building departments, zoning departments, and fire marshal offices.

For a city *building official*, the territory is within the city's borders; thus, the city *building official* has no authority to enforce the building code outside of the city borders. As for the limits of the city *building official's* authority, only those codes identified, such as the building, electrical, plumbing, energy, and mechanical codes adopted by the city, can be enforced by the city *building official*. Anything not within those codes would be considered outside the *building official's* jurisdiction. For example, the *building official* would likely have no jurisdiction enforcing health codes in restaurants, which are typically enforced by the local, county, or state health departments.

Also, there may be more than one organization, agency, or department that has jurisdiction over a particular area, but only one may have authority. A good example of this overlap is the one between local and state fire marshals. If the project is a state project constructed within city limits, the two fire marshals may have jurisdiction regarding the fire code, but only the state fire marshal may have the authority.

CONTRACTUAL AHJ

A "contractual" AHJ may include those organizations that have a business relationship with the building owner, such as insurance companies and utility companies. Since these organizations provide services regarding the owner's building project, they have some control over specific aspects of the project. For example, before issuing a policy, an insurance company may review the construction documents for compliance with its design standards, and the utility company will ensure that the utility service complies with its standards before connecting the utility service to the building.

The Department of Building Safety

The organization tasked with the duties to enforce the jurisdiction's building regulations is what is identified in IBC Section 103 as the "Department of Building Safety," or, more commonly, referred to as "the Building Department." However, being a generic title, building departments can be found under a variety of more official titles throughout the country, some of which include the following:

- Department of Building and Safety
- Development Services Department
- Community Development Department
- Public Works Department
- Building Safety Division
- Planning and Economic Development
- Planning and Development
- Development and Sustainability

Regardless of how they are titled, some building departments are complete departments that report directly to a governing authority (e.g., mayor, city manager, county commissioner, etc.) or they may be a subset of a larger department. For example, the building department may be paired with the zoning department under a larger "planning" department.

Some jurisdictions do not have a building department at all and, under contract, authorize a third-party company to provide building department services for the jurisdiction, such as plan review and building inspection. This type of arrangement is commonly used in locations where construction work is rare and the need to have full-time employees does not make fiscal sense. On the other hand, the quantity of construction may exceed the capacity of the department to efficiently handle the work; therefore, they may seek services from a third-party company to handle the overflow. Third-party services are provided for jurisdictions under three basic models:

- **Full Service:** The third-party company provides all building department duties. One of the company's managers is designated as the *building official* and is given the responsibilities of that position as authorized in the building code.
- **Limited Service:** The third-party company provides all building department duties, except that the jurisdiction retains the *building official* authority by assigning it to one of the jurisdiction's employees.
- **Plan Review Service:** The third-party company provides only plan review services and all other duties are retained by the jurisdiction, including the authority of the *building official*.

THE BUILDING OFFICIAL

As previously mentioned, the position of *building official* is defined in the IBC and the duties and powers are outline in IBC Section 104. The duties and powers of the *building official* include the following:

- Hire employees and delegate some of the *building official's* duties and powers to those employees.
- Review *construction documents* and issue permits.
- Render interpretations of the building code and other codes as authorized.
- Establish policies and procedures for the operation of the building department.
- Approve modifications to the building code.
- Approve alternative materials, designs, and methods.

In IBC Section 103, the *building official* is placed in charge of the Department of Building Safety. However, in large jurisdictions with a sizable number of building department employees, the *building official* could easily be overcome by the responsibilities of managing the department (e.g., personnel issues, budgeting, training, etc.) that those other responsibilities usurp the *building official's* code enforcement duties. Therefore, in some cases, the person given the authority of the *building official* may not be the person in charge of the building department—those duties are assigned to a department manager and the *building official* reports to the department manager (or may be designated an assistant department manager). In this situation, the *building official* can focus on building code enforcement and retains the approval authority afforded the position in the building code.

PLANS EXAMINERS

Since the *building official* is responsible for reviewing *construction documents*, the *building official* may hire "plans examiners" to perform the review duties. For building code enforcement, plans examiners are a quality assurance step for the building department—they make sure buildings comply with the code before they are constructed. The plans examiner will likely be the building department staff member with which the design professional will have the most interaction. The specific duties of a plans examiner is not outlined by the IBC but is typically established by the *building official*.

Although the emphasis here is on the enforcement of the building code, the *building official*, and thus the building department, will likely have responsibility for enforcing other codes such as those for plumbing, mechanical, electrical, energy, and fuel gas. Within the building department, there may be several people performing plan reviews on a single project. Since the codes are complex documents, plans examiners may specialize in a particular code and review a project only for compliance with that code. Common areas where plans examiners specialize include those in the table below.

Common Plans Examiner Specialization

Plans Examiner	Codes Reviewed for Compliance
Building and Life Safety	Nonstructural provisions of the IBC, IECC, and IEBC
Structural	Structural provisions of the IBC
Accessibility	IBC and ICC/ANSI A117.1
Residential	IRC and IECC
Electrical	NEC
Mechanical	IMC and IFGC
Plumbing	IPC and IFGC
Fire	IFC and the fire protection provisions of the IBC

The background and requirements for a plans examiner vary from jurisdiction to jurisdiction. Some plans examiners come from previous positions as inspectors, but many are architects and engineers, with the engineers usually performing plan reviews within their engineering disciplines. The ICC offers certification programs for the various types of plans examiners, and most building departments require certification as a condition of employment.

The "fire plans examiner" may or may not be situated within the building department. Typically, they are part of the fire department and work directly for the *fire code official*. The fire plans examiner will review the plans from a fire prevention perspective, including the review of automatic sprinkler and fire alarm systems.

INSPECTORS

The duties of inspection are given to the *building official* in the IBC, but, as previously mentioned, the *building official* may delegate those duties to a variety of inspectors. Whereas the plans examiner provides the quality assurance for a building department, the inspector provides the quality control by inspecting the building as it is being constructed. The inspector will have the most interaction with the contractor, but the design professional may interact with the inspector when code issues arise in the field.

The IBC identifies in Section 110 what portions and stages of the construction require inspection. These include:

- **Footing and Foundations:** Conducted when footing excavations are complete and reinforcing steel is in place.
- **Concrete Slab and Underfloor Construction:** Conducted when all reinforcing steel, conduit, piping accessories, and other items are in place but before concrete is placed.
- **Lowest Floor Elevation:** Submittal of flood hazard documentation as set forth in IBC Section 1612.5.
- **Frame Inspection:** Conducted when framing, including fire blocking, bracing, and sheathing, is complete. All rough-ins for electrical, plumbing, and other concealed systems must be installed and approved.
- **Lath and Gypsum Board:** Conducted after interior and exterior lathing and gypsum board is in place but before plastering or gypsum board joints and fasteners are taped and finished.
- **Fire-and Smoke-Resistant Penetrations:** Conducted before joints and penetrations are concealed in fire-rated assemblies, *smoke barriers*, and *smoke partitions*.

- **Energy Efficiency:** Ensures compliance with the IECC as referenced in IBC Chapter 13. This includes building insulation *R-values* and *U-factors*, fenestration *U-factors*, and HVAC and water heating efficiency to list a few items.
- **Other Inspections:** As required by the *building official* to ensure compliance with the code and other regulations enforced by the building department.
- **Final Inspection:** Conducted when all work required by the permit is completed.

It is important to stress that the duty of the inspector is to enforce compliance with the approved *construction documents* in the specific areas of code compliance. The building department inspector cannot be used as a mechanism to enforce compliance with non-code-related elements of the *construction documents*; that is the responsibility of the owner to whom the inspector has no obligation.

The background and requirements of inspectors also vary from jurisdiction to jurisdiction, but many are former contractors or subcontractors familiar with working in the field. The ICC offers certification programs for various types of inspection categories, and most building departments require certification as a condition of employment. Common areas where inspectors specialize include those in the table below

Common Inspector Specialization

Inspector	Codes Reviewed for Compliance
Commercial Building	IBC
Commercial Electrical	NEC
Commercial Mechanical	IMC and IFGC
Commercial Plumbing	IPC, IFGC, and ICC/ANSI A117.1
Commercial Energy	IECC
Fuel Gas	IFGC
Accessibility	IBC and ICC/ANSI A117.1
Fire	IBC and IFC
Residential Building	IRC
Residential Electrical	IRC and NEC
Residential Mechanical	IRC
Residential Plumbing	IRC
Residential Energy	IECC
Residential Fire	IRC

Plan Reviews

Before a permit can be issued that allows an owner to proceed with the construction of their project, the project must first be approved through the plan review process. Plan reviews will vary in each jurisdiction, but most conform to a basic five-step process:

1. Applicant submits *construction documents* to building department.
2. Plans examiner reviews *construction documents* and prepares a list of comments.
3. Applicant picks up the list of comments and makes the necessary corrections.
4. Applicant resubmits corrected documents to building department.
5. Plans examiner verifies corrections. If there are no additional comments, then the plans examiner approves the *construction documents* for permit. If there are additional comments, then the process is repeated at step 3.

Typically, the preparer of the *construction documents* will be the applicant making the submission to the building department, which, in most cases, will be the design professional.

The duration of the plan review process is difficult to define, even for building departments. The duration could be anywhere from a few days to several weeks—even months. Some building departments publish or may offer average plan review times so that applicants can factor those durations into their project schedules, but there is no guarantee that the plan review time for any project will be "average." There are a few factors that can influence the duration of the plan review process:

- **Complexity of the Project:** Complex features such as unique building applications, complicated *means of egress* systems, and multiple occupancy groups will require more time on the part of the plans examiners to make sure the project complies with the code. On the other hand, simple projects do not need to be studied thoroughly to understand their nature. For example, large interior shopping malls with amusement features, theaters, and dining will take more time to review than a small office building.
  Size of a project alone may not be indicative of how complex a project will be. A *high-rise building*, for example, that utilizes repetitive floor plates may require less time to review than a smaller single-story building that involves the use and storage of multiple *hazardous materials*.

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- **Quality of the Construction Documents:** Poorly prepared *construction documents* will make it difficult for the plans examiners to comprehend what is indicated and how to interpret them. The result is a longer time to review and almost certainly a longer list of comments. *Construction documents* that clearly present the design intent and code application will require less of the plans examiner's time resulting in a shorter review period and an even shorter list of comments.
- **Workload of the Building Department:** Outside of the applicant's control is the ability of the building department to immediately review a project. With shrinking budgets and reduced staff, building departments may be unable to keep up with the influx of projects and must work through a backlog of submitted documents. When an applicant submits a set of *construction documents* when a backlog exists, it is just added to the queue of other documents awaiting review. Some building departments have implemented expedited plan reviews, but these come with higher plan review fees.

The comments made by plans examiners will come in one of three ways: markups on the *construction documents*, a list of comments on a separate document, or most likely both. The comments are the plans examiner's main form of communication with the design professional, so they should be clear and understandable and provide code citations to direct the design professional to specific requirements.

In making corrections, the design professional should address every comment. If the design professional does not concur with a comment or has questions about a comment, the design professional should contact the plans examiner to discuss it. As a part of the resubmittal to the building department, a complete list of comments with a response to each comment that states how the comment was addressed and where to locate the substantiating information in the *construction documents*.

Code Enforcement and the Building Code Application Process

In the building code application process, the submission of *construction documents* to the *building official* is a form of ***quality control (QC)*** for the design professional, since the *construction documents* are reviewed for compliance after the documents are completed. The result is either a "pass" and a permit is issued or a "fail" and the design professional receives a list of corrections. Since the QC process should not be the primary quality process, the design professional should not rely solely on the jurisdictional plan review to ensure compliance with the building code. An extensive list of corrections requires more of the design professional's time and money and may require more resubmittals that may also increase time and cost, thus delaying construction and reducing profits.

The more efficient approach is to develop a ***quality assurance (QA)*** process, such as the step-by-step process offered within this book, which is used during the development of the design to minimize the number of, or possibly eliminate, corrections received from the jurisdictional plan review. This process should begin at the earliest possible phase of the design process. Unfortunately, unlike the jurisdictional plan review, the design professional has very limited information on which to base a code analysis early in the design process. Therefore, the design professional must select the best possible solution for the present design problem or a "code compliance strategy."

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Definitions

Quality Assurance, or QA

Refers to the procedures for guarding against defects and deficiencies before and during the execution of the work. During design, QA may include procedures such as obtaining data indicating performance, properties, and other attributes which meet the requirements.

Quality Control, or QC

Refers to the procedures for evaluating completed activities and elements of the design for conformance with the requirements. Procedures during design may include document reviews, simulations, and other forms of validation and review, such as meetings with [authorities having jurisdiction].

Source: *Project Delivery Practice Guide*, CSI (Construction Specifications Institute), p. 164.

A code compliance strategy is like preparing a route on a map for an upcoming road trip: you designate your starting and ending points and mark the roads and highways you want to follow, the stops you want to make, and the attractions you want to see. However, once you get out on the road, adjustments need to be made along the way: you skip the next stop because you spent too much time at the last one or unexpected road construction causes you to take another route. Regardless of how you get there, you eventually arrive at your destination. In preparing a code compliance strategy, you map out your route to code compliance by basing decisions on the information you have readily available. As the design progresses, you make adjustments to your code compliance strategy as more information becomes available and the details of the design are generated.

Achieving quality in a building project is a deliberate process that must be implemented by the design team at the beginning of project design. Although quality in building design implies more than just complying with building code requirements, it is the safeguarding of "public health, safety and general welfare"—the intent of building codes—that is directly tied to the design professional's license to practice. Therefore, design professionals should incorporate into office practice a ***quality assurance*** program that covers building code-related issues.

APPENDIX

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A

Architectural Program For Privatized Student Housing

PROJECT SUMMARY

In response to the increasing demand for student enrollment in higher education, the university is developing a plan to work in cooperation with private companies to develop student housing either on or off campus property to increase the quantity of available and affordable housing for students within the campus community area. For projects located on campus property, conformance to university standards is required; however, projects off campus are not required, but are encouraged, to conform to university standards.

Since the Privatized Student Housing (PSH) project is located off of campus property, the developer has chosen the option not to conform fully to the university's standards; however, compliance with local regulations is thus required.

The PSH project goals are as follows:

- Provide an appropriate mix of living options.
- Provide buildings with some longevity but that may conform to local building practices for buildings of comparable size and use.
- Enhance and contribute to the university lifestyle.
- Provide meal facilities for residents.
- Provide sufficient parking for residents.
- Provide amenities for student gatherings, study, and recreation.
- Provide a small convenience shop for residents that is made available to nonresidents.
- Provide the highest quality environment at the lowest possible cost.

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PROJECT SPACES

OVERVIEW

The building will be limited to four stories to stay within the context of building on adjoining and nearby properties.

Below-grade parking is encouraged to minimize size of paved areas on the site.

Project amenities shall be located at ground level.

DETAILED SPACE INVENTORY

Parking Level: Not less than 15,000 sq. ft.

- Sized to accommodate at least one vehicle per apartment. (It is assumed that the parking requirements in the city's zoning ordinance allow a reduced number of onsite parking because of a shared parking program using the university's campus parking and the availability of public transportation within the immediate vicinity.)
- Provide storage for bicycles.

Ground Level (1st Story): 15,000 sq. ft.

Dining hall: 4,500 sq. ft.
- This includes the dining area and kitchen facilities.
- Provide access to public restrooms.

Public restrooms: 500 sq. ft.
- Men's and women's facilities.
- Must be accessible from all areas on the amenities level.

Convenience shop: 950 sq. ft.
- Provide display of merchandise.
- Provide counter for cashier.

Study rooms (2 each): 700 sq. ft. (350 sq. ft. each)
- Accessible by residents without having to exit and reenter building.
- Accessible to public restrooms.
- Locate near lounge.

Lounge: 800 sq. ft.
- Provide views to the exterior.
- Accessible to public restrooms.
- Located near study rooms.

Covered outdoor patio: 800 sq. ft.
- Accessible to pool area.
- Accessible to public restrooms
- Semisecluded from offsite public areas.

Management office: 700 sq. ft.
- Accessible from lobby.
- Located near manager's apartment.

Manager's apartment: 1,100 sq. ft.
- Complete living facilities with three bedrooms, living room, kitchen, dining area, and bathrooms.
- Close proximity to management office.

Exercise room: 600 sq. ft.

- Provide views to exterior.
- Accessible to public restrooms.
- Provide sufficient power for exercise equipment.

Mechanical room: 1,100 sq. ft.

- Location for building's mechanical and electrical systems.
- Will also double as maintenance shop and storage.

Trash room: 250 sq. ft.

- Location for dumpsters for trash and recycling.
- Vehicle access for sanitation department pickup.

Mail room: 300 sq. ft.

- Mailboxes for residents.
- Provide separate room for packages.

Circulation: Remaining area for walls, stairways, corridors, elevators, and lobby (approx. 2,700 sq. ft.).

Residential Levels (2nd through 4th Stories): 15,000 sq. ft. each

Residential units per floor:

- Two-bedroom apartments: 750 sq. ft. each (8 total)
- Three-bedroom apartments: 1,000 sq. ft. each (4 total)
- Four-bedroom apartments: 1,250 sq. ft. each (2 total)

Circulation/structure per floor: Remaining area for walls, stairways, corridors, elevators, and trash chute rooms (approx. 2,500 sq. ft.)

Outdoor amenities:

- Swimming pool: 900 sq. ft.

B

Code Data Information Template

GENERAL CODE INFORMATION

BUILDING: <PROJECT TITLE>

Adopted Codes:

2015 International Building Code [**as amended by <Insert jurisdiction>**]
2015 International Existing Building Code [**as amended by <Insert jurisdiction>**]
2015 International Fire Code [**as amended by <Insert jurisdiction>**]
2015 International Mechanical Code [**as amended by <Insert jurisdiction>**]
2015 International Energy Conservation Code [**as amended by <Insert jurisdiction>**]
2015 International Plumbing Code [**as amended by <Insert jurisdiction>**]
2015 Uniform Plumbing Code [**as amended by <Insert jurisdiction>**]
2015 International Fuel Gas Code [**as amended by <Insert jurisdiction>**]
2014 National Electrical Code (NFPA 70) [**as amended by <Insert jurisdiction>**]

> Delete line below if there are no code modifications, waivers, reports, or other stipulations by the jurisdiction applicable to the project.

Reference Documents: <Insert complete title, reference number, and date as applicable>
Type of Construction: [IA] [IB] [IIA] [IIB] [IIIA] [IIIB] [IV] [VA] [VB]
Fire Sprinklered Throughout: [No] [Yes, NFPA 13-<Edition> per Section 903.3.1.1] [Yes, NFPA 13R-<Edition> per Section 903.3.1.2] [Yes, NFPA 13D-<Edition> per Section 903.3.1.3]

Basement: [None] [1 Level] [2 Levels] [<Number> Levels]
Hazardous Materials: [None]

> Copy and paste below for each chemical used and/or stored in the project. Delete if no hazardous materials.

<**Chemical name**>: <**Quantity**>
Flood Hazard Area: [Yes] [No]

> Delete below if "No" is retained above.

Design Flood Elevation: <**Elevation**> ft.
Climate Zone: <**Zone**>
Occupancy Classification[s]: [<Occupancy>, <Description>] [Separated] [Nonseparated] [Combination of separated and nonseparated occupancies]

> Copy and paste below for each occupancy group in the project.

<**Occupancy**>: <**Description**>

SPECIAL REQUIREMENTS

> Retain only those special requirements that are applicable to the project. If no special requirements on the project, delete entire section. Not all special requirements are listed below. Some special requirements are located in other applicable sections. Review the IBC for any other special requirements applicable to the project and include within this section.

[Covered] [and] [Open] Mall Buildings:

> Delete paragraph below if project does not include an open mall.

Open Mall Perimeter Line: See Site Plan on Sheet <**Insert sheet number**>
Gross Leasable Area (GLA): <**Number**> sq. ft.
Mall Area: <**Number**> sq. ft.

High Rise Buildings:

Height of Highest Occupied Floor above Lowest Fire Vehicle Access: <**Number**> ft.
Additional Exit Stairway Required: [**Yes**] [**No**]
Fire Service Access Elevators Required: [**Yes**] [**No**]
Elevator Designations: <**Designation**>
Fire Command Center: Located in Room <**Number**>
Size of Room: <**Number**> sq. ft. $\geq$ 200 sq. ft. per Section 911.1.3
Minimum Dimension: <**Number**> ft. $\geq$ 10 ft. per Section 911.1.3
Emergency Responder Radio Coverage: See Sheet[**s**] <**Insert sheet number**>

Atriums:

Exit Stairways in Atrium: <**Number**> exit stairways in Atrium / <**Number**> exit stairways total in building = <**Decimal number**> = <**Percent**>% ≤ 50% per Section 404.10

Parking Garages:

Open Parking Garage Openings

Tier	Perimeter Length (ft.)	Perimeter Area (sq. ft.)	Required Opening Area (sq. ft.)[a]	Actual Open Areas (sq. ft.)					Percent of Perimeter Area
				Side <Insert>	Side <Insert>	Side <Insert>	Side <Insert>	Total Area	

[a] 20% of Perimeter Area.

Stages:

Stage Area: <**Number**> sq. ft.
Stage Height: <**Number**> ft.

HEIGHT AND AREA

Actual Floor Areas:

Copy and paste below for each story in the project.

<**Number**> Story: <**Area**> sq. ft.

Tabular Building Height:

Grade Plane Elevation:

Copy and paste below for each point used to determine grade plane.

<**Location**>: <**Elevation**> ft.
Average: <**Elevation**> ft.

Allowable Height in Stories: Using [**nonsprinklered ("NS")**] [**sprinklered ("S")**] [**sprinklered ("S13R") where applicable and nonsprinklered ("NS") for all others**] per Table 504.4.

Copy and paste below for each occupancy group in the project. Retain the "← Most Restrictive" option if the nonseparated occupancies method is used and if the occupancy group is the most restrictive.

Group <**Occupancy**>: [<**Number**> **stories**] [**Unlimited**] [**← Most Restrictive**]

Allowable Height in Feet: [<**Number**> **feet**] [**Unlimited**] using [**nonsprinklered ("NS")**] [**sprinklered ("S")**] condition per Table 504.3.

Actual Height:

> Retain below if building <u>is not</u> sprinklered per NFPA 13R.

Height in Feet: <**Actual Feet Height**> ft. (Measured from grade plane) ≤ <**Allowable Feet Height**> ft., therefore, okay

> Retain below if building <u>is</u> sprinklered per NFPA 13R.

Height in Feet: <**Actual Feet Height**> ft. (Measured from grade plane) ≤ 60 ft. (Group R) and <**Allowable Feet Height**> ft. (All Other Occupancy Groups), therefore, okay

Height in Stories:

> Copy and paste below for each occupancy group in the project.

Group <**Occupancy**>: <**Actual Story Height**> story ≤ <**Allowable Story Height**> stories, therefore, okay

> If the building is sprinklered, retain "and" and one of the following options. The first option is for single-story buildings, the second is for buildings with two or more stories above grade plane, and the third is for building sprinklered using a NFPA 13R installed system.

Tabular Allowable Floor Area (A_t): Using nonsprinklered ("NS") **[and] [sprinklered single-story ("S1")] [sprinklered multiple story ("SM")] [sprinklered ("S13R")]** condition**[s]** per Table 506.2.

> Copy and paste below for each occupancy group in the project. Retain the "← Most Restrictive" option if the nonseparated occupancies method is used and if the occupancy group is the most restrictive.

Group <**Occupancy**>: NS: **[**<**Number**> **sq. ft.] [Unlimited] [← Most Restrictive]**
[S1] [SM] [S13R]: [<**Number**> **sq. ft.] [Unlimited] [← Most Restrictive]**

Allowable Area Increases: Allowable Area (A_a) per Floor Calculation per Section 506.1:

Frontage Increase (I_f): [**Section 506.3, Equation 5-5**] [**0** (**Not required**)]

$$[I_f = [F/P - 0.25]W/30$$

F = <**Open Frontage**> ft.
P = <**Building Perimeter**> ft.
W = <**Open Space Width**> ft.[, **see Weighted Average *W* calculation below**]

I_f = [<**Open Frontage**> / <**Building Perimeter**> − 0.25] <**Open Space Width**> ft./30
I_f = <**Frontage Increase**>]

Weighted Average *W*: Equation 5-4.

$$W = (L_1 \times w_1 + L_2 \times w_2 + L_3 \times w_3 \dots)/F$$

> Replace "Designation" with identification marks used on drawings for complex buildings or with compass directions for simple rectangular buildings.

<**Designation**>**:**

$L_{\text{<Number>}}$ = <**Length**> ft.

$w_{\text{<Number>}}$ = <**Width**> ft.

> Add numbers ***from*** above in calculation below (only three sets are provided; insert more sets if needed).

W = (<**Length**> ft. × <**Width**> ft. + <**Length**> ft. × <**Width**> ft. + <**Length**> ft. × <**Width**> ft.)/<**Open Frontage**>

> Retain the section below to determine allowable area for a single story in multistory buildings; delete section below if the building is a single-story building. In the line below, retain first option for single-occupancy buildings and second option for mixed-occupancy buildings.

Allowable Single-Story Area Calculation: Section [506.2.3] [506.2.4].

> Equation 5-2 below is for single-occupancy, multistory buildings. Use if Section 506.2.3 is selected above.

Equation 5-2: $A_a = A_t + (NS \times I_f) \times S_a$

> Equation 5-3 below is for mixed-occupancy, multistory buildings. Use if Section 506.2.4 is selected above.

Equation 5-3: $A_a = [A_t + (NS \times I_f)]$

> Retain the first options for NS and At values for single occupancy or nonseparated occupancies method. Retain the second options for separated or combination of separated and nonseparated occupancies methods. A_t is the "S1," "SM," or "S13R" value for the occupancy group.

A_t = [<**Tabular Area**> **sq. ft.**] [**See each occupancy group below for tabular floor area**.]

NS = [<**Tabular Area**> **sq. ft.**] [**See each occupancy group below for tabular floor area**.]

I_f = [**0**] <**Frontage Increase**>

> Delete S_a below if building is mixed occupancy.

S_a = 1 story

> Retain paragraph and subparagraphs below if the building is a single-occupancy building.

Single-Occupancy Buildings: Group <**Occupancy**>:

A_t = <**Tabular Area**> sq. ft.

A_a = <**Tabular Area**> sq. ft. + (<**NS Tabular Area**> sq. ft. × <**Frontage Increase**>) × 1

A_a = <**Allowable Story Area**> sq. ft. ≥ <**Actual Story Area**> sq. ft. (largest floor area), therefore, okay

> Retain paragraph and subparagraphs below if the building is a mixed-occupancy building using the nonseparated occupancies method only.

Mixed, Nonseparated Occupancy Buildings: Group <**Occupancy**> (Most Restrictive):

A_t = <**Tabular Area**> sq. ft.

A_a = <**Tabular Area**> sq. ft. + (<**NS Tabular Area**> sq. ft. × <**Frontage Increase**>) × 1

A_a = <**Allowable Story Area**> sq. ft. ≥ <**Actual Story Area**> sq. ft. (largest floor area), therefore, okay

> Retain "Sum of Ratios for Mixed Occupancy" section below if the building is a mixed-occupancy building using the separated occupancies method or a combination of separated and nonseparated occupancies methods.

Sum of Ratios for Mixed Occupancy:

> For separated or combination of separated and nonseparated occupancies methods, copy and paste the calculations below for each occupancy group in the project.

Group <**Occupancy**>:

A_t = <**Tabular Area**> sq. ft.

A_a = [<**Tabular Area**> sq. ft. + (<**NS Tabular Area**> sq. ft. × <**Frontage Increase**>)]

A_a = <**Allowable Floor Area**> sq. ft.

Copy and paste the calculations below for each story in the project.

<**Story**>:

Group <**Occupancy**>: <**Actual Floor Area**> sq. ft. /<**Allowable Floor Area**> sq. ft. = <**Ratio**>

Add numbers from each occupancy group above in calculation below. (Only two are provided; insert additional ratios when more than two occupancy groups are within the story.)

Sum: <**Ratio**> + <**Ratio**> = <**Sum of Ratios**> ≤ 1, therefore, okay

The first option in line below is for single-occupancy, one-story buildings; the second is for mixed-occupancy, one-story buildings; the third is for single-occupancy, multistory buildings; and the fourth is for mixed-occupancy, multistory buildings.

Allowable Building Area Calculation: Section [506.2.1] [506.2.2] [506.2.3] [506.2.4].

Equation 5-1 below is for single-occupancy, one-story buildings. This is also used for mixed-occupancy, one-story buildings when occupancies are separated. Use if Section 506.2.1 or 506.2.2 is selected above.

Equation 5-1: $A_a = A_t + (NS \times I_f)$

Equation 5-2 below is for single-occupancy, multistory buildings. Use if Section 506.2.3 or 506.2.4 is selected above.

Equation 5-2: $A_a = A_t + (NS \times I_f) \times S_a$

Retain the first options for NS and A_t values for single occupancy or nonseparated occupancies method. Retain the second options for separated or combination of separated and nonseparated occupancies methods. A_t is the "S1," "SM," or "S13R" value for the occupancy group.

A_t = <**Tabular Area**> sq. ft.

NS = <**Tabular Area**> sq. ft.

I_f = [**0**] <**Frontage Increase**>

> Delete S_a below if using Equation 5-1 and the building is mixed-occupancy building using the separated occupancies method only. Retain S_a below if using Equation 5-2 for single-occupancy buildings or mixed-occupancy buildings using the nonseparated method only. If a building is two stories, retain "2." If the building is three or more stories, retain "3." For buildings permitted to be sprinklered per NFPA 13R, retain "4."

S_a = [**2**] [**3**] [**4**] stories

Group <**Occupancy**>:

> Calculation below is using Equation 5-1.

A_a =<**Tabular Area**> sq. ft. + (<**NS Tabular Area**> sq. ft. × <**Frontage Increase**>)

> Calculation below is using Equation 5-2.

A_a = <**Tabular Area**> sq. ft. + (<**NS Tabular Area**> sq. ft. × <**Frontage Increase**>)

× <**S_a Stories**>

A_a = <**Allowable Building Area**> sq. ft. ≥<**Actual Building Area**> sq. ft., therefore, okay

> Retain section below and delete above for mixed-occupancy, multistory buildings, where occupancies are separated or where a combination of separated and nonseparated occupancies are used. If a building is two stories, retain "2." If the building is three or more stories, retain "3." For buildings permitted to be sprinklered per NFPA 13R, retain "4."

Total Building Area for Mixed-Occupancy, Multistory Buildings: Sum of ratios for each floor must be less than or equal to [**2**] [**3**] [**4**].

> Copy and paste the line below for each story in the project with the sum of ratios for that story.

<**Story**>: <**Sum of Ratios**>

> Add numbers from above in calculation below (only two are provided for a two-story building; add ratios for stories if building is more than two stories). If a building is two stories, retain “2.” If the building is three or more stories, retain “3.” For buildings permitted to be sprinklered per NFPA 13R, retain “4.”

<**Sum of Ratios**> + <**Sum of Ratios**> = <**Sum of Ratios for Building**> ≤ **[2] [3] [4]**, therefore, okay

Single-Use Open Parking Garage Area and Height:

Tabular Allowable Area and Height: Table 406.5.4.

Allowable Area per Tier: [<**Number**> **sq. ft.**] [**Unlimited**]

Allowable Height: [<**Number**> **tiers**] [**Unlimited**]

Area and Height Increases: Section 406.5.5.

Area Increase: **[25% for open area on 3/4 of tier perimeter length] [50% for open area on all sides] [Not permitted] [Not required]**

Height Increase: **[1 tier] [Not permitted] [Not required]**

Total Allowable Area and Height:

Allowable Area: <**Number**> sq. ft. + ([**0.25**] [**0.5**] × <**Number**> sq. ft.) = <**Number**> sq. ft. ≥ <**Number**> sq. ft. actual area

Allowable Height: <**Number**> tiers + 1 tier = <**Number**> tiers ≥ <**Number**> tiers actual height

FIRE RESISTANCE

> Building elements that may require fire-resistance ratings are listed below. Delete those that are not applicable to the project. Each is provided with a table to provide the member or opening designation used on the drawings, the assembly designation (e.g., UL No., IBC Prescriptive Item No. per IBC Section 721, calculated assembly per IBC Section 722, or other approved methods), the fire-resistance rating (must be equal to or greater than the minimum rating required), and the location in the drawings where the detailed assembly is provided. Some tables will require that the fire-resistance or fire protection rating also be identified.

Fire-Resistance Rating Requirements for Building Elements: Table 601, based on Type [IA (Noncombustible)] [IB (Noncombustible)] [IIA (Noncombustible)] [IIB (Noncombustible)] [IIIA (Combustible)] [IIIB (Combustible)] [IV (Combustible)] [VA (Combustible)] [VB (Combustible)]:

Structural Frame: <**Number**>-hour minimum construction.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

Bearing Walls:

Retain option below only if all exterior walls have a fire separation distance greater than 10.
If some exterior walls are 10 feet or less, then indicate which walls require exposure from both sides and which from the inside only in the "Remarks" column.

Exterior: <**Number**>-hour minimum construction. [**All exterior walls have a fire separation distance greater than 10 feet; therefore, rating is for fire exposure from the inside only per IBC Section 705.5.**]

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

Interior: <**Number**>-hour minimum construction.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

Interior Nonbearing Walls: <**Number**>-hour minimum construction, except as required per other requirements.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

Floor Construction: <**Number**>-hour minimum horizontal assembly.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

Roof Construction: <**Number**>-hour minimum horizontal assembly.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

Fire-Resistance Rating Requirements for Exterior Walls Based on Fire Separation Distance: Table 602.

> Copy and paste lines below for each occupancy group in the project. Copy and paste "Location" paragraph within each occupancy group for each exterior wall segment with a different fire separation distance.

Group <**Occupancy**>:
<**Location**>:
Fire Separation Distance: <**Number**> feet
Fire Rating: <**Number**> hour[**s**]

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

> Delete below if no horizontal exits are used.

Horizontal Exits: 2-hour fire barriers.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

> Delete below if no shafts, enclosed stairways and ramps, or building is a single story with no basements. Hoistways for elevators are considered shafts. Enclosures for interior exit access stairways also conform to the requirements for shafts.

Shafts and Interior Exit Stairways and Ramps: [1-hour fire barriers (penetrating less than 4 stories)] [2-hour fire barriers (penetrating 4 stories or more)] [2-hour fire barriers (penetrating horizontal assemblies of 2 hours or more)] [2-hour fire barriers for smokeproof enclosures].

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

> Delete below if no exit passageways are required. Retain option if interior exit stairways or ramps are extended by an exit passageway.

Exit Passageways: Fire barriers with fire-resistance ratings per Section 1024[**and Section 1023**].

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

> Delete below if not required to divide building into separate fire areas.

Fire Areas: Fire barriers with fire-resistance ratings per Table 707.3.10.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

> Delete below if allowable area is not based on separated occupancies.

Occupancy Separations: Fire barriers or horizontal assemblies with fire-resistance ratings per Table 508.4.

Member	Assembly Designation	Minimum Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

> Delete below if no atriums.

Atriums: 1-hour fire barriers per Section 404.6.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

Delete below if separated control areas are not used for hazardous materials.

Control Areas: Fire barriers with fire-resistance ratings per Table 414.2.2.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

Delete below if no incidental uses. If sprinkler system protection is used in lieu of separation, delete the table and retain ***third*** option regarding smoke partitions.

Incidental Uses: [Use sprinkler system protection in lieu of separation] [Fire barriers with fire resistance ratings] per Table 509. **[Provide smoke partition to control passage of smoke as required by Section 509.4.2.]** The following spaces are considered incidental uses: <**Room Name and number or other designation**>

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

If no fire-resistance rating is required, delete the table.

Corridors: [1-hour fire partitions] [0.5-hour fire partitions] [No fire-resistance rating required] per Table 1020.1.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

Delete below if the project has no Group R occupancies.

[Sleeping Room] [and] [Dwelling Unit] Separations: Fire-resistance per Section 420. Sound transmission per Section 1207.

Walls: [**1**] [**0.5**]-hour minimum fire partitions. Minimum STC of 50.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

Floor/Ceilings: [**1**] [**0.5**]-hour minimum horizontal assemblies. Minimum STC of 50 and IIC of 50.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>				

> Retain title and table below if there are special uses or conditions that require fire-resistance-rated assemblies, such as areas of refuge, elevator lobbies, etc.

Special Fire-Resistance-Rated Applications: For Assembly Type: FB = Fire Barrier; FP = Fire Partition; SB = Smoke Barrier

Member	Special Application	Assembly Type	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
<**Designation**>						

> In item below, retain one or more of the types. If mixed opens are provided, retain last option.

Exterior Wall Opening Protection: Table 705.8. **[Percentages are based on a sprinklered building.] [Calculations per Section 705.8.4 are included where a mix of protected and unprotected openings are provided.]**

> If no openings are required to be protected, the table below can be deleted.

Exterior Wall Rating	Opening	Fire-Protection Rating	Drawing Location
[**2**] [**3**] Hours	<**Door Type**>	$1\frac{1}{2}$ Hours	
	<**Window Type**>	$1\frac{1}{2}$ Hours	
1 Hour	<**Door Type**>	$\frac{3}{4}$ Hour	
	<**Window Type**>	$\frac{3}{4}$ Hour	

> Copy and paste lines below for each story in the project. Copy and paste "Location" paragraph within each story for each exterior wall segment with a different fire separation distance. Ensure drawings show which openings are protected.

<**Story**>:

<**Location**>:

Fire Separation Distance: <**Number**> feet

Percentage Permitted (Unprotected): <**Number**>%

Percentage Permitted (Protected): <**Number**>%

Exterior Wall Area: <**Number**> sq. ft.

Allowable Area (a_u) (% Unprotected × Ext. Wall Area) : <**Number**> sq. ft.

Allowable Area (a_p) (% Protected × Ext. Wall Area): <**Number**> sq. ft.

Actual Area (A_u) (Unprotected): <**Number**> sq. ft. is less than or equal to <**Allowable area**> sq. ft., therefore, okay

Actual Area (A_p) (Protected): <**Number**> sq. ft. is less than or equal to <**Allowable area**> sq. ft., therefore, okay

Mixed Openings Calculation: Equation 7-2.

$(A_p/a_p) + (A_u/a_u)$ is less than or equal to 1

(<**Number**> sq. ft./<**Number**> sq. ft.) + (<**Number**> sq. ft./<**Number**> sq. ft.) = <**Number**> is less than or equal to 1, therefore, okay

Interior Wall Opening Protection:

Fire Doors: Table 716.5.

Door	Assembly		Door Rating	Glazing Type	Glazing Label	Remarks
	Type	Rating				
				Vision Panel		
				Transom/Sidelight		

Fire Windows: Table 716.6.

Window	Assembly		Window Rating	Glazing Label	Remarks
	Type	Rating			

MEANS OF EGRESS

Special Occupant Load Calculations:

Mall Occupant Load: Section 402.8.2.

Equation 4-1: $OLF = (0.00007)(GLA) + 25$

$OLF = (0.00007)($<**Number**> sq. ft.$) + 25$

OLF = <**Number**> sq. ft. per occupant **[; since *OLF* is less than 30, then *OLF* = 30 sq. ft. per occupant per Section 402.8.2.2] [; since *OLF* is greater than 50, then *OLF* = 50 sq. ft. per occupant per Section 402.8.2.2]**

Occupant Load: <**Mall Area**> sq. ft. / <**OLF**> sq. ft. per occupant = <**Number**> occupants

Fixed Seating Occupant Loads: Section 1004.4

<**Space Function**>: Fixed seating with arms. One occupant per seat = <**Number**> occupants

<**Space Function**>: Fixed seating without arms. One occupant per 18 inches of seating length. <**Length**> in./18 in. = <**Number**> occupants

<**Space Function**>: Seating booths. One occupant per 24 inches of seating length. <**Length**> in./24 in. = <**Number**> occupants

> NOTE: Use sections titled "Occupant Load" through "Exit Width" for simple projects. Use tables in "Detailed Means of Egress" section for complex projects.

Occupant Load: Section 1004.

> Copy and paste the lines below for each story in the project.

<**Story**>:

> Copy and paste the lines below for each space within the above identified story.

<**Space Function**>: <**Floor area**> sq. ft. / <**Load factor**> sq. ft. per occupant = <**Number**> occupants

<**Space Function**>: [**Mall Occupant Load**] [**Fixed Seating Occupant Load**] = <**Number**> occupants

Total: <**Number**> occupants (<**Number**> exits required; <**Number**> provided)

Travel Distance: <**Number**> ft. maximum less than or equal to <**Number**> ft. per Table 1016.2

Location: <**Description**>.

Common Path of Egress Travel: <**Number**> ft. maximum less than or equal to <**Number**> ft. per Section 1014.3

Location: <**Description**>.

Exit Width:

> Copy and paste the lines below for each story in the project.

<**Story**>:

Stairs: [<**Number**> **occupants** × **[0.2] [0.3] inch/occupant** = <**Number**> **inches minimum less than or equal to** <**Number**> **inches provided**] [**Not Applicable**]

Other: <**Number**> occupants × [**0.15**] [**0.2**] inch/occupant = <**Number**> inches minimum less than or equal to <**Number**> inches provided

> Delete sections above and retain tables in "Detailed Means of Egress" section below (Occupant Load and Egress Data by Space, Separation of Exit/Exit Access Points, and Egress Width) for complex projects or if egress by each space is required by the building official. Delete tables if sections above are used for simple projects.

Copy and paste the table below for each story in the project. Add rows for each room located within the story.

Detailed Means of Egress:

<Story> Occupant Load and Egress Data by Space

Room No.	Floor Area (sq. ft.)[a]	Use[b]	Area per Occupant (sq. ft.)[a]	No. of Occupants	Add'l Occupants	Total Occupants[c]	Exit/Exit Access Required[d]	Exit/Exit Access Provided	Common Path of Travel[e] (ft.)	Travel Distance[f] (ft.)	Remarks

[a]All areas are gross unless indicated otherwise.

[b]Use number from list below (Ref. Table 1004.1.2):

Retain only those uses below that are applicable to the project.

1. Accessory Storage Areas, Mechanical Equipment Areas
2. Agricultural building
3. Aircraft Hangars
4. Airport Terminal, Baggage Claim
5. Airport Terminal, Baggage Handling
6. Airport Terminal, Concourse
7. Airport Terminal, Waiting Areas
8. Assembly, Gaming Floors
9. Assembly, Exhibit Gallery and Museum
10. Assembly with Fixed Seats
11. Assembly without Fixed Seats, Concentrated
12. Assembly without Fixed Seats, Standing Space
13. Assembly without Fixed Seats, Unconcentrated
14. Bowling Centers, Lanes
15. Bowling Centers, Additional Areas
16. Business Areas
17. Courtrooms
18. Day Care
19. Dormitories
20. Educational, Classroom Area
21. Educational, Shops and Other Vocational Room Areas
22. Exercise Rooms
23. Group H-5 Fabrication and Manufacturing Areas
24. Industrial Areas
25. Institutional Areas, Inpatient Treatment Areas
26. Institutional Areas, Outpatient Areas
27. Institutional Areas, Sleeping Areas
28. Kitchens, Commercial
29. Library, Reading Rooms
30. Library, Stack Area
31. Locker Rooms
32. Mall Buildings (Covered and Open)
33. Mercantile
34. Mercantile, Storage, Stock, Shipping Areas
35. Parking Garages
36. Residential
37. Skating Rinks, Rink
38. Skating Rinks, Deck
39. Swimming Pools, Pool
40. Swimming Pools, Deck
41. Stages and Platforms
42. Warehouses

[c]See "Egress Width" table.

[d]Where two or more exit or exit access doors are required, see "Separation of Exit/Exit Access" table.

[e]Maximum distance for common path of egress travel is per the [**sprinklered**] [**nonsprinklered**] values in Table 1006.2.1.

[f]Maximum travel distance is per the [**sprinklered**] [**nonsprinklered**] values in Table 1017.2.

In the table below, list only those spaces that are required to have two or more exits or exit access doorways.

Separation of Exit/Exit Access Points

Room/Space/Story	Overall Diagonal Measurement (ft.)	Exit Separation Distance (ft.)	Greater than [1/3] [1/2] Over All Diagonal?
			Yes

Egress Width

Room/Space/Story	Number of Occupants	Egress Width per Occupant (inches) (Section 1005.3)	Required Width (inches)	Provided Width (inches)
		[**0.15**] [**0.2**] (Door)		
		[**0.15**] [**0.2**] (Other[a])		
		[**0.2**] [**0.3**] (Stair)		

[a]Includes corridors, exit passageways, and ramps.

Refuge Area Sizing:

See "Accessible Means of Egress" subsection for areas of refuge. Retain applicable refuge area tables. If no refuge areas, delete entire subsection.

Horizontal Exits: Section 1026.4.

Compartment Designation	Occupant Load	Refuge Area Sizing		
		Adjoining Compartment Designation	Total Net Area Required (sq. ft.)[a]	Net Area Provided (sq. ft.)

[a]Calculated at 3 sq. ft. net per occupant of adjoining compartment.

Group I-1, Condition 2, Smoke Compartments: Section 420.4.1.

Compartment Designation	Occupant Loads		Refuge Area Sizing				
	Care Recipients	Other Occupants	Adjoining Compartment Designation[a]	Area for Care Recipients (sq. ft.)[b]	Area for Other Occupants (sq. ft.)[c]	Total Area Required (sq. ft.)	Area Provided (sq. ft.)

[a]Based on largest occupant load of adjoining compartments.

[b]Calculated at 15 sq. ft. per care recipient of adjoining compartment.

[c]Calculated at 6 sq. ft. per occupant of adjoining compartment.

Group I-2 Smoke Compartments: Section 407.5.1.

Compartment Designation	Occupant Loads		Refuge Area Sizing				
	Bed-Confined Care Recipients	Other Occupants	Adjoining Compartment Designation[a]	Area for Bed-Confined Care Recipients (sq. ft.)[b]	Area for Other Occupants (sq. ft.)[c]	Total Area Required (sq. ft.)	Area Provided (sq. ft.)

[a]Based on largest occupant load of adjoining compartments.

[b]Calculated at 30 sq. ft. per bed-confined care recipient of adjoining compartment.

[c]Calculated at 6 sq. ft. per occupant of adjoining compartment.

Group I-3 Smoke Compartments: Section 408.6.1.

Compartment Designation	Occupant Load	Refuge Area Sizing		
		Adjoining Compartment Designation	Area Required (sq. ft.)[a]	Area Provided (sq. ft.)

[a]Calculated at 6 sq. ft. per occupant of adjoining compartment.

Ambulatory Care Facility Smoke Compartments: Section 422.3.2.

Compartment Designation	Occupant Load	Refuge Area Sizing		
		Adjoining Compartment Designation	Area Required (sq. ft.)[a]	Area Provided (sq. ft.)

[a]Calculated at 30 sq. ft. per occupant of adjoining compartment.

Dead-End Corridors: [<Number> ft. maximum ≤ [20] [50] ft. per Section 1018.4] [None]
Location: <**Description**>.

> Delete below if the project has no atrium or there is no exit access travel distance through the atrium on a story other than the level of exit discharge.

Maximum Travel Distance through Atrium Not on Level of Exit Discharge: <**Number**> ft. ≤ 200 ft. per Section 404.9.3

> Retain below if building includes Group R-2 or R-3 occupancies. If emergency escape and rescue openings are not required, retain option in paragraph below and delete table.

Emergency Escape and Rescue Openings: Section 1030. **[Not required; each story is provided with two exits or access to two exits.]**

Door/Window Designation	Story or Stories Located	Clear Opening Area (sq. ft.)	Clear Height (in.)	Clear Width (in.)	Sill Height (in.)	Remarks

Accessible Means of Egress:

Required Accessible Means of Egress: Section 1009.2.

Stairways: <**Location**>

Elevators: <**Location**>

Areas of Refuge:

Stairways: Section 1009.3 **[; provided within stairway enclosures] [; provided in separate areas of refuge adjacent to stairways per Section 1009.6] [; not required per Exception 5 for sprinkler system installed throughout] [; not required at open parking garage per Exception 6] [; not required for smoke-protected assembly seating per Exception 7] [; not required for Group R-2 occupancies per Exception 8] [; not required for the stairways accessed from a refuge area in conjunction with a horizontal exit per Exception 9]**.

Elevators: Section 1009.4 **[; not required since elevator is not considered an accessible means of egress] [; not required at open parking garage per Exception 1] [; not required per Exception 2 for sprinkler system installed throughout] [; not required since elevator is not located within a shaft per Exception 3] [; not required for smoke-protected assembly seating per Exception 4] [; not required for elevator accessed from a refuge area in conjunction with a horizontal exit per Exception 5]**.

Size: Section 1009.6.3.

Copy and paste paragraph below for each story. Round the raw number up to the next whole number.

<**Story**>: <**Number**> occupants/200 = <**Raw Number**> = <**Rounded Number**> wheelchair spaces ≤ <**Number**> wheelchair spaces provided

Exterior Areas for Assisted Rescue: Section 1009.7.

Location: <**Location Description**>

Size: <**Number**> occupants/200 = <**Raw Number**> = <**Rounded Number**> wheelchair spaces ≤ <**Number**> wheelchair spaces provided

Exterior Open Area Percentage: <**Number**> sq. ft. open area/<**Number**> sq. ft. total exterior area = <**Number**> ≥ 0.50

PLUMBING FIXTURES

For the tables below, add rows for each occupancy group in the building.

Calculations:

Water Closets—Based on Occupant Load				
Occupancy Group	**Number of Occupants**	**Ratio (IBC Table 2902.1)**	**Raw Fixture Count (Not Rounded)**	
			Male	**Female**
	Male			
	Female			
		Raw Totals		
		Rounded Totals		

Unassigned Water Closets—Based on [Dwelling Units] [, Sleeping Units] [, Rooms] [, or Cells]			
Occupancy Group	**Number**	**Ratio (IBC Table 2902.1)**	**Fixture Count**
I-2	<**Number**> Rooms	1 per Room	
I-3	<**Number**> Cells	1 per Cell	
R-1	<**Number**> Sleeping Units	1 per Sleeping Unit	
R-2 Apartments	<**Number**> Dwelling Units	1 per Dwelling Unit	

Total Number of Water Closets Required:

Male: <**Number**>

Female: <**Number**>

Unassigned: <**Number**>

Lavatories—Based on Occupant Load				
Occupancy Group	**Number of Occupants**	**Ratio (IBC Table 2902.1)**	**Raw Fixture Count (Not Rounded)**	
			Male	**Female**
	Male			
	Female			
		Raw Totals		
		Rounded Totals		

Unassigned Lavatories—Based on [Dwelling Units] [, Sleeping Units] [, Rooms] [, or Cells]			
Occupancy Group	**Number**	**Ratio (IBC Table 2902.1)**	**Fixture Count**
I-2	<**Number**> Rooms	1 per Room	
I-3	<**Number**> Cells	1 per Cell	
R-1	<**Number**> Sleeping Units	1 per Sleeping Unit	
R-2 Apartments	<**Number**> Dwelling Units	1 per Dwelling Unit	

Total Number of Lavatories Required:

Male: <**Number**>

Female: <**Number**>

Unassigned: <**Number**>

Drinking Fountains

Occupancy Group	Number of Occupants	Ratio (IBC Table 2902.1)	Raw Fixture Count (Not Rounded)
		Raw Total	
		Rounded Total	

Total Number of Drinking Fountains Required: <**Number**>

Bathtubs/Showers

Occupancy Group	Quantity	Ratio (IBC Table 2902.1)	Raw Fixture Count

Total Number of Bathtubs/Showers Required: <**Number**>

Clothes Washer Connections

Occupancy Group	Quantity	Ratio (IBC Table 2902.1)	Raw Fixture Count
R-2 Apartments		1 per 20 Apartments	

Total Number of Bathtubs/Showers Required: <**Number**>

Delete below if project has no dwelling units.

Kitchen Sinks: One sink per dwelling unit.
Service Sinks: Each area to have access to one service sink.
Family or Assisted-Use Toilet Facilities: Section 1109.2.1.

Number of Water Closets for Assembly and Mercantile Occupancies: <**Number**> water closets [<**6; therefore, a family or assisted-use toilet facility is not required**] [≥**6; therefore, one family or assisted-use toilet is required**].

Compliance:

Plumbing Fixtures in Restrooms

Restroom Room No.	Story	Longest Path of Travel (ft.)	Water Closets						Lavatories	
			Required	Provided	Urinal Substitutions		Quantity Accessible	Quantity Ambulatory	Required	Provided
					Provided	% of Required				

Plumbing Fixtures in [Dwelling Units] [, Sleeping Units] [, Rooms] [, or Cells]

Room Description	Water Closets		Lavatories		Bathtubs/Showers		Kitchen Sinks	
	Required	Provided	Required	Provided	Required	Provided	Required	Provided

Clothes Washer Connections

Required	Provided

Location	Quantity

Drinking Fountains

Required	Provided

Location	Quantity	Story	Longest Path of Travel (ft.)

Service Sinks: [1] <**Insert Number**> located in <**Insert Location**>.

FIRE PROTECTION SYSTEMS

Hazard Classifications:

Light (Low) Hazard Occupancies: <**Insert Space**> [**Not Applicable**]
Ordinary (Moderate) Hazard Occupancies: <**Insert Space**> [**Not Applicable**]
Extra (High) Hazard Occupancies: <**Insert Space**> [**Not Applicable**]

Fire Extinguishers:

Class A Fire Hazard

Area Covered	Floor Area (sq. ft.)	Hazard Classification	Floor Area per Unit of A (sq. ft.)	Unit of A Required	Extinguishers Provided			
					Quantity	Extinguisher Rating	Total Unit of A Provided	Max. Actual Travel Distance (ft.)
		[Light (Low)]	[3,000]					
		[Ordinary (Moderate)]	[1,500]					
		[Extra (High)]	[1,000]					

Class B Fire Hazard

Area Covered	Hazard Classification	Minimum Extinguisher		Provided Extinguisher	
		Rating	Max. Travel Distance (ft.)	Rating	Max. Actual Travel Distance (ft.)
	[Light (Low)]	[5-B]	[30]		
	[Ordinary (Moderate)]	[10-B]	[50]		
	[Extra (High)]	[20-B]			
		[40-B]			
		[80-B]			

Delete below if project has no commercial kitchens.

Class K Fire Hazard (IFC Section 904.12.5)

Area Covered	Solid Fuel Cooking Appliances		Fryers (One 1.5 gal./Four Fryers)			Max. Actual Travel Distance (ft.)
	Size	Quantity	Number of Fryers	Qty. Extinguishers Required	Qty. Extinguishers Provided	
	[1.5-gallon] [2.5-gallon]	[2] [1]				

Retain applicable paragraphs below and provide sheet location(s) where design information is located.

Automatic Sprinkler System Design: See Sheet <**Insert sheet number**>
Alternative Automatic Fire-Extinguishing System Design: See Sheet <**Insert sheet number**>
Standpipe System Design: See Sheet <**Insert sheet number**>
Fire Alarm and Detection System Design: See Sheet <**Insert sheet number**>
Smoke Control System Design: See Sheet <**Insert sheet number**>

Smoke and Heat Removal Design:

Mechanical Smoke Removal System Design: See Sheet <**Insert sheet number**>

Retain “sprinklered” option if building is sprinklered per NFPA 13. Use the “nonsprinklered” option for all other fire-extinguishing systems.

Smoke and Heat Vent Design: Calculations for a [**sprinklered**] [**nonsprinklered**] building per Section 910.3.3.

Retain Equation 9-4 if “sprinklered” option is retained in paragraph above. Retain Equation 9-5 if “nonsprinklered” option is retained in paragraph above.

Equation 9-4: $A_{VR} = V/9{,}000$

Copy and paste paragraph and subparagraphs below for each area that requires venting.

<**Vented Area Description**>:

V = <**Volume**> cu. ft.

A_{VR} = <**Volume**> cu. ft./9,000

A_{VR} = <**Area**> sq. ft. required ≤ <**Area**> sq. ft. of vented area provided

Equation 9-5: $A_{\mathrm{VR}} = A_{\mathrm{FA}}/50$

Copy and paste paragraph and subparagraphs below for each area that requires venting.

<**Vented Area Description**>:

A_{FA} = <**Area**> sq. ft.

A_{VR} = <**Area**> sq. ft./50

A_{VR} = <**Area**> sq. ft. required ≤ <**Area**> sq. ft. of vented area provided

Stage Ventilation Design: Ventilation provided via [**roof vents**] [**smoke control**] per Section 410.3.7.
Stage Area: <**Area**> sq. ft.
Stage Height: <**Height**> ft.
Smoke Control System Design: See Sheet <**Insert sheet number**>
Roof Vents: 5% of Stage Area per Section 410.3.7.1.

0.05 × <**Stage Area**> sq. ft. = <**Area**> sq. ft. required ≤ <**Area**> sq. ft. of vented area provided

High-Rise Building Smoke Removal: Provided by the following per Section 403.4.7:
Operable [**Windows**] [**Panels**]: Shown on Sheet <**Insert sheet number**>

Building Perimeter = <**Number**> ft.

Vent Area per Story = (Building Perimeter/50 ft.) × 40 sq. ft.

Vent Area per Story = (<**Number**> ft./50 ft.) × 40 sq. ft.

Vent Area per Story = <**Number**> sq. ft. ≤ <**Number**> sq. ft. vent area provided

Mechanical Air Handling: See Sheet <**Insert sheet number**>
Other Approved Method: <**Describe method**>.
[**See Sheet** <**Insert sheet number**>]

ACCESSIBILITY

Retain only those accessibility requirements that are applicable to the project. Not all accessibility requirements are listed below. Review the IBC, ANSI A117.1, and ADA standards for any other accessibility requirements applicable to the project and include within this section. Retain all options in paragraph below for Groups I-1 and R-1. Retain first option only for Groups R-2, R-3, and R-4. Retain last option only for all other occupancy groups.

Parking and Passenger Loading Facilities: [Section 1106.2] [and] [Table 1106.1].

Total Number of Parking Spaces: <**Number**> spaces

Number of Accessible Parking Spaces Required: <**Number**> spaces ≤ <**Number**> spaces provided

Van-Accessible Spaces Required: Section 1106.5.

<**Number**> accessible spaces provided × 1/6 = <**Number**>, rounded up to <**Number**> van-accessible spaces ≤ <**Number**> spaces provided

> Delete subsection below if project does not include dwelling or sleeping units.

[Dwelling] [and] [Sleeping] Units:

Group I-1, Condition [**1**] [**2**]: Section 1107.5.1.

Total number of [**Dwelling Units**] [**and**] [**Sleeping Units**]: <**Number**> units

Accessible Units Required: [**0.04**] [**0.10**] × <**Number**> Total Number of Units = <**Number**> = <**Rounded number**> units ≤ <**Number**> units provided

Accessible Unit Locations: <**Unit Numbers**>

Type B Units Required: [**All remaining units**] [<**Number**> **units per Section 1107.7.1**] [<**Number**> **units per Section 1107.7.2**] [<**Number**> **units per Section 1107.7.3**] [<**Number**> **units per Section 1107.7.4**] [<**Number**> **units per Section 1107.7.5**].

> Retain paragraph below and provide locations for Type B units if all remaining units are not required to be Type B units per one of the options in the paragraph above.

Type B Unit Locations: <**Unit Numbers**>

Group I-2, Nursing Homes: Section 1107.5.2.Total number of [**Dwelling Units**] [**and**] [**Sleeping Units**]: <**Number**> unitsAccessible Units Required: 0.50 × <**Number**> Total Number of Units = <**Number**> = <**Rounded number**> units ≤ <**Number**> units provided

Accessible Unit Locations: <**Unit Numbers**>

Type B Units Required: [**All remaining units**] [<**Number**> **units per Section 1107.7.1**] [<**Number**> **units per Section 1107.7.2**] [<**Number**> **units per Section 1107.7.3**] [<**Number**> **units per Section 1107.7.4**] [<**Number**> **units per Section 1107.7.5**].

> Retain paragraph below and provide locations for Type B units if all remaining units are not required to be Type B units per one of the options in the paragraph above.

Type B Unit Locations: <**Unit Numbers**>

Group I-2, Hospitals: Section 1107.5.3.

Total number of [**Dwelling Units**] [**and**] [**Sleeping Units**]: <**Number**> units

Accessible Units Required: 0.10 × <**Number**> Total Number of Units = <**Number**> = <**Rounded number**> units ≤ <**Number**> units provided

Accessible Unit Locations: <**Unit Numbers**>

Type B Units Required: [**All remaining units**] [<**Number**> **units per Section 1107.7.1**] [<**Number**> **units per Section 1107.7.2**] [<**Number**> **units per Section 1107.7.3**] [<**Number**> **units per Section 1107.7.4**] [<**Number**> **units per Section 1107.7.5**].

> Retain paragraph below and provide locations for Type B units if all remaining units are not required to be Type B units per one of the options in the paragraph above.

Type B Unit Locations: <**Unit Numbers**>

Group I-2, Rehabilitation Facilities: Section 1107.5.4.

Total number of [**Dwelling Units**] [**and**] [**Sleeping Units**] used for Treatment of Conditions Affecting Mobility: <**Number**> units

All units are Accessible Units.

Group I-3: Section 1107.5.5.

Total number of Sleeping Units: <**Number**> units

Accessible Units Required: 0.03 × <**Number**> Total Number of Units = <**Number**> = <**Rounded number**> units ≤ <**Number**> units provided

Accessible Unit Locations: <**Unit Numbers**>

Special Holding/Housing Cells or Rooms: One accessible unit for each type.

Accessible Unit Locations: <**Unit Numbers**>

Group R-1: Section 1107.6.1.

Total number of [**Dwelling Units**] [**and**] [**Sleeping Units**]: <**Number**> units

Accessible Units Required: <**Number**> units per Table 1107.6.1.1 ≤ <**Number**> units provided

Accessible Unit Locations: <**Unit Numbers**>

Type B Units Required: [**All remaining units**] [<**Number**> **units per Section 1107.7.1**] [<**Number**> **units per Section 1107.7.2**] [<**Number**> **units per Section 1107.7.3**] [<**Number**> **units per Section 1107.7.4**] [<**Number**> **units per Section 1107.7.5**].

> Retain paragraph below and provide locations for Type B units if all remaining units are not required to be Type B units per one of the options in the paragraph above.

Type B Unit Locations: <**Unit Numbers**>

Group R-2, Live/Work Units: Section 1107.6.2.1.

Total number of [**Dwelling Units**] [**and**] [**Sleeping Units**]: <**Number**> units

Type B Units Required: [**All units**] [<**Number**> **units per Section 1107.7.1**] [<**Number**> **units per Section 1107.7.2**] [<**Number**> **units per Section 1107.7.3**] [<**Number**> **units per Section 1107.7.4**] [<**Number**> **units per Section 1107.7.5**].

> Retain paragraph below and ***provide*** locations for Type B units if all units are not required to be Type B units per one of the options in the paragraph above.

Type B Unit Locations: <**Unit Numbers**>

Group R-2, [**Apartment Houses**] [**Monasteries**] [**Convents**]: Section 1107.6.2.2.

Total number of [**Dwelling Units**] [**and**] [**Sleeping Units**]: <**Number**> units

Type A Units Required: 0.02 × <**Number**> Total Number of Units = <**Number**> = <**Rounded number**> units

Number of Type A Units Provided: <**Number**> units [**, reduced per Section 1107.7.1**] [**, reduced per Section 1107.7.2**] [**, reduced per Section 1107.7.3**] [**, reduced per Section 1107.7.4**] [**, reduced per Section 1107.7.5**].

Type A Unit Locations: <**Unit Numbers**>

Type B Units Required: [**All remaining units**] [<**Number**> **units per Section 1107.7.1**] [<**Number**> **units per Section 1107.7.2**] [<**Number**> **units per Section 1107.7.3**] [<**Number**> **units per Section 1107.7.4**] [<**Number**> **units per Section 1107.7.5**].

> Retain paragraph below ***and*** provide locations for Type B units if all remaining units are not required to be Type B units per one of the options in the paragraph above.

Type B Unit Locations: <**Unit Numbers**>

> Retain paragraph and subparagraphs below if Group R-2 dwelling or sleeping units are other than those types indicated above.

Group R-2: Section 1107.6.3.

Total number of [**Dwelling Units**] [**and**] [**Sleeping Units**]: <Number> units

Accessible Units Required: <**Number**> units per Table 1107.6.1.1

Accessible Unit Locations: <**Unit Numbers**>

Type B Units Required: [**All remaining units**] [<**Number**> **units per Section 1107.7.1**] [<**Number**> **units per Section 1107.7.2**] [<**Number**> **units per Section 1107.7.3**] [<**Number**> **units per Section 1107.7.4**] [<**Number**> **units per Section 1107.7.5**].

> Retain paragraph below and provide locations for Type B units if all remaining units are not required to be Type B units per one of the options in the paragraph above.

Type B Unit Locations: <**Unit Numbers**>

Group R-3: Section 1107.6.3.

Total number of [**Dwelling Units**] [**and**] [**Sleeping Units**]: <**Number**> units

Type B Units Required: [**All units**] [<**Number**> **units per Section 1107.7.1**] [<**Number**> **units per Section 1107.7.2**] [<**Number**> **units per Section 1107.7.3**] [<**Number**> **units per Section 1107.7.4**] [<**Number**> **units per Section 1107.7.5**].

> Retain paragraph below and provide locations for Type B units if all units are not required to be Type B units per one of the options in the paragraph above.

Type B Unit Locations: <**Unit Numbers**>

Group R-4, Condition [**1**] [**2**]: Section 1107.6.4.

Total number of [**Dwelling Units**] [**and**] [**Sleeping Units**]: <**Number**> units

Accessible Units Required: [**1 unit**] [**2 units**]

Accessible Unit Locations: <**Unit Numbers**>

Type B Units Required: [**All remaining units**] **[**<**Number**> **units per Section 1107.7.1**] **[**<**Number**> **units per Section 1107.7.2**] [<**Number**> **units per Section 1107.7.3**] [<**Number**> **units per Section 1107.7.4**] **[**<**Number**> **units per Section 1107.7.5**].

> Retain paragraph below and provide locations for Type B units if all remaining units are not required to be Type B units per one of the options in the paragraph above.

Type B Unit Locations: <**Unit Numbers**>

Accessible Assembly Seating:

General Seating: Section 1108.2.2.1.

Number of Fixed Seats: <**Number**> seats

Required Wheelchair Spaces: <**Number**> spaces per Table 1108.2.2.1

[**Luxury Boxes**] [**Club Boxes**] [**and**] [**Suites**]: Section 1108.2.2.2.

> Copy and paste paragraph and subparagraphs below for each box or suite.

<**Box/Suite Location**>:

Number of Fixed Seats: <**Number**> seats

Required Wheelchair Spaces: <**Number**> spaces per Table 1108.2.2.1

Other Boxes: Section 1108.2.2.3.

Number of Boxes: <**Number**> boxes

Number of Boxes Required to have Wheelchair Spaces: 0.20 × <**Number**> boxes = <**Number**> boxes ≤ <**Number**> boxes provided with wheelchair spaces

Number of Fixed Seats: <**Number**> seats

Required Wheelchair Spaces: <**Number**> spaces per Table 1108.2.2.1

Designated Aisle Seats: Section 1108.2.5.

Number of Aisle Seats: <**Number**> seats

Required Designated Seats: 0.05 × <**Number**> aisle seats = <**Number**> seats ≤ <**Number**> designated aisle seats provided

C

Code Data Information for Example Project

GENERAL CODE INFORMATION

BUILDING: PRIVATIZED STUDENT HOUSING

Adopted Codes:

2015 International Building Code
2015 International Fire Code
2015 International Mechanical Code
2015 International Energy Conservation Code
2015 International Plumbing Code
2015 International Fuel Gas Code
2014 National Electrical Code (NFPA 70)
Type of Construction: VA

Fire Sprinklered Throughout: Yes, NFPA 13R-2013 per Section 903.3.1.2

Basement: 1 Level

Hazardous Materials: None

Flood Hazard Area: No

Climate Zone: 4A

Occupancy Classifications: Combination of separated and nonseparated occupancies. Nonseparated throughout first story and separation provided between first and second stories and between basement and first story. Basement Storage Room (614 sq. ft.) is considered accessory to Parking Garage (614 sq. ft./17,473 sq. ft. = 0.035 = 3.5% < 10%; therefore, okay). Trash (281 sq. ft.) and Mechanical Rooms (1,022 sq. ft.) are considered incidental to the residential use ([281 sq. ft. + 1,022 sq. ft.]/14,793 sq. ft. = 0.088 = 8.8% < 10%; therefore, okay).

Applying the Building Code: Step-by-Step Guidance for Design and Building Professionals. Ronald L. Geren, FCSI, AIA

Group A-2: Dining Hall and Kitchen
Group B: Management Office; Study Rooms (2); Exercise Room; Lounge
Group M: Convenience Shop
Group R-2: Apartments, including Manager's Apartment; Trash Room (Incidental Use); Mechanical Room (Incidental Use)
Group S-1: Mail Room; Basement Storage Room (Accessory Occupancy)
Group S-2: Parking Garage; Elevator Equipment Room

HEIGHT AND AREA

Actual Floor Areas:

Basement:	17,473 sq. ft.
1st Story:	14,793 sq. ft.
2nd Story:	14,793 sq. ft.
3rd Story:	14,793 sq. ft.
4th Story:	14,793 sq. ft.
Total	76,645 sq. ft.

Tabular Building Height:

Grade Plane Elevation:

EL01:	909.6 ft.
EL02:	909.4 ft.
EL03:	909.2 ft.
EL04:	909.5 ft.
Average:	909.425 ft.

Allowable Height in Stories: Using sprinklered ("S13R") condition where applicable and nonsprinklered ("NS") for all others per Table 504.4.

Group A-2:	2 stories
Group B:	3 stories
Group M:	3 stories
Group R-2:	4 stories
Group S-1:	3 stories
Group S-2:	4 stories

Allowable Height in Feet: 60 feet using sprinklered ("S13R") condition where applicable (Group R) and 50 feet using nonsprinklered ("NS") for all others per Table 504.3.

Actual Height:

Height in Feet: 46 feet 7 inches (Measured from grade plane) ≤ 60 ft. (Group R) and 50 ft. (All other occupancy groups), therefore, okay

Height in Stories:

Group A-2:	1st story ≤ 2 stories, therefore, okay
Group B:	1st story ≤ 3 stories, therefore, okay
Group M:	1st story ≤ 3 stories, therefore, okay
Group R-2:	4th story ≤ 4 stories, therefore, okay
Group S-1:	1st story ≤ 3 stories, therefore, okay
Group S-2:	Basement ≤ 4 stories, therefore, okay

Tabular Allowable Floor Area (A_t): Using nonsprinklered ("NS") and sprinklered ("S13R") conditions per Table 506.2.

Group A-2:	NS:	11,500 sq. ft. ← Most Restrictive for use at first story
Group B:	NS:	18,000 sq. ft.
Group M:	NS:	14,000 sq. ft.
Group R-2:	NS:	12,000 sq. ft.
	S13R:	12,000 sq. ft.
Group S-1:	NS:	14,000 sq. ft.
Group S-2:	NS:	21,000 sq. ft.

Allowable Area Increases: Allowable Area (A_a) per Story Calculation per Section 506.1:

Frontage Increase (I_f): Section 506.3, Equation 5-5

$I_f = [F/P - 0.25]W/30$

$F = 833$ ft.

$P = 833$ ft.

$W = 29.25$ ft., see Weighted Average W calculation below

$I_f = [833 \text{ ft.}/833 \text{ ft.} - 0.25]29.25 \text{ ft.}/30$

$I_f = 0.73$

Weighted Average W: Equation 5-4.

$W = (L_1 \times w_1 + L_2 \times w_2 + L_3 \times w_3 \ldots)/F$

P1:	$L_1 = 81.33$ ft.
	$W_1 = 22.33$ ft.
P2 (Unmarked):	$L_1 = 751.67$ ft.
	$W_1 = 30$ ft.

$W = (81.33 \text{ ft.} \times 22.33 \text{ ft.} + 751.67 \text{ ft.} \times 30 \text{ ft.})/833 \text{ ft.}$

$W = 29.25$ ft.

Allowable Single-Story Area Calculation: Section 506.2.4.

Equation 5-3: $A_a = [A_t + (NS \times I_f)]$

$A_t =$ See each occupancy group below for tabular floor area.
$NS =$ See each occupancy group below for tabular floor area.
$I_f =$ 0.73

Sum of Ratios for Mixed Occupancy:

Group A-2: Most restrictive on first story.

$A_t = 11,500$ sq. ft.

$A_a = [11,500 \text{ sq. ft.} + (11,500 \text{ sq. ft.} \times 0.73)]$

$A_a = 19,895$ sq. ft.

Group R-2:

$A_t = 12,000$ sq. ft.

$A_a = [12,000$ sq. ft. $+ (12,000$ sq. ft. $\times 0.73)]$

$A_a = 20,760$ sq. ft.

Group S-2:

$A_t = 21,000$ sq. ft.

$A_a = [21,000$ sq. ft. $+ (21,000$ sq. ft. $\times 0.73)]$

$A_a = 36,330$ sq. ft.

Basement:

Group S-2: 17,473 sq. ft./36,330 sq. ft. $= 0.48 \leq 1$, therefore, okay

1st Story:

Group A-2: 14,793 sq. ft./19,895 sq. ft. $= 0.74 \leq 1$, therefore, okay

2nd Story:

Group R-2: 14,793 sq. ft./20,760 sq. ft. $= 0.71 \leq 1$, therefore, okay

3rd Story:

Group R-2: 14,793 sq. ft./20,760 sq. ft. $= 0.71 \leq 1$, therefore, okay

4th Story:

Group R-2: 14,793 sq. ft./20,760 sq. ft. $= 0.71 \leq 1$, therefore, okay

Allowable Building Area Calculation: Section 506.2.4.

Total Building Area for Mixed-Occupancy, Multistory Buildings: Sum of ratios for each floor must be less than or equal to 4 per Exception to Section 506.2.4.

1st Story:	0.74
2nd Story:	0.71
3rd Story:	0.71
4th Story:	0.71
	2.87 $\leq$ 4, therefore, okay

FIRE RESISTANCE

Fire-Resistance Rating Requirements for Building Elements: Table 601, based on Type VA (Combustible):

Structural Frame: 1-hour minimum construction (2 hours minimum as noted where supporting 2-hour horizontal assemblies).

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
B-C1 (Column)	IBC Item # 5-1.1 [Table 721.1(1)]	2 hours	AE004	Supporting 2-hour horizontal assembly for occupancy separation
B-B1 (Beam)	IBC Item # 5-1.1 [Table 721.1(1)]	2 hours	AE004	Supporting 2-hour horizontal assembly for occupancy separation
1-C1 (Column)	UL Design No. X739	2 hours	AE004	Supporting 2-hour horizontal assembly for occupancy separation

Bearing Walls:

Exterior: 1-hour minimum construction (2 hours as noted where supporting 2-hour horizontal assemblies). All exterior walls have a fire separation distance greater than 10 feet; therefore, rating is for fire exposure from the inside only per IBC Section 705.5.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
Wall Type A	UL Design No. U349	2 hours	AE004	Supporting 2-hour horizontal assembly for occupancy separation. With metal panels per assembly item 6F.
Wall Type B	UL Design No. U348	1 hour	AE004	With metal panels per assembly item 6F.
Wall Type C	UL Design No. U356	1 hour	AE004	With exterior insulation and finish system (EIFS) per assembly item 6F.

Interior: 1-hour minimum construction (2 hours as noted where supporting 2-hour horizontal assemblies).

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
Wall Type D	GA File No. WP 4135	2 hours	AE004	Supporting 2-hour horizontal assembly for occupancy separation.
Wall Type E	GA File No. WP 3910	2 hours	AE004	Supporting 2-hour horizontal assembly for occupancy separation. Minimum STC 50 for dwelling unit separation.
Wall Type F	GA File No. WP 3644	1 hour	AE004	Used throughout unless noted otherwise.
Wall Type G	GA File No. WP 3243	1 hour	AE004	Minimum STC 50 for dwelling unit separation.

Interior Nonbearing Walls: 1-hour minimum construction, except as required per other requirements

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
Wall Type F	GA File No. WP 3644	1 hour	AE004	Used throughout unless noted otherwise.
Wall Type G	GA File No. WP 3243	1 hour	AE004	Minimum STC 50 for dwelling unit separation.

Floor Construction: 1-hour minimum horizontal assembly (see "Occupancy Separations" for 2-hour horizontal assembly)

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
Floor Type A	GA File No. FC 5111	1 hour	AE004	Minimum STC 50 for dwelling unit separation. IIC of 68 with carpet and pad.

Roof Construction: 1-hour minimum horizontal assembly

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
Roof Type A	IBC Item # 26-1.1 [Table 721.1(3)]	1 hour	AE004	For sprayed polyurethane foam roofing (Class A) installed above roof deck.
Roof Type B	IBC Item # 30-1.1 [Table 721.1(3)]	1 hour	AE004	For metal roofing over rigid polyisocyanurate insulation installed above deck and fiberglass blanket insulation installed between joists.

Fire-Resistance Rating Requirements for Exterior Walls Based on Fire Separation Distance: Table 602.

Groups A-2, B, M, R-2, S-1, and S-2:

North Walls at East and West Wings:

Fire Separation Distance: 23.67 feet

Fire Rating: 1 hour minimum; rating is for fire exposure from the inside only per IBC Section 705.5. See Exterior Bearing Walls under "Fire-Resistance Rating Requirements for Building Elements" heading for assemblies.

West Wall at West Wing:

Fire Separation Distance: 22.33 feet

Fire Rating: 1 hour minimum; rating is for fire exposure from the inside only per IBC Section 705.5. See Exterior Bearing Walls under "Fire-Resistance Rating Requirements for Building Elements" heading for assemblies.

Shafts and Interior Exit Stairways and Ramps: 2-hour minimum fire barriers (penetrating four stories or more).

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
Wall Type H	UL Design No. U415, U417, or W419	2 hours	AE004	For stairways. Use System E with UL No. 415, System B with UL No. U417, and System C with UL No. W419.
Wall Type J	UL Design No. U415, U417, or W419	2 hours	AE004	For elevator hoistway. Use System B with UL No. 415, System C with UL No. U417, and System B with UL No. W419.

Occupancy Separations: Fire barriers or horizontal assemblies with fire-resistance ratings per Table 508.4.

Member	Assembly Designation	Minimum Fire-Resistance Rating	Drawing Location	Remarks
Floor Type B	Assembly G per ESR-1153	2 hours	AE004	Minimum STC 50 for dwelling unit separation. IIC of 64 with carpet and pad.
Floor Type C	IBC Item # 2-1.1 [Table 721.1(3)]	2 hours	AE004	Minimum STC 50 for dwelling unit separation. Supporting 2-hour construction on 1st story.

Incidental Uses: Use sprinkler system protection in lieu of separation per Table 509. Provide smoke partition to control passage of smoke as required by Section 509.4.2. The following spaces are considered incidental uses:
Mechanical Room (1st Story)

Corridors: 0.5-hour minimum fire partitions per Table 1020.1.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
Wall Type G	GA File No. WP 3243	1 hour	AE004	Minimum STC 50 for dwelling unit separation.

Dwelling Unit Separations: Fire resistance per Section 420. Sound transmission per Section 1207. Walls: 1-hour minimum fire partitions. Minimum STC of 50.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
Wall Type G	GA File No. WP 3243	1 hour	AE004	Minimum STC 50 for dwelling unit separation.

Floor/Ceilings: 1-hour minimum horizontal assemblies. Minimum STC of 50 and IIC of 50.

Member	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
Floor Type A	GA File No. FC 5111	1 hour	AE004	Minimum STC 50 for dwelling unit separation. IIC of 68 with carpet and pad.
Floor Type B	Assembly G per ESR-1153	2 hours	AE004	Minimum STC 50 for dwelling unit separation. IIC of 64 with carpet and pad.
Floor Type C	UL 577	2 hours	AE004	Exposed exterior floor/celling with R-30 insulation

Special Fire-Resistance-Rated Applications: For Assembly Type: FB = Fire Barrier; FP = Fire Partition; SB = Smoke Barrier

Member	Special Application	Assembly Type	Assembly Designation	Fire-Resistance Rating	Drawing Location	Remarks
Wall Type K	Chute Discharge per Section 713.13.4	FB	GA File No. WP 4136	2 hours	AE004	For Trash Room
Wall Type F	Chute Access per Section 713.13.3	FB	GA File No. WP 3644	1 hour	AE004	For Trash Chute Access Room on Stories 2, 3, and 4

Exterior Wall Opening Protection: Table 705.8.

1st Story:

North Elevation, West Wing:

Fire Separation Distance:	23.67 feet
Percentage Permitted (Unprotected):	45%
Exterior Wall Area:	352.8 sq. ft.
Allowable Area (a_u) (% Unprotected × Ext. Wall Area):	158.8 sq. ft.
Actual Area (A_u) (Unprotected):	21 sq. ft. is less than or equal to 158.8 sq. ft., therefore, okay

North Elevation, East Wing:

Fire Separation Distance:	23.67 feet
Percentage Permitted (Unprotected):	45%
Exterior Wall Area:	352.8 sq. ft.
Allowable Area (a_u) (% Unprotected × Ext. Wall Area):	158.8 sq. ft.
Actual Area (A_u) (Unprotected):	69 sq. ft. is less than or equal to 158.8 sq. ft., therefore, okay

West Elevation, West Wing:

Fire Separation Distance:	22.33 feet at closest point and 24.33 feet at furthest point
Percentage Permitted (Unprotected):	45%
Exterior Wall Area:	976.8 sq. ft.
Allowable Area (a_u) (% Unprotected × Ext. Wall Area):	439.6 sq. ft.
Actual Area (A_u) (Unprotected):	21 sq. ft. is less than or equal to 439.6 sq. ft., therefore, okay

2nd, 3rd, and 4th Stories (Each):

North Elevation, West and East Wings (Each):

Fire Separation Distance:	23.67 feet
Percentage Permitted (Unprotected):	45%
Exterior Wall Area:	583.3 sq. ft.
Allowable Area (a_u) (% Unprotected × Ext. Wall Area):	262.5 sq. ft.
Actual Area (A_u) (Unprotected):	76.5 sq. ft. is less than or equal to 262.5 sq. ft., therefore, okay

West Elevation, West Wing:

Fire Separation Distance:	22.33 feet at closest point and 24.33 feet at furthest point
Percentage Permitted (Unprotected):	45%
Exterior Wall Area:	813.3 sq. ft.
Allowable Area (a_u) (% Unprotected × Ext. Wall Area):	366 sq. ft.
Actual Area (A_u) (Unprotected):	180 sq. ft. is less than or equal to 366 sq. ft., therefore, okay

Interior Wall Opening Protection:

Fire Doors: Table 716.5.

Door	Assembly		Door Rating	Glazing Type	Glazing Label	Remarks
	Type	Rating				
Dwelling Unit Entrances	Fire Partition	1 hour	1/3 hour	Vision Panel	None	
				Transom/Sidelight	None	
Stairway Entrances	Fire Barrier	2 hours	1 1/2 hours	Vision Panel	D-H-90	
				Transom/Sidelight	None	
Trash Chute Access Rm.	Fire Barrier	1 hour	3/4 hour	Vision Panel	D-H-45	
				Transom/Sidelight	None	
Trash Room	Fire Barrier	1 hour	3/4 hour	Vision Panel	None	
				Transom/Sidelight	None	

MEANS OF EGRESS

Detailed Means of Egress:

Basement Occupant Load and Egress Data by Space

Room No.	Floor Area (sq. ft.)[a]	Use[b]	Area per Occupant (sq. ft.)[a]	No. of Occupants	Add'l Occupants	Total Occupants[c]	Exits Required[d]	Exits Provided	Common Path of Travel[e] (ft.)	Travel Distance[f] (ft.)	Remarks
B01	17,177	7	200	85	3	88	2	2	0≤100	142≤400	Parking
B02	88	1	300	1	0	1	1	1	18≤100	158≤400	Elevator Equip.
B03	614	1	300	2	0	2	1	1	51≤100	51≤250	Storage

First-Story Occupant Load and Egress Data by Space

Room No.	Floor Area (sq. ft.)[a]	Use[b]	Area per Occupant (sq. ft.)[a]	No. of Occupants	Add'l Occupants	Total Occupants[c]	Exit/Exit Access Required[d]	Exit/Exit Access Provided	Common Path of Travel[e] (ft.)	Travel Distance[f] (ft.)	Remarks
100	521	2	15 net	34	6	40	1	2	0≤125	21≤300	Lobby
101	682	3	100	6	0	6	1	1	49≤100	80≤300	Management Office
102	511	4	50	10	0	10	1	1	42≤100	80≤300	Exercise Room
103	1,115	8	200	5	0	5	1	1	53≤125	53≤250	Manager's Apartment
104	1,022	1	300	3	1	4	1	3	0≤125	34≤250	Mechanical Room
105	281	1	300	1	0	1	1	1	28≤125	35≤250	Trash Room
106	370	2	15 net	24	0	24	1	1	35≤100	49≤300	Study Room
107	339	2	15 net	23	0	23	1	1	35≤100	53≤300	Study Room
108	194	1	300	1	0	1	1	1	24≤100	55≤250	Mail Room
109	698	2	15 net	46	0	46	1	2	0≤75	28≤250	Lounge
110	192	3	100	1	0	1	1	1	31≤100	58≤300	Men
111	229	3	100	2	0	2	1	1	33≤100	51≤300	Women
112	1,023	6	60	17	0	17	1	2	0≤75	54≤250	Convenience Shop
113	3,333	2	15 net	222	0	222	2	4	0≤75	56≤250	Dining Hall
114	1,029	8	200	5	0	5	1	2	0≤75	46≤250	Kitchen
Circ	1,632	8	200	8	66	74	2	2	N/A	N/A	Corridors & Stairways

(*continued overleaf*)

Second-, Third-, and Fourth-Story Occupant Load and Egress Data by Space

Room No.	Floor Area (sq. ft.)[a]	Use[b]	Area per Occupant (sq. ft.)[a]	No. of Occupants	Add'l Occupants	Total Occupants[c]	Exits Required[d]	Exits Provided	Common Path of Travel[e] (ft.)	Travel Distance[f] (ft.)	Remarks
X01	765	8	200	3	0	3	1	1	$41 \le 125$	$165 \le 250$	2-Bedroom, 2-Bath
X02	765	8	200	3	0	3	1	1	$41 \le 125$	$165 \le 250$	2-Bedroom, 2-Bath
X03	765	8	200	3	0	3	1	1	$41 \le 125$	$127 \le 250$	2-Bedroom, 2-Bath
X04	765	8	200	3	0	3	1	1	$41 \le 125$	$127 \le 250$	2-Bedroom, 2-Bath
X05	765	8	200	3	0	3	1	1	$41 \le 125$	$104 \le 250$	2-Bedroom, 2-Bath
X06	765	8	200	3	0	3	1	1	$41 \le 125$	$104 \le 250$	2-Bedroom, 2-Bath
X07	748	8	200	3	0	3	1	1	$48 \le 125$	$98 \le 250$	2-Bedroom, 2-Bath
X08	748	8	200	3	0	3	1	1	$48 \le 125$	$98 \le 250$	2-Bedroom, 2-Bath
X09	975	8	200	4	0	4	1	1	$50 \le 125$	$84 \le 250$	3-Bedroom, 3-Bath
X10	975	8	200	4	0	4	1	1	$50 \le 125$	$84 \le 250$	3-Bedroom, 3-Bath
X11	1,174	8	200	5	0	5	1	1	$51 \le 125$	$78 \le 250$	4-Bedroom, 3-Bath
X12	1,229	8	200	6	0	6	1	1	$51 \le 125$	$78 \le 250$	4-Bedroom, 4-Bath
X13	956	8	200	4	0	4	1	1	$60 \le 125$	$199 \le 250$	3-Bedroom, 3-Bath
X14	956	8	200	4	0	4	1	1	$60 \le 125$	$199 \le 250$	3-Bedroom, 3-Bath
X15	84	8	200	1	0	1	1	1	$8 \le 125$	$11 \le 250$	Trash Access Room
Circ	2,358	8	200	11	52	63 (73)[g]	2	2	N/A	N/A	Corridor & Stairways

[a] All areas are gross unless indicated otherwise.

[b] Use number from list below (Ref. Table 1004.1.2):

1. Accessory Storage Areas, Mechanical Equipment Areas
2. Assembly without Fixed Seats, Unconcentrated
3. Business Areas
4. Exercise Rooms
5. Kitchens, Commercial
6. Mercantile
7. Parking Garages
8. Residential

[c] See "Egress Width" table.

[d] Where two or more exit or exit access doors are required, see "Separation of Exit/Exit Access" table.

[e] Maximum distance for common path of egress travel is per the sprinklered values in Table 1006.2.1: 75 ft. for Groups A and M; 100 ft. for Group B and S; 125 ft. for Group R-2.

[f] Maximum travel distance is per the sprinklered values in Table 1017.2: 250 ft. for Groups A, M, R, and S-1; 300 ft. for Group B; 400 ft. for Group S-2.

[g] Occupant load in parentheses is based on gross floor area of the story and not rounded loads for each space.

Separation of Exit/Exit Access Points			
Room/Space/Story	**Overall Diagonal Measurement (ft.)**	**Exit Separation Distance (ft.)**	**Greater than 1/3 Over All Diagonal?**
113—Dining Hall	87	67	Yes
Basement	252	195	Yes
1st Story	173	129	Yes
2nd Story	252	185	Yes
3rd Story	252	185	Yes
4th Story	252	185	Yes

Egress Width				
Room/Space/Story	**Number of Occupants**	**Egress Width per Occupant (inches) (Section 1005.3)**	**Required Width (inches)**	**Provided Width (inches)**
Dining Hall	222	0.15 (Door)	33.3	99
		0.15 (Other[a])	33.3	99
		0.2 (Stair)	N/A	N/A
All Other Spaces and Stories	≤213	0.15 (Door)	32	33 min.
		0.15 (Other[a])	44	48 min.
		0.2 (Stair)	44	44

[a]Includes corridors, exit passageways, and ramps.

Dead-End Corridors: 19 ft. maximum ≤ 20 ft. per Section 1018.4
Location: Corridor toward Dining Hall by Convenience Shop (Only when overhead grille is closed).

Emergency Escape and Rescue Openings: Section 1030. Not required, since each story is provided with two exits.

PLUMBING FIXTURES

Calculations:

Water Closets—Based on Occupant Load					
Occupancy Group		**Number of Occupants**	**Ratio (IBC Table 2902.1)**	**Raw Fixture Count (Not Rounded)**	
				Male	**Female**
Group A-2	Male	113.5	1/75	1.51	
	Female	113.5	1/75		1.51
Group B	Male	54.5	1/25 for 1st 50; 1/50 for remainder	2.09	
	Female	54.5	1/25 for 1st 50; 1/50 for remainder		2.09
Group M	Male	8.5	1/500	0.02	
	Female	8.5	1/500		0.02
Group S-1	Male	2.5	1/100	0.03	
	Female	2.5	1/100		0.03
			Raw Totals	3.65	3.65
			Rounded Totals	4	4

Unassigned Water Closets—Based on Dwelling Units

Occupancy Group	Number	Ratio (IBC Table 2902.1)	Raw Fixture Count
R-2 Apartments	43 Dwelling Units	1 per Dwelling Unit	43

Total Number of Water Closets Required:

Male:	4
Female:	4
Unassigned:	43

Lavatories—Based on Occupant Load

Occupancy Group	Number of Occupants		Ratio (IBC Table 2902.1)	Raw Fixture Count (Not Rounded)	
				Male	Female
Group A-2	Male	113.5	1/200	0.57	
	Female	113.5	1/200		0.57
Group B	Male	54.5	1/40 for 1st 80; 1/80 for remainder	1.36	
	Female	54.5	1/40 for 1st 80; 1/80 for remainder		1.36
Group M	Male	8.5	1/750	0.01	
	Female	8.5	1/750		0.01
Group S-1	Male	2.5	1/100	0.03	
	Female	2.5	1/100		0.03
			Raw Totals	1.97	1.97
			Rounded Totals	2	2

Unassigned Lavatories—Based on Dwelling Units

Occupancy Group	Number	Ratio (IBC Table 2902.1)	Raw Fixture Count
R-2 Apartments	43 Dwelling Units	1 per Dwelling Unit	43

Total Number of Lavatories Required:

Male:	2
Female:	2
Unassigned:	43

Drinking Fountains

Occupancy Group	Number of Occupants	Ratio (IBC Table 2902.1)	Raw Fixture Count (Not Rounded)
Group A-2	227	500	0.45
Group B	109	100	1.09
Group M	17	1,000	0.02
Group S-1	5	1,000	0.01
		Raw Total	1.57
		Rounded Total	2

Total Number of Drinking Fountains Required: 2

Bathtubs/Showers

Occupancy Group	Number	Ratio (IBC Table 2902.1)	Fixture Count
R-2 Apartments	43 Dwelling Units	1 per Dwelling Unit	43

Total Number of Bathtubs/Showers Required: 43

Clothes Washer Connections

Occupancy Group	Number	Ratio (IBC Table 2902.1)	Raw Fixture Count
R-2 Apartments	43 Dwelling Units	1 per 20 Apartments	2.15
		Raw Total	2.15
		Rounded Total	3

Total Number of Bathtubs/Showers Required: 3

Kitchen Sinks: One sink per dwelling unit.

Service Sinks: Each area to have access to one service sink.

Family or Assisted-Use Toilet Facilities: Section 1109.2.1.

Number of Required Water Closets for Assembly and Mercantile Occupancies: 4 water closets < 6; therefore, a family or assisted-use toilet facility is not required.

Compliance:

Plumbing Fixtures in Restrooms

Restroom Room No.	Story	Longest Path of Travel (ft.)	Water Closets						Lavatories	
			Required	Provided	Urinal Substitutions		Quantity Accessible	Quantity Ambulatory	Required	Provided
					Provided	% of Required				
110—Men	1st	202	4	4	2	50%	1	0	2	2
111—Women		212	4	4	N/A	N/A	1	0	2	2

Plumbing Fixtures in Dwelling Units

Room Description	Water Closets		Lavatories		Bathtubs/Showers		Kitchen Sinks	
	Required	Provided	Required	Provided	Required	Provided	Required	Provided
2-Bed/2-Bath	1	2	1	2	1	2	1	1
3-Bed/3-Bath	1	3	1	3	1	3	1	1
4-Bed/3-Bath	1	3	1	3	1	3	1	1
4-Bed/4-Bath	1	4	1	4	1	4	1	1

Clothes Washer Connections	
Required	**Provided**
3	43
Location	**Quantity**
Each Dwelling Unit	1

Drinking Fountains			
Required		**Provided**	
2		2	
Location	**Quantity**	**Story**	**Longest Path of Travel (ft.)**
Corridor by Elevators	2	1st Story	187

Service Sinks: 1 located in Mechanical Room.

FIRE PROTECTION SYSTEMS

Hazard Classifications:

Light (Low) Hazard Occupancies: Management Office, Lobby, Lounge, Exercise Room, Study Rooms, Dining Hall, and Apartments

Ordinary (Moderate) Hazard Occupancies: Parking Garage, Convenience Shop, Kitchen, Mail Room, Mechanical Room, Trash Room, and Storage

Extra (High) Hazard Occupancies: Not Applicable

Fire Extinguishers:

Class A Fire Hazard

Area Covered	Floor Area (sq. ft.)	Hazard Classification	Floor Area per Unit of A (sq. ft.)	Unit of A Required	Extinguishers Provided			
					Quantity	Extinguisher Rating	Total Unit of A Provided	Max. Actual Travel Distance (ft.)
Parking Garage	17,473	Ordinary (Moderate)	1,500	11.6	8	2-A	16	50
1st Story	9,816	Light (Low)	3,000	3.3	6	2-A	12	75
1st Story	3,355	Ordinary (Moderate)	1,500	2.2				
2nd, 3rd, and 4th Stories (Each)	14,793	Light (Low)	3,000	4.9	3	2-A	6	75

Class B Fire Hazard					
Area Covered	**Hazard Classification**	**Minimum Extinguisher**		**Provided Extinguisher**	
		Rating	**Max. Travel Distance (ft.)**	**Rating**	**Max. Actual Travel Distance (ft.)**
Parking Garage	Ordinary (Moderate)	20-B	50	20-B	50
Mechanical Room & Trash Room	Ordinary (Moderate)	20-B	50	20-B	50

Class K Fire Hazard (IFC Section 904.12.5)						
Area Covered	**Solid Fuel Cooking Appliances**		**Fryers (One 1.5 gal./Four Fryers)**			**Max. Actual Travel Distance (ft.)**
	Size	**Quantity**	**Number of Fryers**	**Qty. Extinguishers Required**	**Qty. Extinguishers Provided**	
Kitchen	1.5 gallons	3	4	1	3	26

Automatic Sprinkler System Design: See Sheet FX100
Fire Alarm and Detection System Design: See Sheet FA100

ACCESSIBILITY

Parking and Passenger Loading Facilities: Section 1106.2.

Total Number of Parking Spaces: 44 spaces
Number of Accessible Parking Spaces Required: 1 space $\leq$ 2 spaces provided
Van-Accessible Spaces Required: Section 1106.5. 2 accessible spaces provided $\times$ 1/6 = 0.33, rounded up to 1 van-accessible space $\leq$ 1 space provided.

Dwelling Units:

Group R-2, Apartment Houses: Section 1107.6.2.2.
Total Number of Dwelling Units: 43 units
Type A Units Required: 0.02 $\times$ 43 Total Number of Units = 0.86 = 1 unit
Number of Type A Units Provided: 1 unit.
Type A Unit Locations: Room 210 (3-Bed/3-Bath)
Type B Units Required: All remaining units.

References

The following codes and reference standards are mentioned within this book. Not all reference standards listed are used by the *International Codes®*.

Codes

2015 International Building Code® (IBC), International Code Council, Inc.
2015 International Energy Conservation Code® (IECC), International Code Council, Inc.
2015 International Existing Building Code® (IEBC), International Code Council, Inc.
2015 International Fire Code® (IFC), International Code Council, Inc.
2015 International Mechanical Code® (IMC), International Code Council, Inc.
2015 International Plumbing Code® (IPC), International Code Council, Inc.
2015 International Residential Code® (IRC), International Code Council, Inc.
NFPA 70, *National Electrical Code®* (NEC), National Fire Protection Association.
NFPA 85, *Boiler and Combustion Systems Hazards Code*, National Fire Protection Association.
NFPA 99, *Health Care Facilities Code*, National Fire Protection Association.
NFPA 101, *Life Safety Code®*, National Fire Protection Association.

Reference Standards

American Association of State Highway and Transportation Officials (AASHTO); www.transportation.org
AASHTO HB-17, *Standard Specifications for Highway Bridges*.
American National Standards Institute (ANSI); www.ansi.org
ANSI Z97.1, *Safety Glazing Materials Used in Buildings—Safety Performance Specifications and Methods of Test*.
American Society of Civil Engineers (ASCE); www.asce.org
ASCE 7, *Minimum Design Loads for Buildings and Other Structures*.
ASCE 24, *Flood Resistant Design and Construction*.

American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE); www.ashrae.org

ASHRAE/IESNA/ANSI 90.1, *Energy Standard for Buildings Except Low-rise Residential Buildings*.

American Society of Mechanical Engineers (ASME); www.asme.org

ASME/ANSI A17.1, *Safety Code for Elevators and Escalators*.

AMSE/ANSI A18.1, *Safety Standard for Platform Lifts and Stairway Chairlifts*.

ASME/ANSI B20.1, *Safety Standard for Conveyors and Related Equipment*.

American Society of Safety Engineers' (ASSE); www.asse.org

ASSE/ANSI Z 359.1, *Safety Requirements for Personal Fall Arrest Systems, Subsystems and Components*.

American Wood Council (AWC); www.awc.org

AWC/ANSI PWF, *Permanent Wood Foundation Design Specification*.

AWC WFCM, *Wood Frame Construction Manual for One- and Two-Family Dwellings*.

ASTM International (ASTM); www.astm.org

ASTM C 754, *Standard Specification for Installation of Steel Framing Members to Receive Screw-Attached Gypsum Panel Products*.

ASTM C 842, *Specification for Application of Interior Gypsum Plaster*.

ASTM C 926, *Standard Specification for Application of Portland Cement-Based Plaster*.

ASTM C 1048, *Standard Specification for Heat-Strengthened and Fully Tempered Flat Glass*.

ASTM C 1396, *Standard Specification for Gypsum Board*.

ASTM D 226, *Standard Specification for Asphalt-Saturated Organic Felt Used in Roofing and Waterproofing*.

ASTM D 2859, *Standard Test Method for Ignition Characteristics of Finished Textile Floor Covering Materials*.

ASTM D 2898, *Test Methods for Accelerated Weathering of Fire-retardant-treated Wood for Fire Testing*.

ASTM E 84, *Test Methods for Surface Burning Characteristics of Building Materials*.

ASTM E 90, *Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements*.

ASTM E 108, *Test Methods for Fire Tests of Roof Coverings*.

ASTM E 119, *Standard Test Methods for Fire Tests of Building Construction and Materials*.

ASTM E 136, *Test Method for Behavior of Materials in a Vertical Tube Furnace at 750° F*.

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ASTM E 492, *Standard Test Method for Laboratory Measurement of Impact Sound Transmission Through Floor-Ceiling Assemblies Using the Tapping Machine*.

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