Chapter 1

Types of Building Construction

Revised by
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Chapter Contents

Key Terms

building construction (types of), combustible construction, construction (Type I), construction (Type II), construction (Type III), construction (Type IV), construction (Type V), fire-resistive construction, floor framing system, heavy timber construction, noncombustible construction, ordinary construction, roof, structural element, truss, wood frame construction

A well-established means of codifying the performance of a building's structural elements during a fire is to classify them by types of construction, based on the materials used for the structural elements and the degree of fire resistance afforded by each element.

In early codes, only two classifications of construction were identified: fireproof and nonfireproof. The term *fireproof* was replaced by the term *fire resistive,* because it was recognized that no material or building is totally fireproof and that the building contents can produce a significant fire without involving the structure. It is possible, however, to design buildings that will resist a fire without suffering serious structural damage. Appropriate fire-resistive design, balanced against anticipated fire severity, is the objective of structural fire protection requirements in modern codes.

Several distinct types of construction that use combustible framing were originally classified based on the materials—masonry or wood—used in the exterior wall construction and the type and size of the framing members (i.e., heavy timber versus conventional framing). As fire resistance ratings for construction assemblies were recognized in building codes, subclassifications of building types were added for both noncombustible and combustible types of construction, based on the degree of fire resistance provided.

Code regulations governing the size, area, and height of buildings and their allowable uses are usually predicated on the relative fire load and other factors represented by the occupancy and the construction materials used in the building.

This chapter identifies the basic types of building construction in terms of their anticipated performance during a fire. These construction types are recognized in NFPA 220, *Standard on Types of Building Construction,* and in the model building codes. It also recognizes the current classification system of building construction equated with the traditional descriptive terms used to identify building types (e.g., *fire resistive, noncombustible, ordinary, frame,* etc.) that no longer are prime references to construction types. It also addresses fire protection of building elements; the value of exterior walls, interior walls, and partitions; floor framing systems; trusses; floor/ceiling assemblies; and roof framing and coverings.

For related topics, see the following: Section 1, Chapter 2, "Fundamentals of Structurally Safe Building Design"; Section 12, Chapter 1, "Planning for Public Fire-Rescue Protection"; Section 18, Chapter 1, "Confinement of Fire in Buildings"; Section 19, Chapter 2, "Structural Integrity During Fire"; and Section 19, Chapter 4, "Analyzing Structural Fire Damage."

CONSTRUCTION CLASSIFICATIONS

U.S. Classifications

The construction types currently identified by NFPA and the International Code Council (ICC) fall into ten subtypes in the NFPA system and nine subtypes in the ICC system. Subtypes are derived from

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five fundamental construction types, in almost every case: (1) fire resistive, (2) noncombustible, (3) ordinary (exterior protected), (4) heavy timber, and (5) wood frame. The previously published Standard Building Code (SBC) used six construction types. These descriptive names, while still referenced, no longer define the construction types as precisely as needed. The names are helpful, however, in tracing the development of building types.

ICC was formed by Building Officials and Code Administrators (BOCA), International Congress of Building Officials (ICBO), and Southern Building Code Congress International (SBCCI). The 2000 ICC International Building Code (IBC) was meant to succeed the building codes of these organizations. However, earlier editions of their building codes are still being adopted in some places—for example, California. Drawing on its experience with addressing structural fire protection, NFPA has also developed a building code as documented in NFPA 220 and NFPA *101*®, *Life Safety Code*®.

Classification Notation

To achieve better uniformity of building construction classifications, the Model Codes Standardization Council (MCSC) established a committee in 1972 to study the classifications and fire resistance requirements for the types of construction used in the model building codes and to develop recommendations for the model building code organizations.

As a result of the MCSC comparative study, its successor, the Board for the Coordination of the Model Codes (BCMC) proposed that the basic types of construction now recognized in the codes be continued but that they be reordered to some degree and be divided into two groups: (1) noncombustible and (2) combustible. It was also proposed that the identifying names for types of construction, such as *fireproof, ordinary, heavy timber,* and so on, be dropped because current design methods and architecture no longer follow the concepts in use when the named building types were established. The classifications proposed are shown in Table 19.1.1. These are the classifications recognized in NFPA 220 and *NFPA 5000*®, *Building Construction and Safety Code*®.

The MCSC also concluded that to rationally compare the various types of construction, a notational system was needed to identify the fire resistance required for three basic elements of the building. These elements are: (1) the exterior wall, (2) the primary structural frame, and (3) the floor construction. A three-digit notation was developed, as follows:

1. *First digit*. Hourly fire resistance requirement for exterior-bearing wall fronting on a street or lot line
2. *Second digit*. Hourly fire resistance requirement for structural frame or columns and girders supporting loads from more than one floor
3. *Third digit*. Hourly fire resistance requirement for floor construction

A comparison of types of construction, based on the MCSC notational system, as found in five building codes, is shown in Table 19.1.2.

For heavy timber construction, the notation *H* and not a digit was used for the structural frame and floor construction designations. Heavy timber construction is unique because it is identified by detailed requirements relating mainly to the size of structural members and their connections. Properties such as combustibility or fire resistance are not specifically included in the requirements for heavy timber construction, except that exterior walls are required to be of noncombustible construction.

Thus, for example, a "332" building would have 3 hour fire-resistant exterior bearing walls, a 3 hour fire-resistant structural frame, and 2 hour fire-resistant floor construction, and would correspond to the *NFPA 5000* Type I (332) building, the BOCA National Building Code Type 1B building, the ICBO Uniform Building Code Type I FR (fire resistive) building, the SBCCI Standard Building Code Type II building, and the ICC International Building Code Type 1A.

A standard nomenclature was also developed for identifying and defining the structural elements in buildings as they relate to fire resistance. For example, it was found in reviewing various codes and fire protection standards that floor construction was referred to by such terms as "floors," "floor assemblies," "floor and ceiling assemblies," and "floor deck construction." If codes agree, for example, that "floor construction" includes the floor deck and all structural elements directly supporting the loads from the floor, as recommended by MCSC, then some misinterpretation of a code's intent would be avoided.

TABLE 19.1.1 Model Codes Standardization Council Recommended Types of Construction

Noncombustible		
Type I (443) Type I (332)	Type II (222) Type II (111) Type II (000)	
Combustible		
Type III (211) Type III (200)	Type IV (2HH)	Type V (111) Type V (000)

TABLE 19.1.2 Comparison of Construction Types (Based on the MCSC National System)

NFPA 220	I (443)	I (332)	II (222)	II (111)	II (000)	III (211)	III (200)	IV (2HH)	V (111)	V (000)
UBC	—	I FR	II FR	II 1-hr	II N	III 1-hr	III N	IV HT	V 1-hr	V-N
BNBC	1A	1B	2A	2B	2C	3A	3B	4	5A	5B
SBC	I	II	—	IV 1-hr	IV unp	V 1-hr	V unp	III	VI 1-hr	VI unp
IBC	—	1A	1B	IIA	IIB	IIIA	IIIB	IVHT	VA	VB

International Perspective

With regard to building construction in Australia, Belgium, Canada, Denmark, Finland, France, Germany, Great Britain, Italy, Japan, Netherlands, New Zealand, Norway, Russia, Sweden, Switzerland, and the United States, time temperature curves used to conduct fire resistance tests for building materials are virtually identical for the first 2 hours. After that period of time, most countries use a slightly similar curve, except for Japan, which uses a less severe exposure after 2 hours. Some countries limit heat transmission as a requirement for fire doors. In most cases this is not a requirement in the United States, and when it is a requirement, it is for only the first 30 minutes of the test. Two other building construction-related differences are that fire departments tend to be more aggressive in the United States than they are in most European countries and that there are many more unsprinklered properties outside the United States than there are within the United States.

Construction type classification in building codes is more of a convenience than a necessity. The National Building Code of Canada (NBCC) does not classify buildings in the traditional manner as do United States codes but rather specifies fire-resistive requirements for the structural components of a building, depending on its occupancy and its story height and floor area. In this code, two basic types of construction (i.e., combustible and noncombustible) are recognized. These are further subdivided by the characteristics of the materials used in construction under fire conditions.

CLASSIFICATION OF BUILDING CONSTRUCTION TYPES

Following the completion of the MCSC recommendations in 1974, a number of changes were adopted to the requirements for types of construction to agree with the MCSC classifications. However, it was recognized that some conflicts still remained among building codes. In 1975, the BCMC established a committee to develop more detailed recommendations for types of construction.

In 1980 the committee's recommended definitions of types of construction and fire resistance requirements were finalized. The requirements are based on five basic types of construction. Two are identified as noncombustible construction (Types I and II) and three as combustible construction types (Types III, IV, and V). Table 19.1.3 gives the fire resistance requirements for the structural frame, interior bearing walls, floor construction, and roof construction of the five basic types of construction. The table lists the building components that are essential to the stability of the building as a whole and comprise the "structural frame." The members of floor or roof panels that have no connection to the columns are considered part of the floor or roof construction and are not classified as a part of the structural frame.

Some of the terminology used to describe and classify building construction types is presented as follows:

- *Fire resistance rating.* The time, in minutes or hours, that materials or assemblies have withstood a fire exposure as determined by tests, or methods based on tests, as prescribed by the applicable building code. Applicable test methods include NFPA 251, *Standard Methods of Tests of Fire Resistance of Building Construction and Materials,* ASTM E119, *Standard Test Methods for Fire Tests of Building Construction and Materials,* or UL 263, *Standard for Fire Tests of Building Construction and Materials.* Where other methods such as calculation procedures are used to determine fire resistance, the calculations are to be based on the fire exposure and acceptance criteria specified in standardized test procedures such as NFPA 251. Standardized calculation methods include ASCE/SFPE 29, *Standard Calculation Methods for Structural Fire Protection,* and ACI 216.1/TMS 0216.2, *Standard Method for Determining Fire Resistance of Concrete and Masonry Assemblies.* The referenced test methods and associated calculation methodologies are useful in comparing the fire resistance of building materials but are not necessarily indicative of how the building materials might perform in an actual building fire. See Section 19, Chapter 2, "Structural Integrity During Fire," for more information on how the fire performance of building materials is determined.
- *Noncombustible material.* A material that, in the form in which it is used and under the conditions anticipated, will not ignite, burn, support combustion, or release flammable vapors when subjected to fire or heat. Materials that are reported as passing ASTM E136, *Standard Test Method for Behavior of Materials in a Vertical Tube Furnace at 750 Degrees C,* shall be considered noncombustible materials.
- *Limited-combustible material.* Refers to a building construction material not complying with the definition of noncombustible material that, in the form in which it is used, has a potential heat value not exceeding 3500 Btu/lb (8141 kJ/kg) where tested in accordance with NFPA 259, *Standard Test Method for Potential Heat of Building Materials,* and includes either of the following: (1) materials having a structural base of noncombustible materials, with a surfacing not exceeding a thickness of 1/8 in. (3.2 mm) that has a flame spread index not greater than 50; and (2) materials, in the form and thickness used, having neither a flame spread index greater than 25 nor evidence of continued progressive combustion, and of such composition that surfaces that would be exposed by cutting through the material on any plane would have neither a flame spread index greater than 25 nor evidence of continued progressive combustion, when tested in accordance with NFPA 255, *Standard Method of Test of Surface Burning Characteristics of Building Materials.* Materials subject to increases in combustibility or to a flame-spread index beyond the limits herein established through the effects of age, moisture, or other atmospheric conditions are considered combustible.
- *Combustible material.* A material that, in the form in which it is used and under the condition anticipated, will ignite and burn. It is further described as a material that does not meet the definition of noncombustible material or limited-combustible material.

Type I Construction

Type I construction (formerly referred to as fire resistive) is construction in which the structural members are noncombustible

TABLE 19.1.3 Fire Resistance Ratings for Type I Through Type V Construction (hr)

	Type I		Type II			Type III		Type IV	Type V	
	442	*332*	*222*	*111*	*000*	*211*	*200*	*2HH*	*111*	*000*
Exterior Bearing Walls										
Supporting more than one floor or columns or other bearing walls	4	3	2	1	0	2	2	2	1	0
Supporting one floor only	4	3	2	1	0	2	2	2	1	0
Supporting a roof only	4	3	1	1	0	2	2	2	1	0
Interior Bearing Walls										
Supporting more than one floor or columns or other bearing walls	4	3	2	1	0	1	0	2	1	0
Supporting one floor only	3	2	2	1	0	1	0	1	1	0
Supporting roofs only	3	2	1	1	0	1	0	1	1	0
Columns										
Supporting more than one floor or columns or other bearing walls	4	3	2	1	0	1	0	H	1	0
Supporting one floor only	3	2	2	1	0	1	0	H	1	0
Supporting roofs only	3	2	1	1	0	1	0	H	1	0
Beams, Girders, Trusses, and Arches										
Supporting more than one floor or columns or other bearing walls	4	3	2	1	0	1	0	H	1	0
Supporting one floor only	2	2	2	1	0	1	0	H	1	0
Supporting roofs only	2	2	1	1	0	1	0	H	1	0
Floor-Ceiling Assemblies	2	2	2	1	0	1	0	H	1	0
Roof-Ceiling Assemblies	2	1½	1	1	0	1	0	H	1	0
Interior Nonbearing Walls	0	0	0	0	0	0	0	0	0	0
Exterior Nonbearing Walls	0	0	0	0	0	0	0	0	0	0

Note: See applicable building requirements for more information.
H = Heavy timber members.
Source: *NFPA 5000®*, *Building Construction and Safety Code®*, Table 7.2.11, 2006, p. 5000-89.

and have a fire resistance as specified in Table 19.1.3. This classification is divided into two subtypes, Type I (442) and Type I (332). Reductions in the hourly rating might be permitted by the applicable building code. The basic difference between the subtypes is in the level of fire resistance specified for the structural frame. The fire resistance requirements for Type I (442 and 332) construction were selected because they provide reasonable fire safety for the structure for occupancies with moderate- and low-combustible contents. In occupancies with higher fire loads and hazardous uses, fire resistance may be supplemented by additional protection, usually including an automatic fire-extinguishing system. Even in occupancies with moderate fire loads, such as in mercantile and in some factory industrial and storage uses, supplementary fire safety precautions are usually required. These include restrictions on the building size or requirements for automatic fire-extinguishing equipment.

In Type I construction, only noncombustible or limited-combustible materials are permitted for the structural elements of the building. This regulation is well accepted and appears in practically every modern building code. Obviously, if combustible structural materials were allowed in noncombustible building types, the whole concept of their allowable use (height and area) would become meaningless. However, for practical reasons, the use of some combustible materials in Type I and Type II buildings are permitted for other than structural components. Roof coverings, some types of insulating materials, and limited amounts of interior finish and flooring do not add significantly to the fire hazard or fire load if these materials are properly regulated and qualified by fire tests.

Some codes have attempted to regulate combustible materials by using two or three alternatives that allow for the acceptance of materials having relatively low fuel content and surface burning characteristics. The purpose of this definition was to recognize certain materials or nonhomogenous assemblies containing limited amounts of combustible materials, such as gypsum wallboard which, although covered with paper, is used as a fire-resistive material. These alternate definitions include limits on surface flame spread rating (per NFPA 255) and on the heat content (per NFPA 259)—the latter being 3500 Btu per lb (8050

J/kg) for limited-combustible material, somewhat less than half that of untreated wood.

Rather than complicate the definition for the accommodation of certain materials, a more fundamental approach is to define limited uses and combustibility characteristics of materials that may be acceptable in buildings of Type I construction. This approach was followed in the NBCC and by the BCMC committee in its recommendations for the allowable kinds and extent of use of combustible material in the construction of Type I and II buildings.

Type II Construction

Type II construction (formerly referred to as noncombustible construction) is a construction type in which the structural elements are entirely of noncombustible or limited-combustible materials. Type II construction can be further classified as protected—Type II (222) or Type I (111)—in which the structural members have some degree of fire resistance, either 2 hour or 1 hour, or unprotected—Type II (000)—in which the structural members have no fire resistance rating. An example of protected construction is structural steel with spray-on fire proofing applied. Applicable building codes typically include additional provisions for exterior structural bearing walls of Type II construction.

The fire resistance required in Type II (222 or 111) construction will afford adequate fire safety for residential, educational, institutional, business, and assembly occupancies, without supplementary restrictions. Height limits, however, are commonly prescribed for this type of construction. When used for other occupancies involving a greater fire loading, additional fire safety precautions are usually required, such as more stringent area limitations and automatic fire-extinguishing equipment. In occupancies with a low fire load attributed to contents, the absence of fuel in noncombustible construction not only helps prevent the spread of fire but also reduces potential risk of a fire starting within the structure itself.

The limitation on combustible material is valuable because it acts to prevent fire from spreading through concealed spaces or involving the structure itself. Because of this attribute, a fire in a building of Type I and Type II construction can be controlled more readily (Figure 19.1.1). Requirements for exterior walls of Type II construction are specified by the applicable building code or standard that is used by the authority having jurisdiction (AHJ).

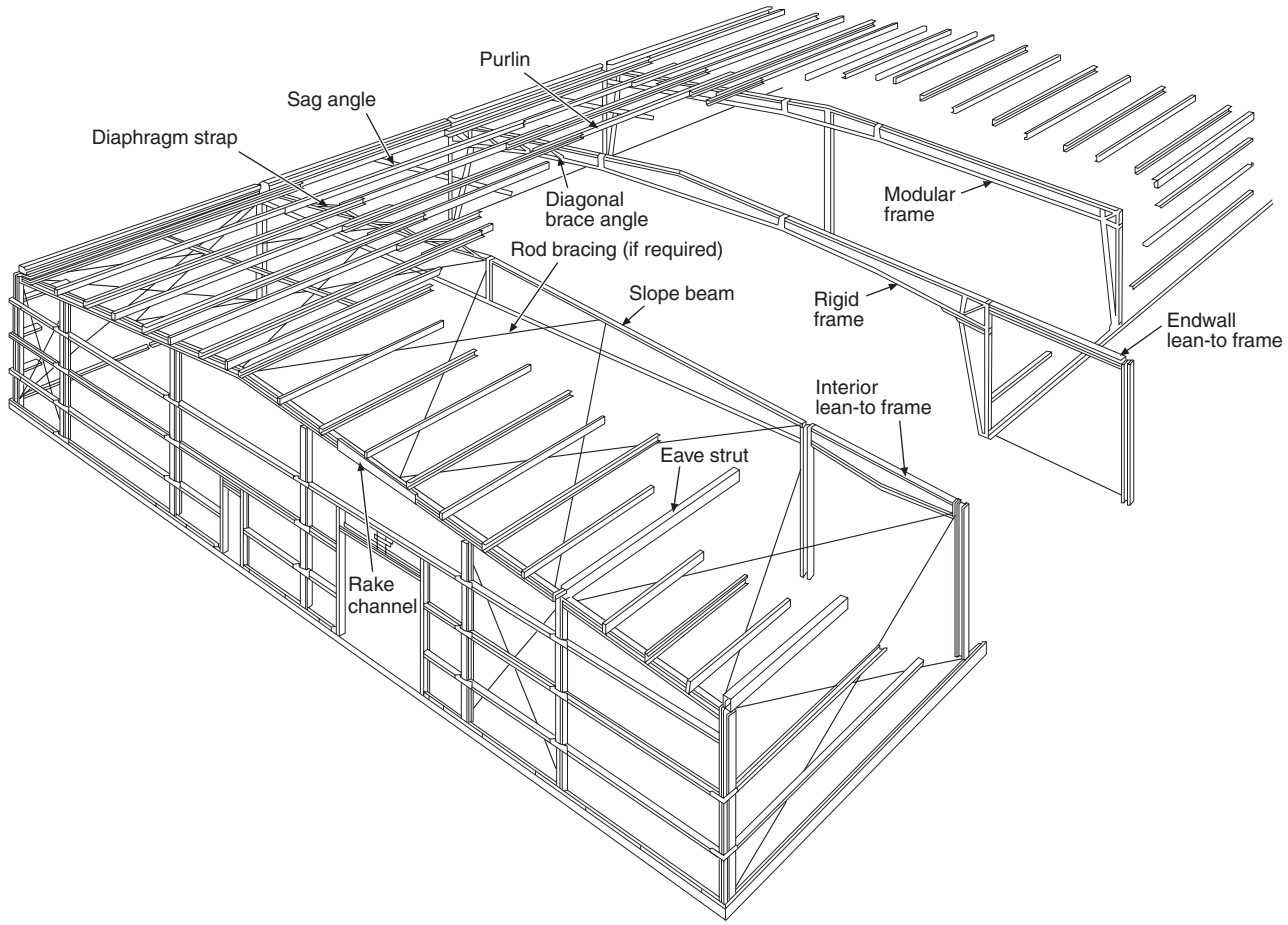

FIGURE 19.1.1 Framing System Representative of Type II (Noncombustible, Unprotected) Construction, Showing Preengineered Pitched Roof and Lean-To Framing with Structural Elements of Unprotected Steel

Type III Construction

Type III construction (formerly referred to as exterior protected or ordinary construction) is a construction type in which all or part of the interior structural elements may be of noncombustible, limited-combustible, or approved combustible materials as permitted by the applicable building code. The exterior walls are required to be of noncombustible or limited-noncombustible materials possessing a fire resistance rating in accordance with the applicable building code. Type III construction is further divided into protected and unprotected subtypes. Protected construction, Type III (211), has a 1 hour fire resistance for the floors and structural elements. Type III (200) construction has no fire resistance for the floors or structural elements. Whether or not fire resistance is provided, it is essential that all concealed spaces be properly fire blocked in buildings of combustible construction. This must be done with care in all furred spaces, partitions, ceiling spaces, and attics. Codes are very specific as to the materials used for fire blocking and the locations where it is required. To be effective, fire blocking must completely close off and subdivide the combustible construction into limited areas, thereby restricting the spread of fire and hot gases and allowing additional time for detection and evacuation of the building or area involved.

The 1 hour fire resistance provided in Type III (211) construction offers a measure of safety for fire fighting and evacuation before the construction itself becomes involved. However, combustible parts of any fire-rated assembly are likely to be burning actively before the end of the rated time period. For this reason, that portion of the fire load represented by combustible structural elements must be considered as part of the total potential fire load, whether or not the construction is protected.

Type IV Construction

Type IV construction (formerly referred to as heavy timber) is a construction type in which structural members—that is, columns, beams, arches, floors, and roofs—are basically of unprotected wood (solid or laminated) with large cross-sectional areas, with minor exceptions. No concealed spaces are permitted in the floors and roofs or other structural members. NFPA 220 and most model building codes are specific in the minimum dimensions permitted for the various wood structural members and minimum fire-resistive ratings required for interior columns, arches, beams, girders, and trusses of materials other than wood that may be permitted as acceptable alternatives to wood members (Table 19.1.4).

Walls, both interior and exterior, including structural members framed into them, can be of noncombustible or limited-combustible materials acceptable to the code being applied. Brick and stone were the traditional materials used in early heavy timber, or "mill," construction.

During a fire, heavy timber construction resists failure longer than a conventional wood frame structure because the structural members are larger, have a smaller surface to mass ratio, and take longer to burn. As the wood member burns, a layer of char develops, which acts like insulation and slows down the rate of burning. The large wood members, therefore, can continue to carry their structural loads due to the mass of unburned wood.

TABLE 19.1.4 Recommended Nominal Dimensional Requirements for BCMC Type IV (2HH) Construction

	Supporting Floors	*Supporting Roofs*
Columns	8 in. × 8 in.	6 in. × 8 in.
Beams and girders	6 in. × 10 in.	4 in. × 6 in.
Arches	8 in. × 8 in.	6 in. × 8 in., 6 in. × 6 in., 4 in. × 6 in.
Trusses	8 in. × 8 in.	4 in. × 6 in.
Floors	3 in. T & G or 4 in. on edge w/1-in. flooring	
Roofs		2 in. T & G or 3 in. on edge or 1⅛ in. plywood

Note: T & G = tongue and groove.
For SI units: 1 in. = 25.4 mm.

Heavy timber construction is more properly considered a building system, not just a construction type using large-size framing members. It was developed during the mid-1800s by insurance interests for the purpose of reducing fire losses in the many textile factories, paper mills, and storage buildings in the New England states. Through the intelligent use of combustible materials of sufficient mass, the absence of concealed spaces, and by paying attention to details to avoid sharp corners and ignitable projections, the chance of rapid spread of fire is lessened and the probability of serious structural damage is reduced. Examples of heavy timber construction are shown in Figures 19.1.2 and 19.1.3.

Type V Construction

Type V construction (formerly referred to as wood frame) is a type of construction in which the structural members are entirely of wood or any other material permitted by the code being applied (Figure 19.1.4). Depending on the exterior horizontal separation to adjacent buildings, the exterior walls may or may not be required to be fire resistive.

Type V construction is probably more vulnerable to fire, both internally and externally, than any other building type. Accordingly, it is essential that greater attention be given to the details of construction of this basically light wood-frame building. Fire blocking in exterior and interior walls at ceiling and floor levels, in furred spaces, and other concealed spaces can retard the spread of fire and hot gases in these vulnerable areas. Type V construction is subdivided into two subtypes: Type V (111) construction, which has 1 hour fire resistance throughout, including the exterior walls; and Type V (000) construction, which has no fire protection or fire resistance requirements, except for the exterior walls when horizontal separation is less than 10 ft (3 m).

FIGURE 19.1.2 Elements of a Building of Type IV (Heavy Timber) Construction. Note the large size of the columns and beams and the absence of concealed spaces. The exterior nonbearing wall at far left is of lightweight corrugated steel.

FIGURE 19.1.3 A Variation of Type IV (Heavy Timber) Construction with Haunched Arches of Laminated Wood (Glue-Laminated Construction) and Beams Anchored to Arches by Steel Hangers

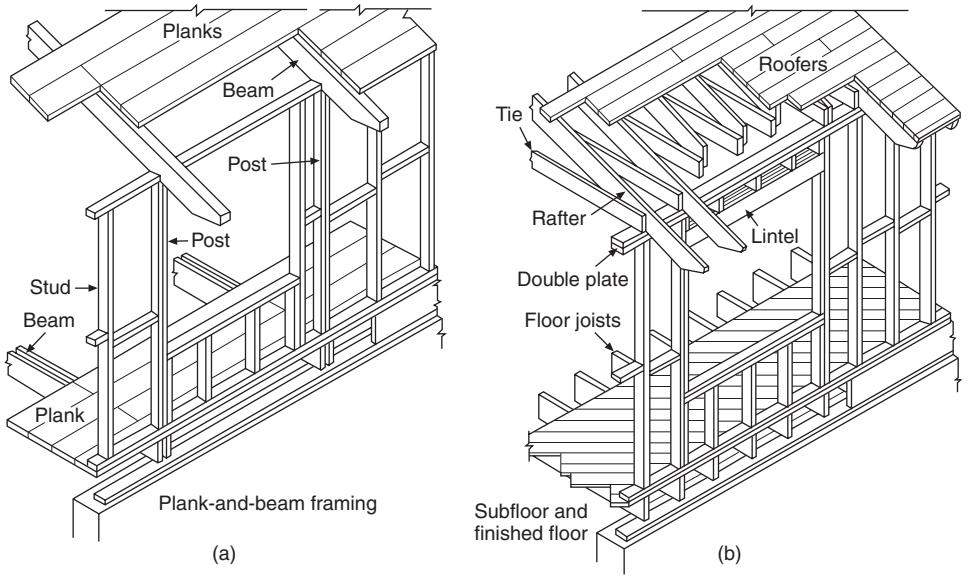

FIGURE 19.1.4 Two Variations on Basic Type V (Wood Frame) Construction: (a) Plank-and-Beam Framing in Which a Few Large Members Replace Many Small Members Used in Typical Wood Framing, (b) Conventional Wood Framing (Western or Platform Construction). Fire blocking is essential in concealed spaces.