Fire Rated Construction for Engineers

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Introduction

- **Why do we fire rate buildings?**
  - Part of Life Safety
  - Many historical building fires with significant loss of life.
  - Primary source of modern Building Codes.

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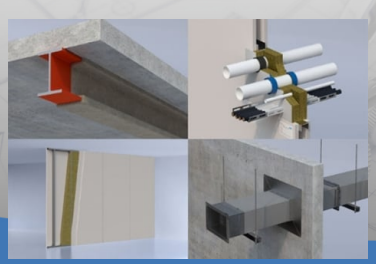
Introduction

- **Passive Fire Protection** - IBC Chapter 7
  - **Definition:**
    - The containment of fire via the use of construction materials in rated assemblies *(i.e. walls, floors, ceilings, etc.)*
    - Organizes the building into smaller compartments to prevent and/or slow the spread of fire and smoke.



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Introduction

- **Protection of Structural Elements**
  - Construction Type (Ch. 6)
  - Fire rating (IBC Table 601 and IBC §704)
- Same intent as seismic design
  - Collapse prevention

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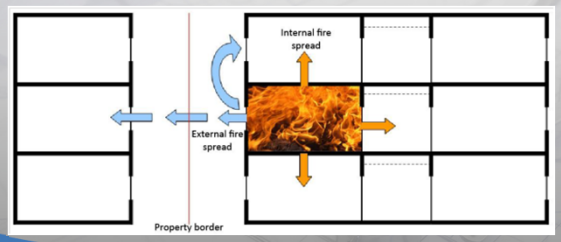
Introduction

- **Compartmentation**
  - Fire rated walls, floors, and ceilings
    - Vertical Assemblies (IBC 705 – 709)
    - Horizontal Assemblies (IBC 711)



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Construction Type

- Types I and II (602.2)
  - Noncombustible

Ogden Juvenile Courthouse, Utah

"Here comes the smolder." – Flynn Rider

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Type III Construction

- Type III (602.3)
  - Exterior walls:
    - Noncombustible
    - *Fire-Retardant-Treated (FRT) wood exterior wall*
      - 2-hour rating or less
      - Manufactured lumber cannot be FRT
      - Structural strength of FRT must be reduced per Manufacturer.
  - Interior elements
    - Any material permitted

Roosevelt, Washington

"Well, a fake reputation is all a man has." – Flynn Rider

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IBC 602: Construction Type

Syracuse, Utah

- Type IV (602.4)
  - Heavy Timber (HT)
    - ***Cross Laminated Timber***
  - Exterior walls:
    - Noncombustible materials
    - *FRT wood exterior wall*
      - 2-hour rating or less
  - Interior building elements
    - Solid or laminated wood
    - No concealed spaces.
- Type V (602.5)
  - Any material permitted

"Go see if I hurt that man to death" – Willie

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Mass Timber

- Cross-Laminated Timber (CLT) is here…
- This is perhaps the biggest change in the 2021 IBC and was added into Utah Code (effective May 5, 2020)
- The Utah Building Code now allows Mass Timber buildings up to 18-stories and having a height of 270-feet!

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IBC 602.4

- (4) Type IV options:
  - Type IV-HT (Heavy Timber)
  - Type IV-C (CLT – Mostly exposed)
  - Type IV-B (CLT – Mostly protected)
  - Type IV-A (CLT – Completely protected)
- The American Wood Council has a one-page sheet providing a comparison between each:
- https://awc.org/pdf/tmt/TMT-TypeofConstructionComparison-180316.pdf

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Mass Timber

- Added requirements to ***IBC Table 601***
- Added allowable height, story, and area provisions to ***IBC Tables 504.3***, ***504.4***, and ***506.2***.
- Added a definition of "Mass Timber" and "Noncombustible Protection" to Chapter 2.
- Added new code inspection requirement for a "***Connection Protection Inspection***" in IBC 110.3.12.

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Mass Timber

- ***Fire barrier separations*** within Type IV-B and IV-C shall have ½-inch gypsum separation on the interior of the building per IBC 508.4.4.1 and 509.4.1.1.
- IBC 703.8 and 703.9 provide ***testing*** and ***sealing*** requirements for intersections and abutting edges.
- Added ***special inspection*** requirements via IBC Table 1705.19.

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Required Rating

- **Minimum ratings come from Table 601**

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a,b]	2[a,b,e]	1[b,c]	0[c]	1[b,c]	0	3[a]	2[c]	2[c]	HT	1[b,c]	0
Bearing walls												
Exterior[c,f]	3	2	1	0	2	2	3	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	3	2	2	1/HT[g]	1	0
Nonbearing walls and partitions Exterior	See Table 705.5											
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	0	0	0	See Section 2304.11.2	0	0
Floor construction and associated secondary structural members (see Section 202)	2	2	1	0	1	0	2	2	2	HT	1	0
Roof construction and associated secondary structural members (see Section 202)	1½[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	1½	1	1	HT	1[b,c]	0

ICC, 2021 IBC

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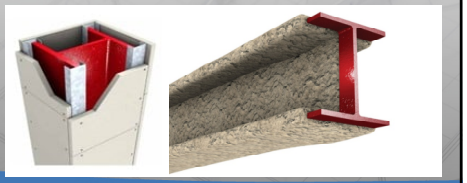
Fire Protection

- **Structural Fire Protection**
  - Essential structural elements shall be protected to prevent catastrophic damage
  - Methods:
    - Spray-applied
    - Intumescent paint
    - Encasement



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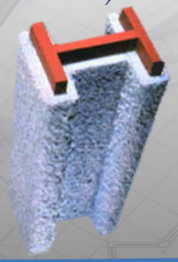
Primary Structural Frame

- **Protection of Columns** *(IBC 704.2)*
  - "… the entire column shall be provided with individual encasement protection by protecting it on all sides for the full column height, including…"
- **Other Primary Structural Frame** *(IBC 704.3)*
  - Other than columns
  - Support more than:
    - 2 floors, or
    - 1 floor and 1 roof, or
    - > 2 story bearing wall
  - Individual encasement for full length



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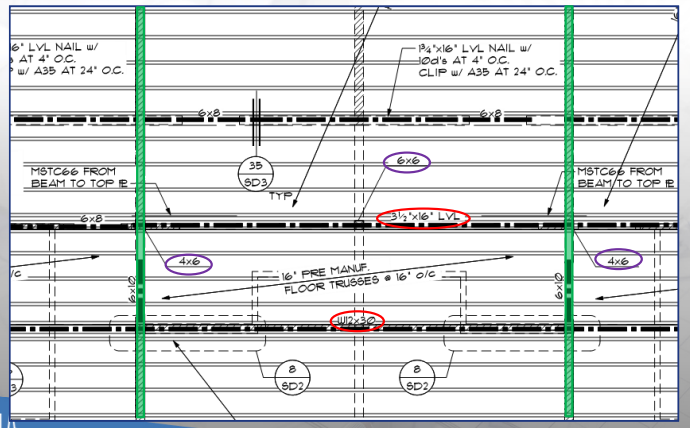
Structural Member



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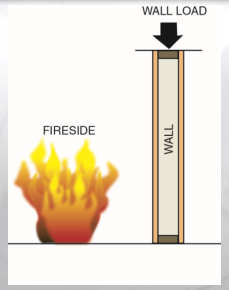
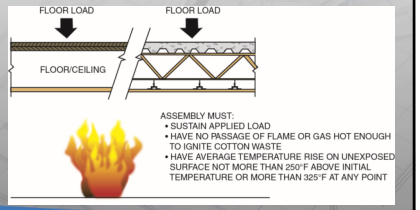
Compartmentation



- Vertical Assemblies
  - IBC 705: Exterior Walls *(EW)*
  - IBC 706: Fire Walls *(FW)*
  - IBC 707: Fire Barriers *(FB)*
  - IBC 708: Fire Partitions *(FP)*
  - IBC 709: Smoke Barriers *(SB)*
- Horizontal Assemblies
  - IBC 711



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Fire Walls (706)

- Used to separate portions of buildings
- "…shall provide a complete separation".

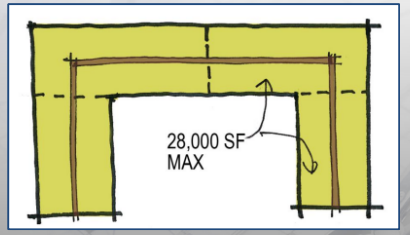

Table 506.2
R-1
Type V-B
One-Story
Sprinklered

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Fire Barriers (707)

- Simpler than "fire walls"
- Used for…
  - Shaft enclosures (§713.4)
  - Interior exit stairways/ramps (§1023.1)
  - Enclosures for exit access stairways (§713.4)
  - Exit passageways (§1024.3)
  - Horizontal exits (§1026.1)
  - Atriums (§404.6)
  - Incidental uses (Table 509)
  - Control areas (§414.2.4)
  - Separated occupancies (Table 508.4)
  - Fire areas (Table 707.3.10)

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Fire Partitions (708)

- Simpler than "fire barriers"
- Used for…
  - I-1, R-1, R-2, and R-3 separation walls (§420.2)
  - Separating tenant spaces in mall building (§402.4.2.1)
  - Corridor walls (§1020.1)
  - Elevator lobby separation (§3006.2)
  - Egress balconies (§1021.2)

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Smoke Barriers (709)

- The intent is to divide areas of a building into separate smoke compartments.
- Used for…
  - Group I-2 (§407.5)
  - Group I-3 (§408.6)
  - Part of Smoke Control System (§909.5)
  - Areas of Refuge (§1009.6.4)
  - Underground Buildings (§405.4.2)

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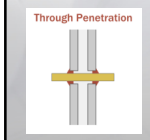
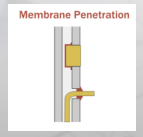
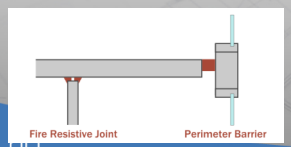
Wall Assemblies







- Common Section Layouts
  - Projections ***(EW Only)***
  - Material and Fire Ratings
  - **Structural Stability**
    - ***(EW and FW Only)***
  - **Continuity**
  - **Supporting Construction**
    - ***(Not EW or SB)***
  - Openings
  - **Penetrations**
    - ***(Not EW)***
  - Joints, Ducts & Air Transfer
  - Parapets ***(EW Only)***

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Fire Partitions (708)

- **Summary**:

Requirements	Wall Types		
	Firewalls	Fire Barriers	Fire Partitions
Fire-resistance-rated materials	X	X	X
Protected openings	X	X	X
Wall assembly	X	X	X
Vertical continuity	X	X	
Structural stability	X		

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Exterior Walls (705)

- **Structural Stability** (§705.6):

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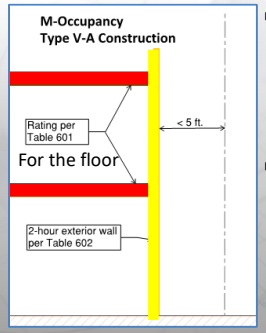
Exterior Walls (705)

- ***IBC 705.6:*** ***Ext. Walls – Structural Stability***



- *"Interior structural elements that brace the exterior wall but that are **not located within the plane** of the exterior wall shall per **Table 601** for **that** element.*
- *Structural elements that brace the exterior wall but are located **outside** or **within the plane** of the exterior wall per **Tables 601 and 602** for the **exterior wall**."*

"Can I come into the out now?" – Oh

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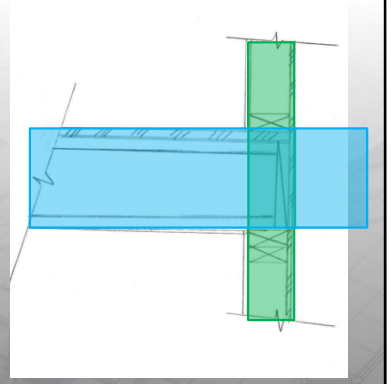
Exterior Wall (705)

- What is Exterior Wall?
  - Bottom Plates
  - Studsl
  - Top Plates
  - Wall Sheathing
  - Rim Board or blocking
- Floor or Roof?
  - Joists
  - Floor/Roof Sheathing



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Fire Walls (706)

- **Structural Stability** (§706.2):
  - "…shall be designed and constructed to ***allow collapse*** of the structure ***on either side*** without collapse of the wall…"
  - How is this done?
  - 2015 IBC now refers to all examples in NFPA 221 as compliant.

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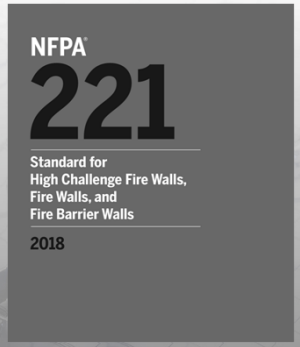
Fire Walls (706)

- **NFPA 221:** Three basic types are described
  - Cantilever Walls
  - Tied Walls
  - Double Walls



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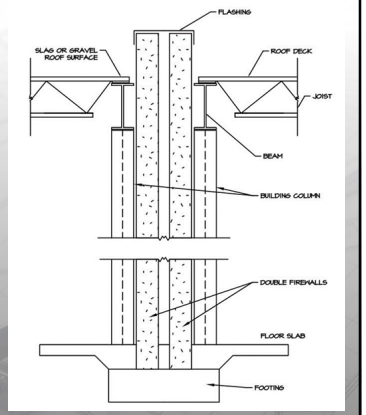
Fire Walls (706)

- **Cantilever Fire Walls:**
  - Must be designed for 5psf lateral load
  - No connections between the wall and building frame on either side
  - Flashing must be designed for easy release
  - Foundation must be designed to resist moment from lateral load



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Fire Walls (706)

- **Cantilever Fire Walls:**

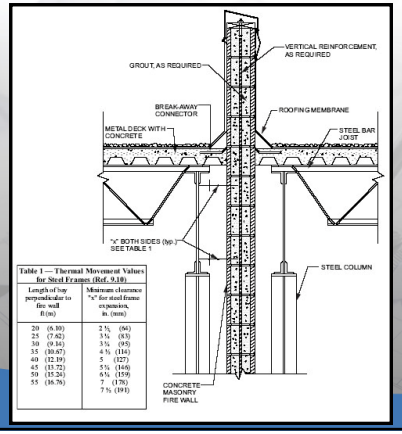

Table 1 — Thermal Movement Values for Steel Frames (Ref. 9.10)

Length of bay perpendicular to fire wall ft (m)	Minimum clearance "x" for steel frame expansion, in. (mm)
20 (6.10)	2 ½ (64)
25 (7.62)	3 ¼ (83)
30 (9.14)	3 ¾ (95)
35 (10.67)	4 ½ (114)
40 (12.19)	5 (127)
45 (13.72)	5 ½ (140)
50 (15.24)	6 ¼ (159)
55 (16.76)	7 (178)
	7 ½ (191)

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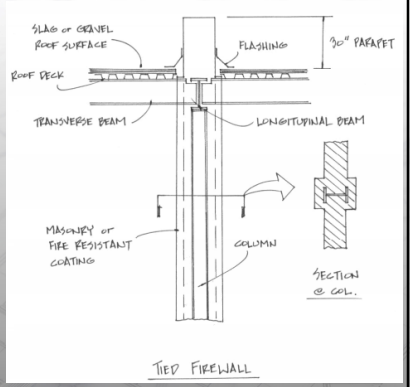
Fire Walls (706)

- **Tied Fire Walls:**
  - Ties roof structures on each side together such that the horizontal pull from the sagging "collapsed" members is carried by the horizontal force resisting system on the other side.



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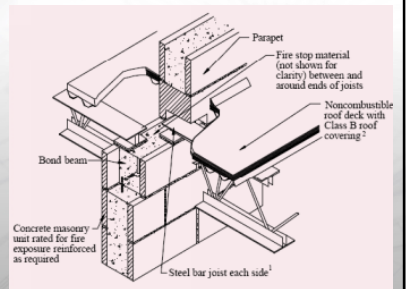
Fire Walls (706)

- **Tied Fire Walls:**
  - Works best when framing on either side is at the same level and primary members are perpendicular to the wall.



Notes:
1. Joists may be aligned if bond beam width permits proper installation of firestop material between joist ends. Stagger joists (as shown) as necessary.
2. 30 in. (762 mm) parapet is required unless all conditions are met: a) roof deck is noncombustible; b) roof covering is Class B (minimum); and c) no openings within 4 ft (1.22 m) of fire wall.
3. Top chord bearing wood joists similar.

Figure 2—Laterally Supported Loadbearing Fire Wall

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Fire Walls (706)

- **Tied Fire Walls:**
  - The sagging force, or horizontal pull is calculated as follows:
  - ***H = (WL²)/(8S)***
    - H = Horizontal pull
    - W = Dead load of roof
    - L = Truss or beam span
    - S = Sag
      - S = 0.09L structural steel
      - S = 0.07L open-web steel joists
      - S = 0.06L for wood trusses

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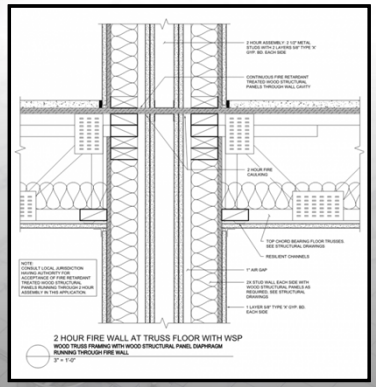
Fire Walls (706)

- **Double Fire Walls:**
  - Two walls adjacent to each other
  - Each only connected to respective frame
  - Each wall provides required fire rating



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Fire Walls (706)

- **Double Fire Walls:**

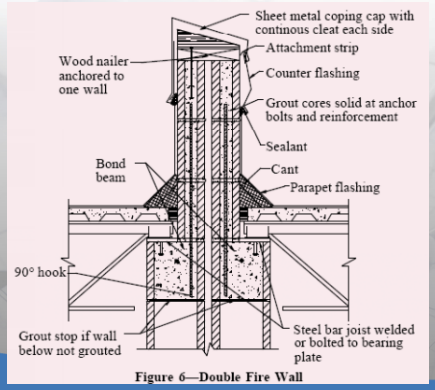

Figure 6—Double Fire Wall

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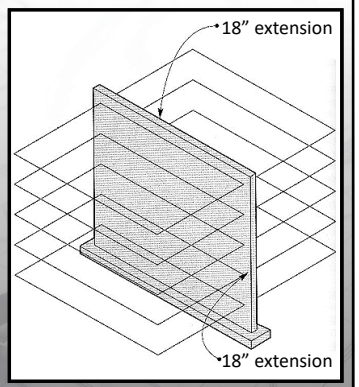
Fire Walls (706)

- **Horizontal Continuity** (§706.5):
  - "…continuous from exterior wall to exterior wall…"
  - Shall extend ***18 inches*** beyond exterior wall
  - As usual, there are several exceptions…



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Fire Walls (706)

- **Exceptions:**
  - May terminate at interior surface of *combustible* sheathing/siding provided the *exterior wall* has ***1-hour*** rating for at least ***4-feet*** on either side of fire wall. Openings in this area protected for ***¾-hour***.
  - May terminate at interior surface of *noncombustible* sheathing/finish provided sheathing/finish extends at least ***4-feet*** on either side of fire wall.
  - May terminate at interior surface of *noncombustible* sheathing where the building on both sides of the fire wall is ***sprinklered***.

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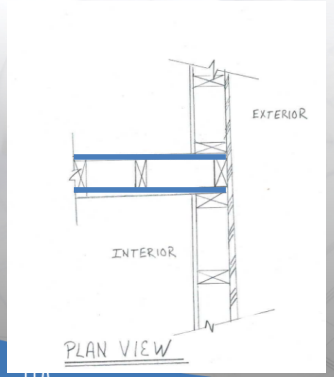
Fire Walls (706)

- Horizontal Continuity
  - Gypsum continuous through exterior wall
  - Top and bottom plates?
  - Exceptions may require interruption of exterior sheathing.



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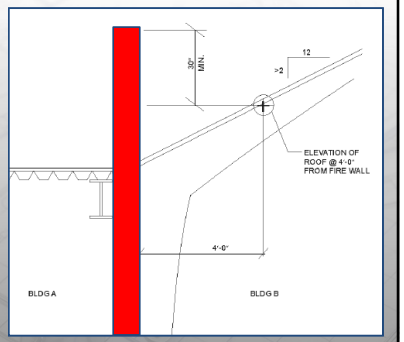
Fire Walls (706)

- **Vertical Continuity** (§706.6):
  - *"…shall extend from the foundation to a termination point at least **30-inches** above both adjacent roofs."*
  - Several exceptions…



International Code Council, 2015 IBC Commentary®

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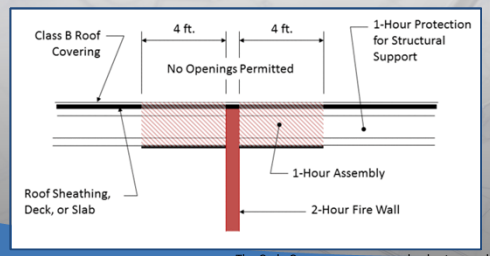
Fire Walls (706.6)

- Exception 2:
  - **2-Hour Walls:** May terminate at sheathing provided…
    a) Lower roof assembly is 1-hour rated for 4-feet, and…
    b) Openings are not located in roof w/in 4-feet, and…
    c) Each building provided w/ Class 'B' roof covering



The Code Corner, www.specsandcodes.typepad.com

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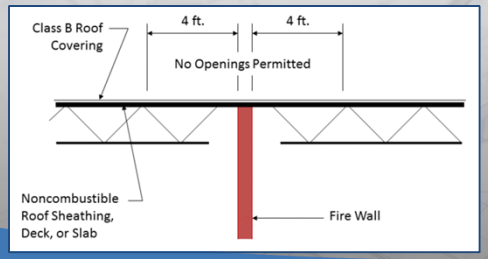
Fire Walls (706.6)

- Exception 3:
  - **Noncombustible Sheathing:** May terminate at sheathing provided…
    a) Openings are not located in roof w/in 4-feet, and…
    b) Each building provided w/ Class 'B' roof covering



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Fire Walls (706.6)

- Exception 4:
  - **Type III, IV and V:** May terminate at combustible sheathing provided…
    a) Openings are not located in roof w/in 4-feet, and…
    b) Each building provided w/ Class 'B' roof covering, and…
    c) Sheathing consists of fire-retardant-treated wood for a distance of 4-feet on each side of wall, or…
    d) 5/8-inch Type 'X' gypsum is applied on the underside of the sheathing for a distance of 4-feet on each side of wall.

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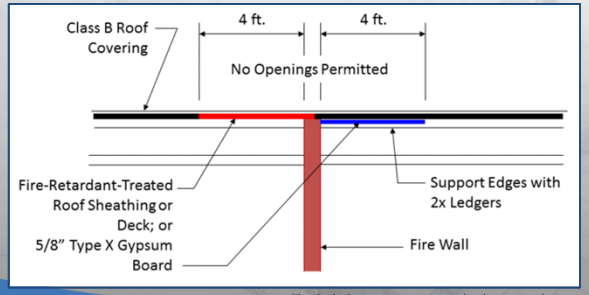
Fire Walls (706)

- Exception 4.3:
  - **Type III, IV and V:** May terminate at combustible sheathing provided…



The Code Corner, www.specsandcodes.typepad.com

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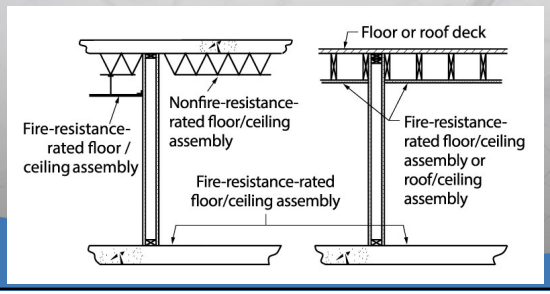
Fire Barriers (707)

- **Continuity** (§707.5):
  - "…shall extend from the top of the foundation or floor-ceiling assembly below to the underside of the floor or roof sheathing, slab or deck above and be ***securely attached*** thereto."



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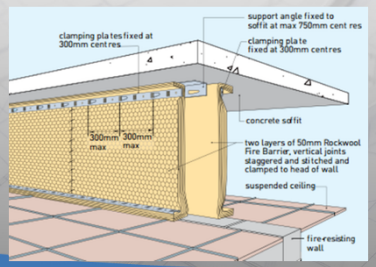
Fire Barriers (707)

- **Continuity** *(cont.)*:
  - Continuous through concealed spaces.
  - Joints at intersections per §715.
  - Voids at intersections to be filled with noncombustible materials.



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Fire Partitions (708)

- **Continuity** (§708.4):
  - "…shall extend from the top of the foundation or floor-ceiling assembly below to the underside of the floor or roof sheathing, slab or deck ***or*** to the fire-resistance-rated floor/ceiling or roof/ceiling assembly above…"
  - If not continuous to the sheathing… ***fire blocking*** and ***draft stopping*** is required (708.4.2)
  - Supporting construction same as partition, Except:
    - In Types IIB, IIIB, and VB for walls separating:

      Mall tenant spaces, dwelling or sleeping unit, or corridors

      (708.4.1)

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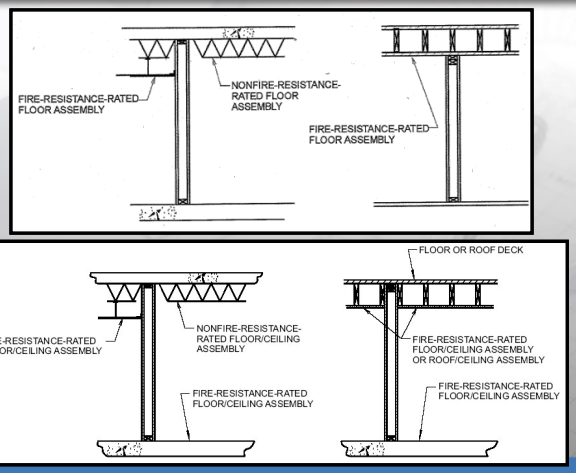
Fire Partitions (708)



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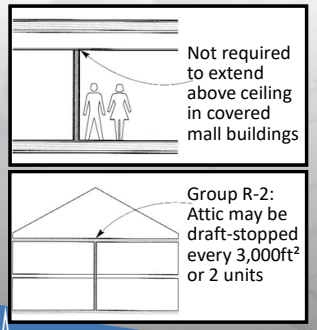
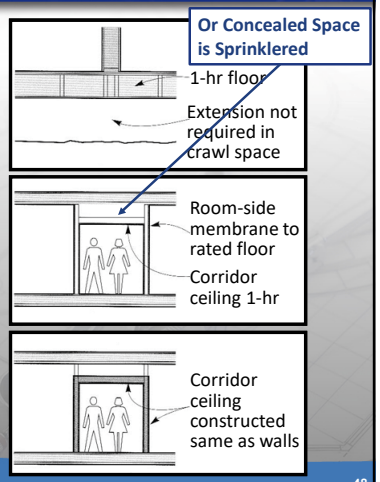
Fire Partitions (708)

- **Continuity** (§708.4):
  - Exceptions…





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Smoke Barriers (709)

- **Continuity** (§709.4)
  - "…shall form an effective membrane continuous from the top of the foundation or floor/ceiling below to the underside of the floor or roof sheathing…"
  - Includes continuity through ***concealed spaces***.
  - Supporting construction to have same fire rating
    - Except in Types IIB, IIIB, and VB construction

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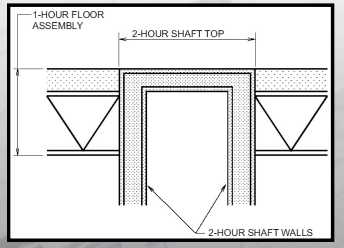
Continuity

- Continuous through Floor or Roof
  - Exterior Walls
    - Penetrations allowed
  - ***Fire Walls***
  - ***Fire Barriers***
  - Fire Partitions*
- Terminate below Ceiling
  - Fire Partitions
  - Smoke Barriers
  - Smoke Partitions



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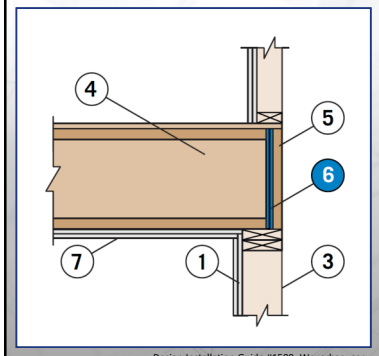
Continuity



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Simpson DG Hanger

- ***Fire Walls***
- ***Fire Barriers***

"Oh, Jameson pays me a fair wage. If it was 1961." – Peter Parker

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Supporting Construction

- **Supporting Construction**
  - Fire Walls, Fire Barriers, Fire Paritions
  - Same fire-rating as wall.
  - Hollow spaces fire blocked at floor.
  - Exceptions:
    - None for Fire Walls
    - Various for Fire Barriers and Fire Partitions
- **Structural Members Only**
  - Per IBC 704
  - Restrictions for openings, continuity, etc. do not apply to supporting construction
  - Example: Treat fire rating similar to load transfer for discontinuous shear wall.

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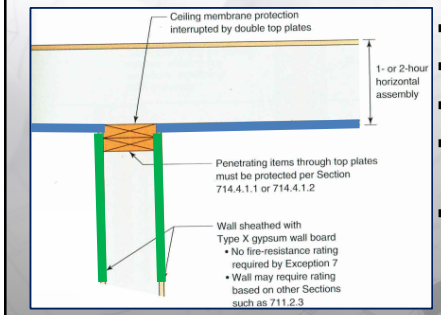
Membrane Penetrations

- ***2018 IBC 714.5.2: Exception 7:***



ICC, Significant Changes to the IBC ®

- 1-hr and 2-hr ceiling
- Double top plate
- Type X gypsum on wall
- Penetrations of top plate protected per 714
- Ceiling membrane tight to top plate

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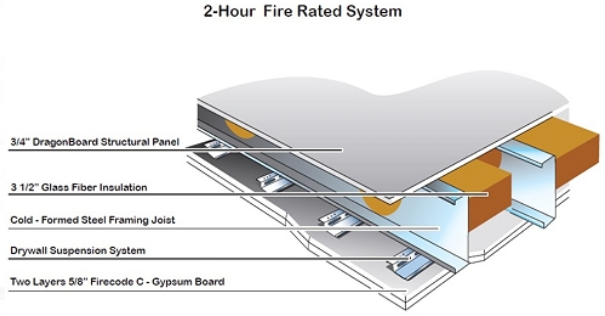
Horizontal Assemblies



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Horizontal Assemblies

- Floor & roof assemblies requiring a fire-resistance rating
- **Fire-Resistance Rating** (§711.2.4):
  - Type of construction → Table 601
  - Mixed occupancies → §508.4
  - Floor assembly occupancy separation → §707.3.10
  - Sleeping and dwelling unit separations (§420.3)

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Horizontal Assemblies

- **Restrained** (§703.2.3):
  - *"…**shall not** be considered restrained"* unless satisfactory evidence is provided.
  - Classification comes from ASTM E 119 or UL 263.
  - *"Restrained construction **shall be identified** on the construction documents."*

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Horizontal Assemblies

- **Restrained** (§703.2.3):
  - ***ASCE 29:*** Standard Calculation Methods for Structural Fire Protection
  - *"Floor and roof assemblies and individual beams in buildings shall be considered restrained when the surrounding or supporting structure is capable of resisting substantial thermal expansion…"*
  - So, what are some examples?

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Horizontal Assemblies

- **Restrained** (§703.2.3):
  - Example: 3-hour post-tensioned concrete podium

TABLE 721.1(1) —continued
MINIMUM PROTECTION OF STRUCTURAL PARTS BASED ON TIME PERIODS FOR VARIOUS NONCOMBUSTIBLE INSULATING MATERIALS[m]

STRUCTURAL PARTS TO BE PROTECTED	ITEM NUMBER	INSULATING MATERIAL USED	MINIMUM THICKNESS OF INSULATING MATERIAL FOR THE FOLLOWING FIRE-RESISTANCE PERIODS (inches)			
			4 hours	3 hours	2 hours	1 hour
4. Bonded or unbonded post-tensioned tendons in pre-stressed concrete[e, i]	4-1.1	Carbonate, lightweight, sand-lightweight and siliceous[f] aggregate concrete				
		Unrestrained members:				
		Solid slabs[k]	—	2	1 1/2	—
		Beams and girders[j]				
		8" wide	3	4 1/2	2 1/2	1 3/4
		greater than 12" wide		2 1/2	2	1 1/2
	4-1.2	Carbonate, lightweight, sand-lightweight and siliceous aggregate				
		Restrained members:[k]				
		Solid slabs[k]	1 1/4	1	3/4	—
		Beams and girders[j]				
		8" wide	2 1/2	2	1 3/4	—
		greater than 12" wide	2	1 3/4	1 1/2	—

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Any Questions?

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