Collaborative Bachelor's Degree Program of Fire Protection and Safety Engineering Technology between Southwest Jiaotong University and Oklahoma State University, U.S.A.

FPST 1213 Fire and Safety Hazard Recognition

Building Construction
and
Occupancy Classifications

1

Objectives

- Know basic construction terms
- Understand the five types of construction
- Understand occupancy classifications
- Know basic construction materials and components

2

Building Construction Codes

- International Code Council
  - International Building Code – IBC
  - International Fire Code – IFC
- National Fire Protection Association
  - NFPA 101 – *Life Safety Code*
  - NFPA 220 – *Types of Building Construction*
  - NFPA 5000 – *Building Construction and Safety Code*

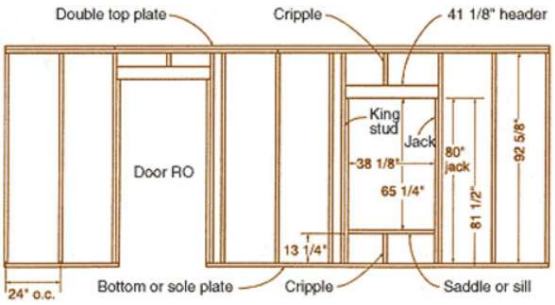
3

Basic Building Components

- Structural Frame
- Load Bearing Walls
- Non-Bearing Walls
- Floor Construction
- Roof Construction

4

Basic Wall Construction



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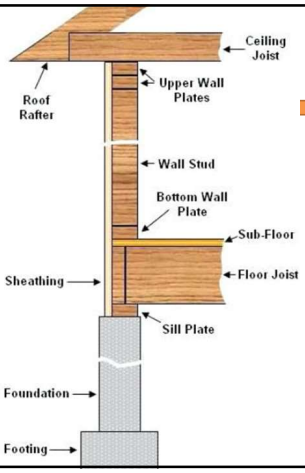
Wall Section



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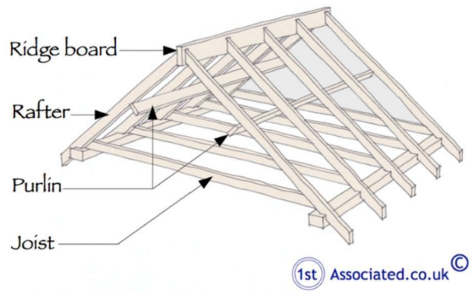
Roof Construction



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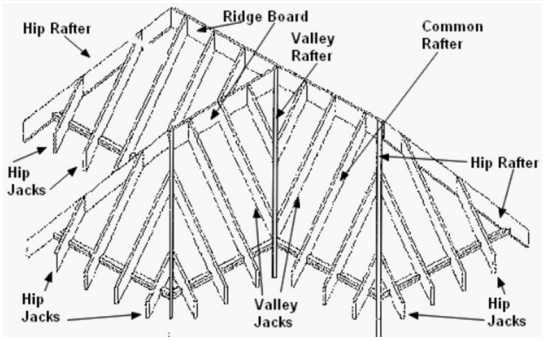
Rafters



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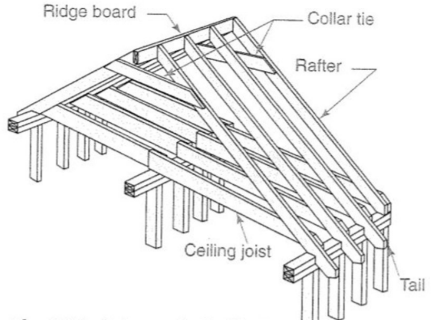
Joists



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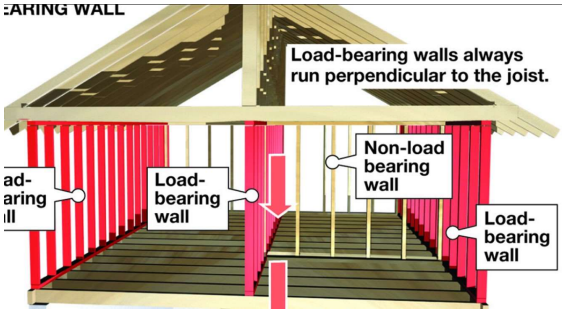
Pre-fabricated Joist

10

Prefabricated truss

11

Walls



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Construction Types

- I – Fire Resistive
- II – Noncombustible
- III – Ordinary
- IV – Heavy Timber
- V – Wood Frame

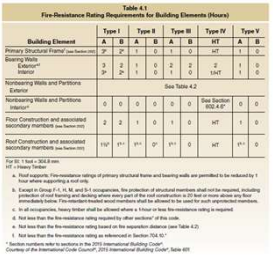

Table 4.1
Fire-Resistance Rating Requirements for Building Elements (Hours)

Building Element	Type I A	Type I B	Type II A	Type II B	Type III A	Type III B	Type IV HT	Type V A	Type V B
Primary Structural Frame (see Section 202)	3[a]	2[a]	1	0	1	0	HT	1	0
Bearing Walls									
Exterior[e,f]	3	2	1	0	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	1-hr[a]	1	0
Nonbearing Walls and Partitions Exterior	See Table 4.2								
Nonbearing Walls and Partitions Interior[d]	0	0	0	0	0	0	See Section 602.4.6[c]	0	0
Floor Construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof Construction and associated secondary members (see Section 202)	1½[b]	1[a,c]	1[a,c]	0[c]	1[a,c]	0	HT	1[a,c]	0

For SI: 1 foot = 304.8 mm
HT = Heavy Timber

a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.
b. Except in Group F-1, H, M, and S-1 occupancies, fire protection of structural members shall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.
c. In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.
d. Not less than the fire-resistance rating required by other sections of this code.
e. Not less than the fire-resistance rating based on fire separation distance (see Table 4.2).
f. Not less than the fire-resistance rating as referenced in Section 704.10.

* Section numbers refer to sections in the 2015 International Building Code®.
Courtesy of the International Code Council®, 2015 International Building Code®, Table 601

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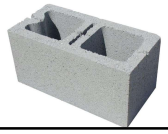
Type I – Fire Resistive

- Noncombustible materials
  - Reinforced or Precast Concrete
  - Masonry
  - Protected Steel
- Highest level of safety
- Structural stability

Courtesy of Ron Moore and McKinney (TX) Fire Department



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Type II - Noncombustible

- Noncombustible materials that do not meet stricter requirements of Type I
- Open web steel joist
- Can incorporate combustible materials

Courtesy of Scott Strassburg

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Open-Web Steel Joist

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Type II

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Type III - Ordinary

- Exterior walls constructed of noncombustible materials and interior elements of any permitted material
- Fire-stopping

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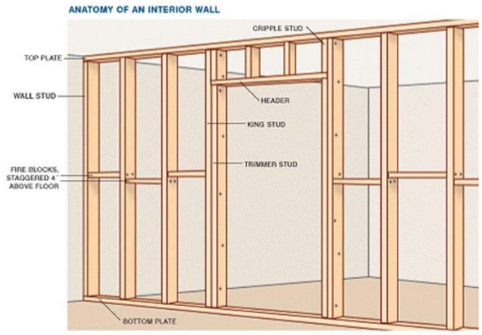
Fire Stops



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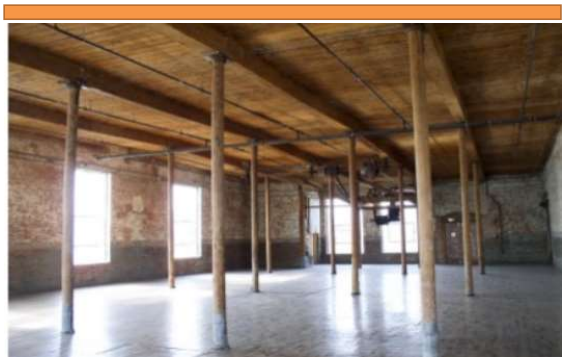
Type III - Ordinary



Courtesy of McKinney Fire Dept.

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Type IV – Heavy Timber

- Large-dimensioned lumber (>4") for all structural elements
- Extremely stable and more resistant to collapse
- May include small-dimensioned lumber glued together

Courtesy of Dave Coombs

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Type V – Wood Frame

- Exterior bearing walls entirely wood or other combustible materials
- Framing materials include wood studs, steel or aluminum studs, or wood sill plates
- Includes wood truss systems

Courtesy of Walt Schneider

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Building Construction

International Code Council (ICC)

- International Building Code (IBC)
- Nine Subtypes

National Fire Protection Association

- NFPA 5000 – Building Construction and Safety Code
- Ten Subtypes

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NFPA 5000 Construction Types

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

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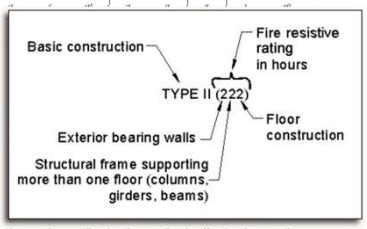
NFPA 5000

Table 7.2.1.1 Fire Resistance Ratings for Type I Through Type V Construction (hr)

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

H: Heavy timber members *(see text for requirements).*
[a]See 7.3.2.1.
[b]See Section 7.3.
[c]See 7.2.3.2.12, 7.2.4.2.3, and 7.2.5.6.8.



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NFPA Standard Notation

- 1.3.1*

* = additional explanatory information is Annexed

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indicates material that has been extracted from another NFPA document. As an aid to the user, the complete title and edition of the source documents for extracts in mandatory sections of the document are given in Chapter 2 and those for extracts in informational sections are given in Annex D. Extracted text may be edited for consistency and style and may include the revision of internal paragraph references and other references as appropriate. Requests for interpretations or revisions of extracted text shall be sent to the technical committee responsible for the source document.

Information on referenced publications can be found in Chapter 2 and Annex D.

Chapter 1 Administration

1.1* Scope.

Δ **1.1.1 Title.** NFPA *101, Life Safety Code*, shall be known as the *Life Safety Code*®, is cited as such, and shall be referred to herein as "this *Code*" or "the *Code*."

1.1.2 Danger to Life from Fire. The *Code* addresses those construction, protection, and occupancy features necessary to minimize danger to life from the effects of fire, including smoke, heat, and toxic gases created during a fire.

1.1.3 Egress Facilities. The *Code* establishes minimum criteria for the design of egress facilities so as to allow prompt escape of occupants from buildings or, where desirable, into safe areas within buildings.

1.1.4 Other Fire-Related Considerations. The *Code* addresses other considerations that are essential to life safety in recognition of the fact that life safety is more than a matter of egress. The *Code* also addresses protective features and systems, build-

1.2* Purpose. The purpose of this *Code* is to provide minimum requirements, with due regard to function, for the design, operation, and maintenance of buildings and structures for safety to life from fire. Its provisions will also aid life safety in similar emergencies.

1.3 Application.

1.3.1* New and Existing Buildings and Structures. The *Code* shall apply to both new construction and existing buildings and existing structures.

1.3.2 Vehicles and Vessels. The *Code* shall apply to vehicles, vessels, or other similar conveyances, as specified in Section 11.6, in which case such vehicles and vessels shall be treated as buildings.

1.4* Equivalency. Nothing in this *Code* is intended to prevent the use of systems, methods, or devices of equivalent or superior quality, strength, fire resistance, effectiveness, durability, and safety over those prescribed by this *Code.*

1.4.1 Technical Documentation. Technical documentation shall be submitted to the authority having jurisdiction to demonstrate equivalency.

1.4.2 Approval. The system, method, or device shall be approved for the intended purpose by the authority having jurisdiction.

1.4.3* Equivalent Compliance. Alternative systems, methods, or devices approved as equivalent by the authority having jurisdiction shall be recognized as being in compliance with this *Code.*

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Annex A Explanatory Material

Annex A is not a part of the requirements of this NFPA document but is included for informational purposes only. This annex contains explanatory material, numbered to correspond with the applicable text paragraphs.

A.1.1 The following is a suggested procedure for determining the *Code* requirements for a building or structure:

(1) Determine the occupancy classification by referring to the occupancy definitions in Chapter 6 and the occupancy Chapters 12 through 42. *(See 6.1.14 for buildings with more than one use.)*
(2) Determine if the building or structure is new or existing. *(See the definitions in Chapter 3.)*
(3) Determine the occupant load. *(See 7.3.1.)*
(4) Determine the hazard of contents. *(See Section 6.2.)*
(5) Refer to the applicable occupancy chapter of the *Code*, Chapters 12 through 42. *[See Chapters 1 through 4 and Chapters 6 through 11, as needed, for general information (such as definitions) or as directed by the occupancy chapter.]*
(6) Determine the occupancy subclassification or special use condition, if any, by referring to Chapters 16 and 17, day-care occupancies; Chapters 18 and 19, health care occupancies; Chapters 22 and 23, detention and correctional occupancies; Chapters 28 and 29, hotels and dormitories; Chapters 32 and 33, residential board and care occupancies; Chapters 36 and 37, mercantile occupancies; and Chapter 40, industrial occupancies, which contain subclassifications or special use definitions.
(7) Proceed through the applicable occupancy chapter to verify compliance with each referenced section, subsection, paragraph, subparagraph, and referenced codes, standards, and other documents.
(8) Where two or more requirements apply, refer to the occupancy chapter, which generally takes precedence over the base Chapters 1 through 4 and Chapters 6 through 11.

or interference with the normal use and occupancy of a building but provides for fire safety consistent with the public interest.

Protection of occupants is achieved by the combination of prevention, protection, egress, and other features, with due regard to the capabilities and reliability of the features involved. The level of life safety from fire is defined through requirements directed at the following:

(1) Prevention of ignition
(2) Detection of fire
(3) Control of fire development
(4) Confinement of the effects of fire
(5) Extinguishment of fire
(6) Provision of refuge or evacuation facilities, or both
(7) Staff reaction
(8) Provision of fire safety information to occupants

A.1.3.1 Various chapters contain specific provisions for existing buildings and structures that might differ from those for new construction.

A.1.4 Before a particular mathematical fire model or evaluation system is used, its purpose and limitations need to be known. The technical documentation should clearly identify any assumptions included in the evaluation. Also, it is the intent of the Committee on Safety to Life to recognize that future editions of this *Code* are a further refinement of this edition and earlier editions. The changes in future editions will reflect the continuing input of the fire protection/life safety community in its attempt to meet the purpose stated in this *Code.*

A.1.4.3 An equivalent method of protection provides an equal or greater level of safety. It is not a waiver or deletion of a *Code* requirement.

The prescriptive provisions of this *Code* provide specific requirements for broad classifications of buildings and structures. These requirements are stated in terms of fixed values, such as maximum travel distance, minimum fire resistance

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Occupancy Classifications

- "Occupancy". The purpose for which a building or other structure, or part thereof, is used or intended to be used.
  - NFPA 5000 3.3.446
  - NFPA 101 3.3.196
- Occupancy Classifications
  - Established because certain occupancies will have higher fire loads and greater numbers of occupants within them than others
  - Helps gain reasonable expectation of hazard building presents

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Occupancy Classifications Single Occupancy

- Assembly
- Business
- Educational
- Day Care
- Factory/Industrial
- Institutional
- Mercantile
- Residential
- Residential Board and Care
- Storage
- Utility/Miscellaneous

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Assembly

- Any building, structure, or compartment used for gathering of 50 or more persons
- ICC has sub-groups

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Business

Buildings that provide working place for large numbers of occupants in an office environment other than mercantile

Typically includes group areas and individual working spaces

ICC — Educational occupancies for students above the 12th grade

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Educational

- Any building or portion used for education of 6 or more persons through 12th grade
  - NFPA
    - More then 4 hours per day; more than 12 hours per week
    - An educational occupancy is distinguished from an assembly occupancy in that the same occupants are regularly present

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Day Care

Occupancy used to provide care, maintenance, and supervision, by other than their relatives or legal guardians, for less than 24 hours per day.

NFPA	4 or more children
ICC	More than 5 children Could be Educational or Institutional Complicated

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Industrial / Factory

- NFPA – Industrial
  - Products are manufactured or in which processing, assembling, mixing, packaging, finishing, decorating, or repair operations are conducted codes
- ICC – Factory
  - Similar to above but excludes hazardous and storage occupancies

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Institutional

- ICC Group I – Institutional
  - Propel not capable of self-preservation or detained for penal or correctional purposes
- NFPA 101
  - Detention & Correctional
    - used to house one or more persons under varied degrees of restraint or security where such occupants are mostly incapable of self-preservation because of security measures not under the occupants' control

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Mercantile

- Any building that is used to display or sell merchandise
- Contain large quantities of combustible materials and potential for high life loss
- Arrangement of merchandise can result in high fire load and can restrict exit access

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Residential

- IBC – Provide sleeping accommodations under conditions other than institutional
- NFPA – Structures having no more than two dwelling units, including detached units, semidetached units, and duplexes
- Not exempted in model codes
- Not subject in periodic inspections

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Storage

- Used to store goods, merchandise, products, vehicles, or animals
- NFPA
  - Warehouses
  - Storage units
  - Freight terminals
  - Parking garages
  - Aircraft hangars
  - Grain elevators
  - Barns
- IBC – what is being stored

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Utility / Miscellaneous

- IBC only
- Buildings or structures that do not fit any other classification
- Incidental or accessory buildings or structures that do not pose a hazard to primary occupancy
- Example:
  - Carport
  - barn

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Multiple-use Occupancy

- Multiple occupancies = two or more classes of occupancy within the structure
  - Mixed
    - Each structure is classified appropriately and separated from the others
    - Separated
      - Fire walls

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Separated vs Non-separated

- NFPA 101
  - Does not require separation
  - Use most restrictive occupancy requirements for entire facility
- ICC
  - Separation requirements

Table 4.6
Required Separation of Occupancies (Hours)

Occupancy	A, E		I-1[a],I-3, I-4		I-2		R[a]		F-2, S-2[a], U		B[a], F-1, M, S-1		H-1		H-2		H-3, H-4		H-5	
	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS	S	NS
A, E	N	N	1	2	2	NP	1	2	N	1	1	2	NP	NP	3	4	2	3	2	NP
I-1[a], I-3, I-4	—	—	N	N	2	NP	1	NP	1	2	1	2	NP	NP	3	NP	2	NP	2	NP
I-2	—	—	—	—	N	N	2	NP	2	NP	2	NP	NP	NP	3	NP	2	NP	2	NP
R[a]	—	—	—	—	—	—	N	N	1[c]	2[c]	1	2	NP	NP	3	NP	2	NP	2	NP
F-2, S-2[a], U	—	—	—	—	—	—	—	—	N	N	1	2	NP	NP	3	4	2	3	2	NP
B[a], F-1, M, S-1	—	—	—	—	—	—	—	—	—	—	N	N	NP	NP	2	3	1	2	1	NP
H-1	—	—	—	—	—	—	—	—	—	—	—	—	N	NP	NP	NP	NP	NP	NP	NP
H-2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	N	NP	1	NP	1	NP
H-3, H-4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1[c]	NP	1	NP
H-5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	N	NP

S = Buildings equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1.[e]
NS = Buildings not equipped throughout with an automatic sprinkler system installed in accordance with Section 903.3.1.1.[e]
N = No separation requirement.
NP = Not permitted

a. See Section 420.[c]
b. The required separation from areas used only for private or pleasure vehicles shall be reduced by 1 hour but not to less than 1 hour.
c. See Section 406.3.4.[c]
d. Separation is not required between occupancies of the same classification.
e. See Section 422.2[c] for ambulatory care facilities.

[c] Section numbers refer to sections in the 2015 International Building Code®.
Courtesy of the International Code Council®, 2015 International Building Code®, Table 508.4.

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CONSTRUCTION MATERIALS

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Construction Materials

- Usefulness determined by properties or characteristics
  - Combustibility
  - Thermal conductivity
  - Rate of thermal expansion
  - Variation of strength with temperature

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Wood

- Solid Lumber
  - Dimensional lumber
  - Boards
  - Timbers
- Engineered Lumber
  - Constructed offsite and shipped to site

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Laminated Members

- Small, flat strips jointed together with glue
  - Glulam
  - Ply wood
- Advantages
  - More sizes and shapes
- Contain joints
  - More glue contact surface
  - p. 156

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Watch Videos

- Plywood
- OSB
- Particle board

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Panels

- Used for roofs, subflooring, and siding
- Require less labor
- "Graded" for structural use and exposure durability

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Fire-Retardant Treatment

- Permitted by building codes for certain applications
- Treated wood
  - Resists ignition
  - Has increased fire endurance
  - Should not be confused with materials that are fire resistant
    - Resistant = inherent properties of the material itself
    - Retardant = coating of chemicals applied to material or added to material

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Masonry

Fundamental construction technique — Stacking individual units on top of one another and bonding them into a solid mass	
Inherently resistant to fire and insects	
Disadvantages	Compression only…not tension
Mortar	Keeps them together and keeps the apart

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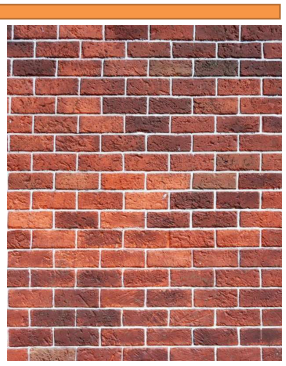
Brick

- Produced from variety of locally available clay and shale
- Manufactured by placing clay in molds then drying bricks
- Fired in kiln; intense heat converts to a ceramic material



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Concrete Block

- Most commonly used is hollow concrete block
- Also produced as bricks or solid blocks

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Concrete

- Produced from Portland cement, coarse and fine aggregates, and water
- Strength depends on:
  - Reinforcement – "Rebar"
  - Water-to-cement ratio

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This is not cement

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Advantages of Steel

- Low carbon content
  - More carbon = more combustible
- Strongest of structural materials
- Subject to tight quality control
- Relatively expensive, but can be used in smaller quantities

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Disadvantages of Steel

- Melts when exposed to tremendous levels of heat
- Tendency to rust
- Loss of strength when exposed to heat of fire

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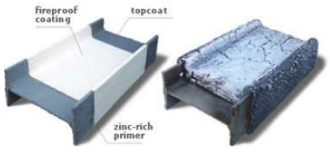
Fire Protection of Steel

- Most common method — Use of insulating material
- Lightweight materials
- Sprayed-on coating
- Intumescent coating
  - Coating expands when exposed to heat to better insulate



Fireproof coating system before and after fire exposure

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Steel

- Construction of structural framework that supports floors, roof, and exterior walls
- Connection design extremely important
- Must include means to resist wind load and other lateral forces
- Joist and girder frames
  - Girders support joists
    - Allows for larger open areas with needing load bearing walls

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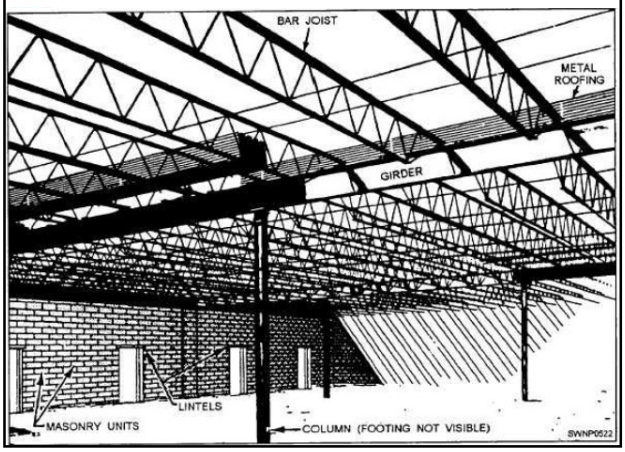

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Steel Trusses

- Can carry loads across greater spans more economically than solid beams
- Open web joist

60

COMPONENTS

61

Walls

- Bearing Wall
- Nonbearing Wall
- Curtain Wall
- Fire Wall
- Parapet Wall
- Partition
- Party Wall

62

Curtain Wall

Exists when a building is constructed using a structural frame for its main structural support

Separates interior environment from exterior to simply enclose the building

High-rises
Nonbearing

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Fire Walls

- Erected to limit maximum spread of fire
- Act as an absolute barrier to a fire under conditions of a total burnout on either side
- Assigned different fire-resistance ratings

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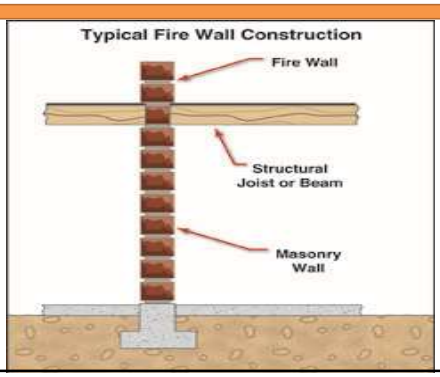
Fire Wall



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Characteristics of Fire Walls

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Fire Wall

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Parapet Wall

- Exterior wall portion that extends above the roof
  - Originally used to defend buildings from military attack, but today they are primarily used as guard rails and to prevent the spread of fires
  - A fire wall is a form of a parapet wall

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Partition Wall

- Fire barriers but are not fire walls
  - Used to separate occupancies and in corridors
  - Typically made
    - Gypsum
      - Drywall
      - Sheetrock®
        - USG - United States Gypsum Corporation
      - High moisture content makes for good fire resistance
    - Concrete block
    - Plaster

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Party Wall

- Lies on a lot line between two buildings and is common to both buildings
- Almost always load bearing
- Erected to limit maximum spread of fire
  - No holes
- Frequently functions as fire wall and extends through a building from the basement through the roof, capped with a parapet

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Doors

- Swinging
- Sliding
- Folding
- Vertical
- Revolving
- Fire

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Fire Doors

- Protect openings in fire-rated walls
- Effective at limiting spread of fire and total fire damage
- Differences from ordinary doors
  - Solid
  - Windows have wire mesh
  - Must have closers
  - Must always be kept closed
    - Typically found propped open
  - Many classifications
    - p. 209

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Fire Door Classification

- Hourly fire-protection rating
- Alphabetical letter designation
  - Type of opening to be protected
- Combination of hour and letter
  - May be found on existing fire doors, but no longer used
- Labeled
  - Painted
  - Counterfeit

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Fire Door Frames and Hardware

- Door must be equipped with hardware that holds door closed under stresses and pressures of fire exposure
- If door is installed in a frame, frame must also withstand exposure
- Inconsistencies with wall ratings
  - The fire wall hourly rating may not always have to match the fire door rating
    - Due to different evaluation methods
    - Check the standards

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Collaborative Bachelor's Degree Program of Fire Protection and Safety Engineering Technology between Southwest Jiaotong University and Oklahoma State University, U.S.A.

Evaluation Methods

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Will not be on exam