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Self-Certification Training – Structural Basics

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Technical Lead - Structural

Structural Codes

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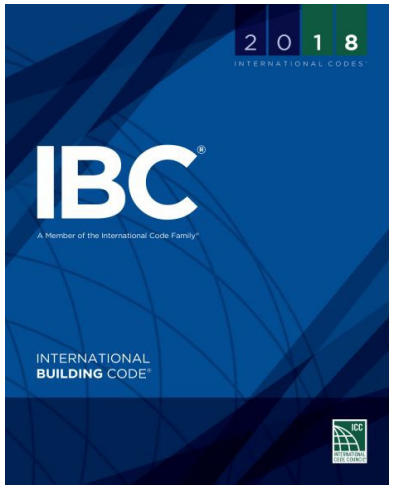
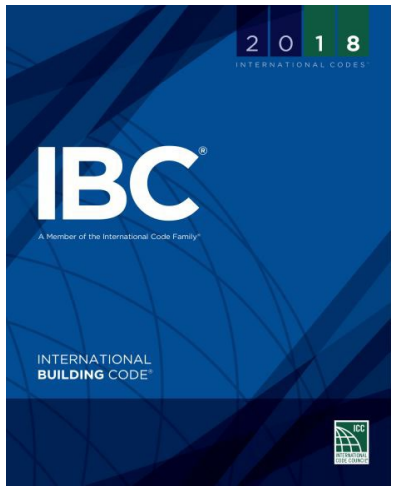
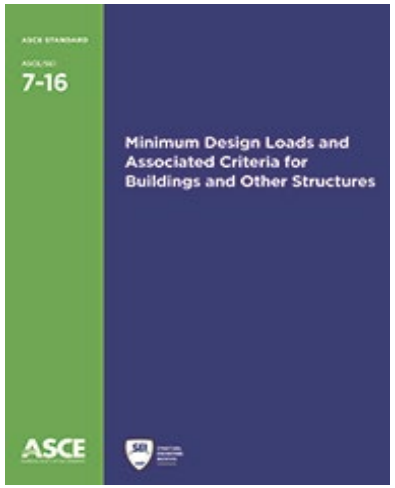
Admin and Scope → **Load** → **Material Specific Resistance**

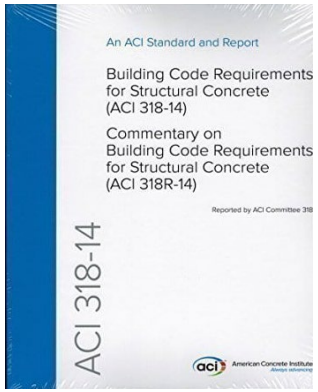
Free of their ACI overlords

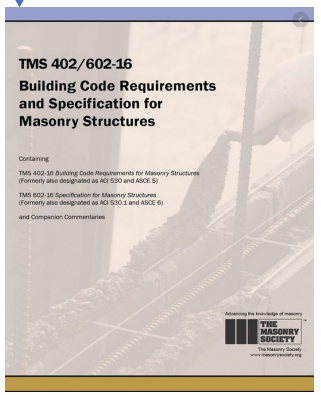


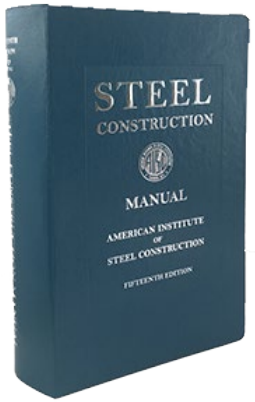
We will mostly only be covering admin and loading items in this presentation



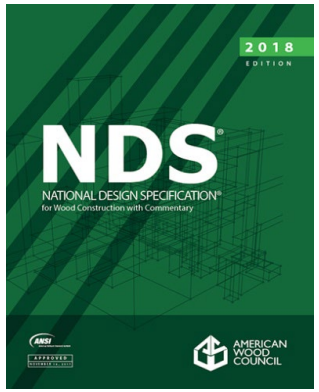








*Probably AISI S240



General Structural Notes (GSN)

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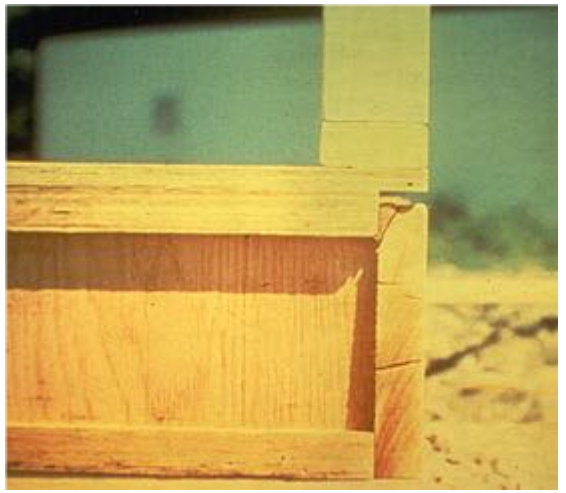
- Building Code
- Design Live Loads
- Roof Rain Intensity –Important in Arizona.
- Wind Design Data
- Earthquake Design Data
- Geotechnical Report Number and Date
  - for minor projects without a geotechnical report see the phoenix amendment to 1803.2 or policy document/TRT
- Soil Bearing Values
- Statement of special inspections
- Structural Observations
- Deferred Submittals
- Material Specifications
  - Make sure the notes actually apply to this project



Frequently Confused Structural Options

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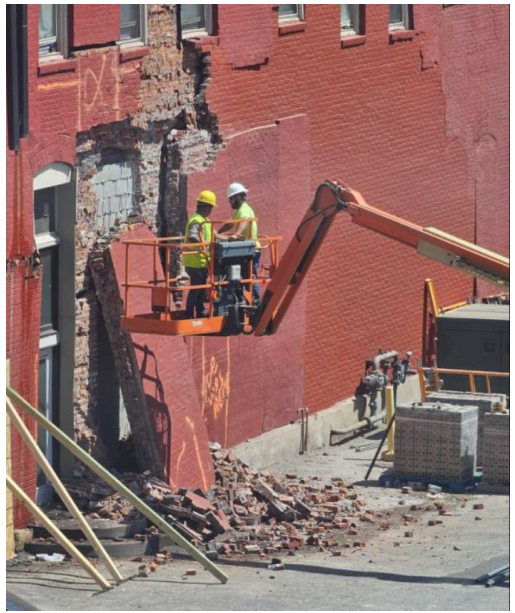
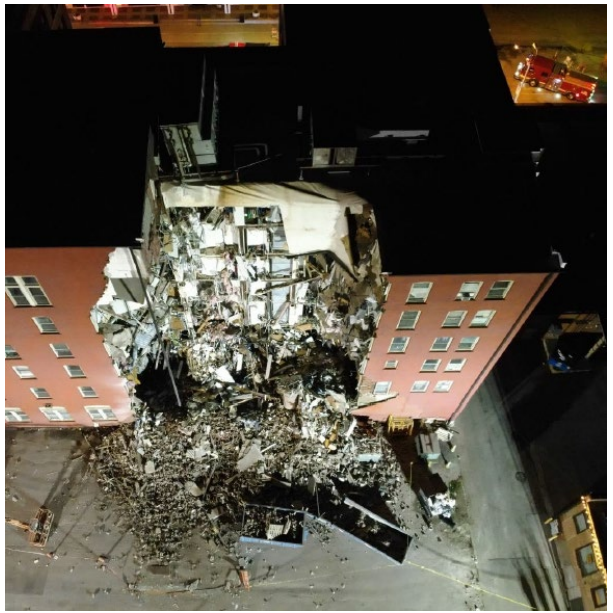
Deferred Submitals

- Identified before a permit is issued, but
- Performed and submitted after a permit is issued



Delegated Designs

- Design task given to another designer, can be performed before a permit is issued.



Deferred Submittals

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LIMITED ITEMS CAN BE DEFERRED

- See the Phoenix deferred submittal policy document https://www.phoenix.gov/pddsite/Documents/TRT/dsd_trt_pdf_00469B.pdf

Do not defer:

- Stairs
- Guards (Guardrails)
- Structural Connections

Deferred Submittals

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The construction permit drawings should:

- Identify all deferred design items,
- Show deferred items on the plans and in the details,
- Specify the design loads for the deferred items,
- Detail the supports for the deferred items.

Each deferred submittal is required to be reviewed and approved by the design team including peer reviewer before they get to the field for construction (or to the office for an office review).

Delegated Designs

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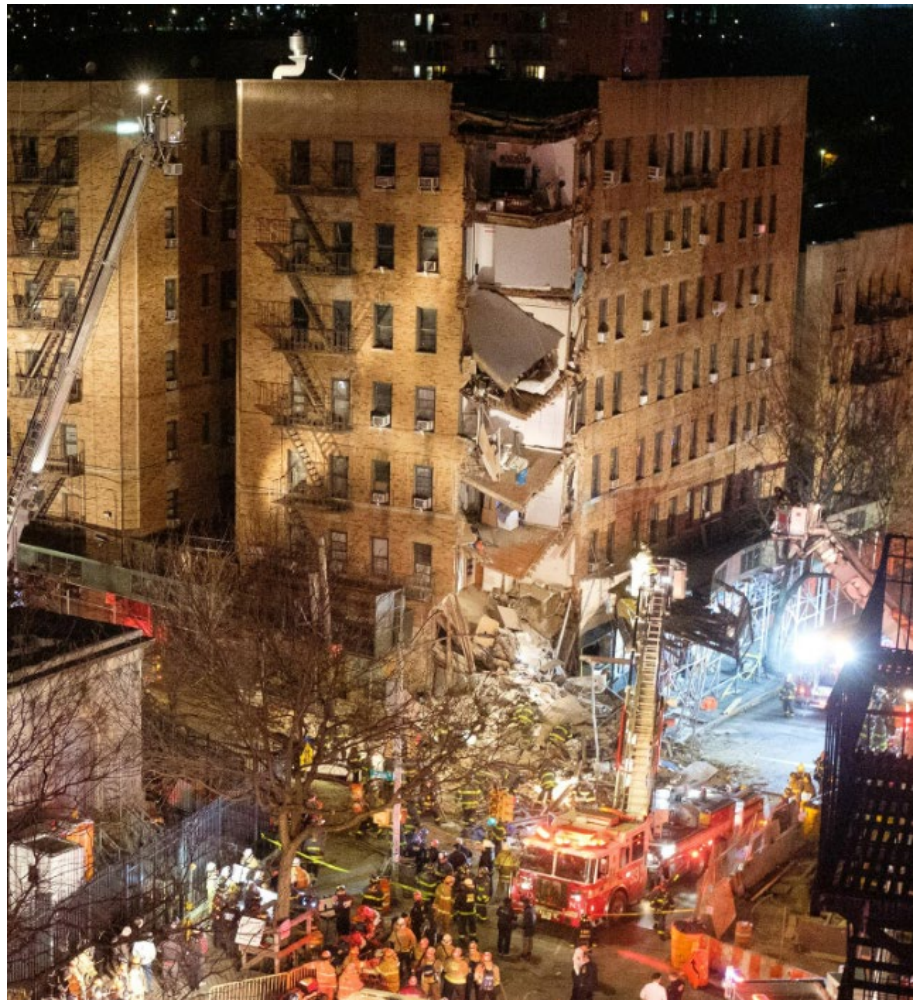
Any portion of the structural design may be delegated to another qualified licensed engineer by the engineer of record.

Delegated Design drawings need to be regular design drawings and are not shop drawings!



Metal Buildings and Precast Concrete

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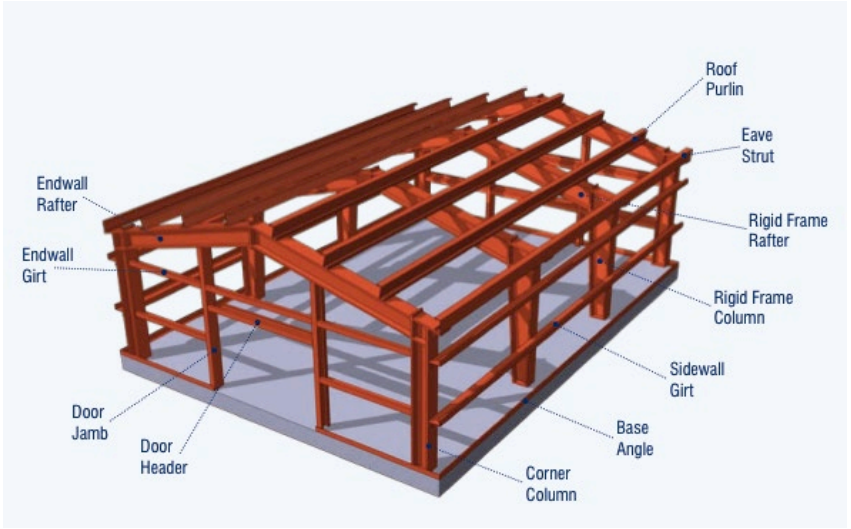
Metal Buildings and Precast Concrete Structures are an example of a delegated design performed before a permit is issued



Check:

- Are the drawings sealed with an ARIZONA seal?
- Are the drawings labelled “FOR CONSTRUCTION”?
- Do the drawings appear complete? Notes, Plans, Details – including the moment frame connections?
- Do the drawings look like this project?

Common Load Issues

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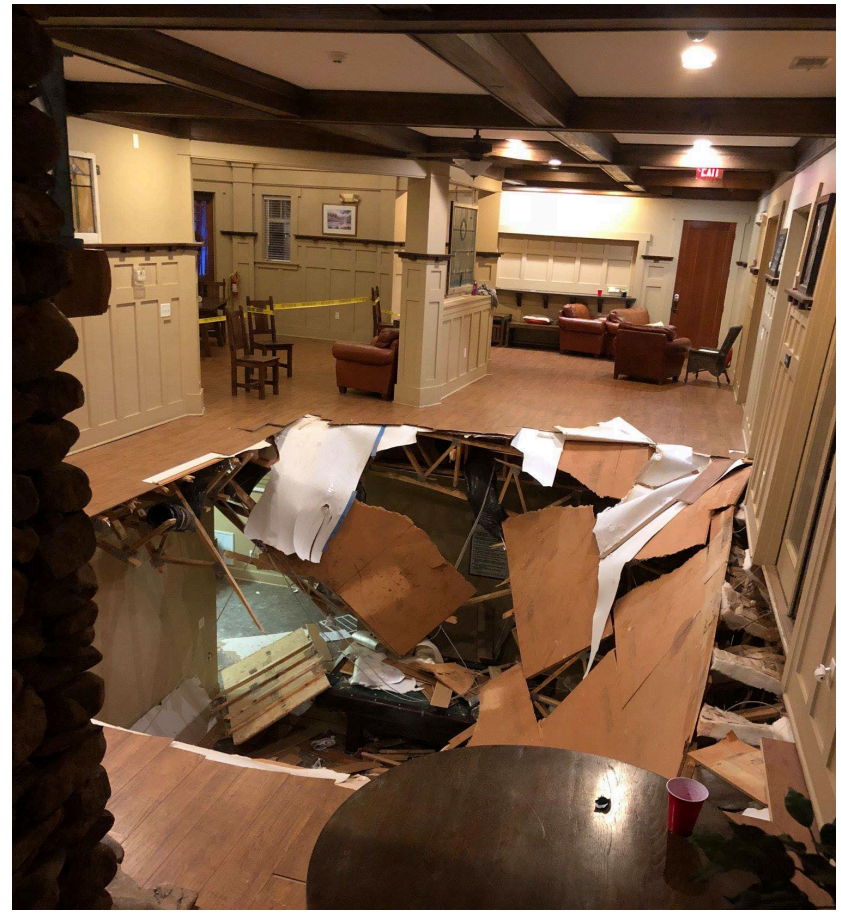
Live Loads:

- Too low in assembly areas and corridors that serve them. IBC Table 1607.1.
- Live loads over 50 psf are posted in a conspicuous location. IBC 106.1



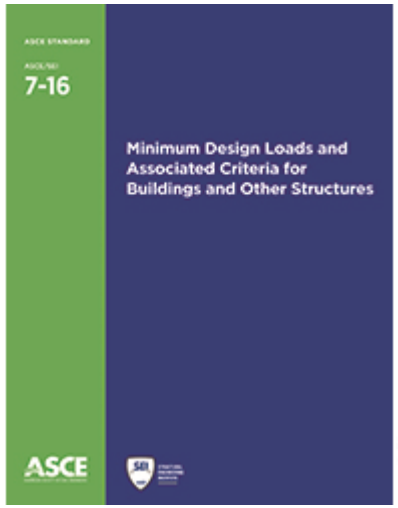
Dead Loads:

- Not coordinated with actual finishes and construction shown on architectural drawings.
    - Frequent mismatch between roof covering and number of layers of gypsum board.

Wind Loads:

- Exposure Category B chosen arbitrarily over Exposure Category C resulting in approximately 30% missing wind load.
- Missing parapet and overhang wind loads
- Partially enclosed buildings aren't designed for increased internal pressures

Wind Exposure Category



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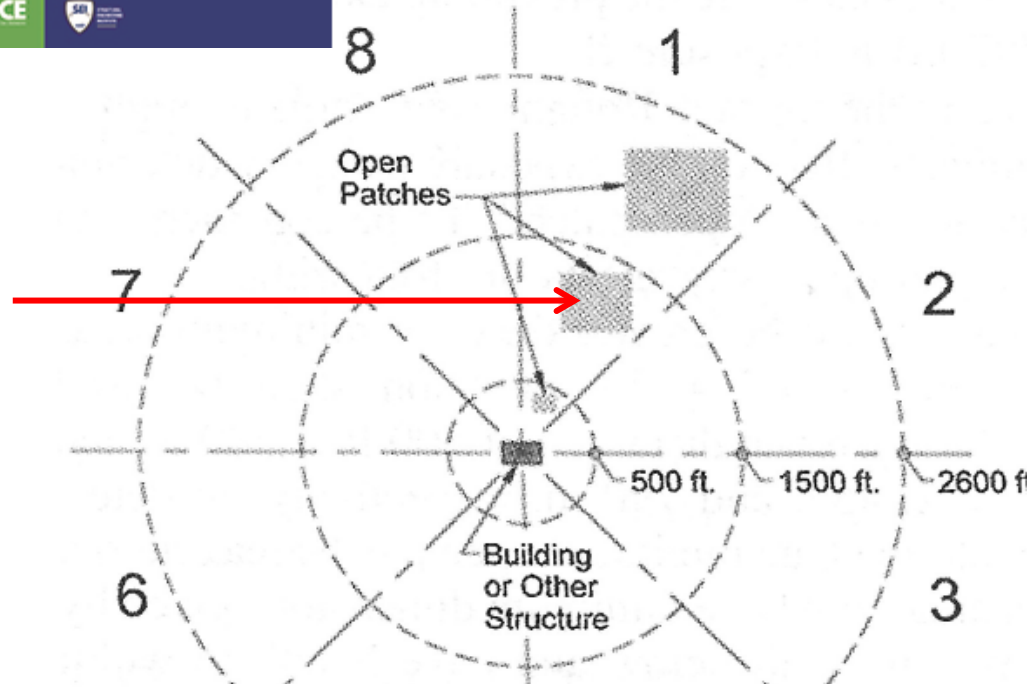
- Frequently *Exposure Category* B being used in inappropriate locations, resulting in less safe buildings.

- What ASCE 7 says:
  - For each wind direction the *Exposure Category* is to be determined by the worst case 45° sector.
  - *Surface Roughness* describes one quadrant considering open patches contribution.
  - *Exposure Category* describes the worst of the *Surface Roughness* in the two quadrants over the required distance from the structure.

- Many areas of Phoenix that are not developed are *Surface Roughness* C.

- Where *Exposure Category* B is used it is best to perform an analysis of the percent of open patches to confirm.



North direction Exposure Category is determined by worst case of quadrants 8 and 1

Wind Exposure Category Cont.

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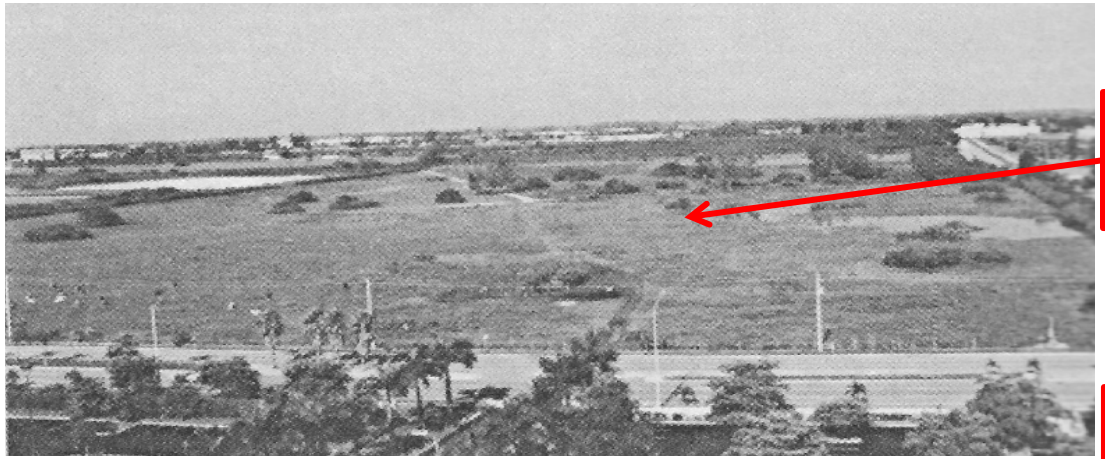
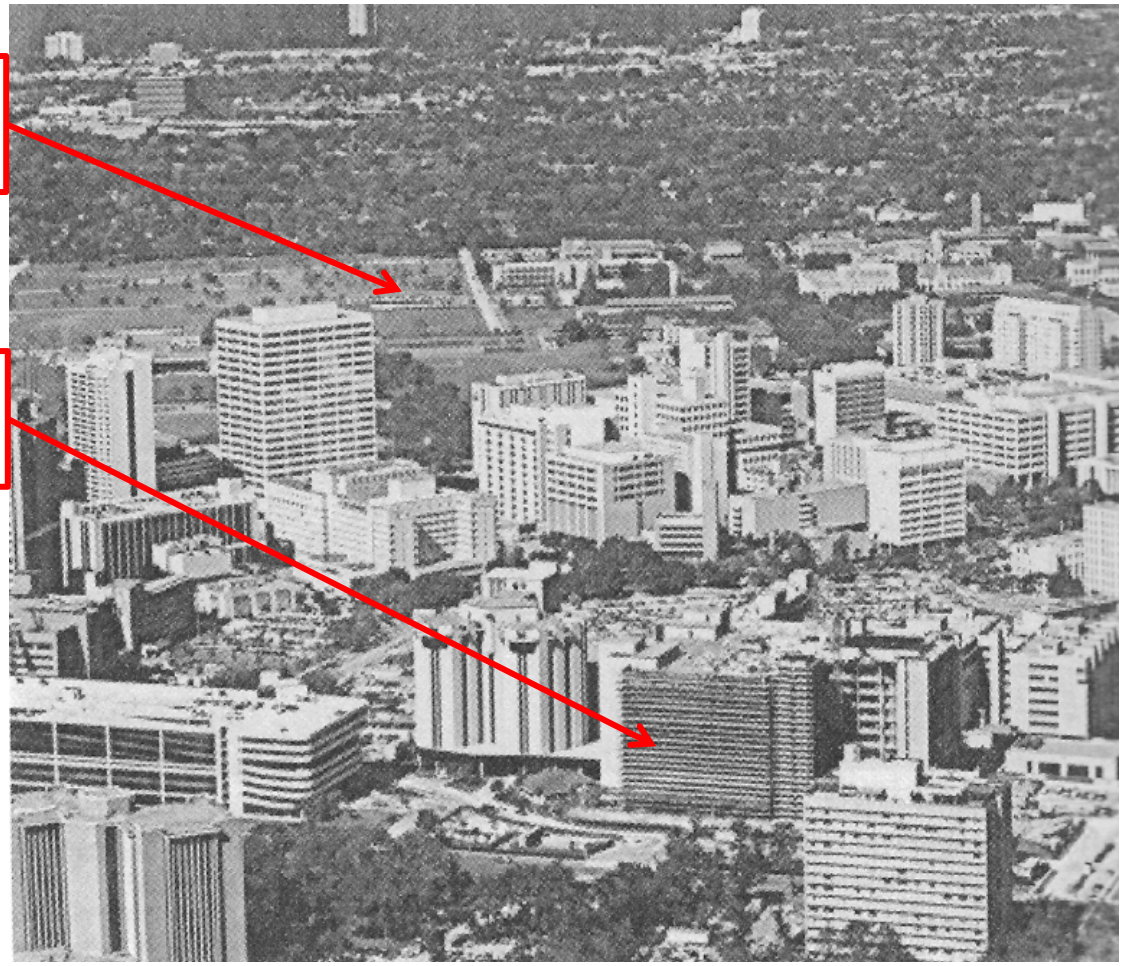
Surface Roughness B: Urban and suburban areas with numerous, closely spaced obstructions that have the size of single-family dwellings or larger



Roughness C

Roughness B



Surface Roughness C: Open terrain with scattered obstructions that have heights generally less than 30 feet.

Wind Exposure Category Cont.

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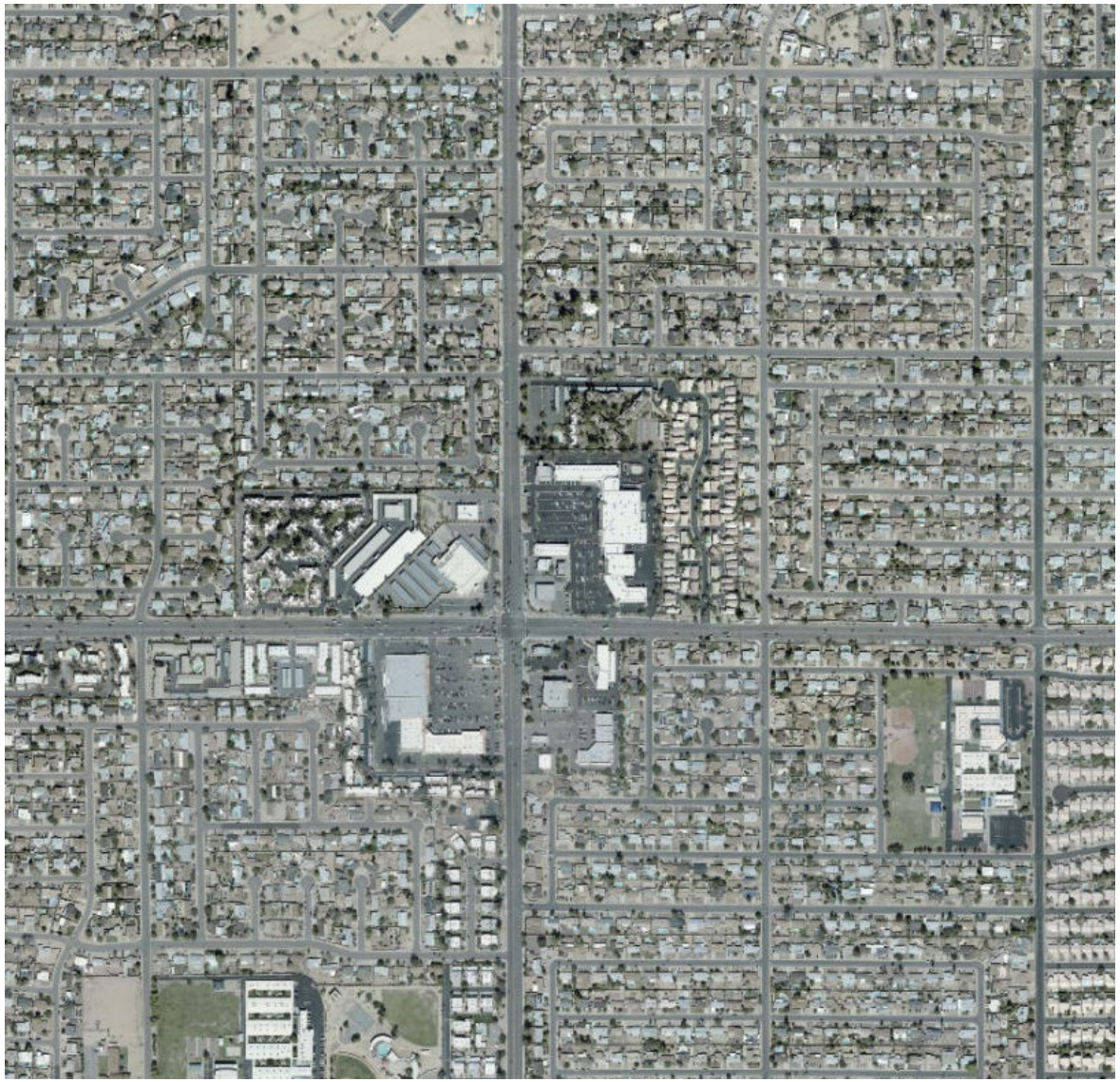

Phoenix is *Surface Roughness* C where not developed!

Wind on Parapets and Overhangs

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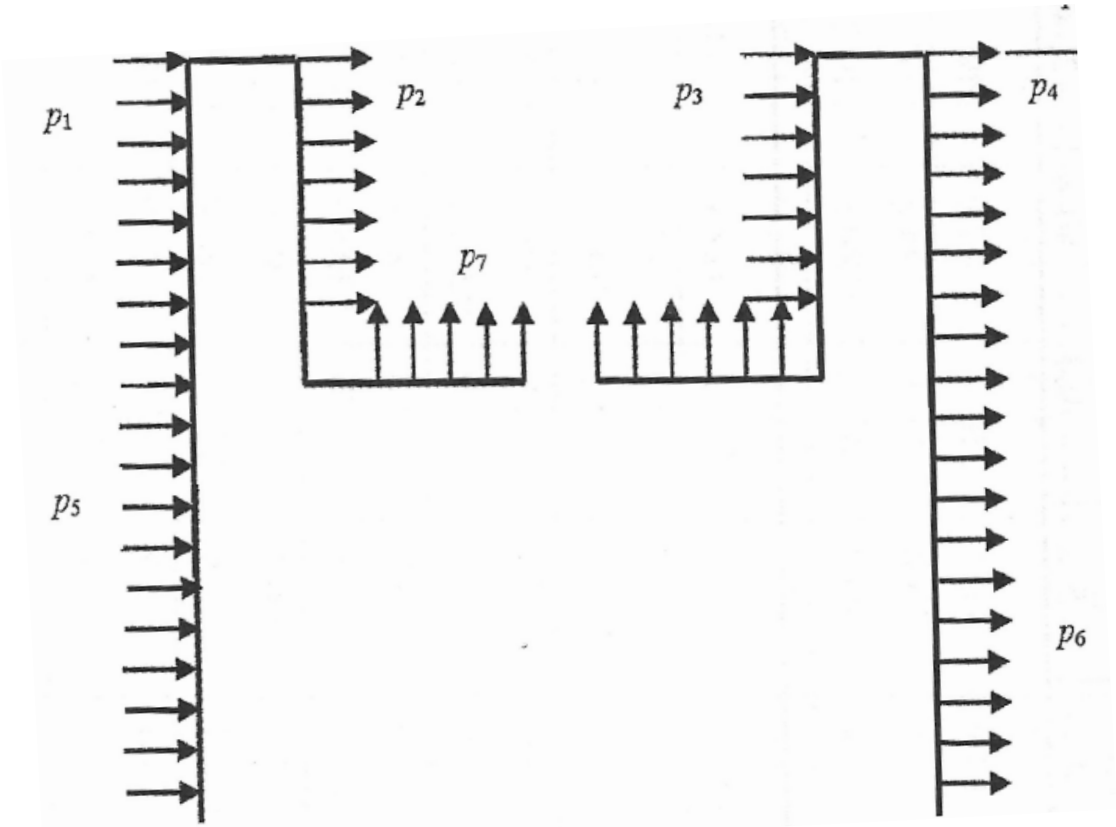
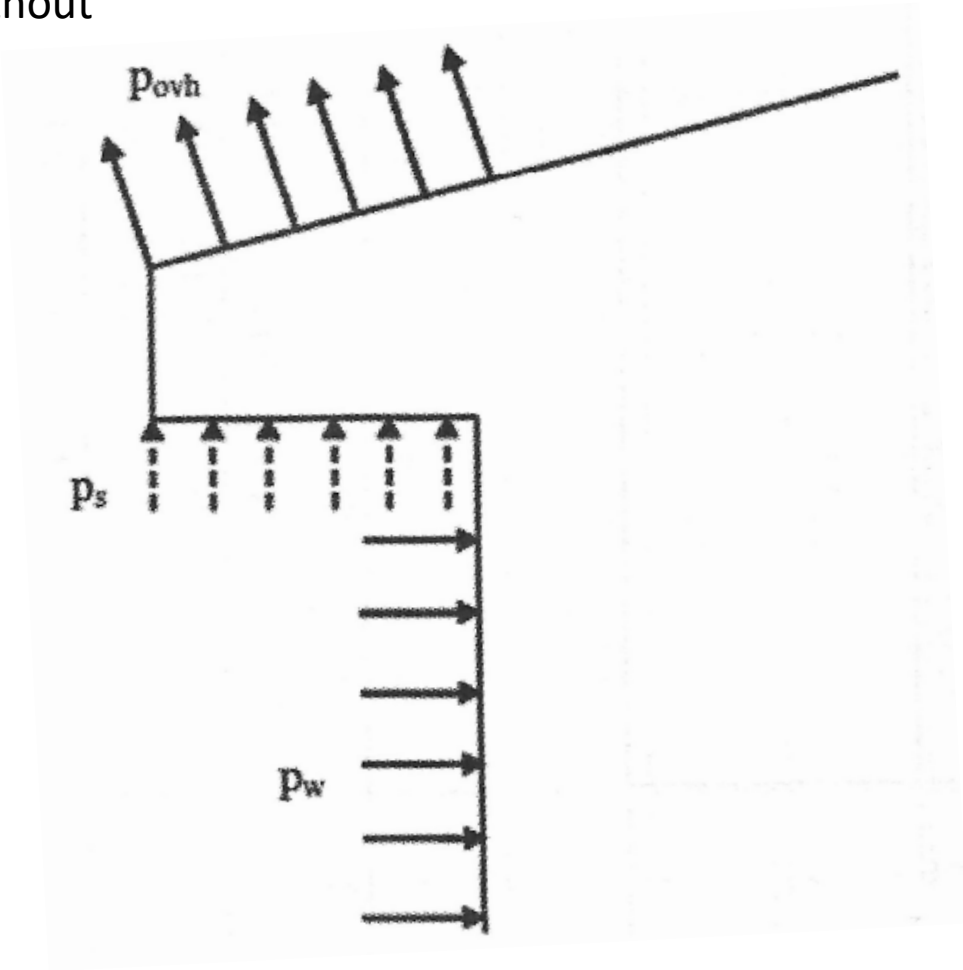
•Parapets and overhangs have high wind loads as the wind pushes on one side while it pulls on the other side.

•Buildings with parapets have much higher wind load than those without





Wind on Partially Enclosed Bldgs

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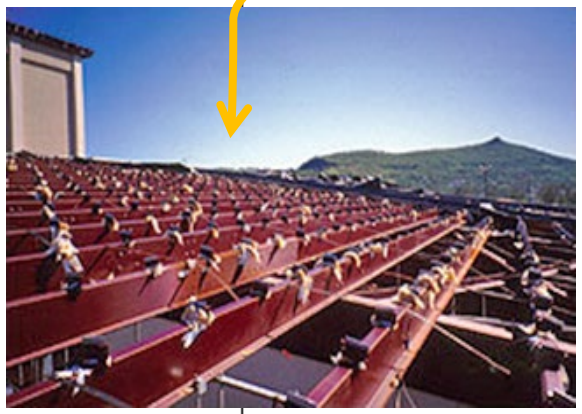
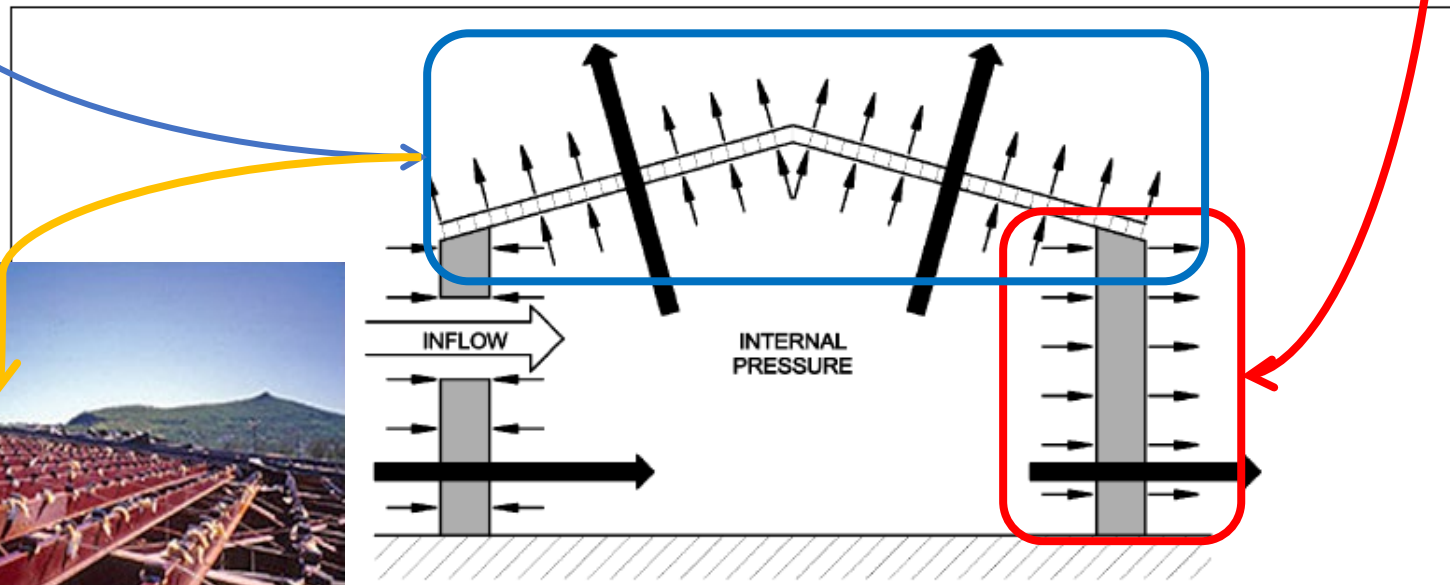
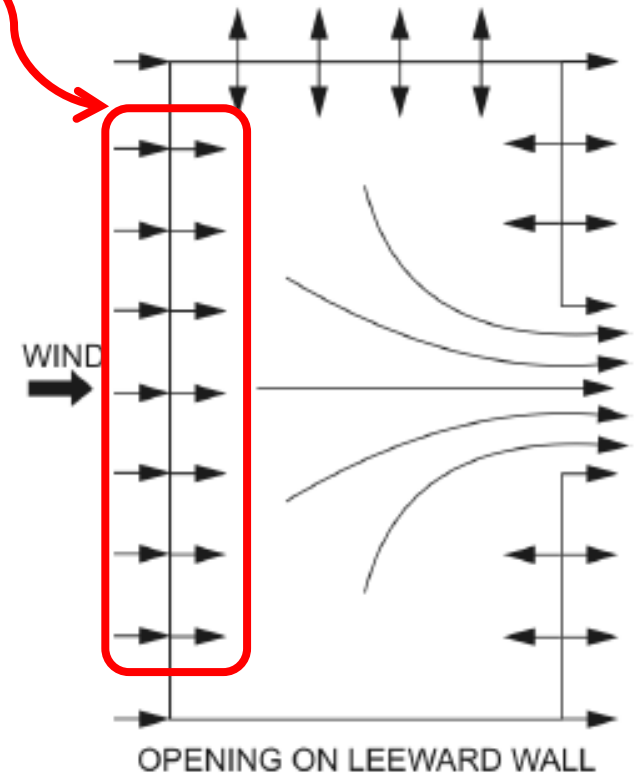
- Partially enclosed buildings have much higher internal pressures
- This results in higher forces on the individual components
- Requirements for wind loads on doors and exterior windows in IBC 1709.5… yes doors and windows are actually regulated





Commentary Figure 1609.2
EFFECTS OF OPENINGS IN THE BUILDING ENVELOPE



Commentary Figure 1609.1(2)
OPENING IN EXTERIOR WALL OF BUILDING

Common Load Issues Continued

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Earthquake Loads:

- Soil site class C chosen arbitrarily resulting in approximately 20% missing earthquake load
  - Sometimes dramatically large missing load if resulting Seismic Design Category is A used instead of B.
- Structure separation for earthquake pounding is not provided

Rain Loads:

- Rain ponding potential ignored or incorrectly checked only with strength and not stiffness.
  - ASCE 7-16 updated its definitions of susceptible bays to clarify where its required to check.
  - From 2007 to 2017 rain load building damage losses in Texas and Arizona were nearly equal to snow load losses in New England

Earthquake Building Pounding

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- Building pounding occurs when two adjacent buildings collide.
- Earthquakes cause pounding when adjacent building have little or no separation.
- Can be extremely severe if impact takes place between floor levels
- Phoenix is lucky that it's earthquake chances and motion are low, but they are not zero
- Only way to design for pounding is with separation.

Roof Rain Load and Ponding

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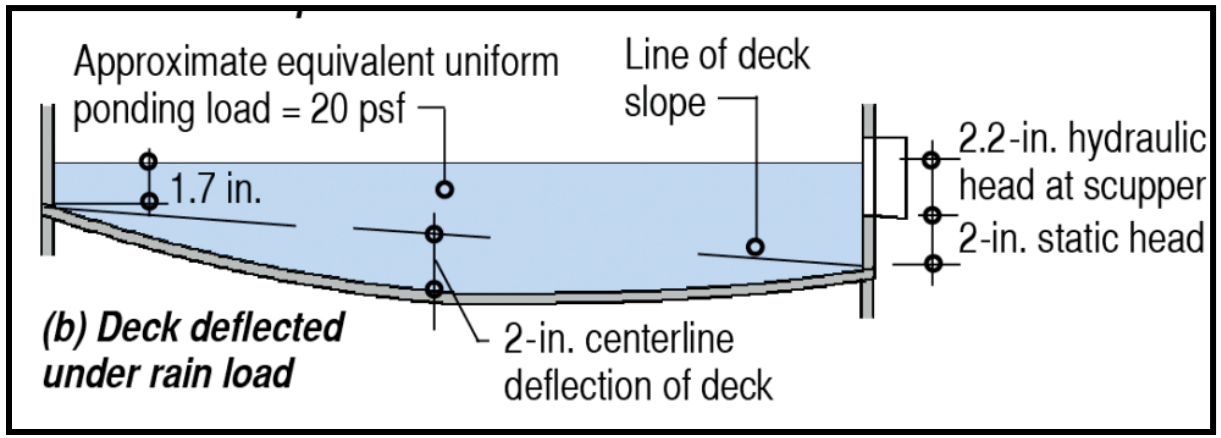

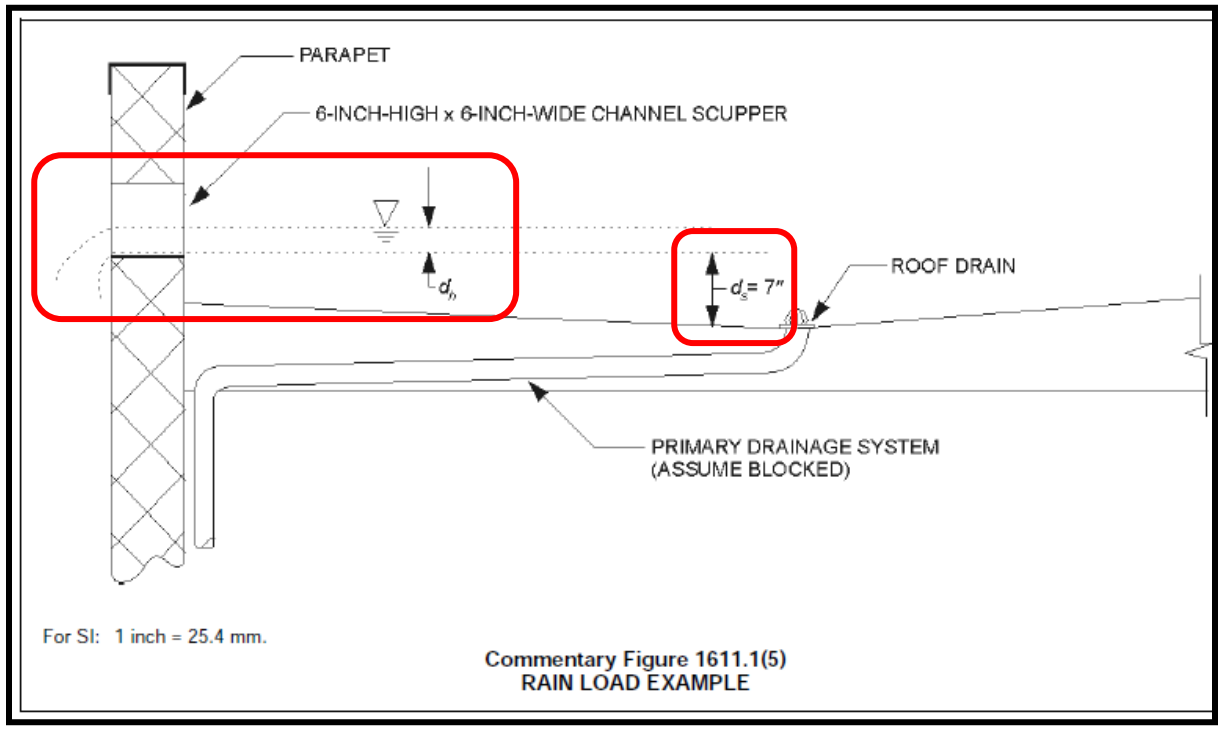

- Rain causes mild pond
- Roof deflects
- More water ponds
- Roof deflections more
- Continues until failure or equilibrium from stiffness

Overlapping Information with Architectural Details

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IBC 706 Fire walls – structural independence (Section 706.2)

706.2 Structural stability.
Fire walls shall have sufficient structural stability under fire conditions to allow collapse of construction on either side without collapse of the wall for the duration of time indicated by the required fire-resistance rating or shall be constructed as double fire walls in accordance with NFPA 221.

Overlapping Information with Architectural Details

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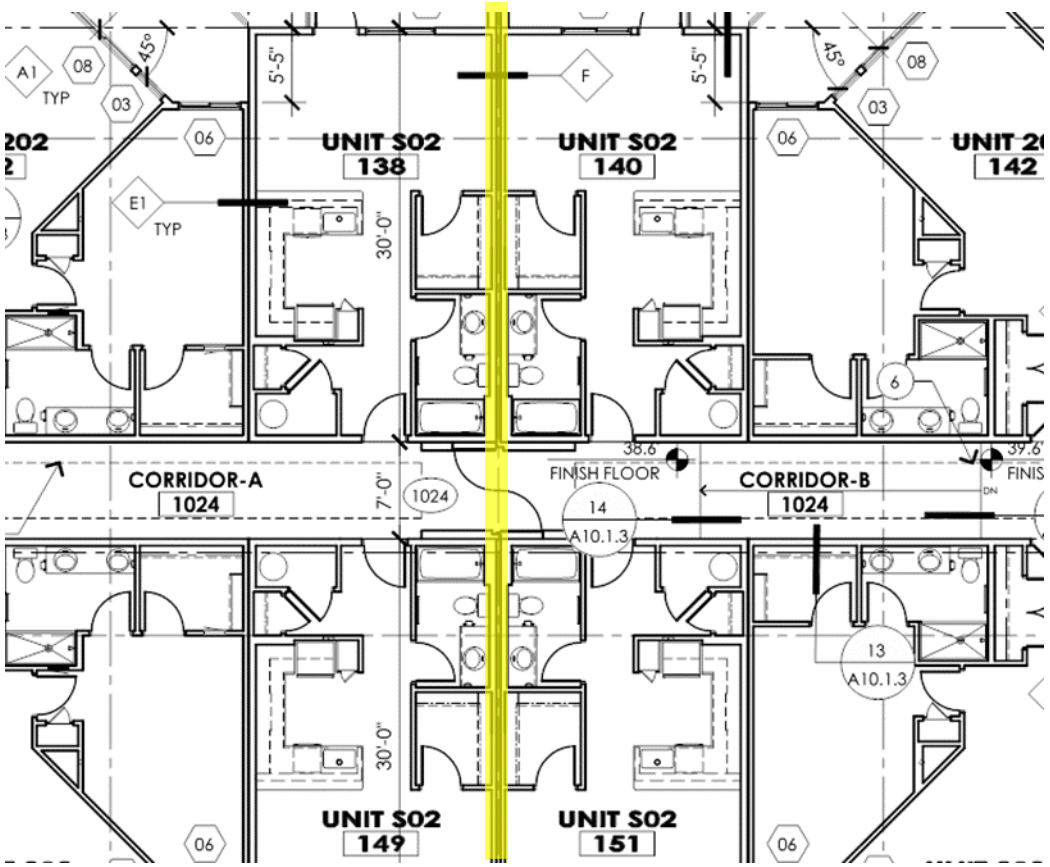

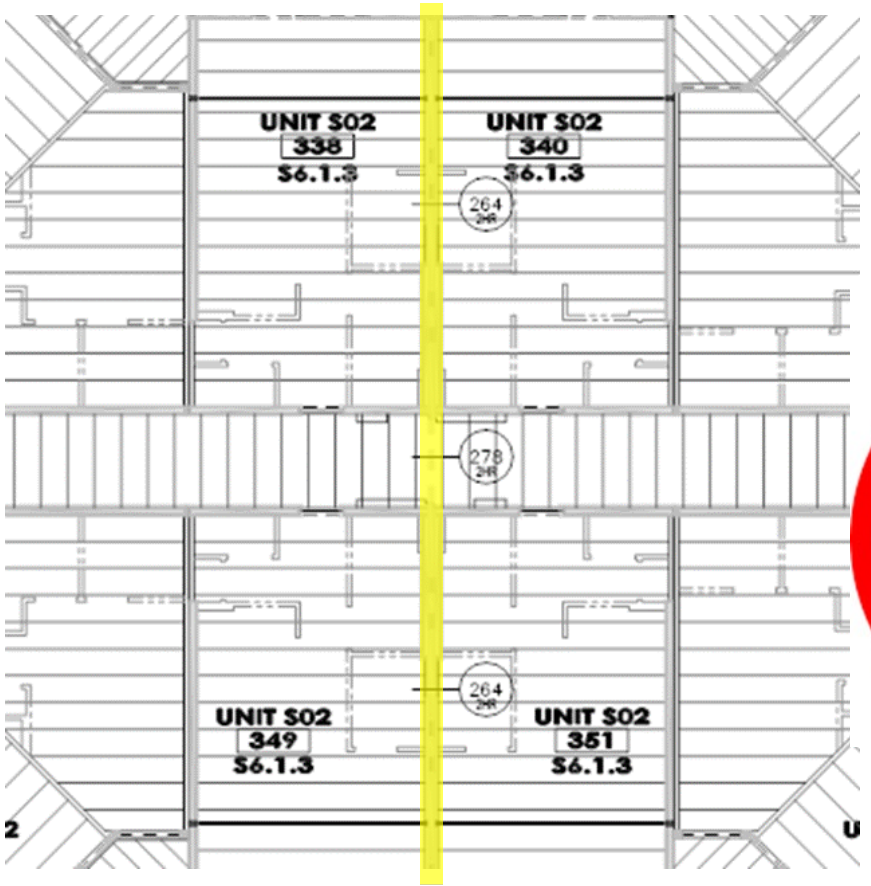

Overlapping Information with Architectural Details

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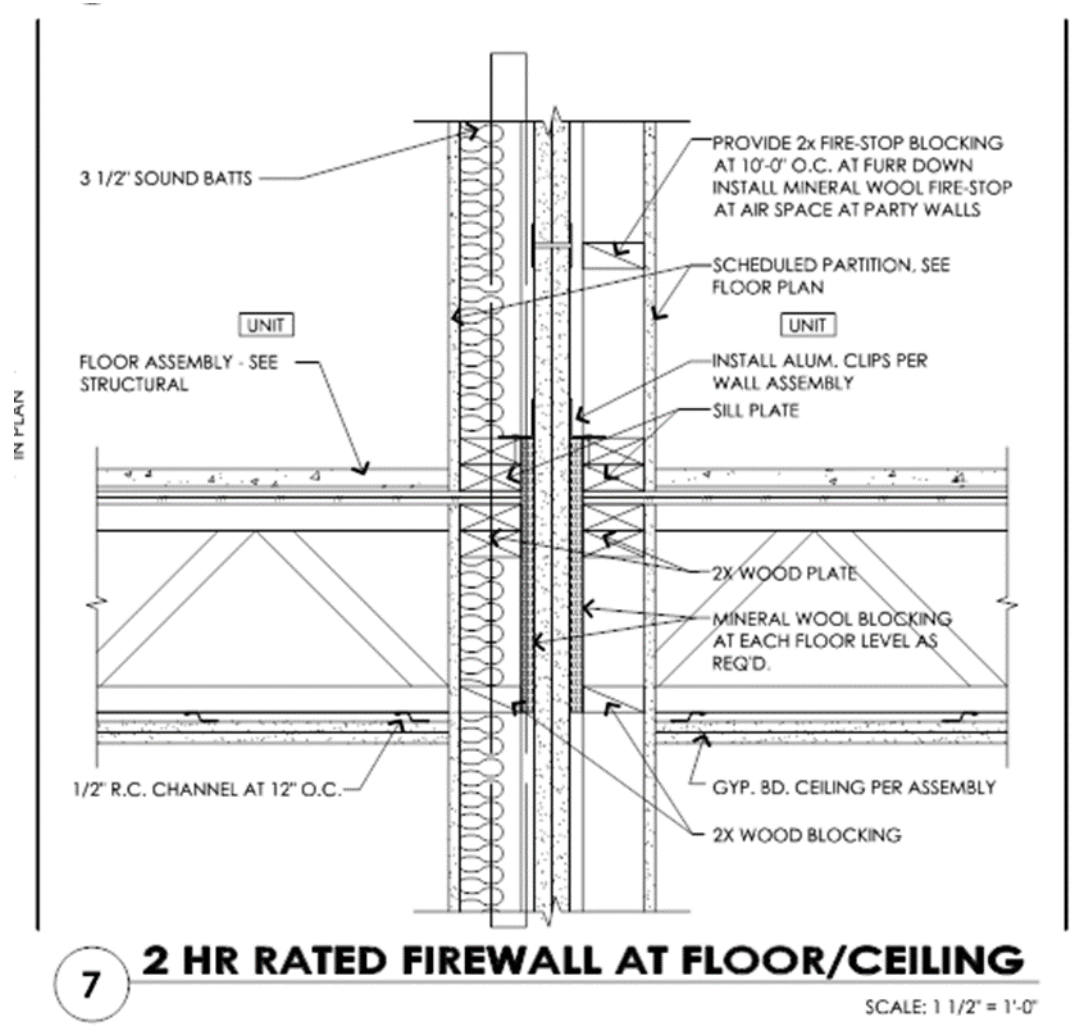
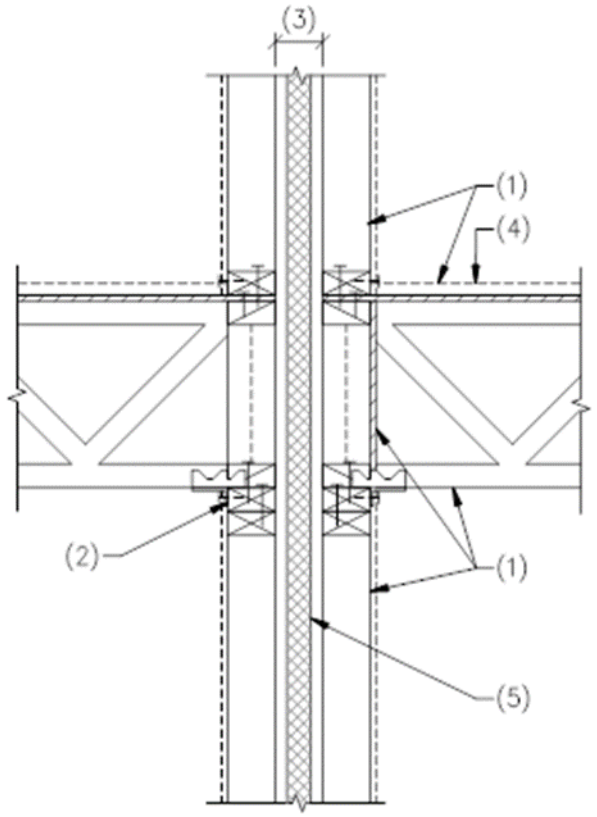


7 **2 HR RATED FIREWALL AT FLOOR/CEILING**

SCALE: 1 1/2" = 1'-0"



NOTES:

1. UNIT STUD WALL AND FLOOR FRAMING PER DETAIL 201.
2. CONTINUOUS 2X DOUBLE TOP PLATE WITH 16d AT 12" O.C.
3. GAP PER ARCH'L.
4. TOPPING PER PLAN.
5. 2 HOUR RATED ASSEMBLY PER ARCH'L.

NOTE:
A. DETAIL SYMMETRICAL ABOUT GAP.
B. AT SHEAR WALLS, PLATE AND SHEAR PANEL NAIL SPACING PER SHEAR WALL SCHEDULE.

264 PREFAB WOOD TRUSS AT WOOD STUD WALL – 2 HOUR WALL

14–1326 NO SCALE

Overlapping Information with Architectural Details

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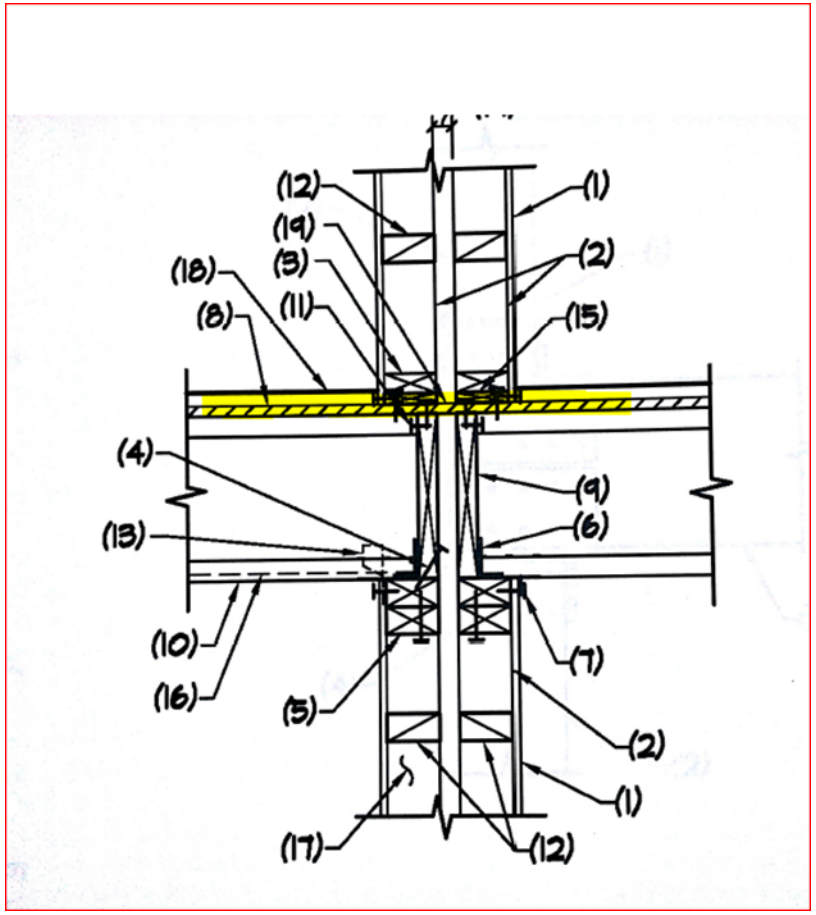

Overlapping Information with Architectural Details

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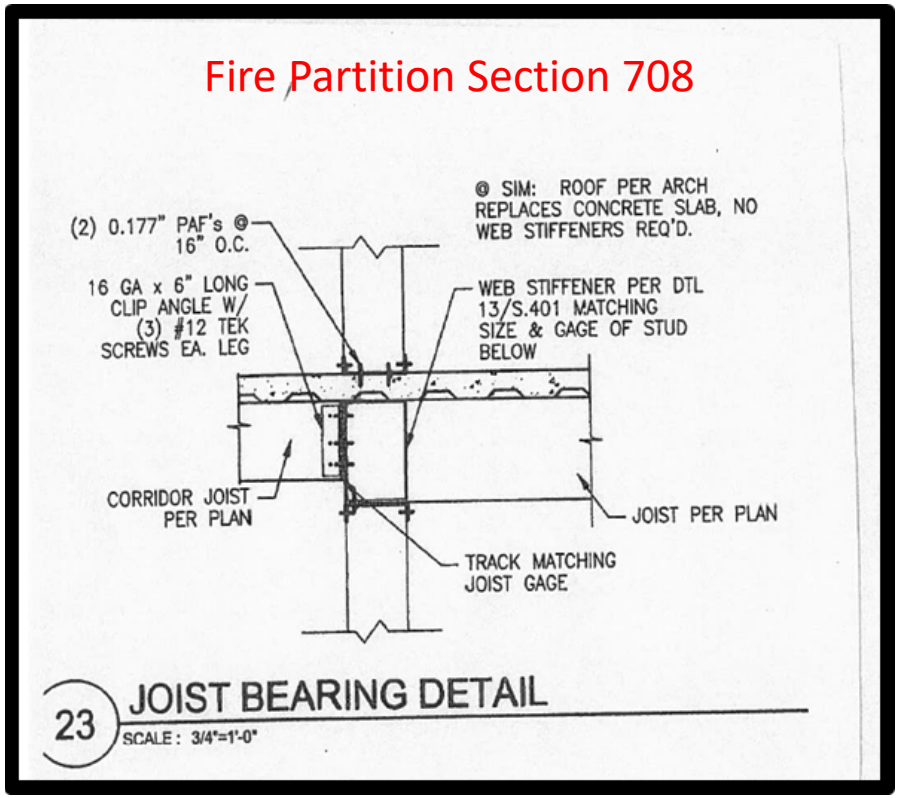
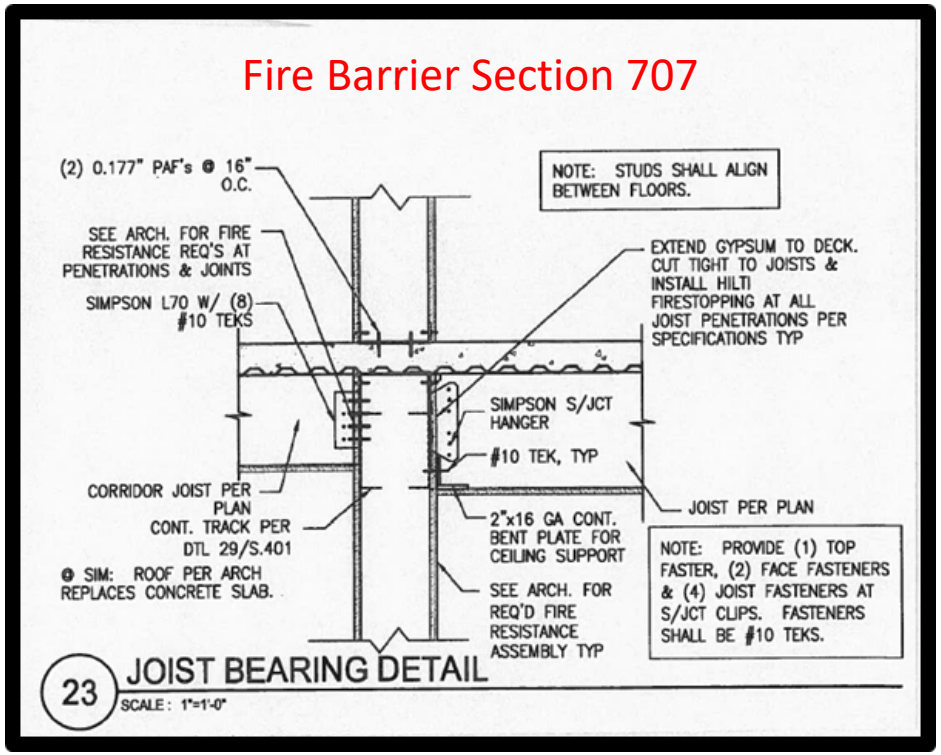
Fire Partition Section 708



Which Detail Should You Use?

Fire Barrier Section 707



Overlapping Information with Architectural Details

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IBC 704.2, 704.3, 704.4 – individual protection of structural members

- Columns
  - Individual encasement protection*
- Primary structural frame other than columns (see Chapter 2 for definition)
  - Individual encasement protection if supporting more than 2 levels of stuff
- Secondary members
  - Individual encasement or membrane protection

Overlapping Information with Architectural Details

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Part of Cedar Rapids building falls to the ground, damages vehicle

Published: Fri Jul 24 2020

Part of Cedar Rapids building falls to the ground, damages vehicle

Published: Fri Jul 24 2020

See IBC 1404.6 through 1404.10 for heavy veneer anchorage. Frequently links to TMS 402 and TMS 602.

Roof Framing Plan

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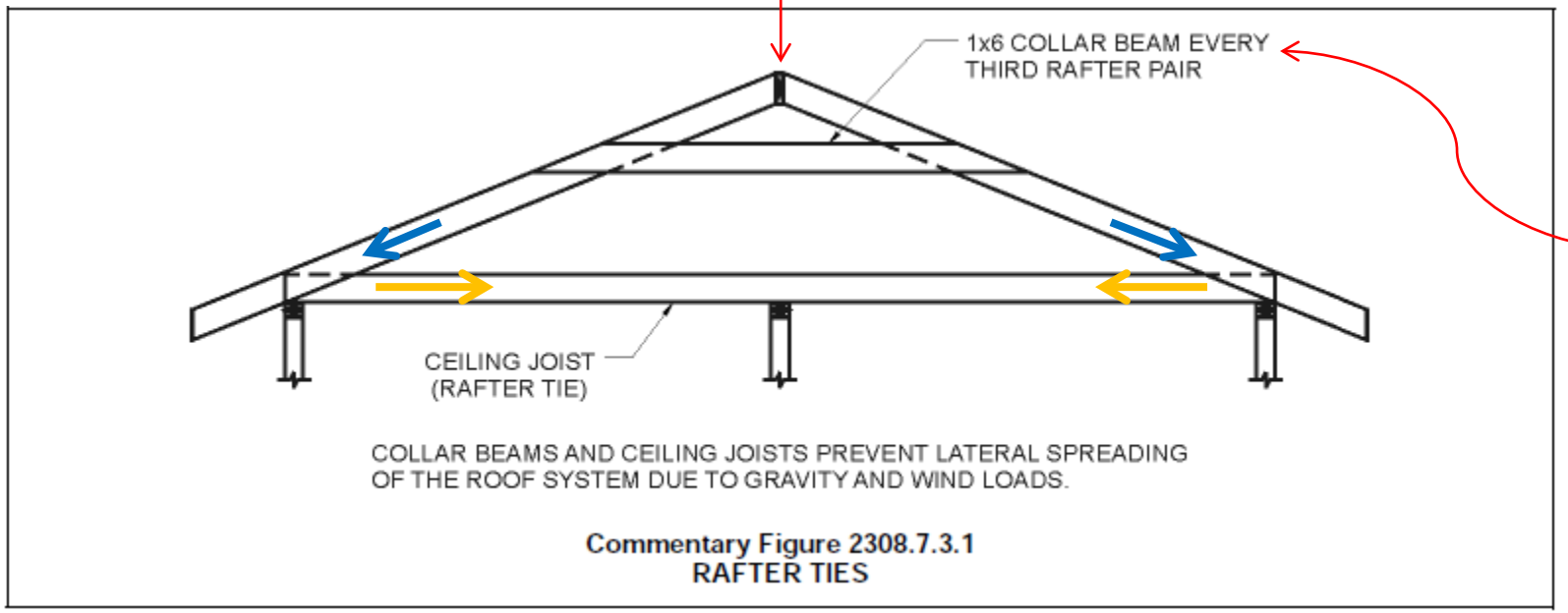
IRC and Conventional Roof Construction IBC 2308

- Ceiling joists are an integral part of the construction
- They resist the thrust outwards on the walls as there is no beam at the top of the ridge

Ridge board versus a ridge beam



COLLAR BEAMS AND CEILING JOISTS PREVENT LATERAL SPREADING OF THE ROOF SYSTEM DUE TO GRAVITY AND WIND LOADS.

Commentary Figure 2308.7.3.1
RAFTER TIES

These things are for wind uplift

Elevator Support

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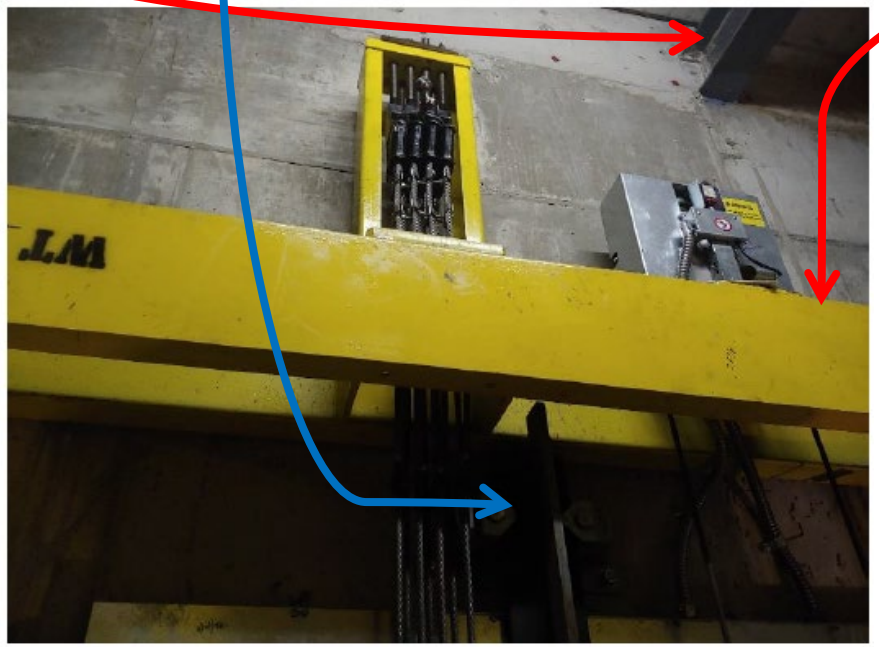
- Hoistway beams are only for construction and maintenance
- The guide rails infrequently take the loading of the elevators
- Elevators supported inside hoistways deliver their load to "elevator machine beams"



Picture 1: One of two sides supporting the elevator weight. The opposite side supports the drive motor and counterweight. Notice the hoist beam above. Elevators weight has traditionally been supported by the equipment and anchorages in elevator equipment rooms, above a hoistway, but these rooms are no longer common.

- Counterweights typically weigh 1.4 times the weight of the elevator

- Did you design your walls for this? Have columns for this? What happens at non-bearing walls?

- Add'l info in June 2014 structure magazine article

Picture 2: The same "dead" side that holds the side of the cables that do not move. This beam installed by the elevator manufacturer is supported by the hoistway wall. It is doubted this load was communicated to the building designer. This hoistway consists of both masonry and concrete walls.

Details

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Check Connections:
Failures very frequently occur at connections, so ensure the important connections are provided and they make sense.

Shear Walls and Diaphragms

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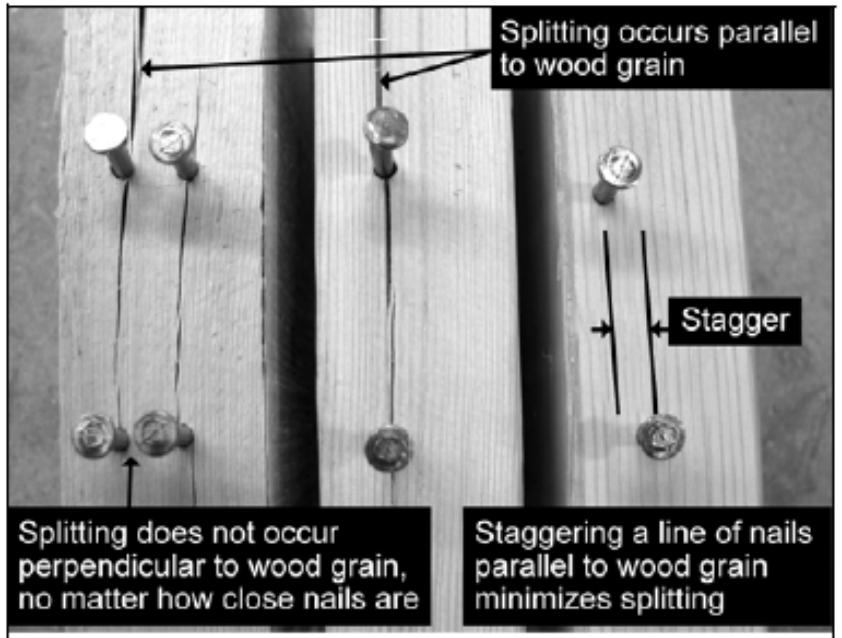
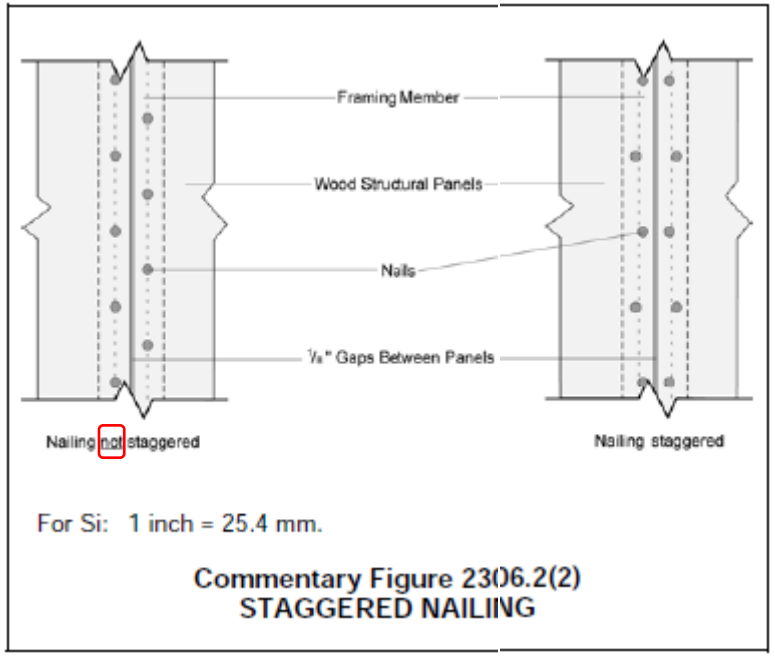
- That probably isn't staggered nailing in your diaphragm and shear wall panel edges typical detail



Commentary Figure 2306.2(1)
HOW WOOD SPLITS AND
HOW STAGGERING MINIMIZES SPLITTING



Commentary Figure 2306.2(2)
STAGGERED NAILING

Remodels and Alterations

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Must use IEBC.

- Show what the existing structure is and how your changes are incorporated into it.
- 5% gravity load rule clarified to 5% more load from dead, live, or snow load.
- Usually have a 10% lateral demand to capacity ratio rule.
- Older structures may not be capable of offsetting presumed Roof live load capacity with new dead load.

Lateral Load Detailing

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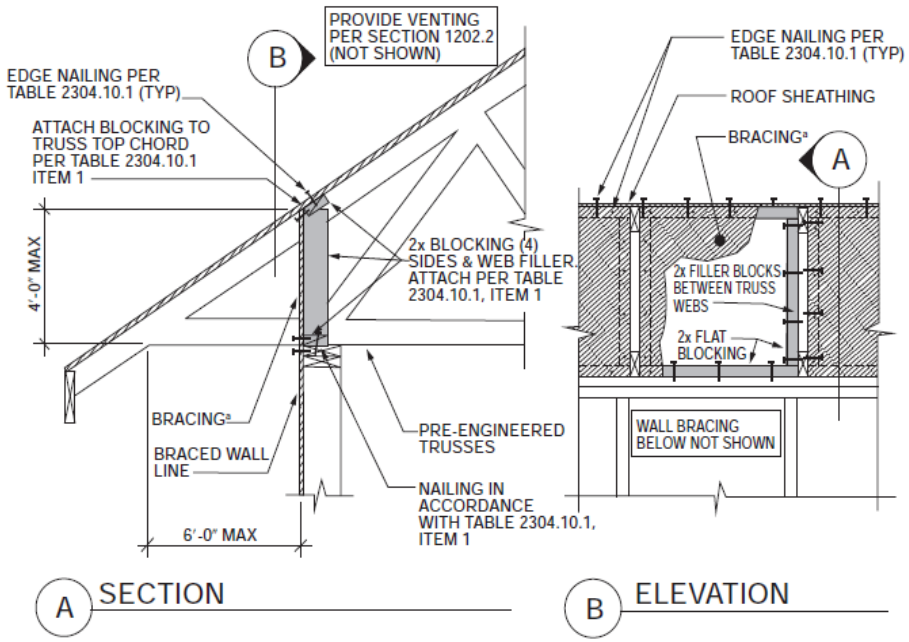
- Loads in the roof and floor diaphragms have a path to reach the shear walls

- Large openings in diaphragms and shear walls have reinforcement



a. Methods of bracing shall be as described in Table 2308.6.3(1) DWB, WSP, SFB, GB, PBS, PCP or HPS.

)4.8 mm.

FIGURE 2308.6.7.2(2)
BRACED WALL PANEL TOP PLATE CONNECTION

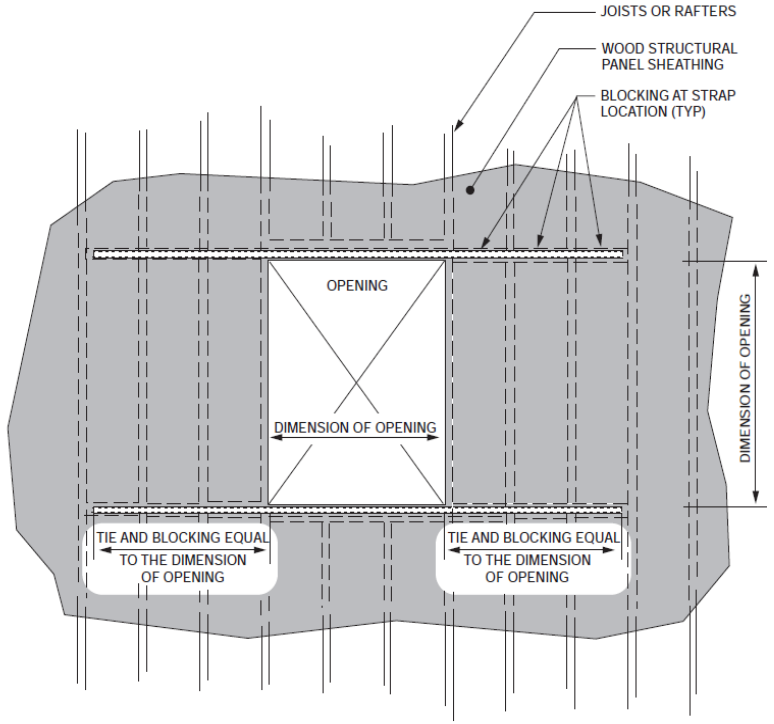


FIGURE 2308.4.4.1(1)
OPENINGS IN FLOOR AND ROOF DIAPHRAGMS

Wood Shrinkage

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IBC 2304.3.3 Shrinkage effects on wood framing over three stories

Shrinkage almost exclusively takes place perpendicular to the grain for wood, not longitudinally.

Scenario sprinkler lines to roof: (3) 2x10s platform framed and (12) 2x top plates or sills.

Assume Kiln Dried (KD) wood is specified (because you don't like getting sued from green wood at 30%). Moisture content = 19%.

S = (3 x 9.25"+ 12 x 1.5") x (19%-6%) x 0.002
S = 1.19 inches from foundation to roof plate

- If balloon framed then = 0.47 inches.
- Mixed wood and masonry/concrete structures.

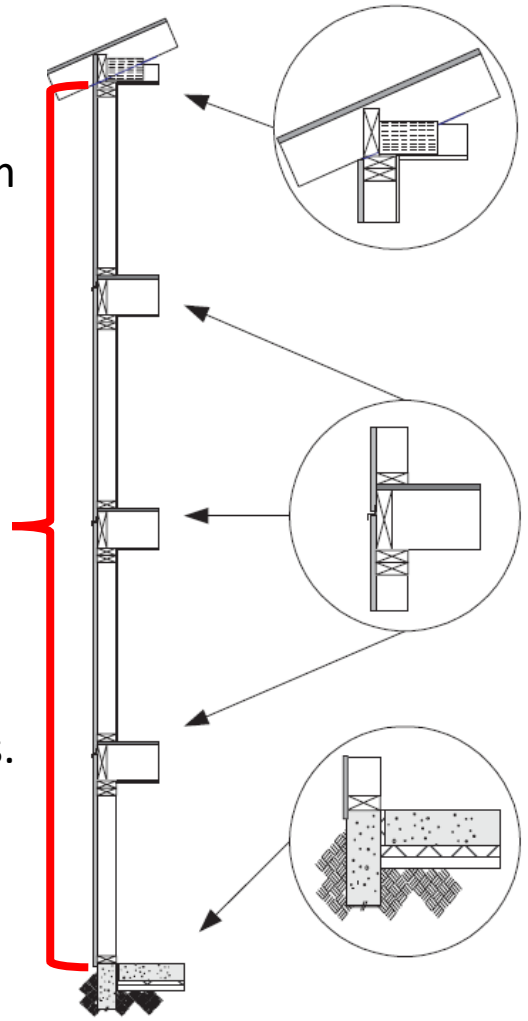

Table 1. Average Outdoor and Indoor EMC

Location	Average Outdoor EMC (%)	Average Indoor EMC (%)
Los Angeles, CA	10	9
San Diego, CA	12	10
Twentynine Palms, CA	6	6
San Francisco Bay Area	13	9
Sacramento Valley (CA)	11	8
N. Coast Red. (CA)	14	9
Sierra Nevada (CA)	11	7
San Joaquin Valley (CA)	11	8
Phoenix/Tucson, AZ	7	6

$S = D \times M \times C$ Where S = Shrinkage, inches
D = Dimension, inches
M = Change in moisture content, percent
C = Shrinkage coefficient, 0.0020 for Western softwood species

Lateral Load Detailing

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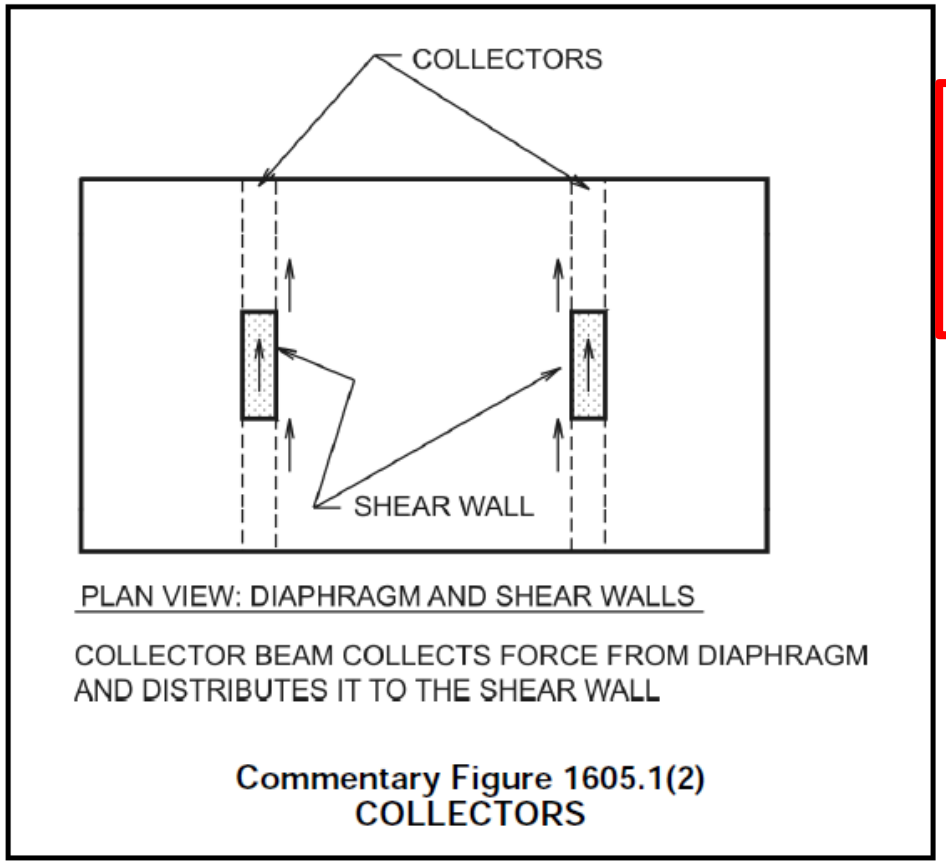
- Diaphragms have collectors provided so force can reach a shear wall

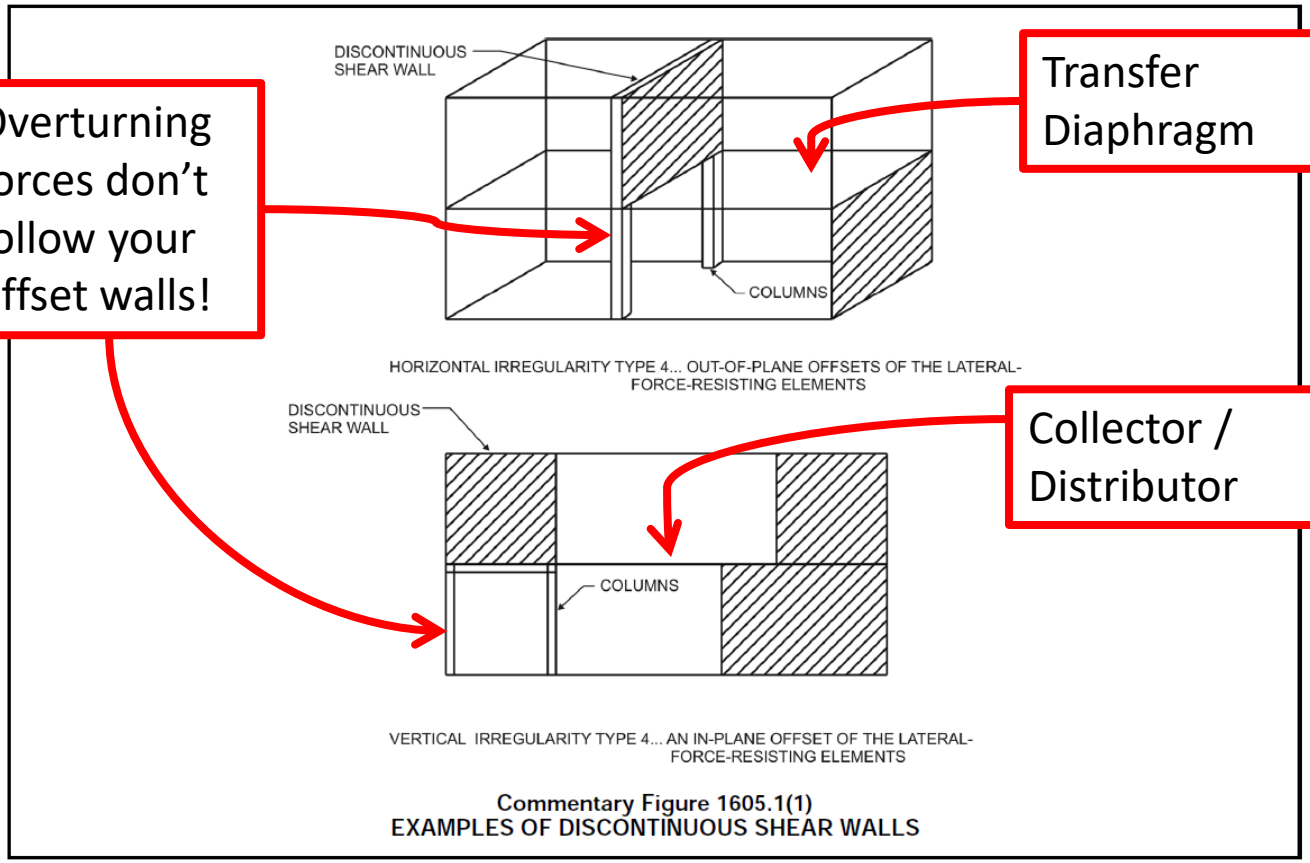
•Discontinuous shear walls have adequate detailing to transfer forces. This can get very complicated if you offset walls.



Overturning forces don't follow your offset walls!

Transfer Diaphragm

Collector / Distributor



Calculations

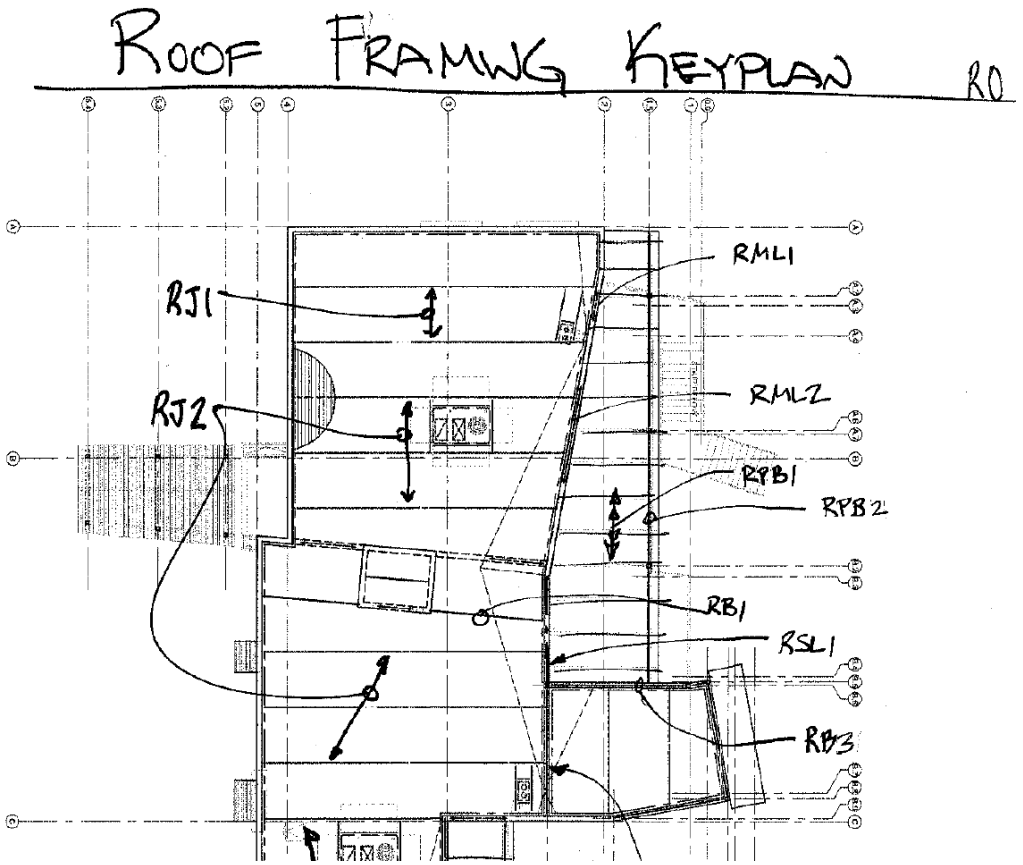
Data matches the GSN's

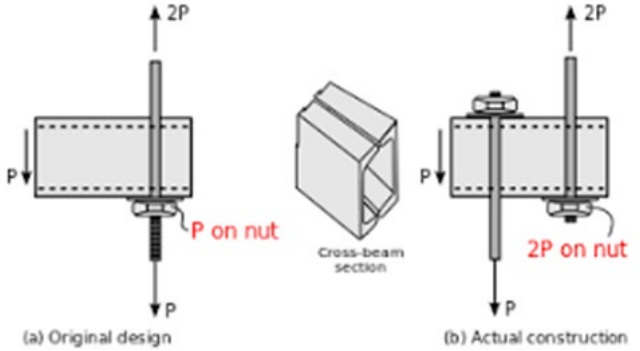
- Wind exposure
- Seismic data
- Soils data

Sketches of framing plans (keyed plans)

Summaries for program input and output

Hand calculations to validate connection details.





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QUESTIONS?

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