

Existing Building Evaluations Using the IEBC



COURSE DESCRIPTION

- Existing buildings offer a lot of unique opportunities and challenges when it comes to upgrades or modifications. IEBC prescribed alterations for existing buildings and additions can require creative solutions to address owner desired modifications.
- This presentation provides an understanding for IEBC code, the structural impacts from alterations, additions and methods of implementing structural improvements.



LEARNING OBJECTIVES

At the end of this course, participants will be able to:

1. Understand the three compliance methods of the IEBC

2. Know when a seismic retrofit will be required for an existing building

3. Structural upgrades that happen during a re-roof.

4. How framing is retrofitted to support heavier loads.

5. How existing buildings might be strengthened.



A Brief History Lesson of Existing Building Codes

IEBC Rules of Thumb

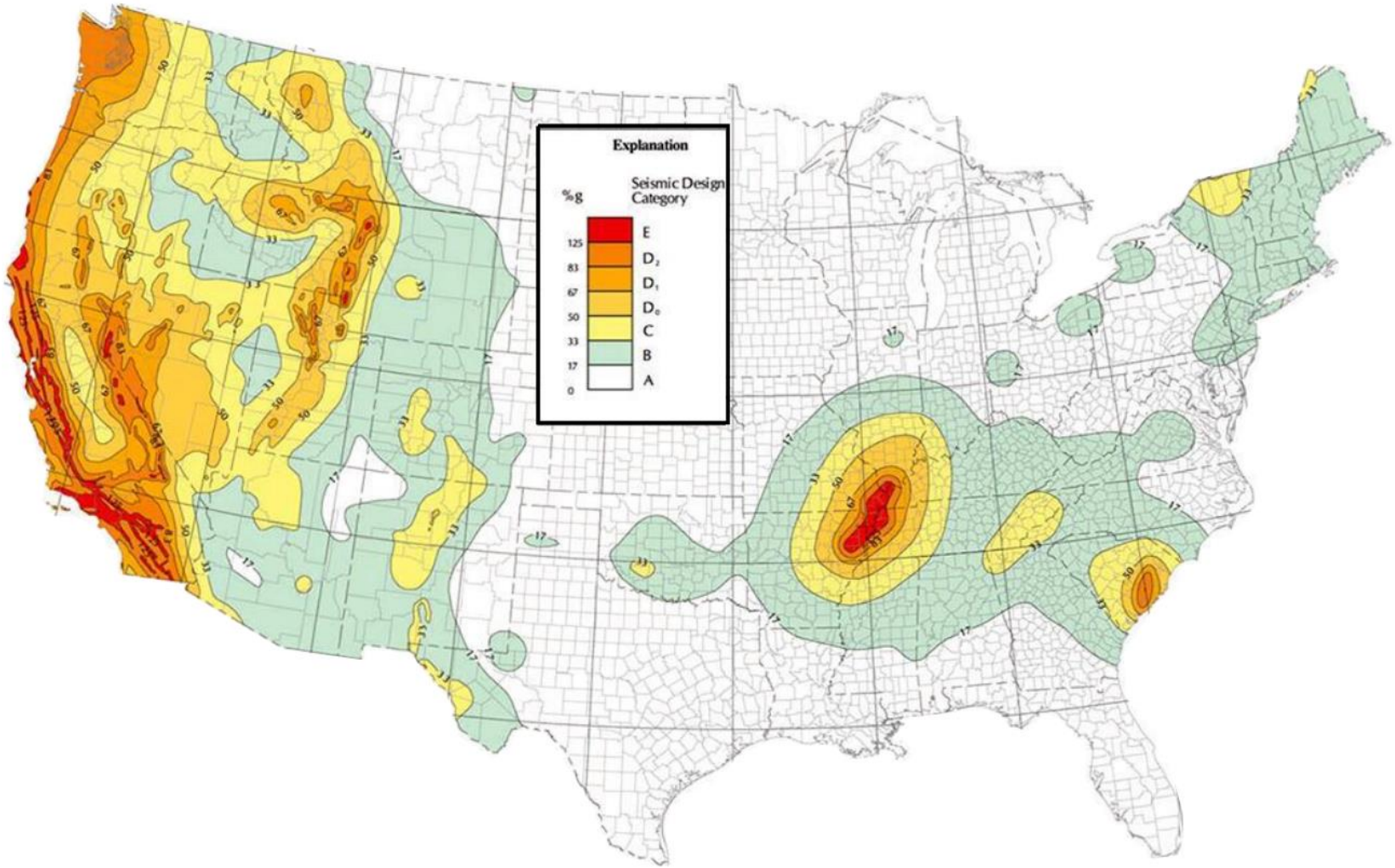


Rule of Thumb – Work Area

- Portion of building consisting of reconfigured spaces.
- Rooms, floors, entire wings of building or just specific walls, ceilings or structural elements.



Rule of Thumb – Seismic Design Category



Rule of Thumb – 5% and 10% Rules

Cannot increase loading by more than:

5% for Gravity
- RTU
- Topping slab
- Higher live load
- Snow drift
- Column removal

10% for Lateral
- Brick veneer
- Opening in shear wall

Cannot decrease capacity.







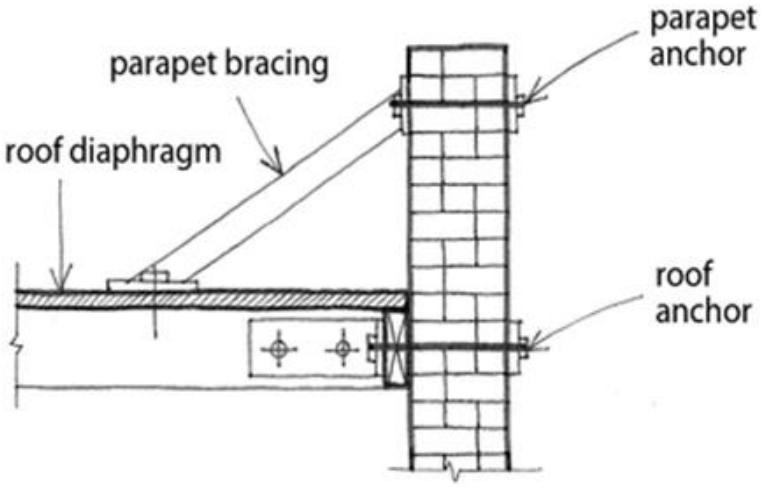
Rule of Thumb – Bracing Walls

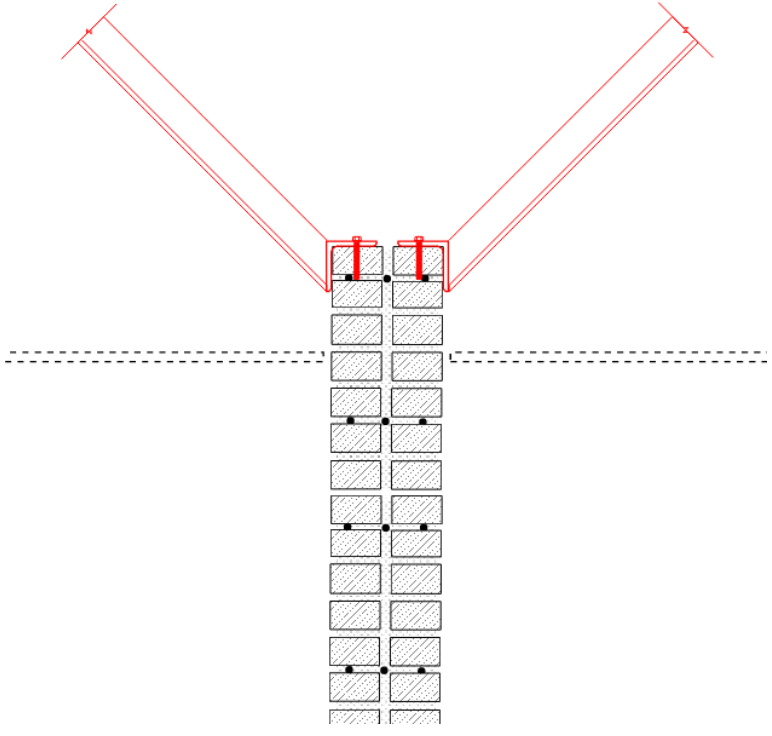
Bracing of Unreinforced Masonry (URM) parapets on reroofing

- Usually done with diagonal parapet kickers
- The Utah Construction Code also includes appendages such as cornices, spires, towers, tanks, signs, statuary, etc.,

Bracing of Unreinforced Masonry (URM) partitions

- Usually done with diagonal bracing above ceiling level
- All walls withing work area and adjacent to egress paths





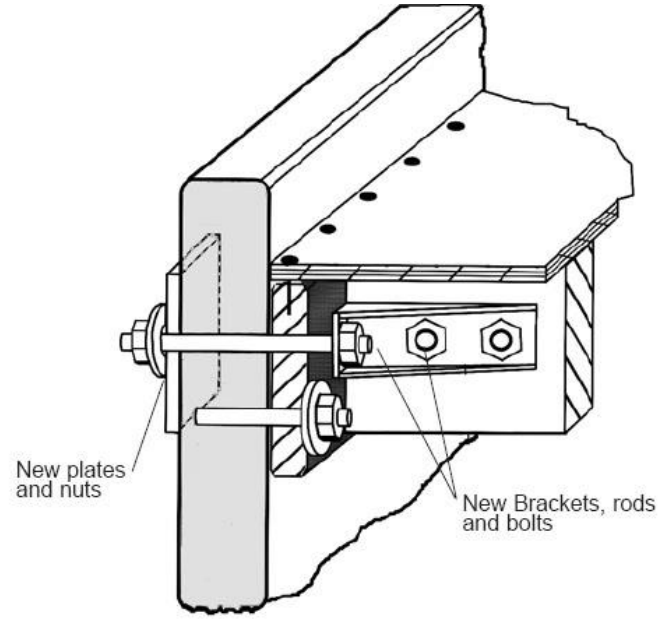
Rule of Thumb – Anchoring Walls

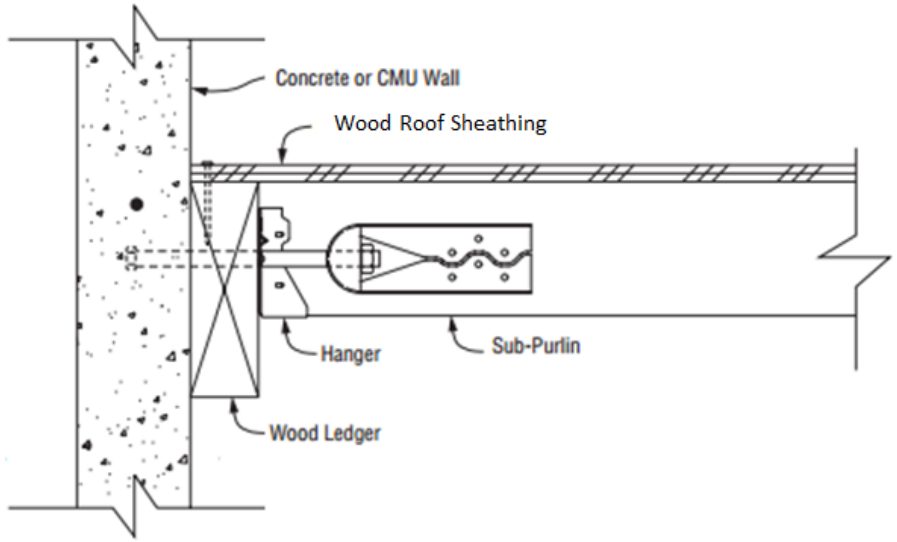
Anchorage for concrete and reinforced masonry walls

- Wall anchors at roof line of wood or metal roofs.

Anchorage for URM walls

- Wall anchors at floor and roof lines of all roofs





Rule of Thumb – Addition



- Extension or increase in floor area, number of stories or height of an existing structure

Rule of Thumb – Alteration

- Construction or renovation to an existing structure, other than a repair or addition



Rule of Thumb – Substantial Structural Alteration

- Alterations to gravity structural members that support more than 30%* of the total floor and roof area within a 5-year period.

**Includes mezzanines, penthouses, and in-filled courts and shafts*

$$\frac{30\%}{5 \text{ Years}}$$

Rule of Thumb – Change of Occupancy

Change of Occupancy - Change in use of building from original design intent

Building Risk Categories

- Category I – Low hazard to human life – Agricultural facilities, certain temporary facilities
- Category II – Typical Building – Office, Residential
- Category III – Substantial hazard to human life – K-12 and Higher Ed Schools, Public Assembly
- Category IV – Highest Risk. Essential Facilities such as Police and Fire Stations, Hospital



Risk Category I	97 mph
Risk Category II	103 mph
Risk Category III	109 mph
Risk Category IV	113 mph

Risk Category from Table 1.5-1	Snow Importance Factor, I_s	Ice Importance Factor—Thickness, I_i	Ice Importance Factor—Wind, I_w	Seismic Importance Factor, I_e
I	0.80	0.80	1.00	1.00
II	1.00	1.00	1.00	1.00
III	1.10	1.15	1.00	1.25
IV	1.20	1.25	1.00	1.50

Rule of Thumb – Design Criteria

Considering New and Replacement Materials

Full IBC

- 100% of the prescribed forces
- Classified as “Ordinary” unless it can be demonstrated that “Intermediate” or “Special” system detailing can be achieved

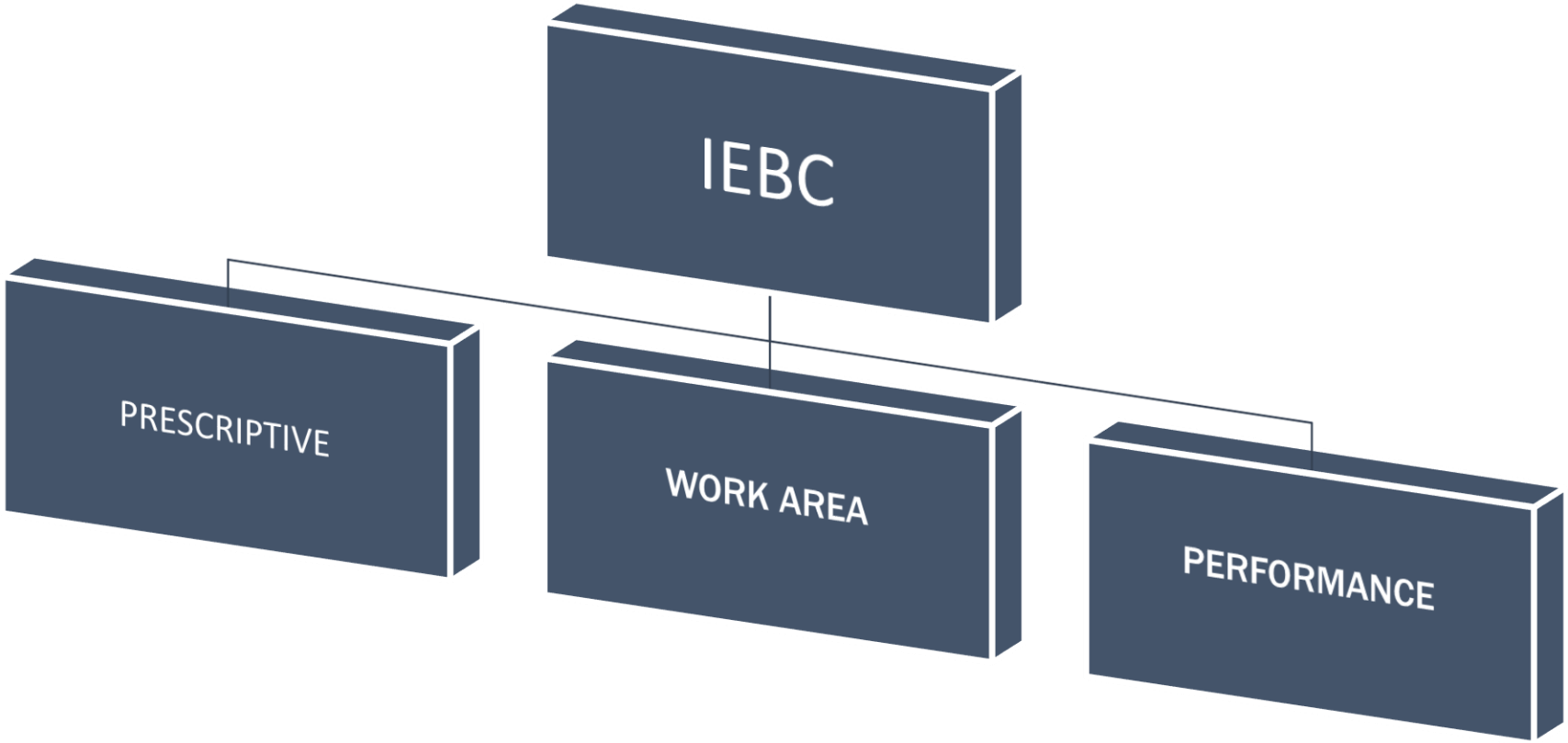
Evaluating Existing Materials

Reduced IBC

- 75% of prescribed forces
- Alternate approaches with ASCE 41 or IEBC App. A



Methods to Approach an Existing Building



Prescriptive Method (Ch. 5)

Additions

- 5% rule and 10% rule – Always
- Structurally independent additions must satisfy Full IBC
- Structurally "tied" addition – existing and new must satisfy Full IBC if 10% rule cannot be met

Prescriptive Method (Ch. 5)

Alterations

- 5% and 10% rules - Always
- Bracing of URM parapets on reroofing (SDC: C, D and E) – Roof area exceeds 25%
- Bracing of URM partitions (SDC: C, D and E) – Work area exceeds 50%
- Anchoring concrete and RM walls to roof (SDC: C, D and E) – Work area exceeds 50%
- Anchoring URM walls to roof and floor (SDC: C, D and E) – Work area exceeds 50%

Substantial structural alteration and SCD F

- Altered building must satisfy Reduced IBC code– Work area exceeds 50%

Voluntary lateral alterations (upgrades)

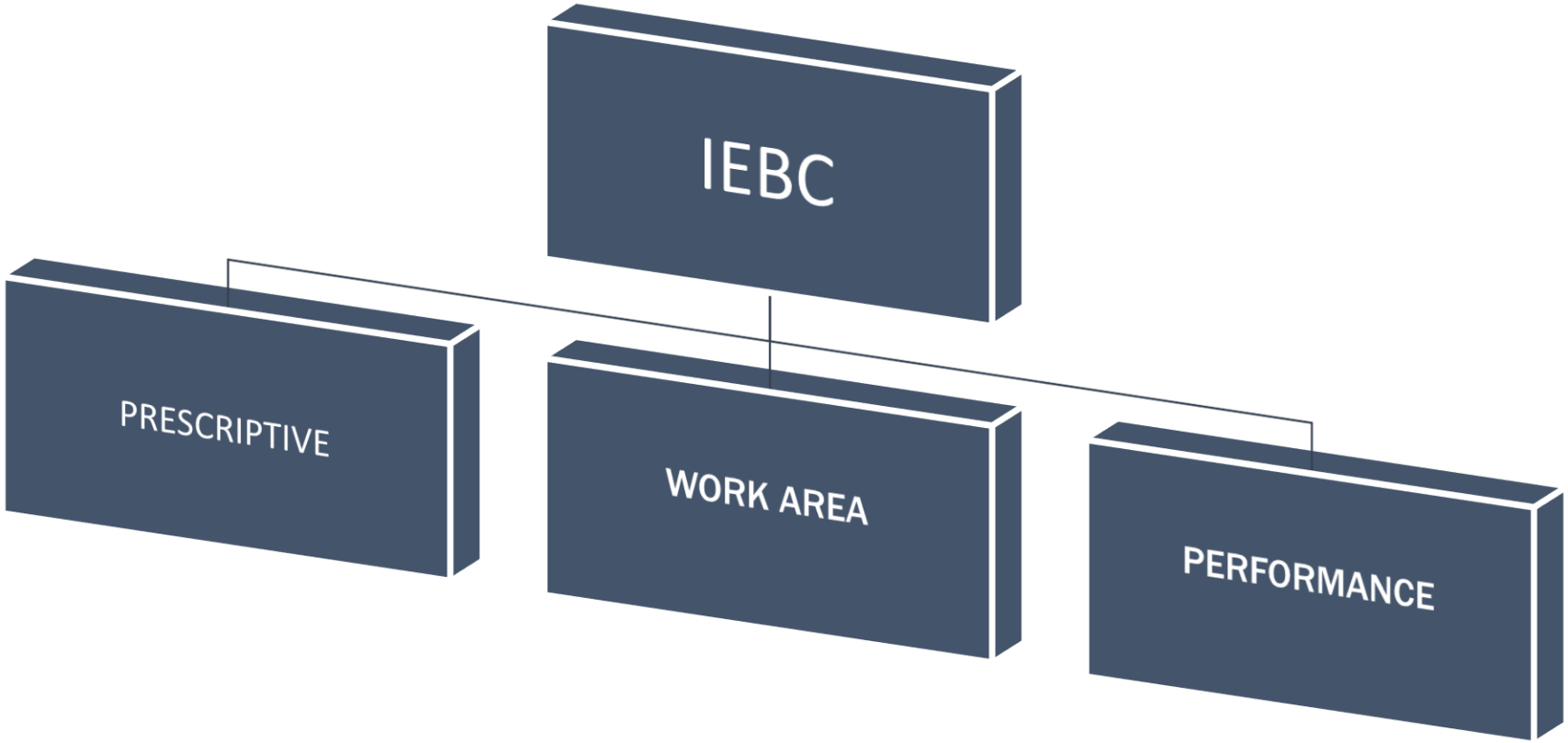
- Anything intended to improve lateral systems but not required by any other "triggers" does not need to meet a specific code level force.
- Cannot reduce capacity of existing lateral system
- New elements and their connections to existing elements must comply with Full IBC forces
- A structural irregularity cannot created

Prescriptive Method (Ch. 5)

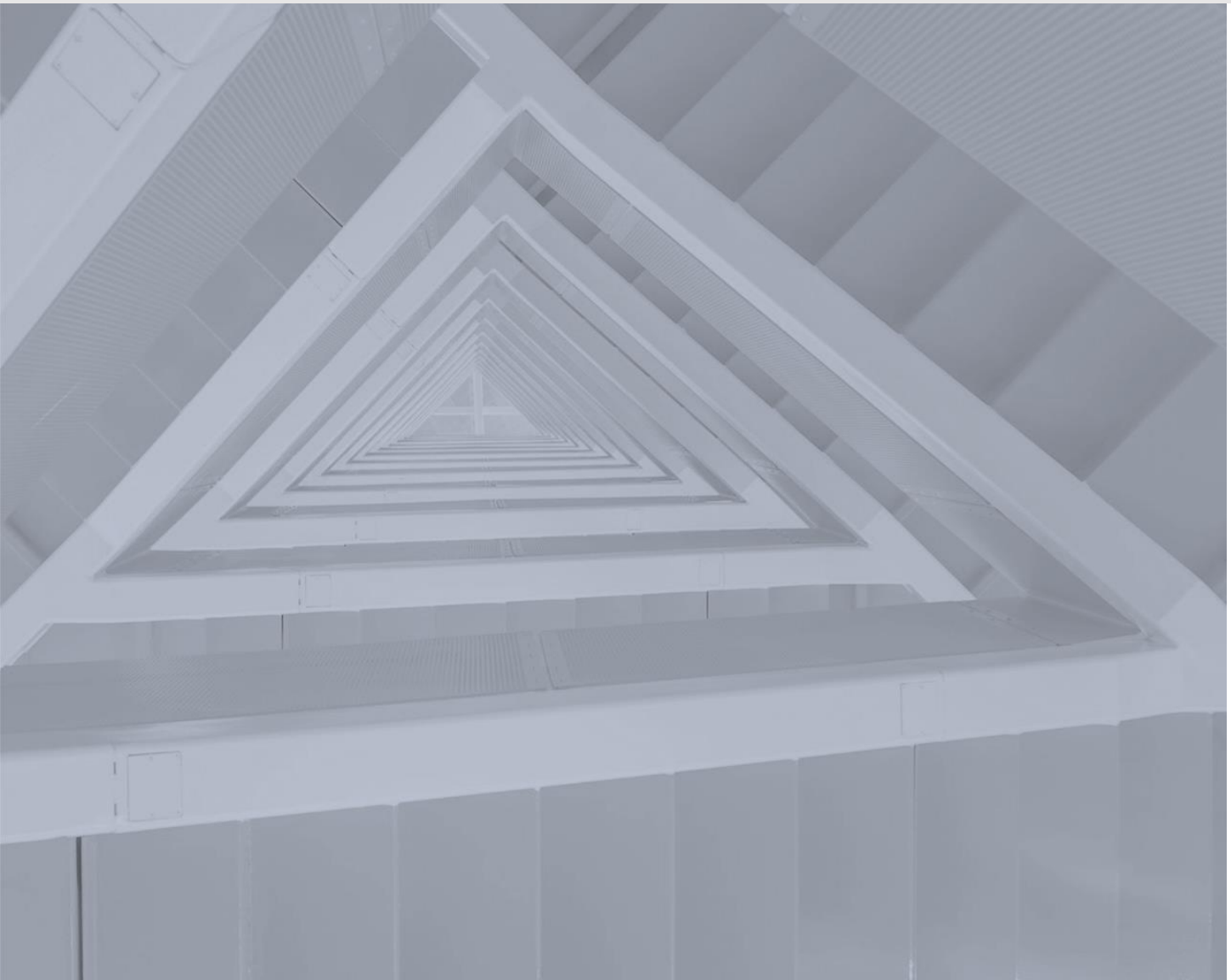
Change of Occupancy

- Where a change results in a building being assigned to a **higher** risk category
- Utah code also includes that when the change of occupancy results in a design occupant load increase of 100% or more
- Triggers an upgrade in which the building must satisfy Full IBC
- Exceptions:
  - New occupancy is less than 10% of the building area and not Risk Category IV
  - Change from Risk Category I or II to a Risk Category III and Sds is less than 0.33
  - URM buildings going to Risk Category III in SDC A or B per Appendix A of IEBC

Methods to Approach an Existing Building



Work Area Method (CH. 6 to 12)



Alteration requirements

- Level 1
- Level 2
- Level 3

Additions

Change of Occupancy

Work Area Method –Level 1 Alteration (Ch. 7)

- No space reconfiguration – only removal and replacement of covering for existing elements - “Paper and Paint”
- Cannot be “less safe than its existing condition.”





Work Area Method –Level 1 Alteration (Ch. 7)

Structural requirements

- 5% rule – **Always (10% not allowed)**
- Bracing of Unreinforced Masonry (URM) parapets on reroofing (SDC: D and E) – **Roof area exceeds 25%** - Reduced IBC code
- Evaluate roof and connections of roof to framing and walls (115 mph Wind Zones) – **Roof area exceeds 50%** - Reduced IBC code

Work Area Method –Level 2 Alteration (Ch. 8)

- “Catch All” section for Work area method – Space reconfiguration up to 50% work area



Work Area Method –Level 2 Alteration (Ch. 8)

Structural Requirements

- Everything for Level 1 Alteration including the 5% and 10% rules
  - If 10% rule cannot pass or an irregularity is created, the entire structure must be analyzed but can be done using Reduced IBC seismic forces
- Voluntary lateral alterations – same as prescriptive

Work Area Method –Level 3 Alteration (Ch. 9)

- Work area exceeds 50% of the building area or Substantial Structural Alteration is triggered





Work Area Method –Level 3 Alteration (Ch. 9)

Structural requirements

- Everything for Level 1 and 2 Alterations including the 5% and 10% rules
- If there is a Substantial Structural Alteration, the lateral system of the altered structure must satisfy Full wind and Reduced seismic IBC forces
  - If only the lowest level is involved with the alteration, only lateral load-resisting elements in and below
- Bracing of Unreinforced Masonry (URM) parapets during a reroof (SDC: D and E)
- Bracing of Unreinforced Masonry (URM) partitions in work area and egress paths (SDC: D and E)
- Anchoring concrete and RM walls to roof (SDC: C, D or E)
- Anchoring URM walls to roof and floor (SDC: C, D or E)
- SDC F requires the altered structure to meet Reduced seismic IBC forces

Work Area Method –Other Sections (CH. 10, 11, & 12)

Change of Occupancy – Ch 10

- Same as prescriptive method

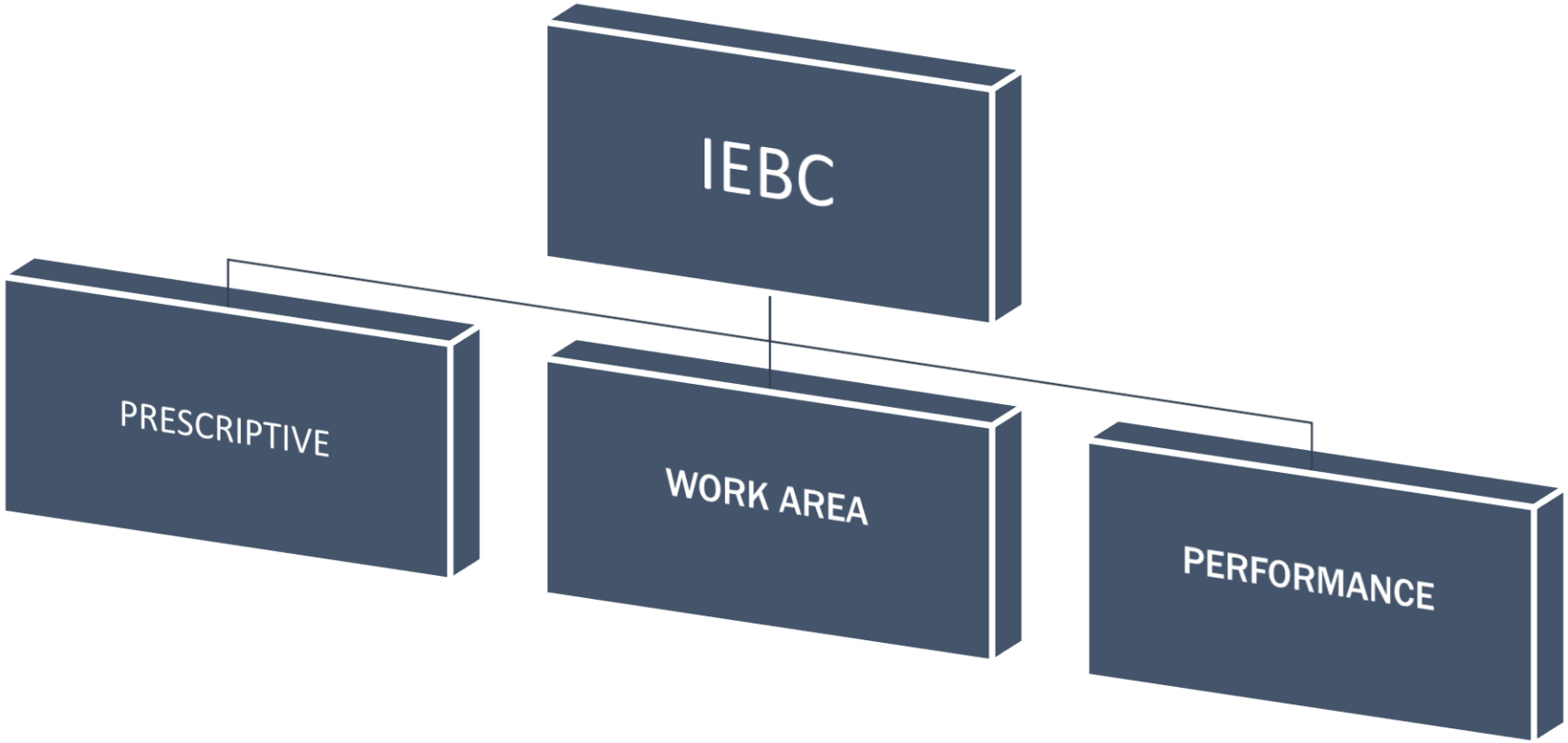
Additions – Ch 11

- Same as prescriptive method

Historic Buildings – Ch 12

- Complete upgrade not required but must review the structure and provide a report of any dangerous conditions so that they can be remedied.

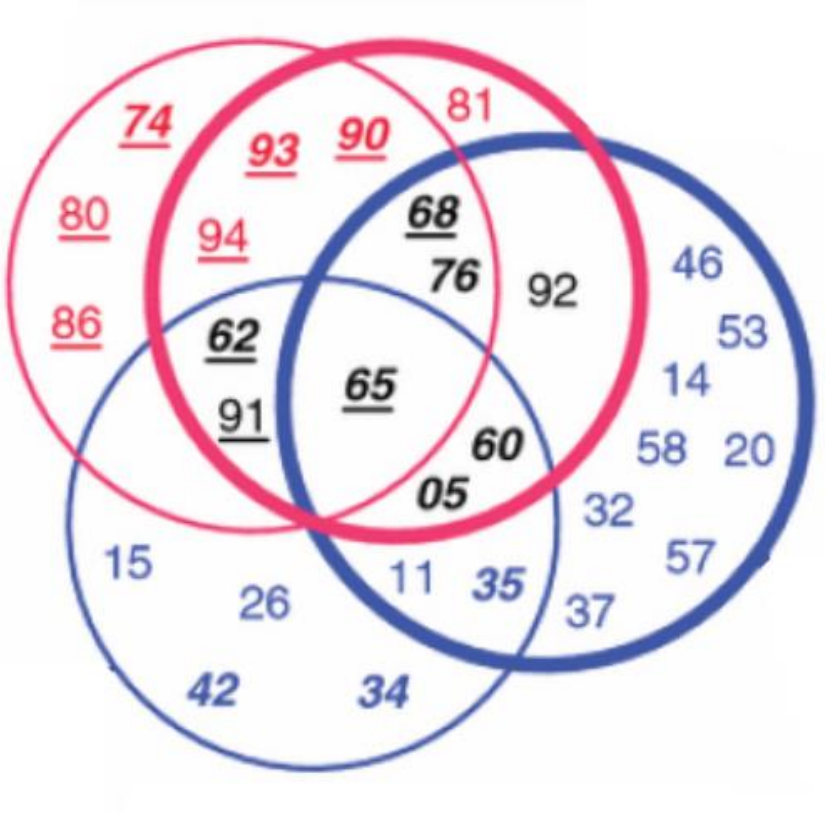
Methods to Approach an Existing Building



Performance Method (CH. 13)

Existing Building uses a scoring system to prove that the alterations will improve the existing conditions although not to new construction requirements.

- Structural requirements:
  - Provide an analysis of the existing building to resist Full IBC forces and document how to upgrade inadequate elements for the “code official”





When does a renovation trigger a seismic upgrade?

Seismic Triggers to Upgrade a Structure

Triggers

- Change of occupancy that results in a higher risk category - Full IBC (IEBC 506.4.3 and 1006.3
- Design occupant load increase of 100% or more - Full IBC (Utah State Amendment)
- Work area exceeds 50% and the work involves a substantial structural alteration (Reduced IBC)
- Access to Risk Category IV (Full IBC)



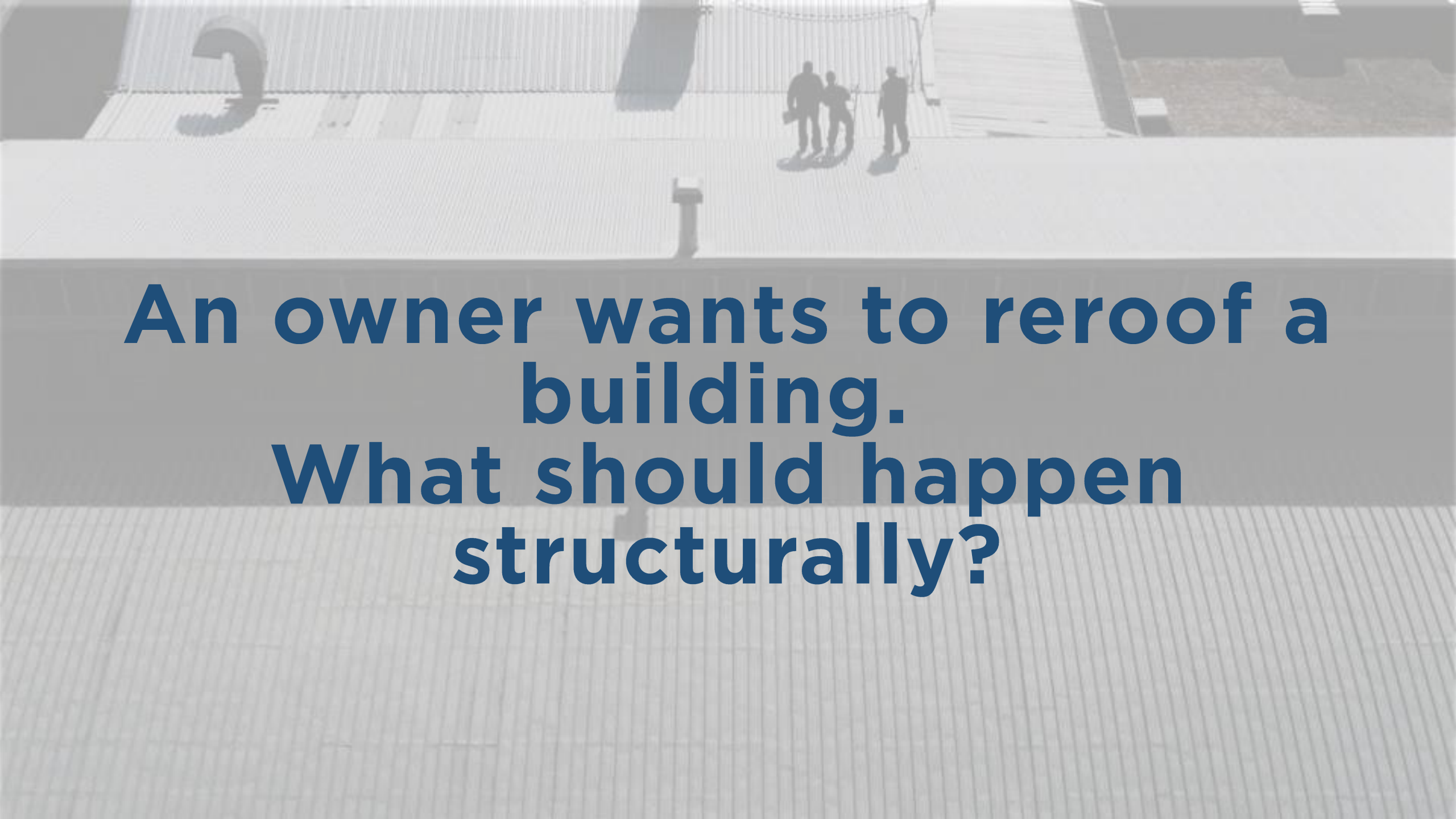
What happens when the owner wants to voluntarily upgrade a structure?

Voluntary Upgrades to a Structure (IEBC 806.4)

- Structural Alterations intended to exclusively improve the lateral force resisting systems and are not triggered by other IEBC code sections do not need to meet Full IBC

IF:

- Capacity of existing structural systems to resist forces is not reduced
- New structural elements must be detailed and connected per IBC (Full IBC)
- New or relocated non-structural elements must be detailed and connected per IBC (Full IBC)
- Alterations do not create a structural irregularity or make an existing irregularity worse



An owner wants to reroof a building. What should happen structurally?

Structural Requirements for Building Re-Roof



- 5% Rule
  - Exception if solely second layer of roofing weighing less than 3 pounds per square foot
- Provide diaphragm sheathing (recommended)
- URM Parapet bracing
- Anchoring walls to roof



New Sheathing Installation





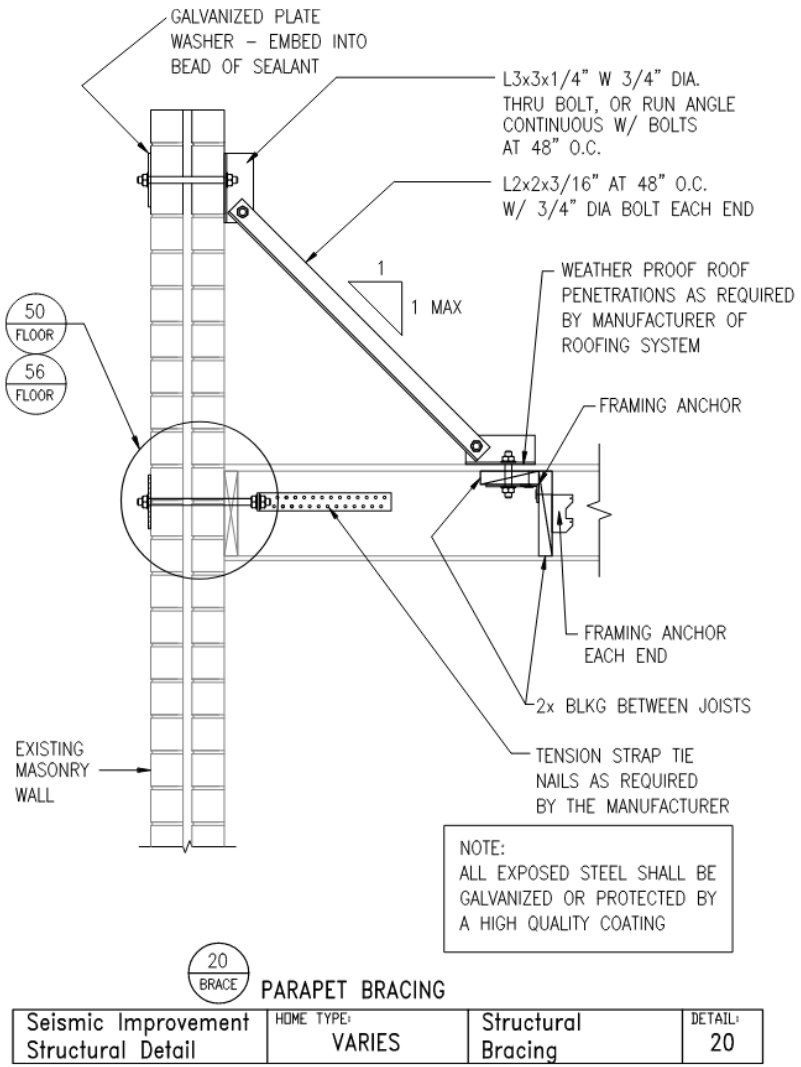
New Sheathing Over Planking

Parapet Bracing



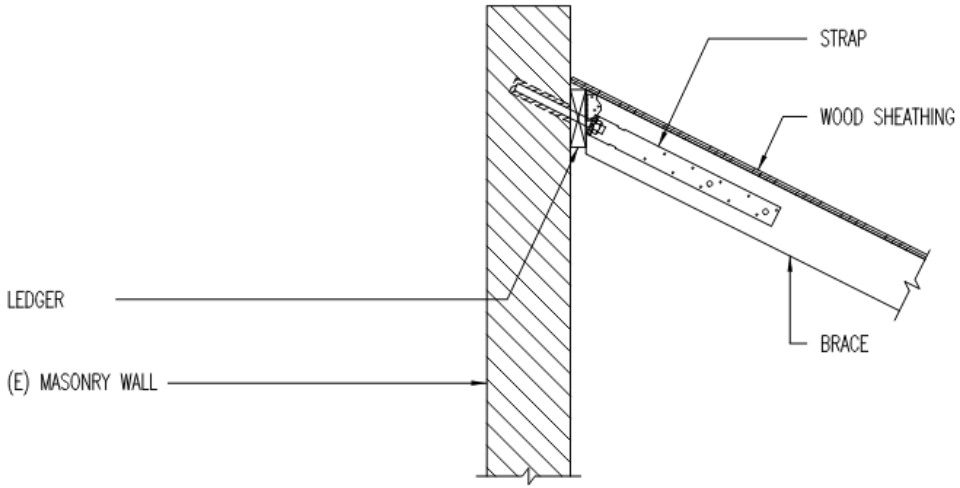
- Usually done with diagonal parapet kickers
- Local codes might also include bracing for cornices, spires, towers, tanks, signs, statuary, etc.

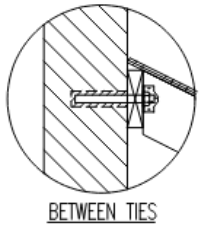
Parapet Bracing





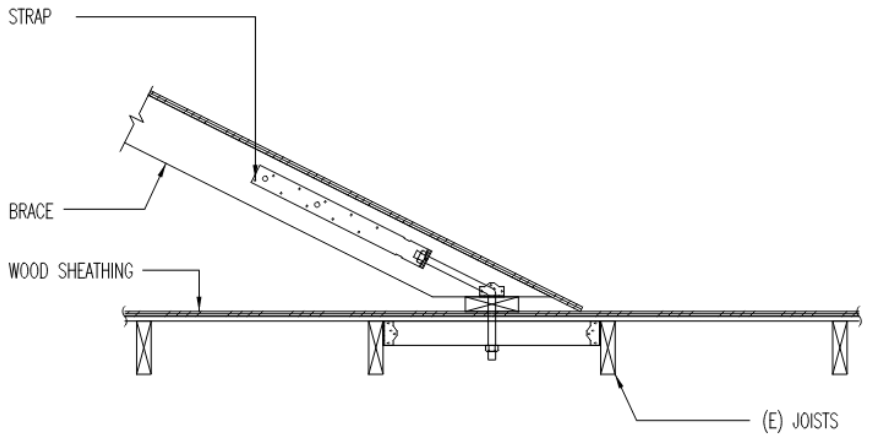
Parapet Bracing

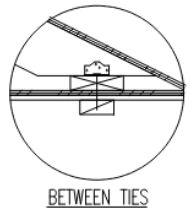




PARAPET BRACING DETAIL

NO SCALE

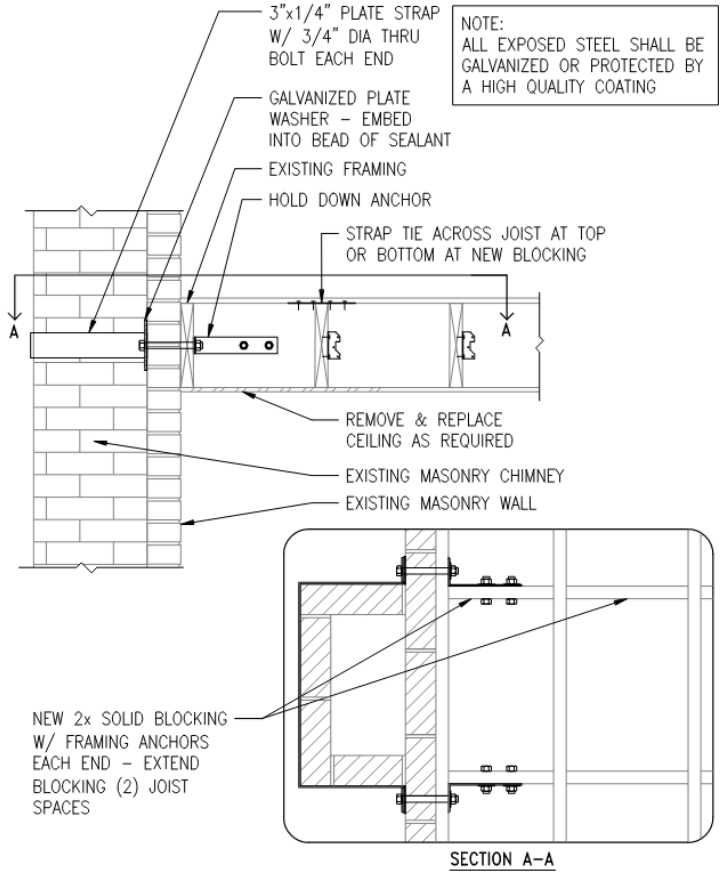




PARAPET ANCHORAGE DETAIL

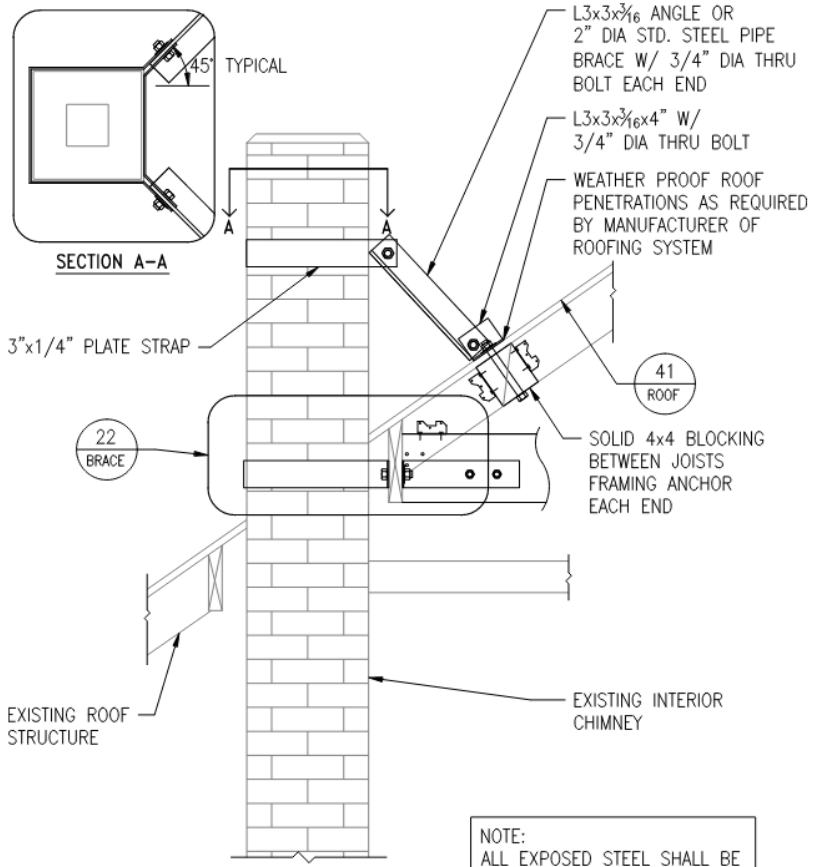
NO SCALE

Chimney Bracing



24 BRACE EXTERIOR CHIMNEY TO FLOOR ANCHORAGE @ JOISTS PARALLEL TO WALL

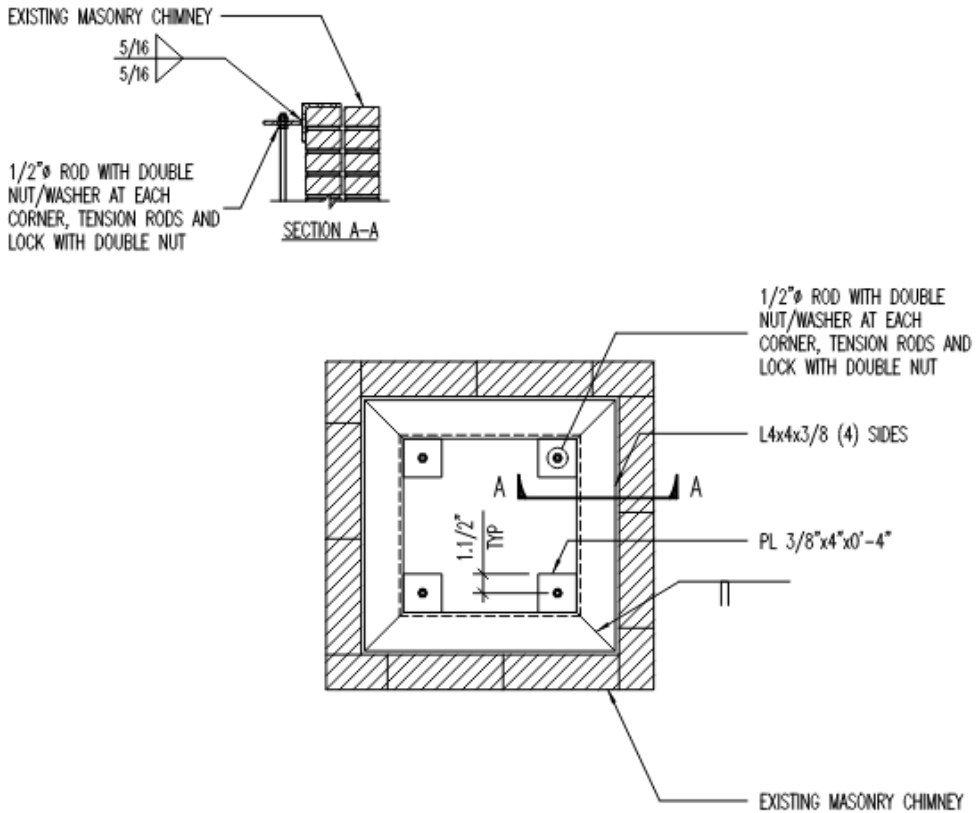
Seismic Improvement Structural Detail	HOME TYPE: VARIES	Structural Bracing	DETAIL: 24



25 BRACE EXTERIOR CHIMNEY TO ROOF ANCHORAGE

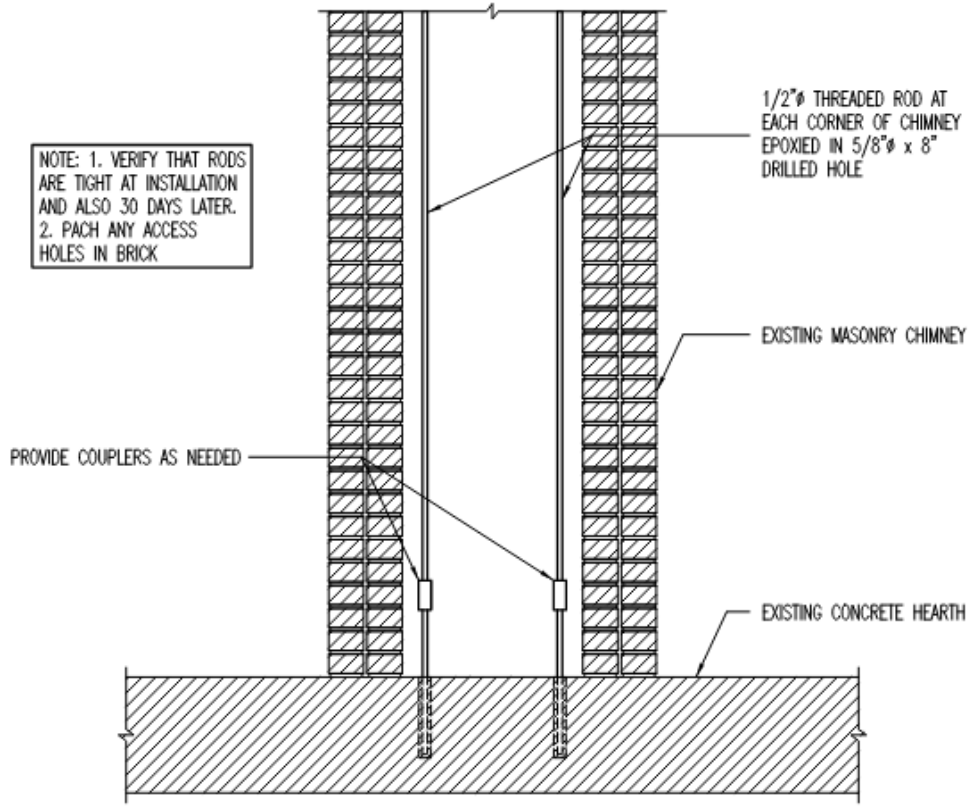
Seismic Improvement Structural Detail	HOME TYPE: VARIES	Structural Bracing	DETAIL: 25

Chimney Bracing



6 CHIMNEY REINFORCEMENT AT TOP OF CHIMNEY

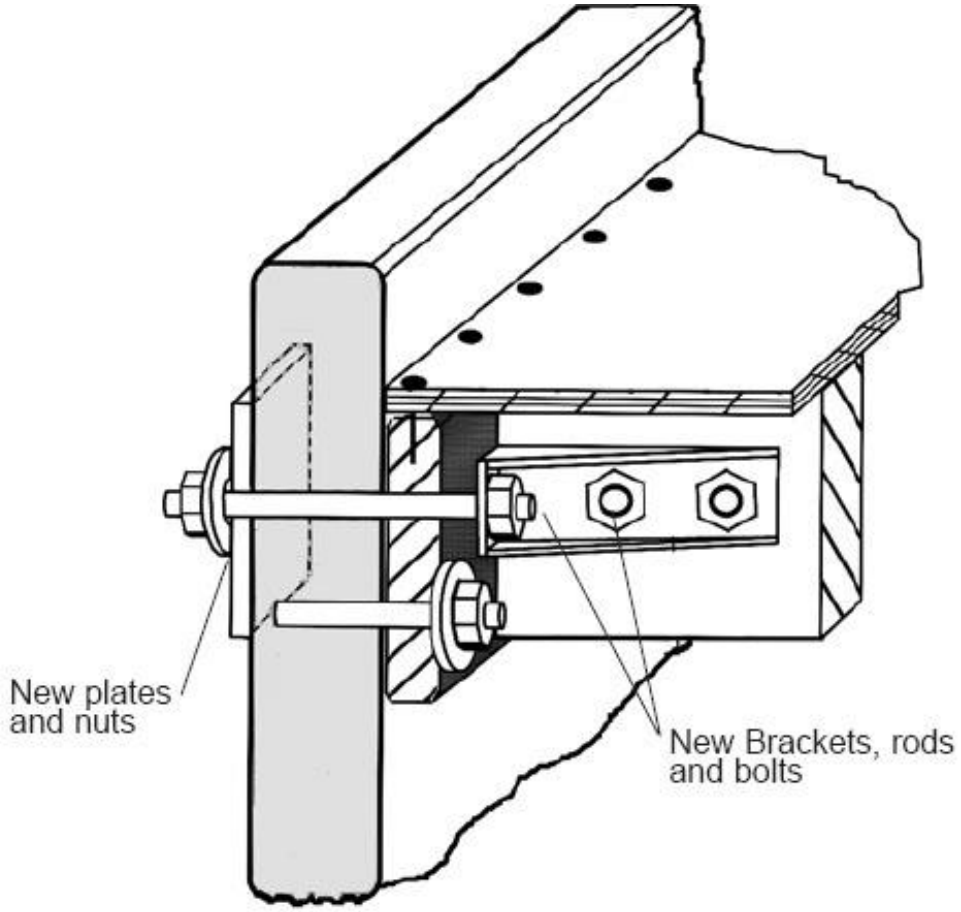
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7 CHIMNEY REINFORCEMENT AT BASE

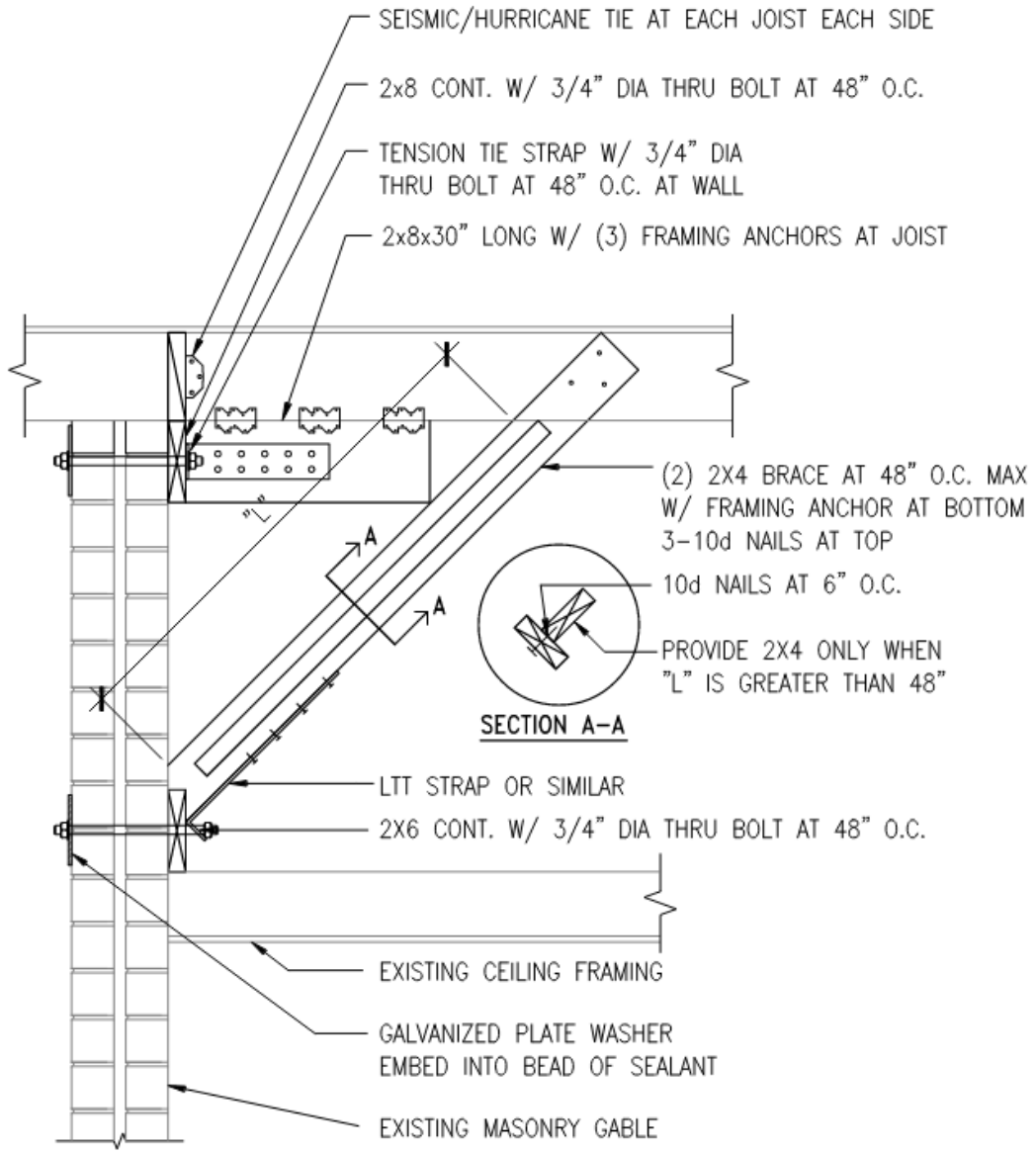
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Structural Requirements for Building Re-Roof



- Anchorage of roof to walls
- Current condition must be capable of resisting reduced IBC forces

Anchorage of Roof to Walls

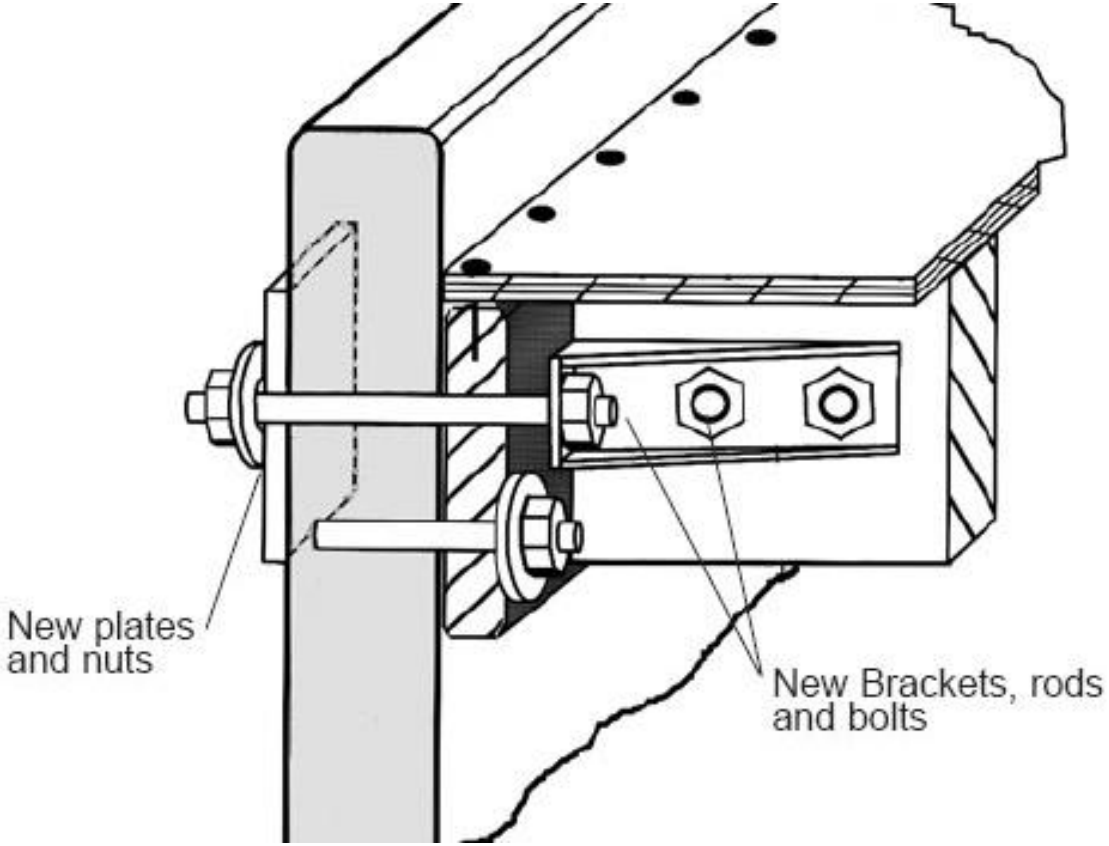


21 BRACE URM GABLE BRACING

Seismic Improvement Structural Detail	HOME TYPE: VARIES	Structural Bracing	DETAIL: 21

Anchorage of Roof to Walls



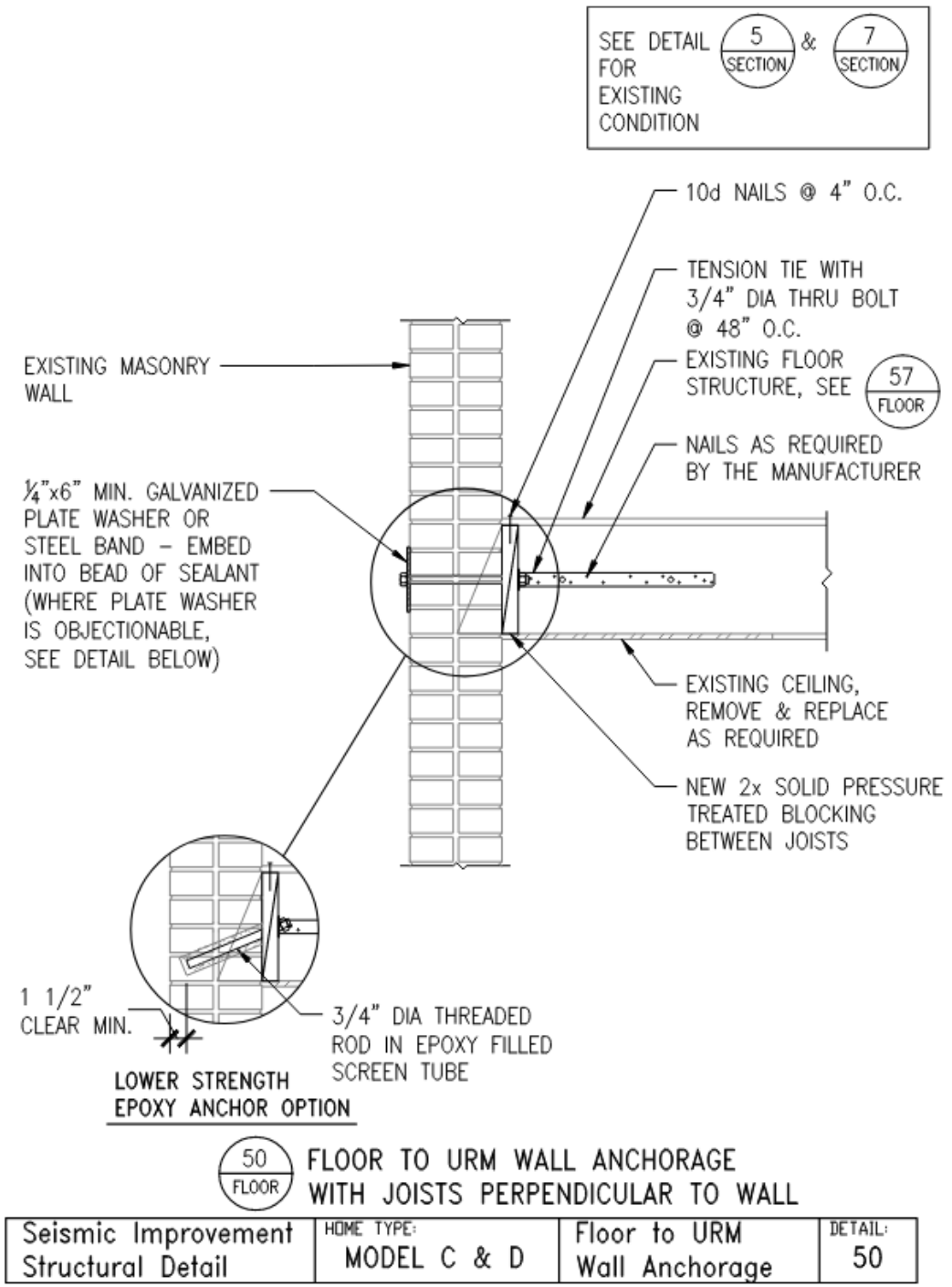


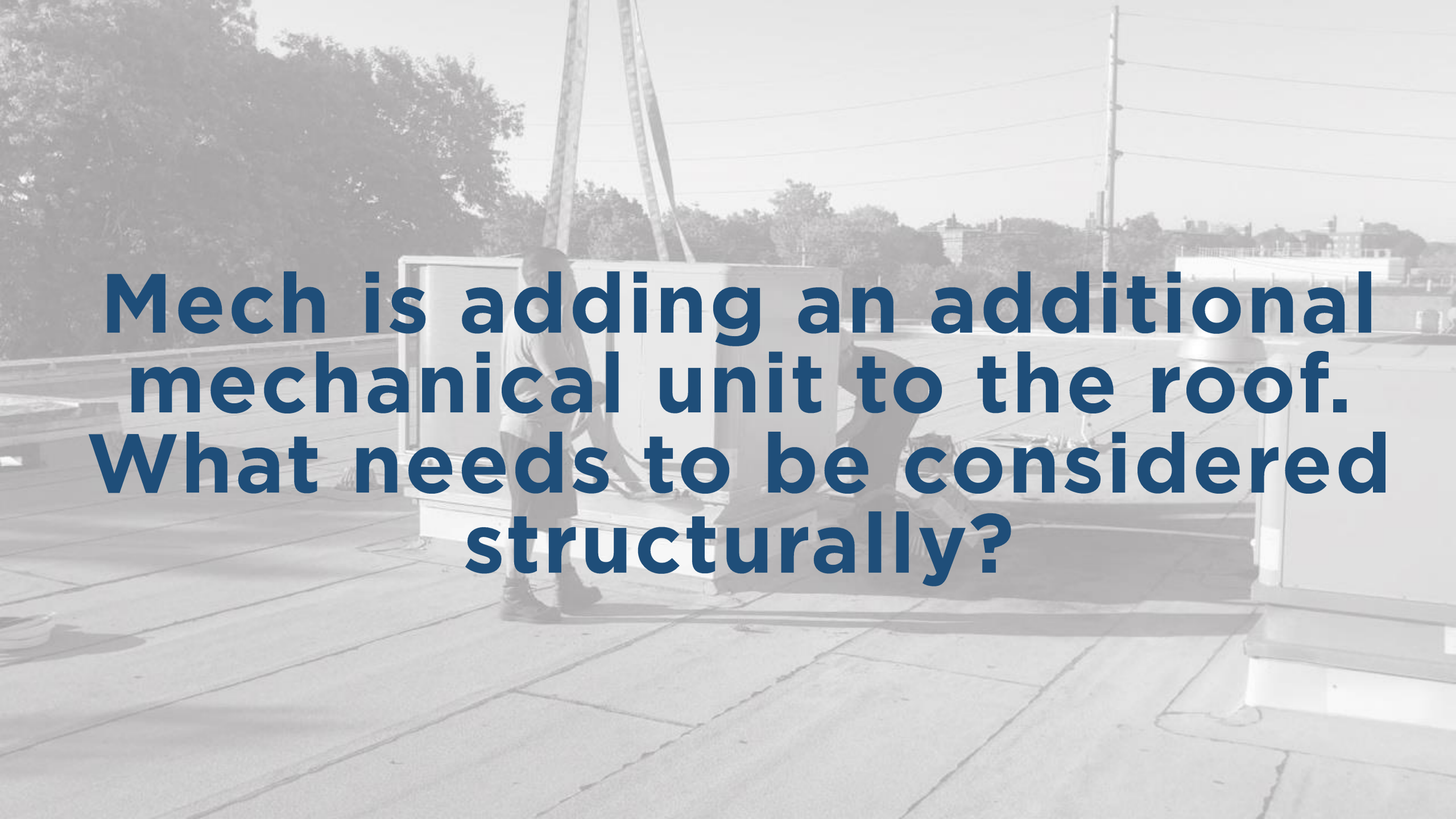
Anchorage of Roof to Walls



Ask questions in the Q&A chat

Anchorage of Floor to Walls





Mech is adding an additional mechanical unit to the roof. What needs to be considered structurally?

How Roof or Floor Framing is Retrofitted to Support Heavier Loads









Rule of Thumb – 5% Rule

Cannot increase loading or reduce capacity by more than:

Increased Loading

- Add an RTU
- Solar Panels
- Topping slab
- Higher live load
- New Snow drift condition

Reduced Capacity

- Column removal
- Removing bracing on vertical elements
- Cutting a hole in a beam for a pipe
- Removal of bracing





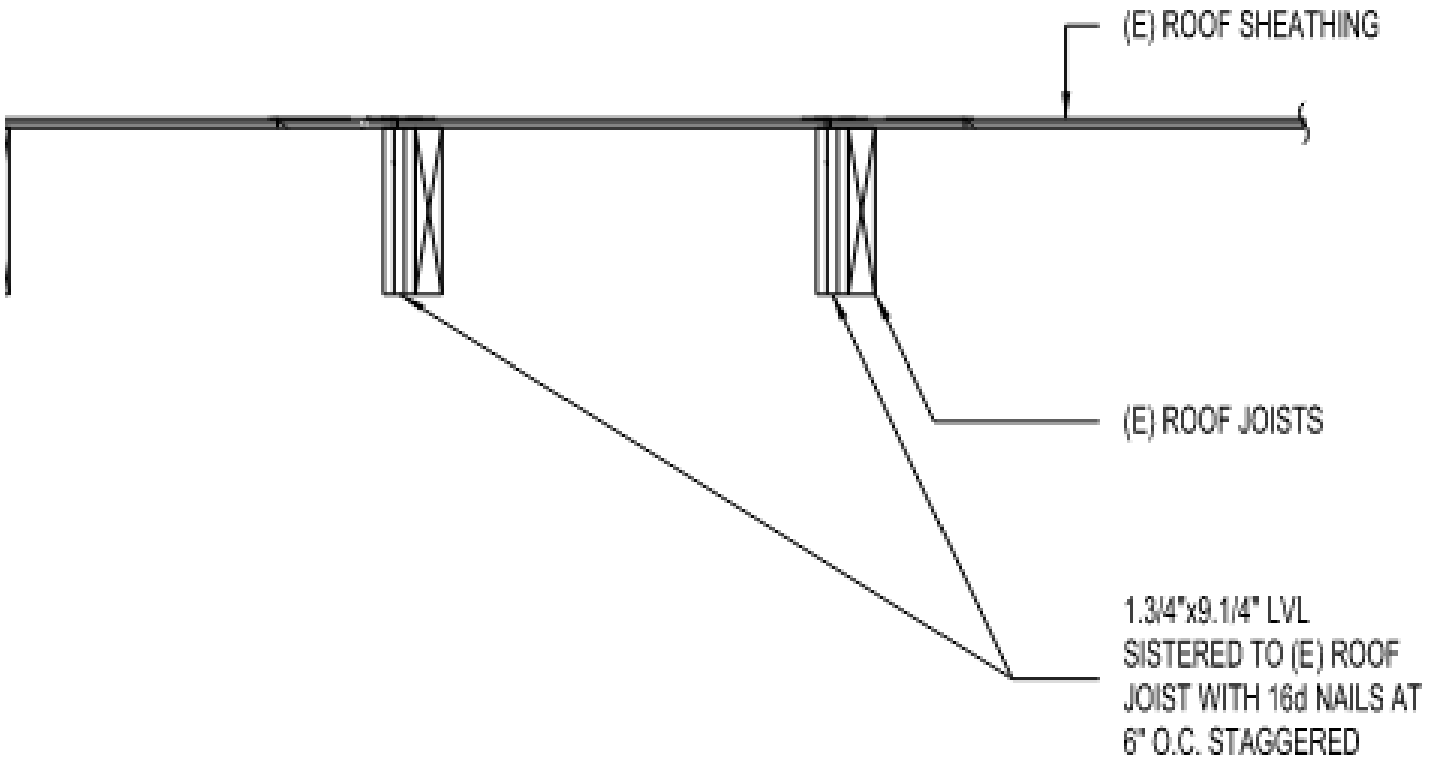


What if we exceed the 5% rule?



Wood Joist Upgrade –Sistered





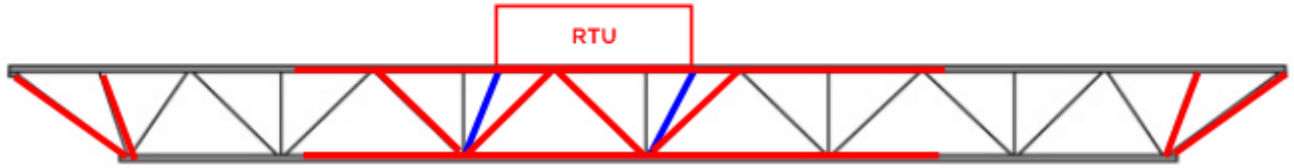
Wood Truss Upgrade –Chord and Web Reinforcing

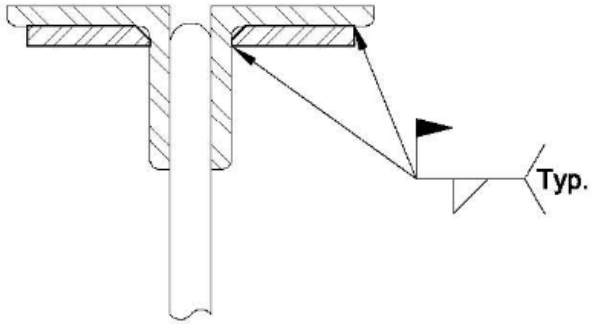


Wood Joist Upgrade – Additional Supports

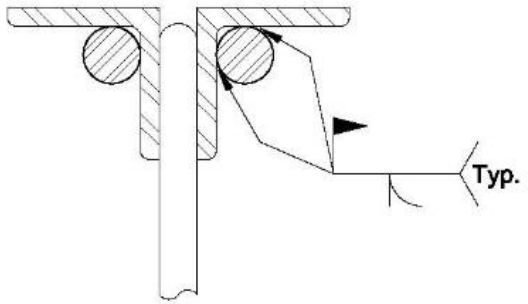


Steel Joist Upgrade

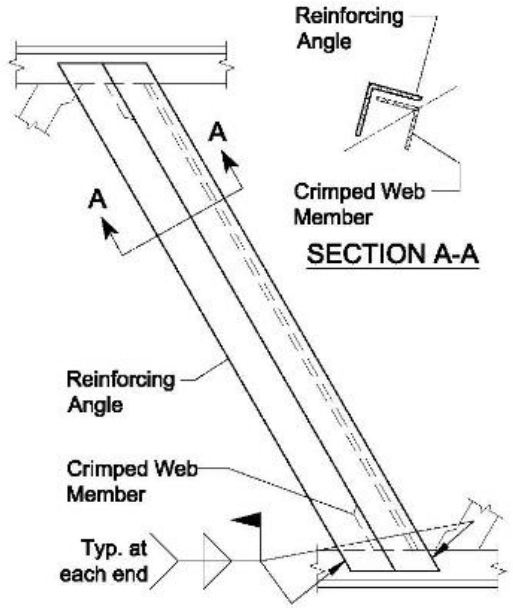




Top Chord Reinforcement - Plates



Top Chord Reinforcement - Rods



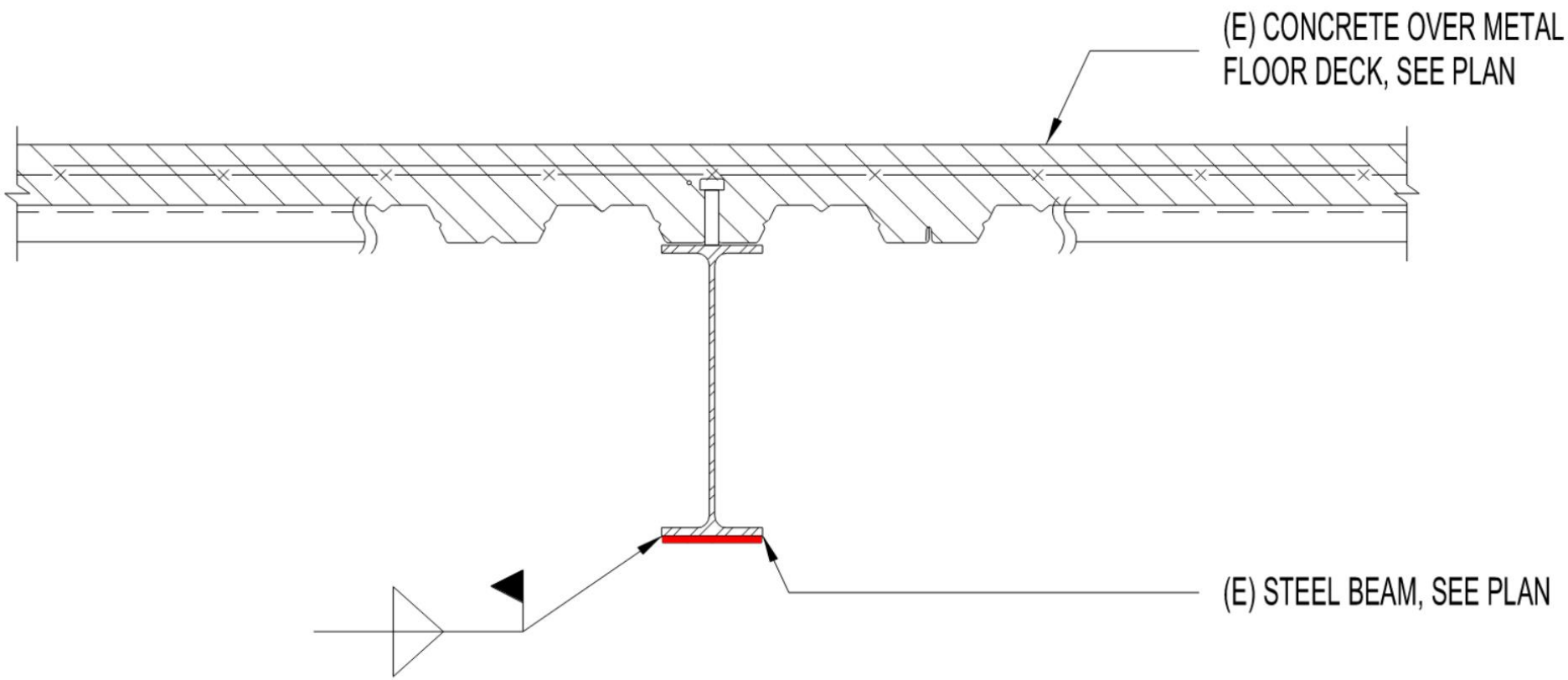
Web Reinforcement



Split Joist



Steel Beam Upgrade











Footing Upgrade

Roof Upgrades During Re-Roof





Structural requirements for New Mechanical Units on Roof

- 5% Rule
- Exception for replacing units of same weight, size, and location.

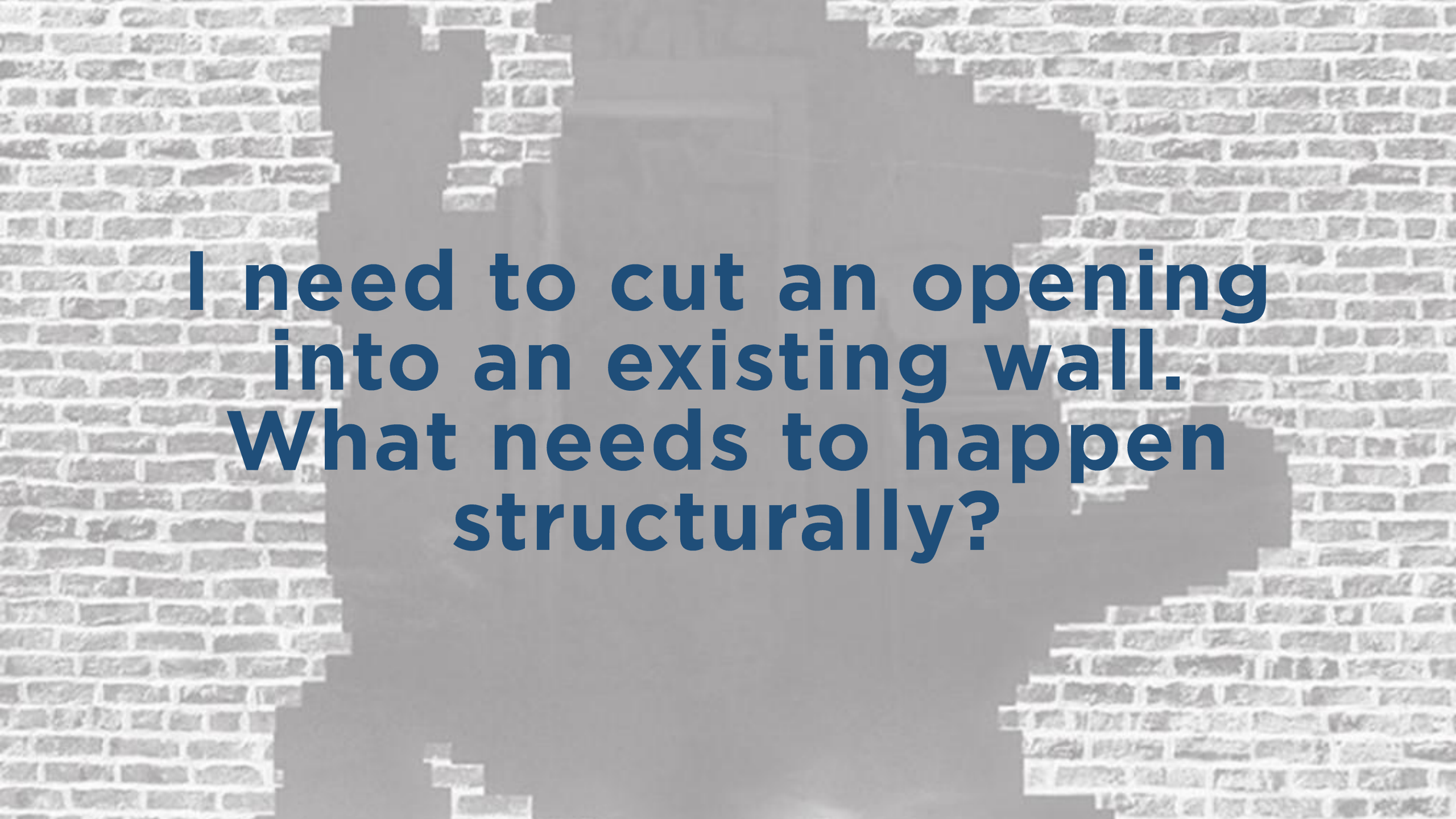


Mechanically Fastened



Ballasted

Structural Requirements for PVA Additions

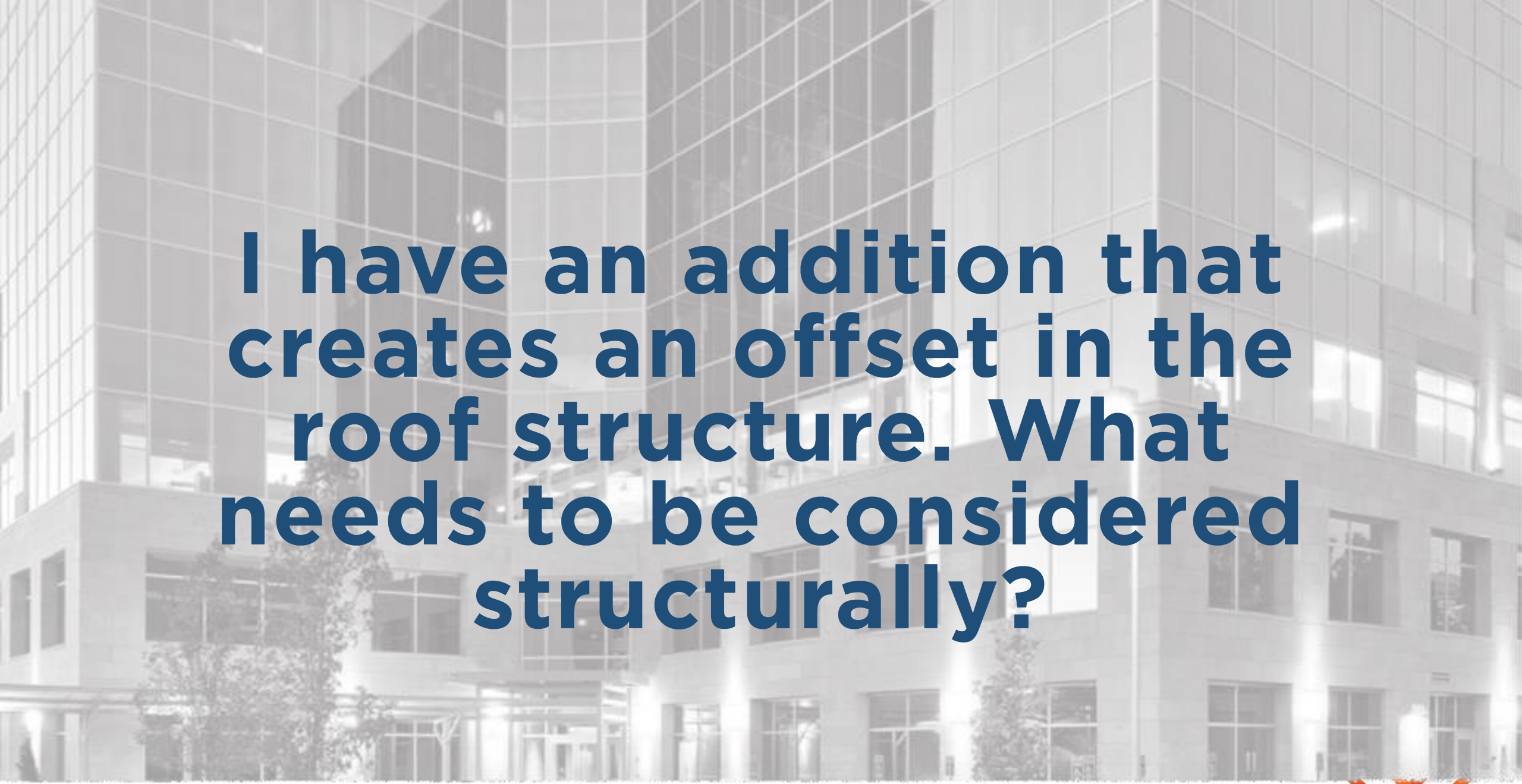

I need to cut an opening into an existing wall. What needs to happen structurally?





- Need gravity-carrying elements to support load above.
- 10% Rule

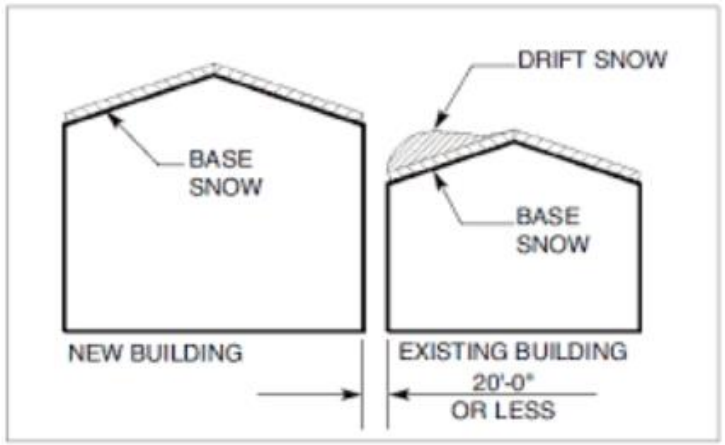
Structural Requirements for New Wall Openings



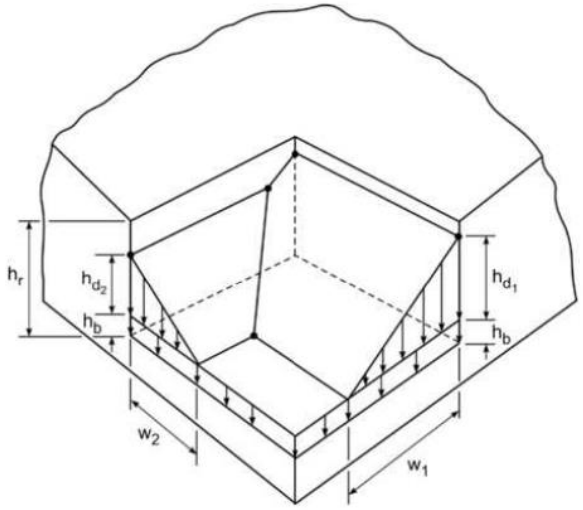
I have an addition that creates an offset in the roof structure. What needs to be considered structurally?

Adjacent Buildings (IEBC 303.2)

- Within 20 ft of high roof



Roof Offsets



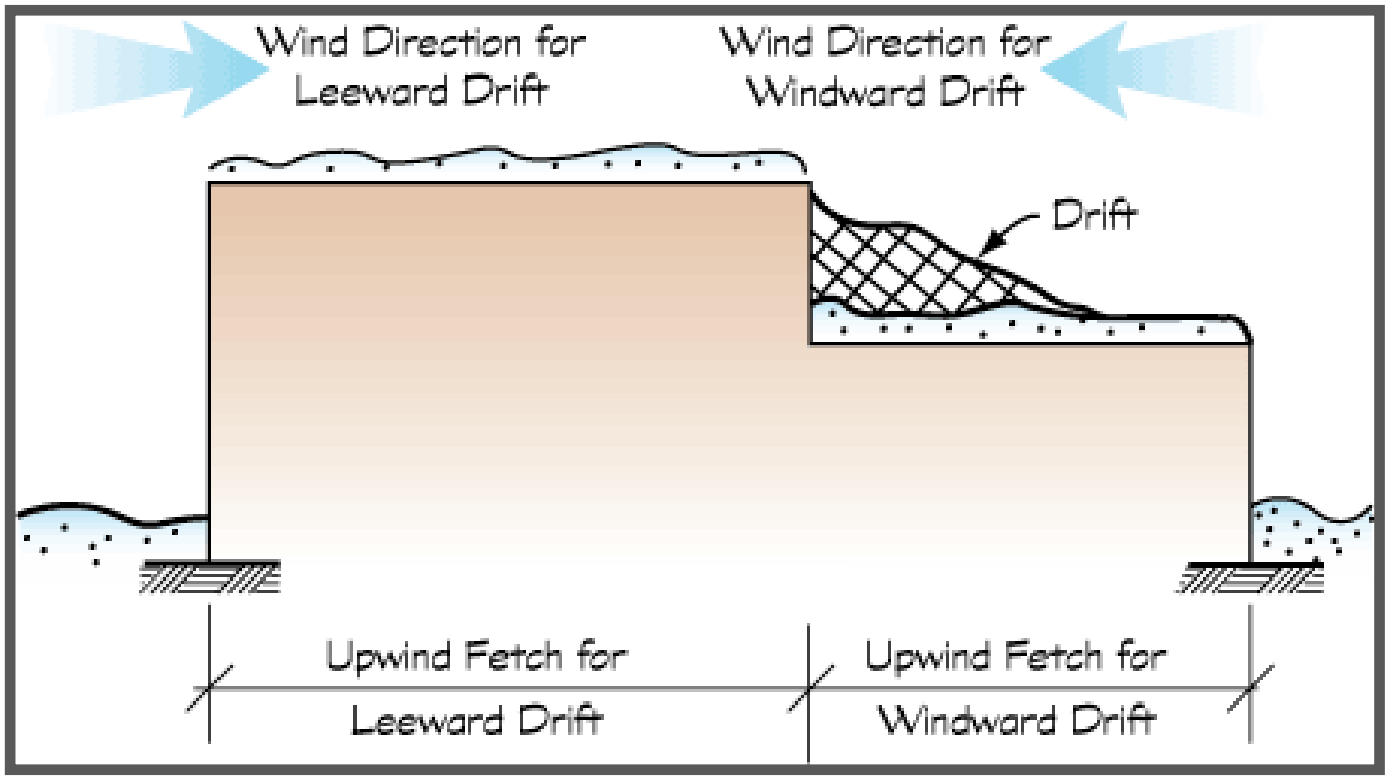
Uniform Snow Loads on Upper Roof not Shown

Change in Use

Table 7.3-2 Thermal Factor, C_t

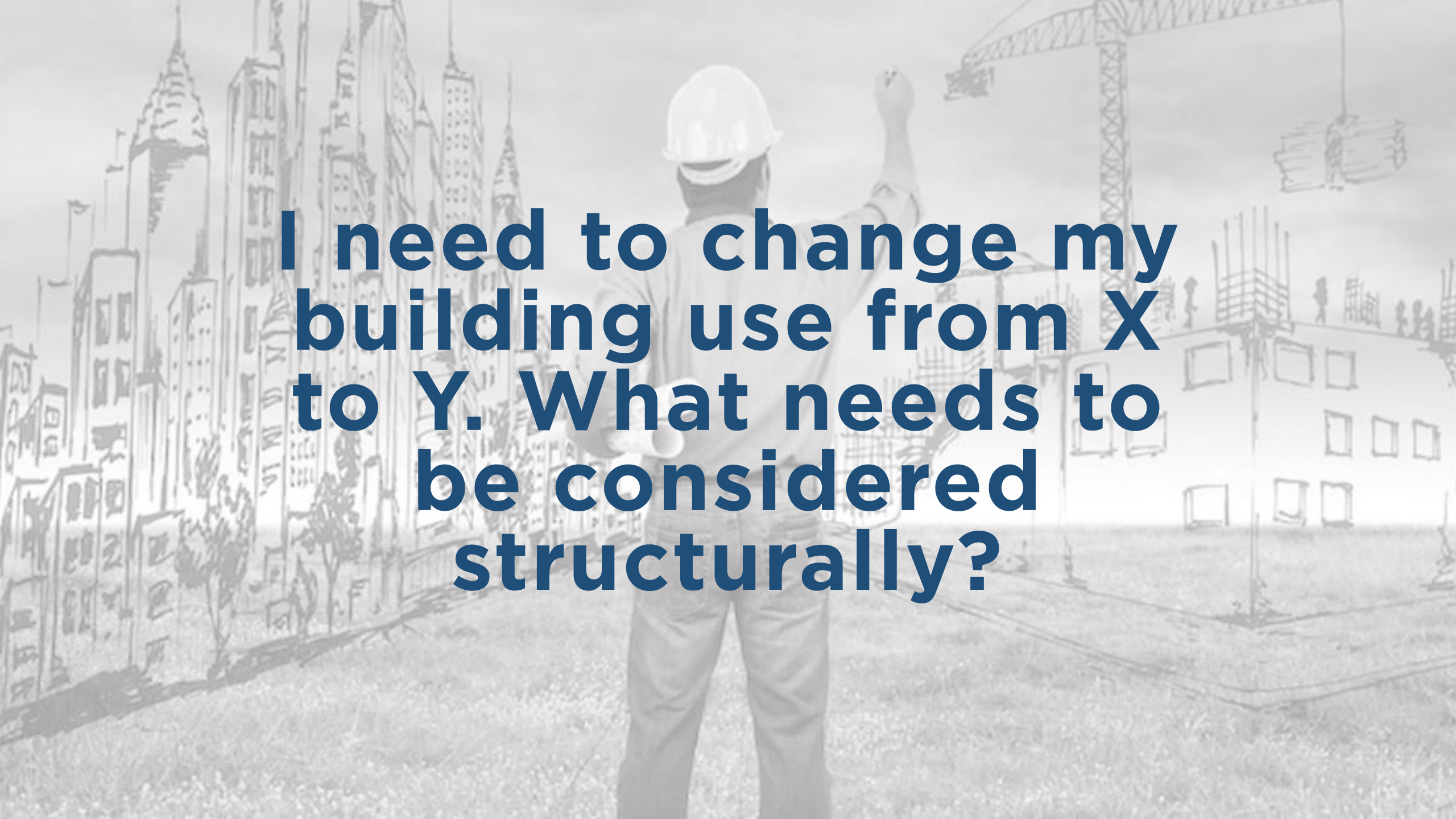
Thermal Condition[a]	C_t
All structures except as indicated below	1.0
Structures kept just above freezing and others with cold, ventilated roofs in which the thermal resistance (R-value) between the ventilated space and the heated space exceeds $25°F \times h \times ft^2/Btu$ ($4.4\ K \times m^2/W$)	1.1
Unheated and open air structures	1.2
Freezer building	1.3
Continuously heated greenhouses[b] with a roof having a thermal resistance (R-value) less than $2.0°F \times h \times ft^2/Btu$ ($0.4\ K \times m^2/W$)	0.85

Structural Requirements for Induced Snow Drift



- Potential snow loads on adjacent buildings
- Code indicates that Owners of adjacent properties shall be advised if roof snow loads will increase on their building.

Structural Requirements for Offsets in Roof Structure



I need to change my building use from X to Y. What needs to be considered structurally?

Structural requirements when a change of occupancy results in an increase in Building Risk Category





Category I

Category IV

Structural requirements for change of use?



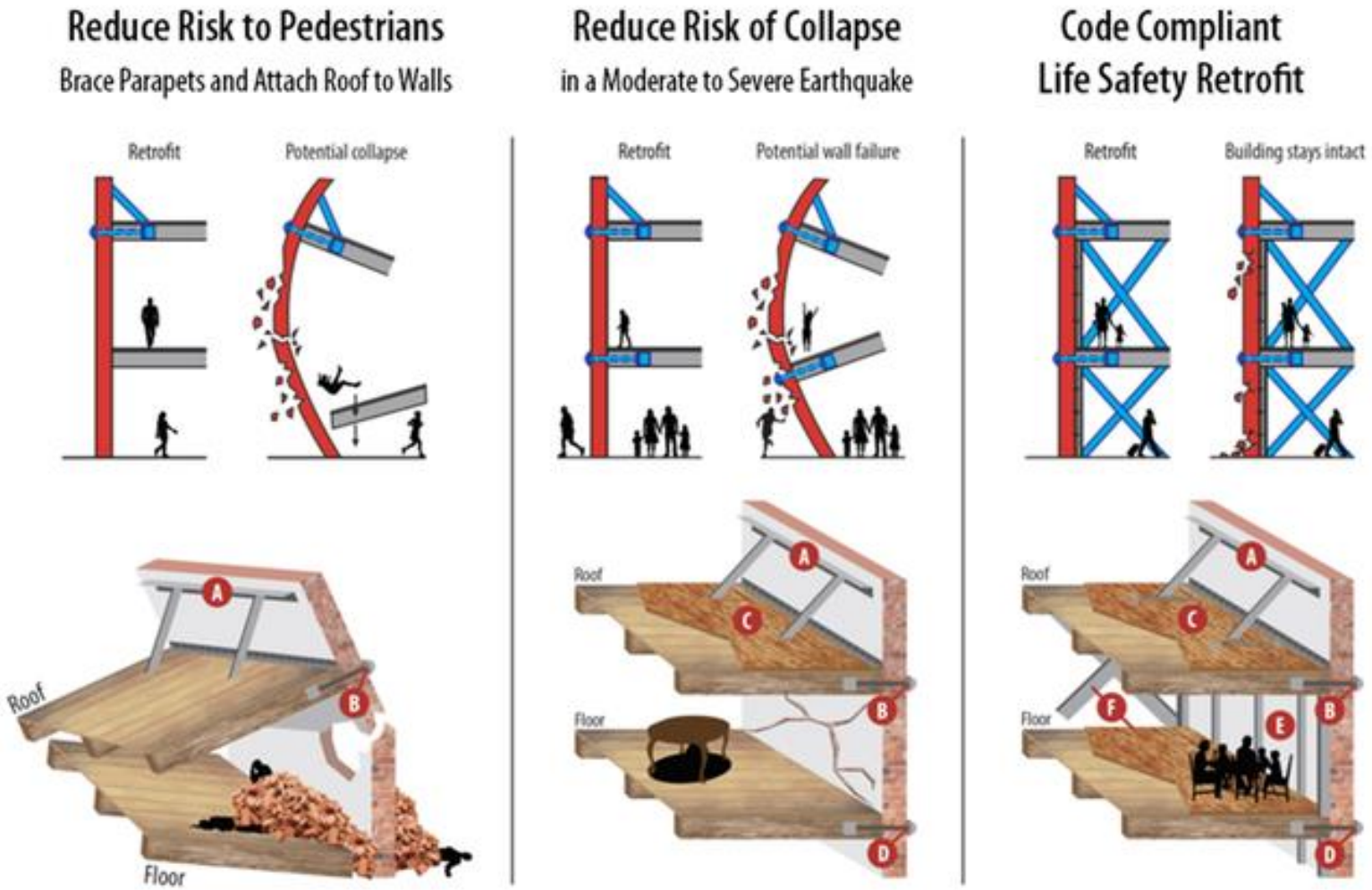
- 5% and 10% rules considered
- % Area alteration (10%)
- Same risk but higher load

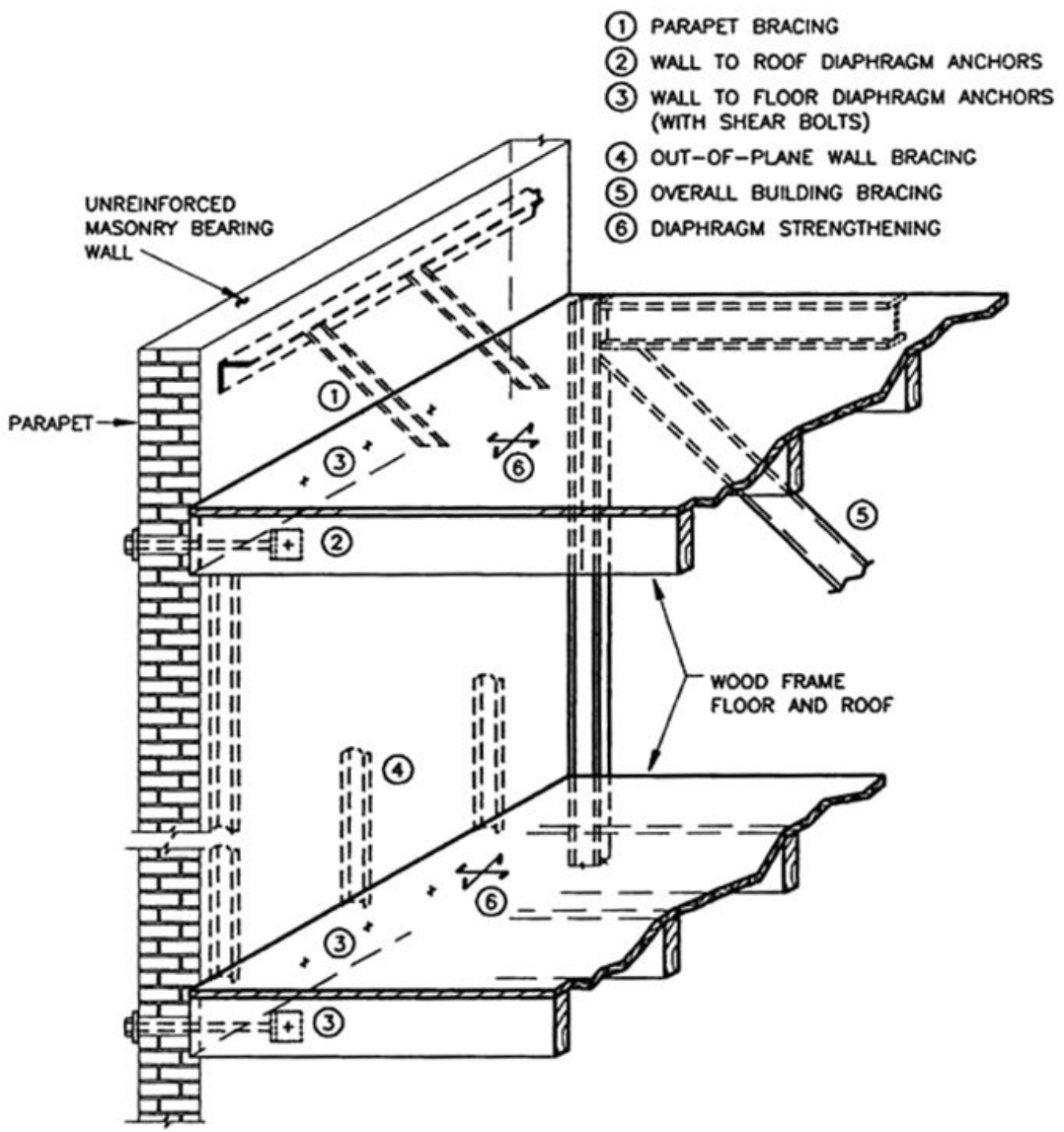




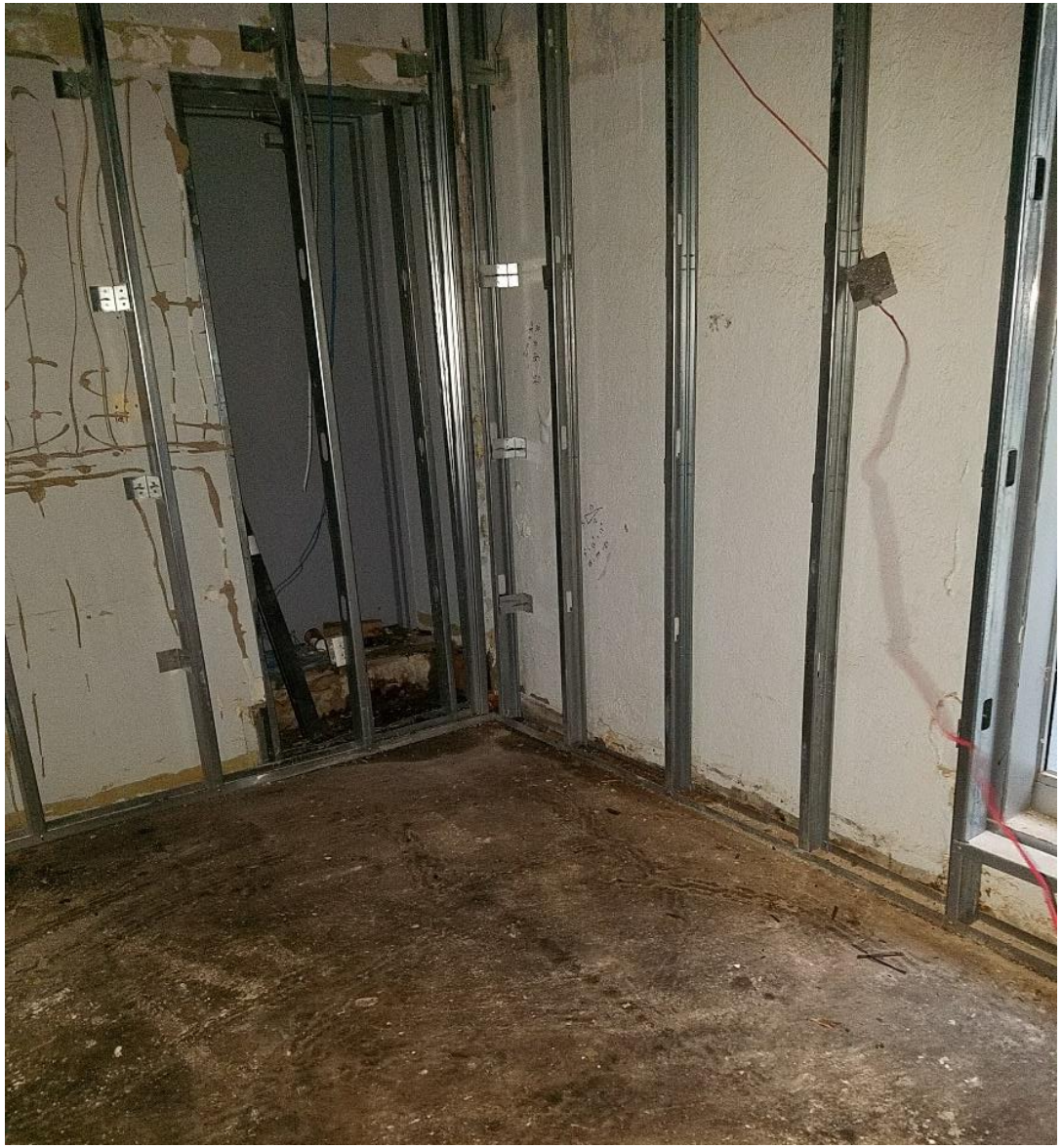
Strengthening Unreinforced Masonry Walls

Retrofitting unreinforced masonry buildings

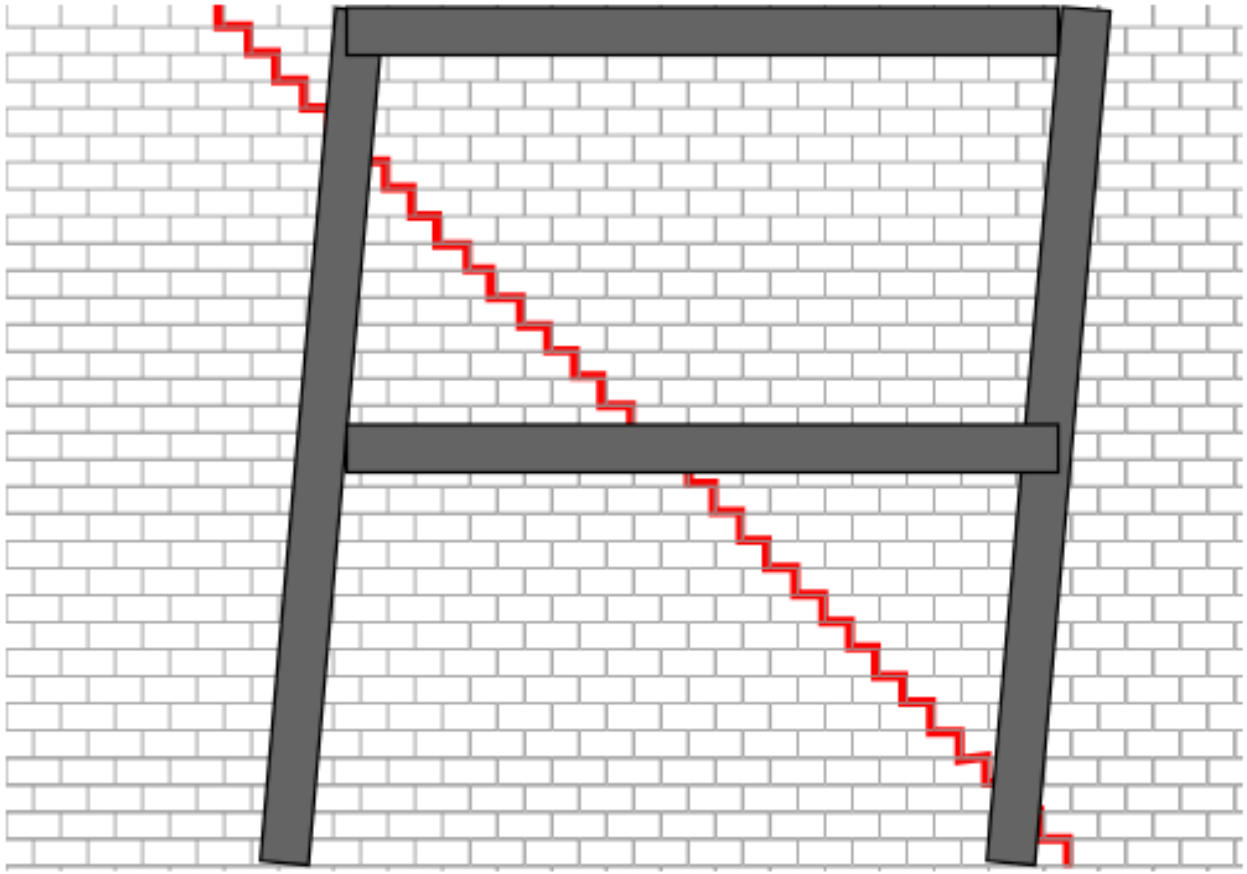




Strongtie.com



Avoid Moment Frames



Add Steel Cross Bracing



Applying a Reinforced Shotcrete Wall to Existing URM Walls



Applying a Reinforced Shotcrete Wall to Existing URM Walls



FRP on a Masonry Wall



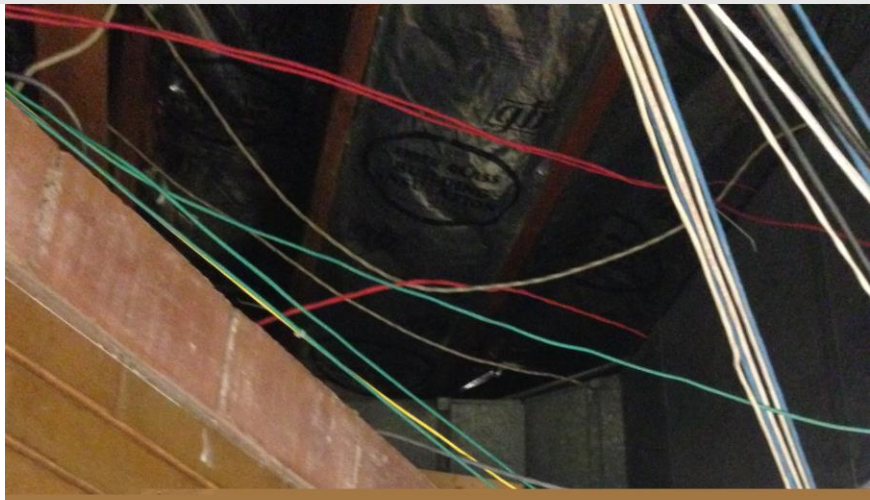


Bracing Cantilever Partition Walls

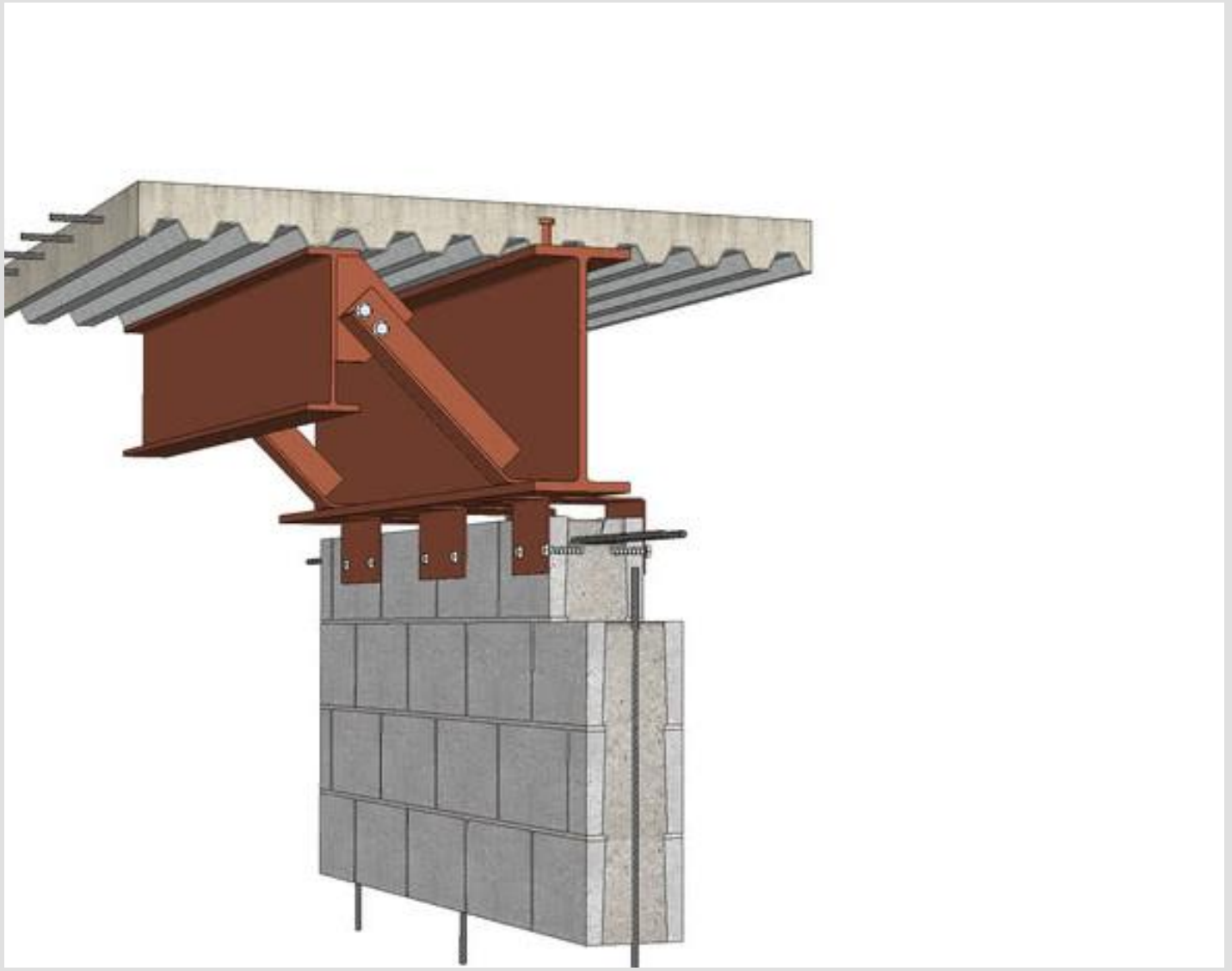
Anchorage for URM walls

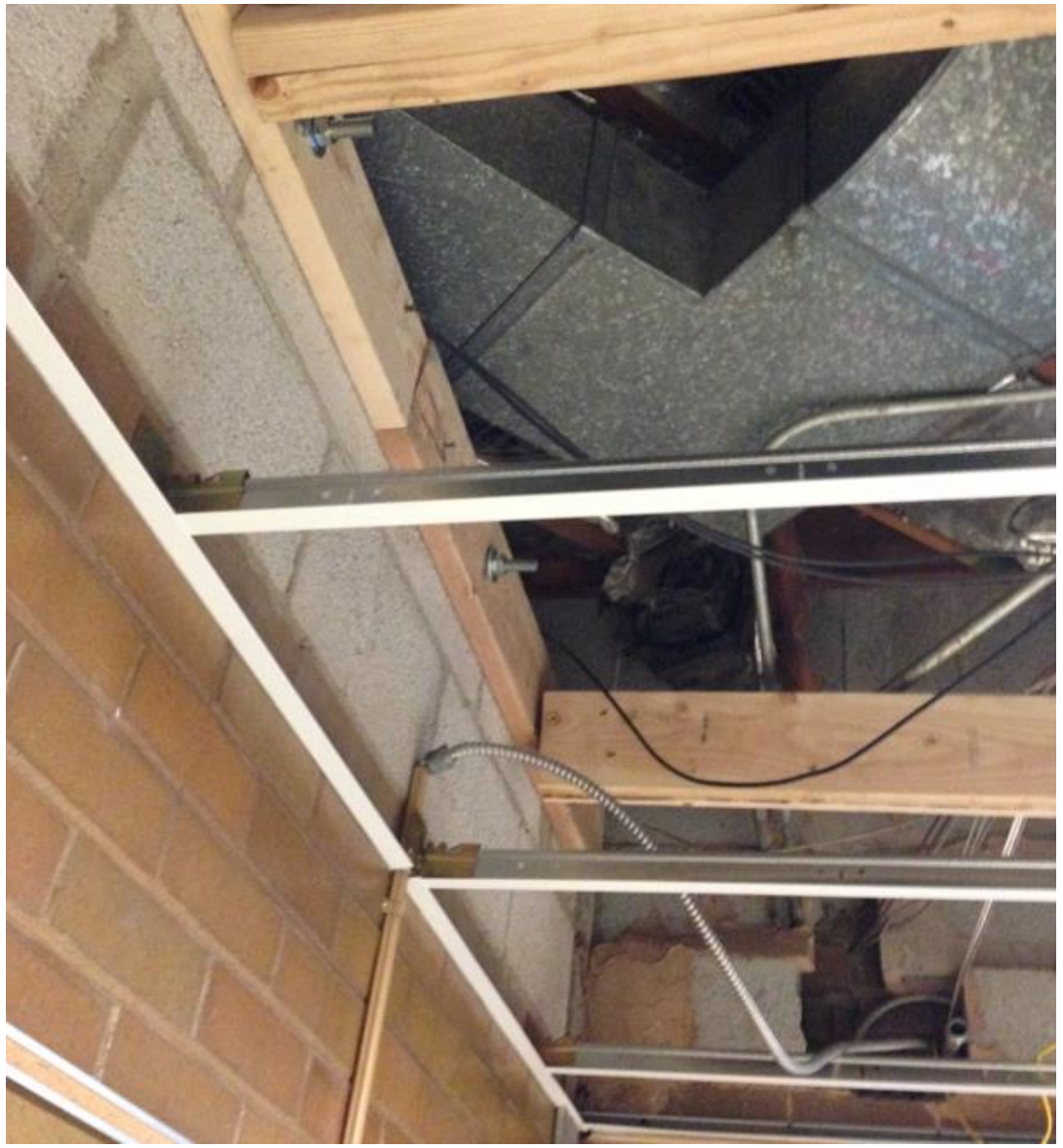
- URM walls were commonly constructed being
- unsupported at top of wall
- Ceilings acting as only support system for out of plane seismic forces

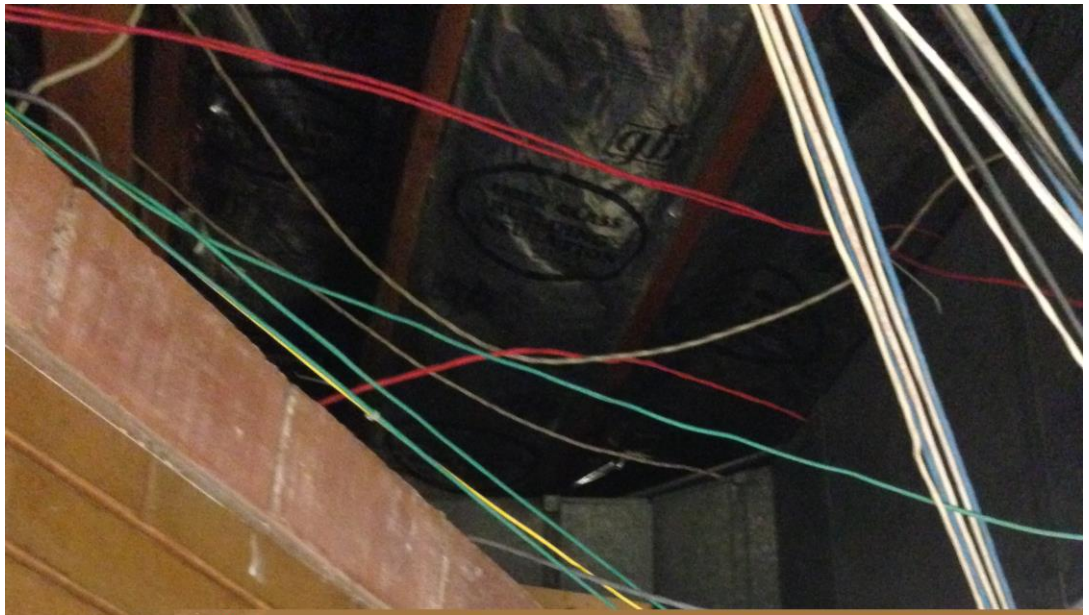




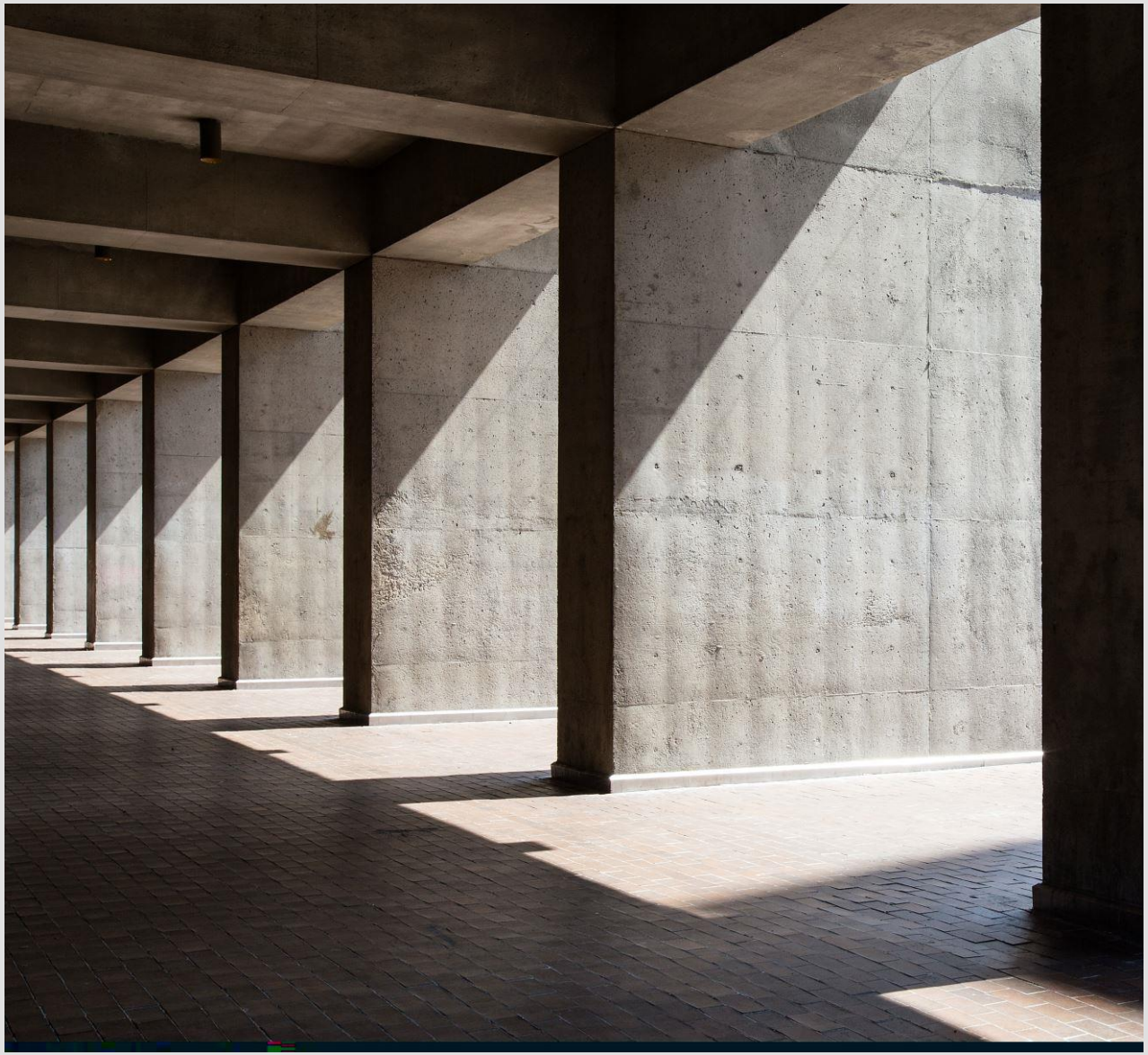
Bracing Cantilever Walls







Strengthening Wood and Concrete Structures



Concrete Upgrades

Concrete Column Strengthening





Concrete Column Strengthening



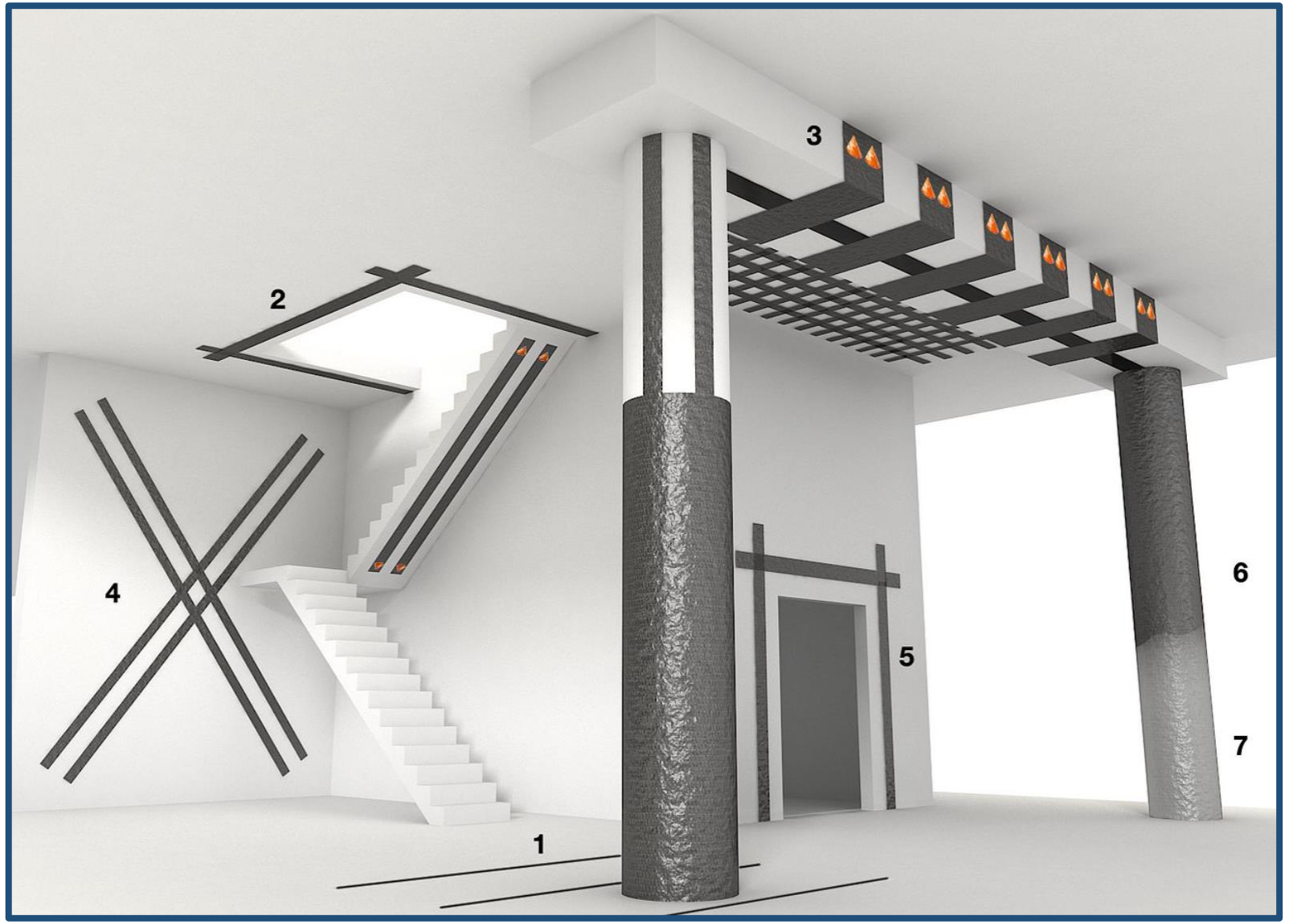
Fiber Reinforced Polymer (FRP)



Fiber Reinforced Polymer (FRP)



Fiber Reinforced Polymer (FRP)



Fiber Reinforced Polymer (FRP) Column Retrofit



Fiber Reinforced Polymer (FRP) Column Retrofit



Concrete Wall Strengthening



Concrete Wall Strengthening Options

- FRP
- Shotcrete
- Fabric Reinforced Cementitious Matrix (FRCM)





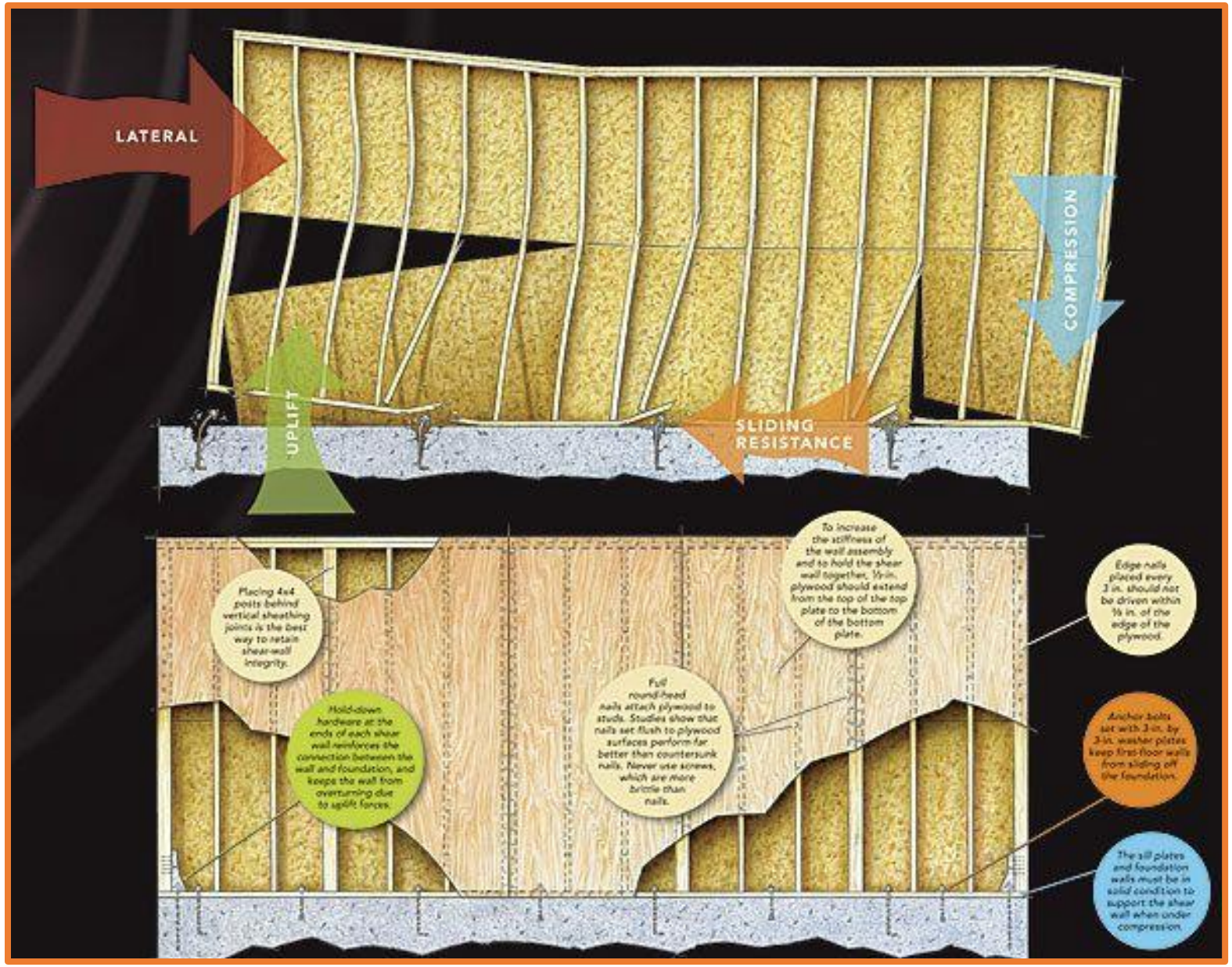


PC: https://news.strongtie.com/

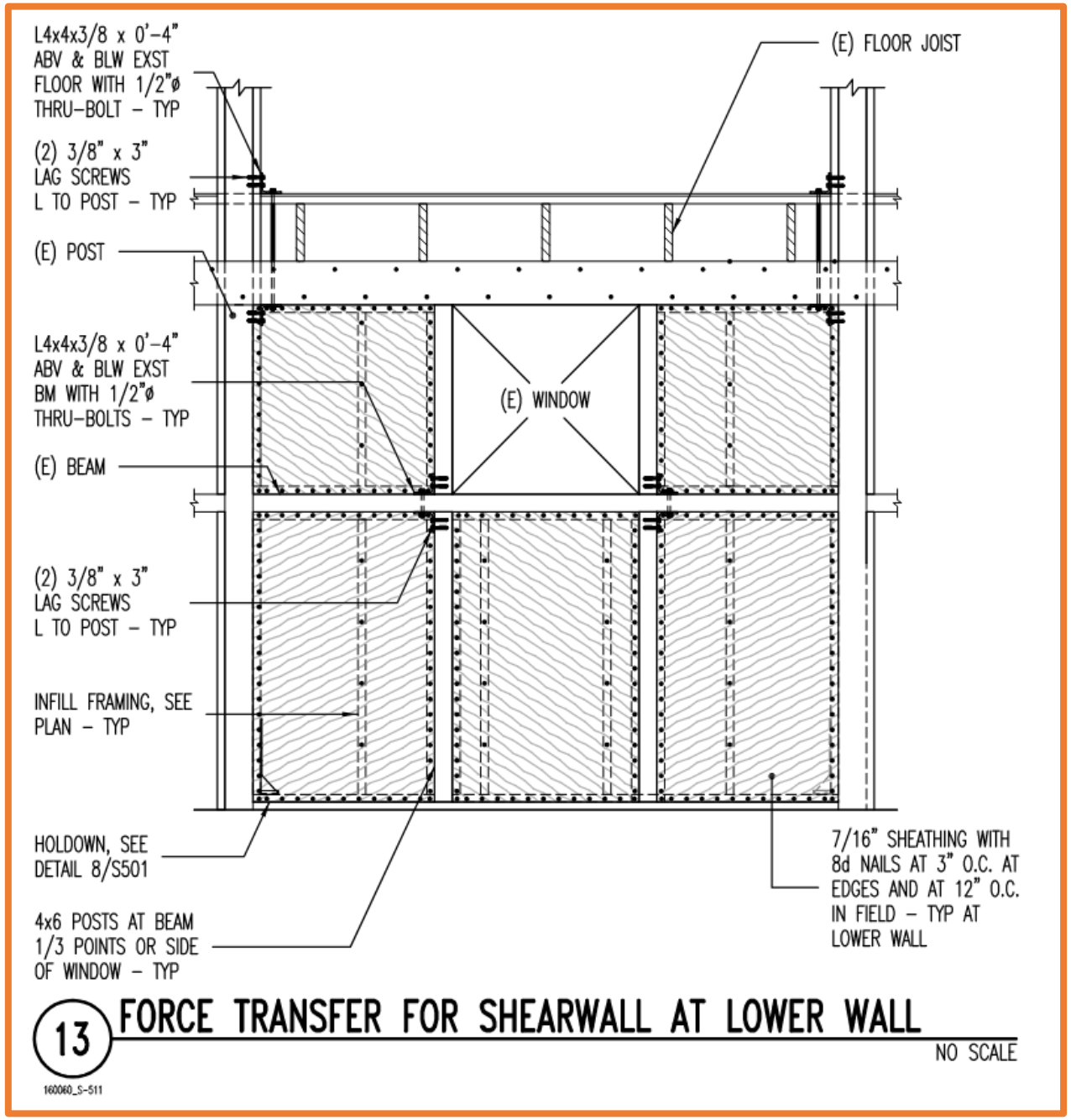
Fabric Reinforced Cementitious Matrix (FRCM)


Wood Structural Upgrades

How a Wood Shear Wall Resists Lateral Forces



Wood Shear Wall Upgrades



Wood Shear Wall Upgrades





Wood Shear Wall Upgrades

- Sheathing placed on inside face of wall.
- Required additional holdowns for anchorage
  - Consider double hold downs to develop forces into post-installed anchors



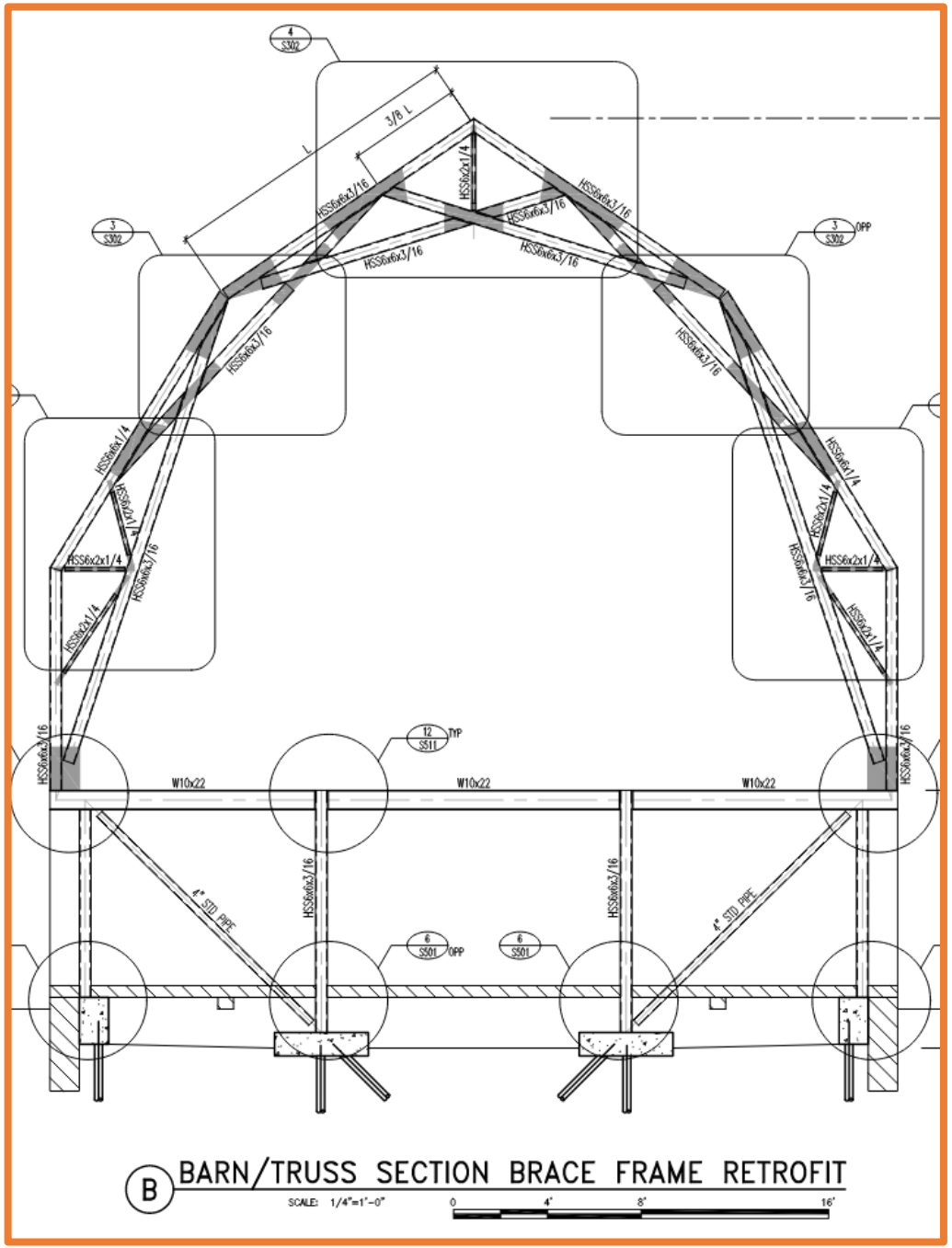
Steel Strengthening Wood Structure



Steel Strengthening Wood Structure



Steel Strengthening Wood Structure



Steel Strengthening Wood Structure





TAKEAWAYS

- Am I following the 5% and 10% rules for gravity and lateral?
- Does this building have any URM?
- Is the re-roof more than 25% of the roof area?
- Is the work surpassing the Work Area – 50% threshold?
- Is there a Change of Occupancy?
  - Risk Cat change or increase in occupancy.
- Did I create a Snow Drift problem?

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