

[TODAY'S TOPIC]

# common challenges in light wood-frame gravity structural design

# schaefer

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*Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.*

# big picture gravity questions at kickoff

construction type

> Type VA or VB



photo credit | MA Design

# big picture gravity questions at kickoff

## construction type

### > Type IIIA or IIIB

- Exterior walls are non-combustible (FRT)

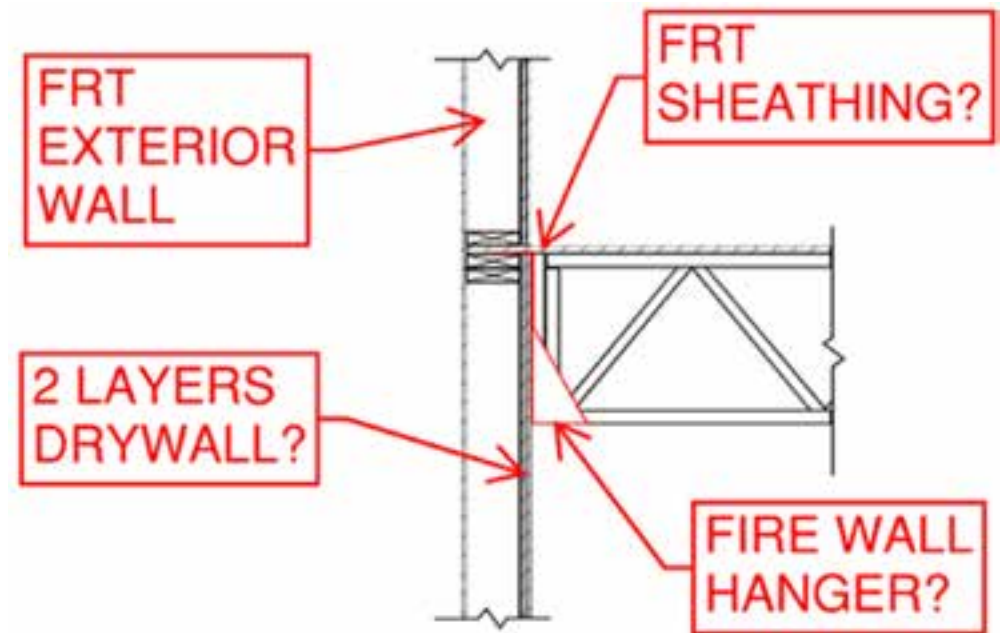
### > How to cantilever for decks or canopies through exterior walls?

- No FRT/PT options yet
- Steel or aluminum?
- Or is PT cantilevering through the walls an option?

# big picture gravity questions at kickoff

## construction type

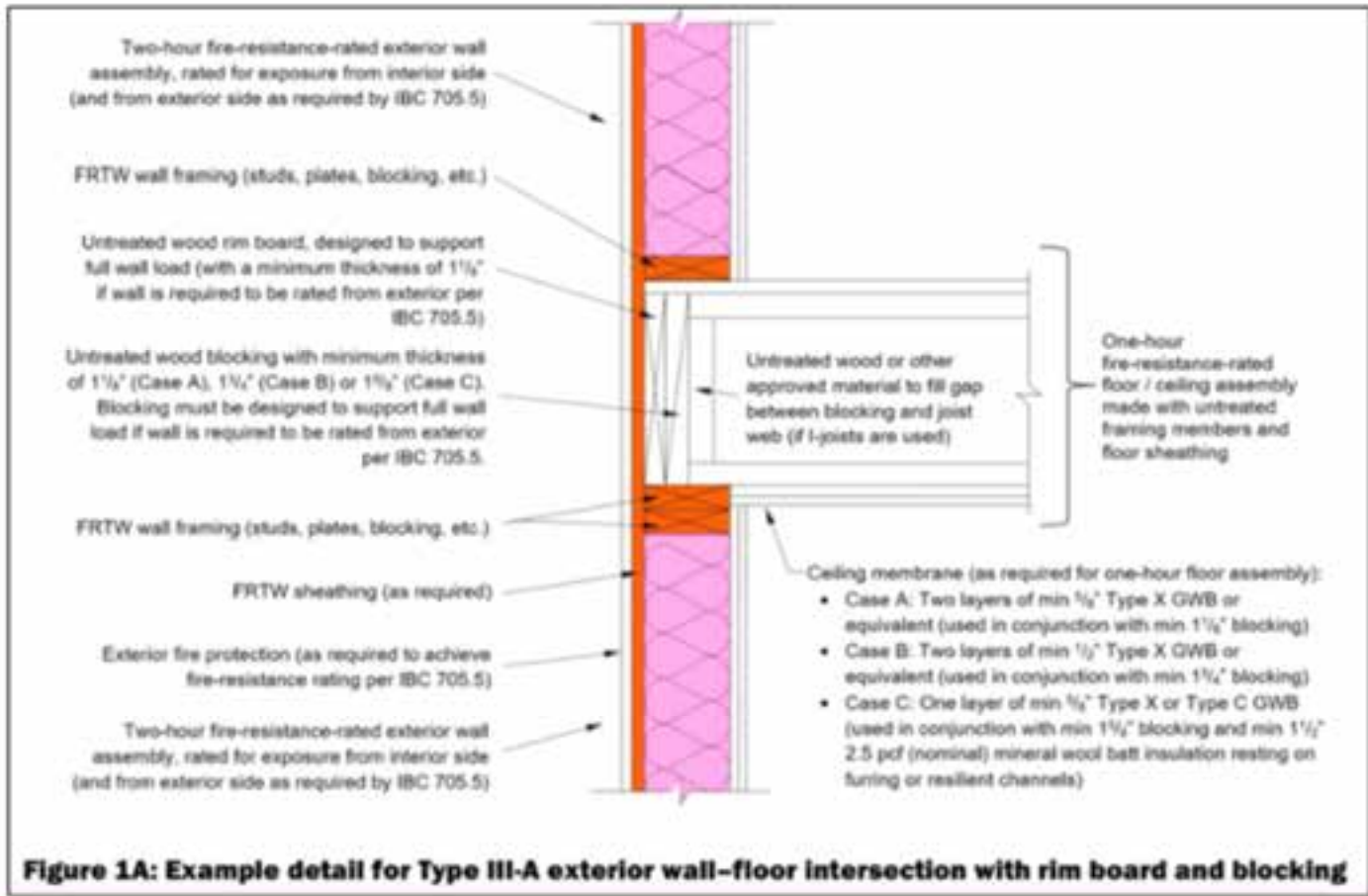
- > Type IIIA or IIIB
- > Non-Combustible Exterior Walls (FRT)
- > 2-Hour Rated Load Bearing Walls



# big picture gravity questions at kickoff

- > AWC's DCA3 provides floor to wall intersection detailing options
- > Addresses both continuity provisions + requirements for FRT elements in exterior wall plane





Type IIIA Exterior Wall Assembly DCA3 | intersecting floors

# IBC 2024 Changes | floor-to-wall intersections

> Two key changes:

- Clarification of fire resistance continuity requirements for exterior walls

## 2021 International Building Code

**705.6 Continuity** . The fire-resistance rating of exterior walls shall extend from the top of the foundation or floor/ceiling assembly below to one of the following:

1. The underside of the floor or roof sheathing, deck or slab above.
2. The underside of a ~~one-hour fire-resistance-rated floor/ceiling or roof/ceiling assembly~~ assembly having a fire-resistance rating equal to or greater than the exterior wall and the fire separation distance is greater than 10 feet .

# IBC 2024 Changes | floor-to-wall intersections

Example: Type IIIA Construction,  
Group R-2, 2 hour exterior wall,  
1 hour floor

Since FRR of exterior wall is greater than FRR of floor, the exterior wall's FRR must extend to the underside of the floor sheathing. This doesn't mean that the wall needs to fully bypass the floor, but we do need to demonstrate the wall's 2 hour FRR through the depth of the floor.





# IBC 2024 Changes | floor-to-wall intersections

## > Code Change #2:

- Clarifies material requirements for floor construction at exterior wall intersections
  - i.e.) Does floor sheathing, joists, rim board at exterior walls in Type III Construction need to be FRTW?

# IBC 2024 Changes | floor-to-wall intersections

**705.6.1 Supporting construction-Floor Assemblies in Type III Construction** . Construction that ~~In~~ Type III construction where a floor assembly supports gravity loads from fire-resistance-rated exterior walls shall have a fire-resistance rating that is equal to or greater than the required fire resistance rating of the supported wall. For achieving the required fire-resistance rating for exposure from the interior of the building, ceiling materials shall be permitted to contribute to the required fire-resistance of the supporting construction.— an exterior wall, the fire-resistance rating of the portion of the floor assembly that supports the exterior wall shall not be less than the fire-resistance rating required for the exterior wall in Table 601. The fire-resistance rating provided by the portion of the floor assembly supporting and within the plane of the exterior wall shall be permitted to include the contribution of the ceiling membrane when considering exposure to fire from the inside. Where a floor assembly supports gravity loads from an exterior wall, the building elements of the floor construction within the plane of the exterior wall, including but not limited to, rim joists, rim boards, and blocking, shall be in accordance with the requirements for interior building elements of Type III Construction.

Where a floor assembly supports gravity loads from an exterior wall, the building elements of the floor construction within the plane of the exterior wall, including but not limited to rim joists, rim boards, and blocking shall be in accordance with the requirements for interior building elements of Type III Construction.

Interior building elements (floor construction) in Type III is not required to be FRTW

# big picture gravity questions at kickoff

construction type

> Is there a podium?



# big picture gravity questions at kickoff

## construction type

- > Is there a podium
- > Type I Construction
- > Podium thickness typically governed by deflection
  - What deflection criteria to use?

# podiums below light framed residential

ACI 318-14

**Table 8.3.1.1—Minimum thickness of nonpre-stressed two-way slabs without interior beams (in.)<sup>[1]</sup>**

$f_y$ , psi <sup>[2]</sup>	Without drop panels <sup>[3]</sup>			With drop panels <sup>[3]</sup>		
	Exterior panels		Interior panels	Exterior panels		Interior panels
	Without edge beams	With edge beams <sup>[4]</sup>		Without edge beams	With edge beams <sup>[4]</sup>	
40,000	$\ell_n/33$	$\ell_n/36$	$\ell_n/36$	$\ell_n/36$	$\ell_n/40$	$\ell_n/40$
60,000	$\ell_n/30$	$\ell_n/33$	$\ell_n/33$	$\ell_n/33$	$\ell_n/36$	$\ell_n/36$
75,000	$\ell_n/28$	$\ell_n/31$	$\ell_n/31$	$\ell_n/31$	$\ell_n/34$	$\ell_n/34$

# podiums below light framed residential

ACI 318-14

- > For a 30-foot bay, minimum thickness is approximately 11-inches
  - Some stop here and move on

# podiums below light framed residential

ACI 318-14

**Table 24.2.2—Maximum permissible calculated deflections**

Member	Condition		Deflection to be considered	Deflection limitation
Flat roofs	Not supporting or attached to nonstructural elements likely to be damaged by large deflections		Immediate deflection due to maximum of $L_r$ , $S$ , and $R$	$\ell/180^{[1]}$
Floors			Immediate deflection due to $L$	$\ell/360$
Roof or floors	Supporting or attached to nonstructural elements	Likely to be damaged by large deflections	That part of the total deflection occurring after attachment of nonstructural elements, which is the sum of the time-dependent deflection due to all sustained loads and the immediate deflection due to any additional live load <sup>[2]</sup>	$\ell/480^{[3]}$
		Not likely to be damaged by large deflections		$\ell/240^{[4]}$

<sup>[1]</sup>Limit not intended to safeguard against ponding. Ponding shall be checked by calculations of deflection, including added deflections due to ponded water, and considering time-dependent effects of sustained loads, camber, construction tolerances, and reliability of provisions for drainage.

<sup>[2]</sup>Time-dependent deflection shall be calculated in accordance with 24.2.4, but shall be permitted to be reduced by amount of deflection calculated to occur before attachment of nonstructural elements. This amount shall be calculated on basis of accepted engineering data relating to time-deflection characteristics of members similar to those being considered.

<sup>[3]</sup>Limit shall be permitted to be exceeded if measures are taken to prevent damage to supported or attached elements.

<sup>[4]</sup>Limit shall not exceed tolerance provided for nonstructural elements.

# big picture Gravity questions at kickoff

> Podium thickness typically governed by deflection

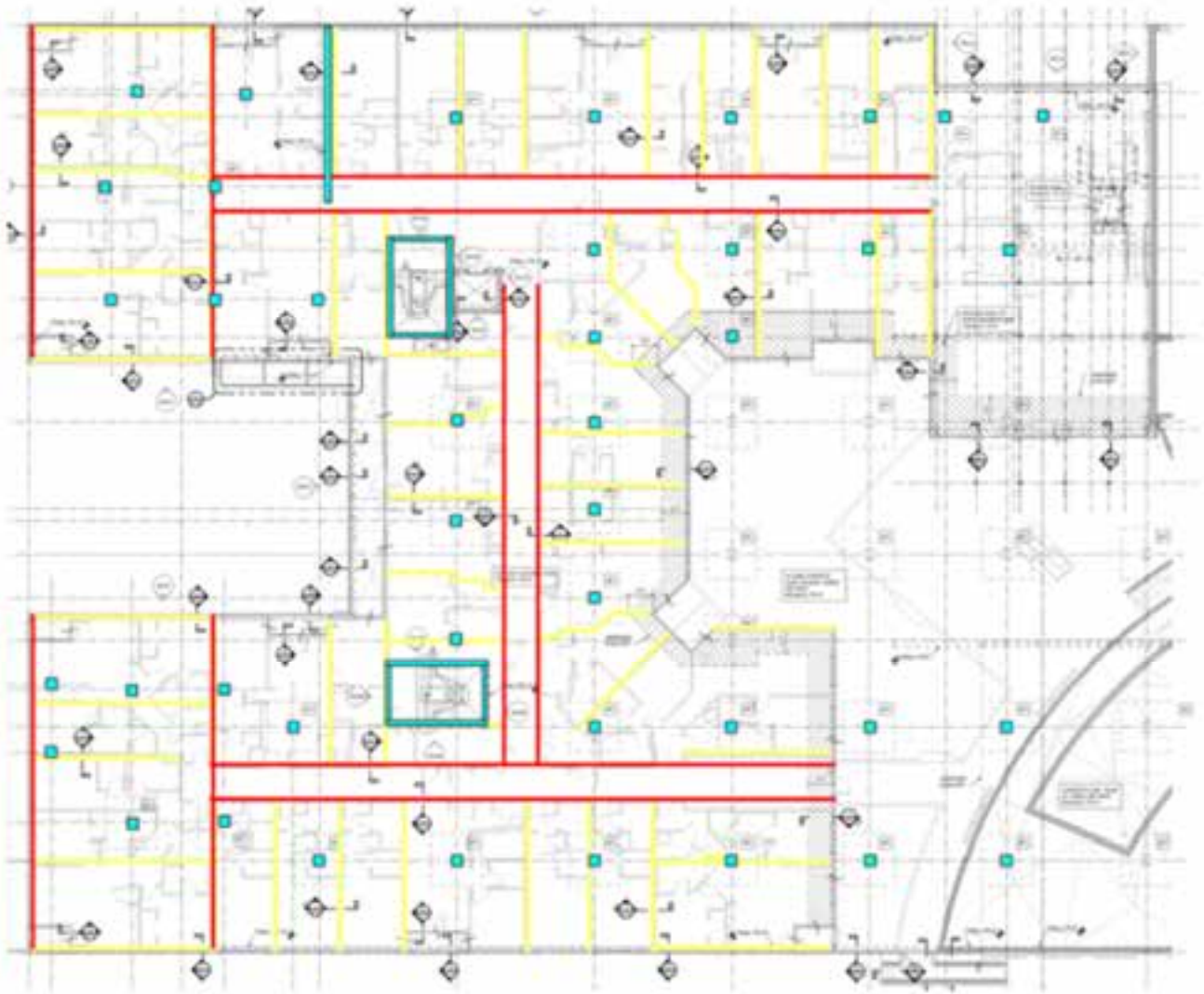
- L/480 long term DL +LL at light Framed Wood Above
  - For a 30'x30' grid,  $\Delta \approx 1$ -inch
- L/600 where supporting Masonry Veneer per BIA recommendations



# podiums below light framed residential

## light-framed wood framing direction implications

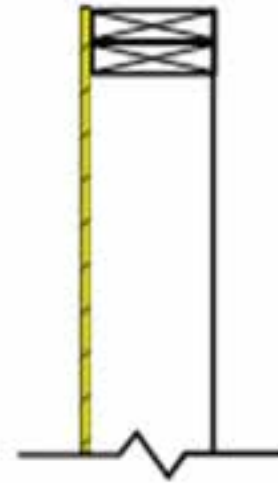
- > Framing Corridor-to-Exterior
  - Two heavy line loads adjacent to each other
  - Often located over a drive aisle
- > Framing Demising-to-Demising
  - Line loads are spread out more
  - Typically save 2"-4" in podium thickness



# load bearing wall design

## what's required to brace a stud?

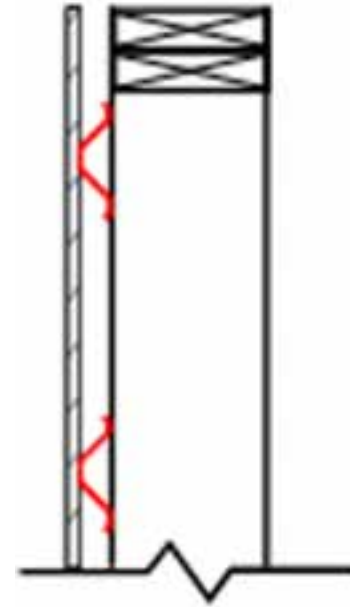
- Per NDS Appendix A.11.3 –  
“Adequately sheathed on one side”
- Industry standard would include drywall



# load bearing wall design

what's required to brace a stud?

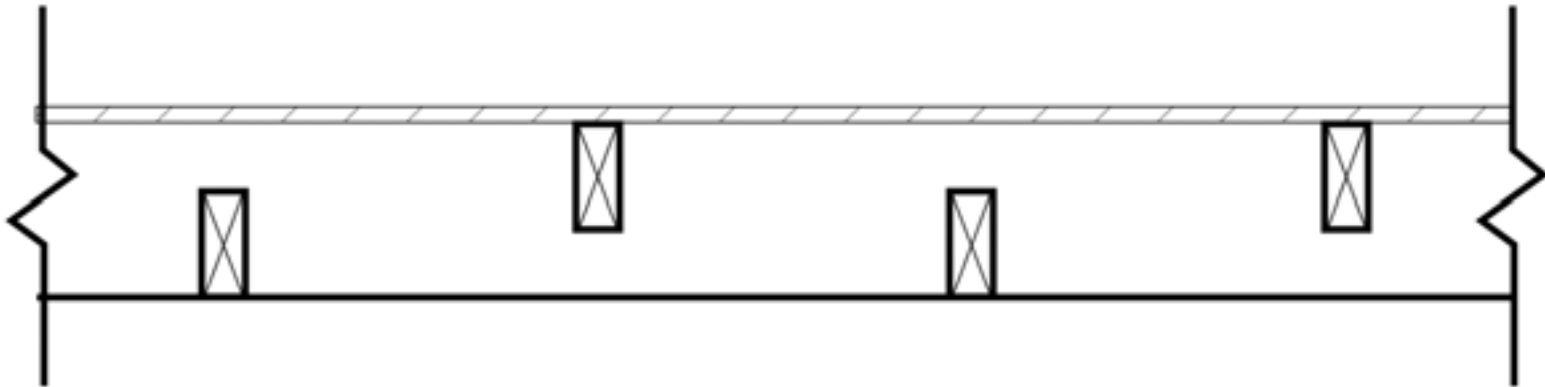
- What about resilient channel directly applied to one face?
  - Probably not



# load bearing wall design

what's required to brace a stud?

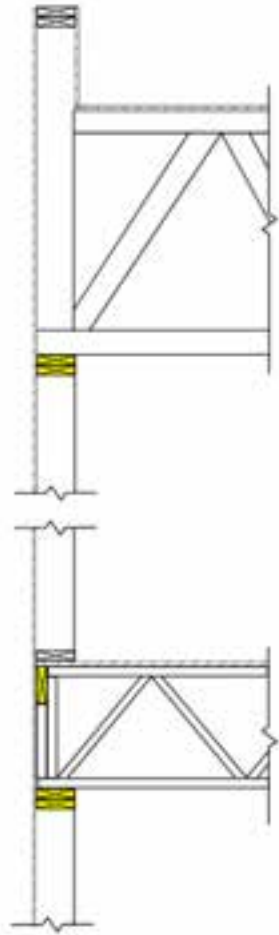
- > Staggered studs?
- > Shear wall – blocking



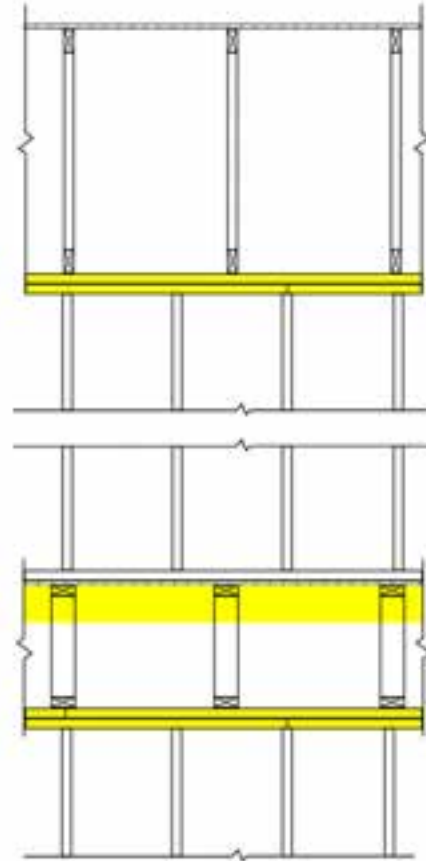
# load bearing wall design

to align or not to align bearing studs?

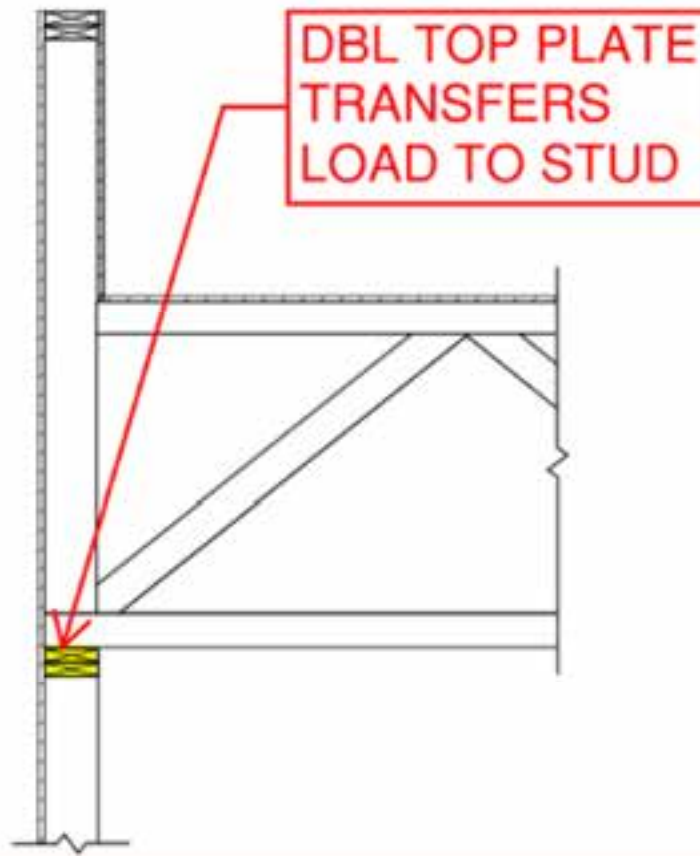
- Pros + cons
- How to avoid aligning studs
- How to align studs



Load Path,  
Load Path,  
Load Path.



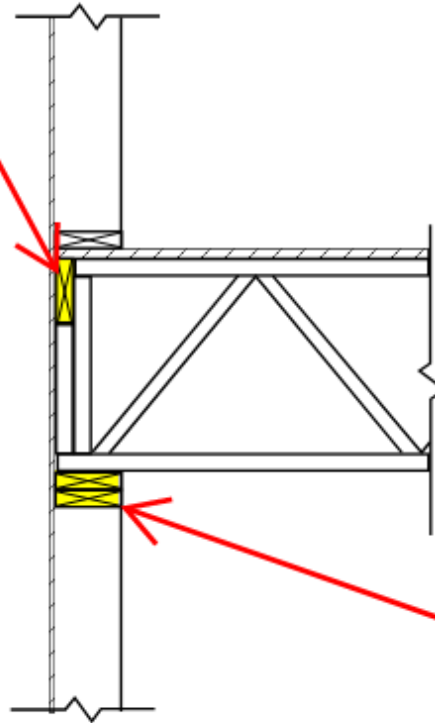
why does it matter?



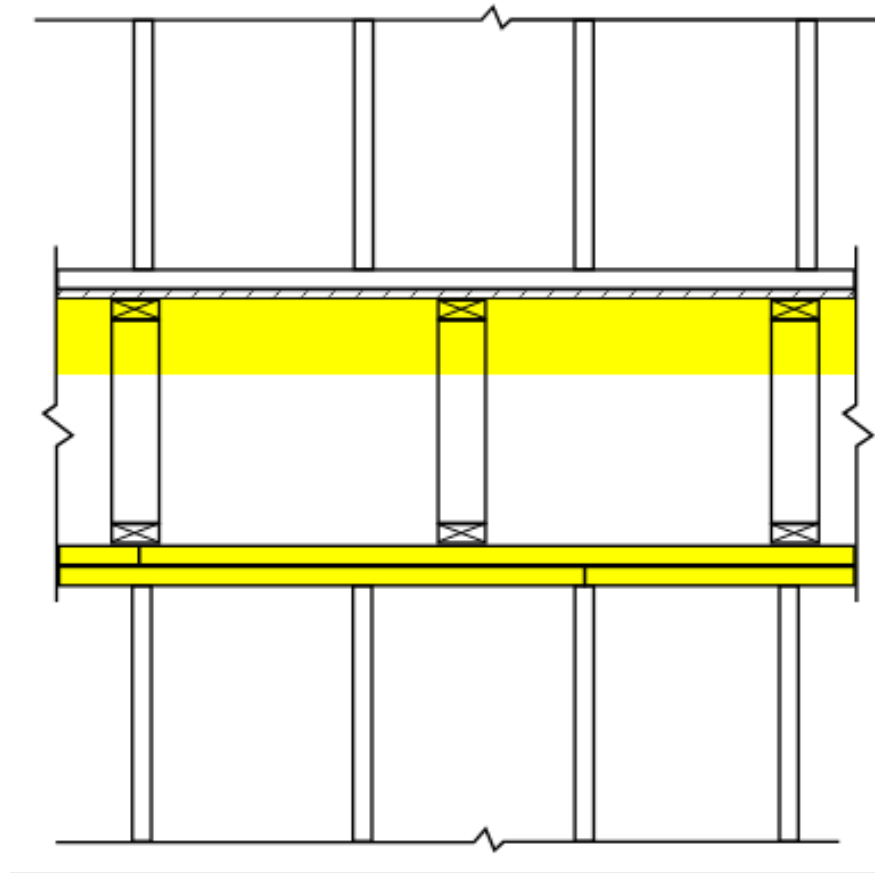
load bearing wall design | misaligned bearing studs



RIBBON BOARD  
TRANSFERS  
GRAVITY TO TRUSS



DBL TOP PLATE  
TRANSFERS  
LOAD TO STUD

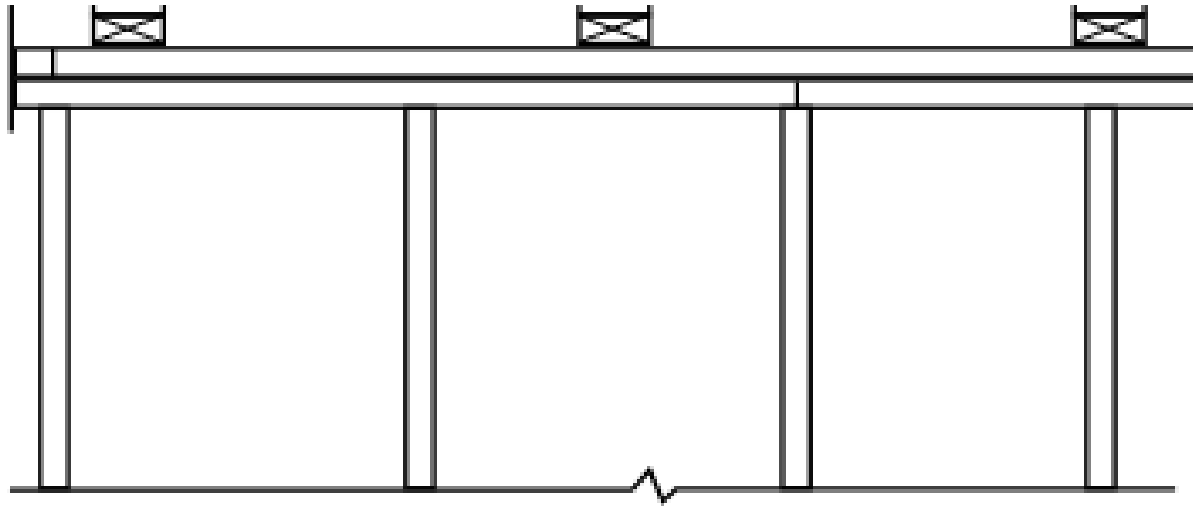


load bearing wall design | misaligned bearing studs

# double top plate capacity

If analyzed as continuous

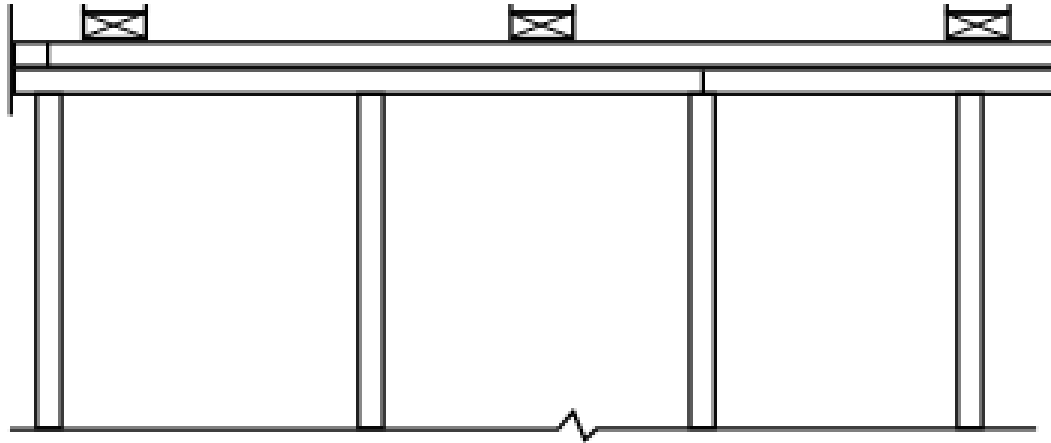
> Increases calculated shear demand and reduces bending moment



# double top plate capacity

If analyzed as (2) individual members rather than (1) composite shape

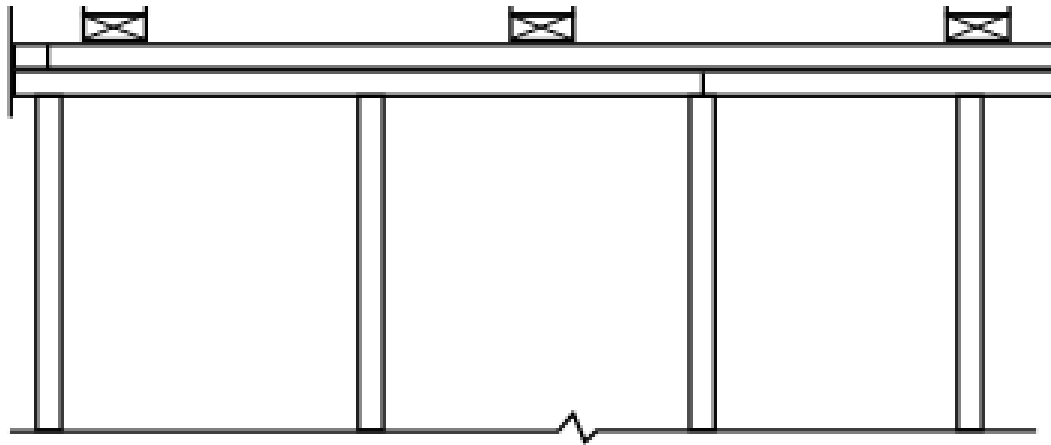
- > Composite action would help moment capacity, but not shear capacity
- > Fasteners will slip
- > Unreasonable number of fasteners required
- > Shear capacity would govern with very little benefit realized



# double top plate capacity

## Takeaways:

- > Capacity varies based on stud spacing and species
- > Can often justify (2)2x plate transferring one truss/joist reaction
- > Unlikely to justify larger capacity than one level at typical truss spans



# pros + cons

## don't align studs

### PROS

- > Easier to economize stud spacing to meet demand/capacity ratio
- > Less up-front coordination with GC

## align studs

### PROS

- > Direct load path
- > Reduce/eliminate gravity transfer members
- > Easier plumbing stack coordination

### CONS

- > May require rim board or other detailing to maintain load path

### CONS

- > Up-front coordination with GC
- > Added studs where 16"oc required

# misaligned bearing studs | alternate details

## full-depth rim board

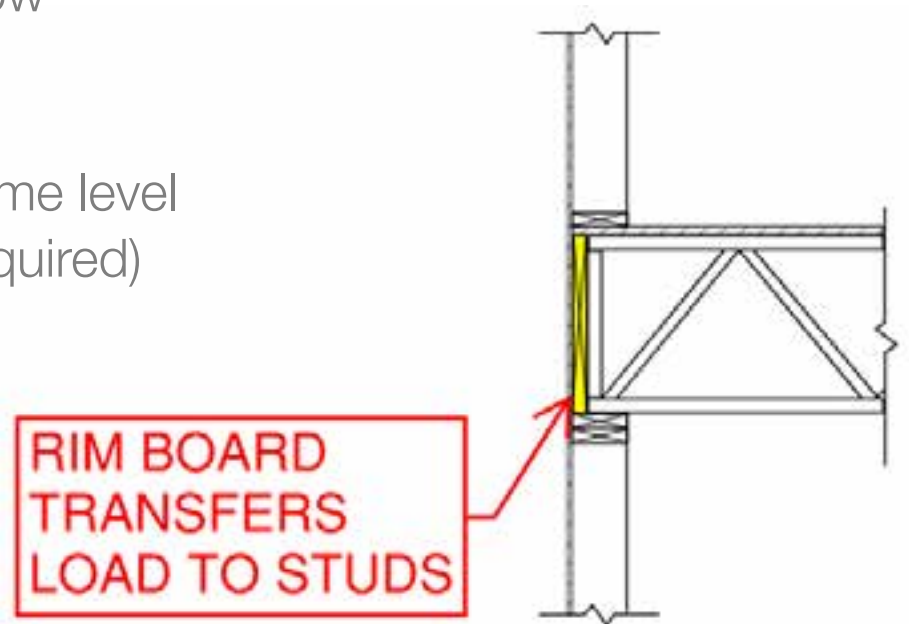
- > Stud load transfers through bottom plate and floor sheathing into full-depth rim board
- > Rim board spans to mis-aligned stud below

## PROS

- > Can distribute heavy truss reactions at same level
- > Use as header (add plies + hangers as required)

## CONS

- > LVL/LSL required
- > Expensive, availability



# misaligned bearing studs | alternate details

## partial-depth rim board with notched truss bearing

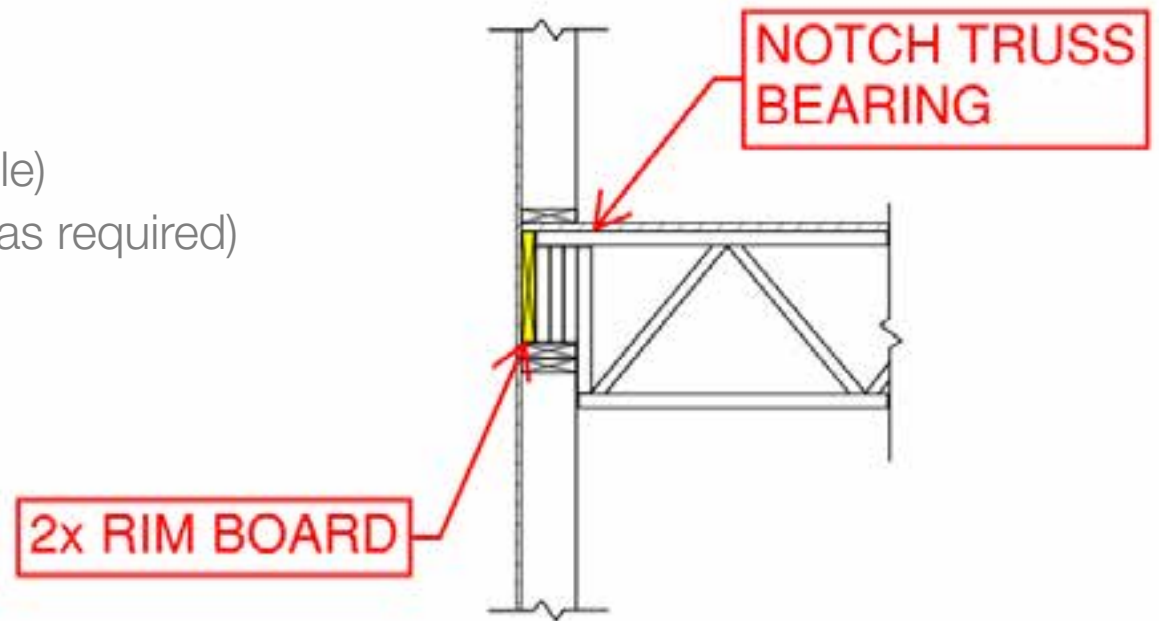
- > Stud load transfers through bottom plate and floor sheathing into 2x rim board
- > Rim board spans to mis-aligned stud below

### PROS

- > 2x material (lower cost, more available)
- > Use as header (add plies + hangers as required)
- > Accommodates higher headers

### CONS

- > Non-standard truss
- > Taller studs





# misaligned bearing studs | alternate details

## rim truss

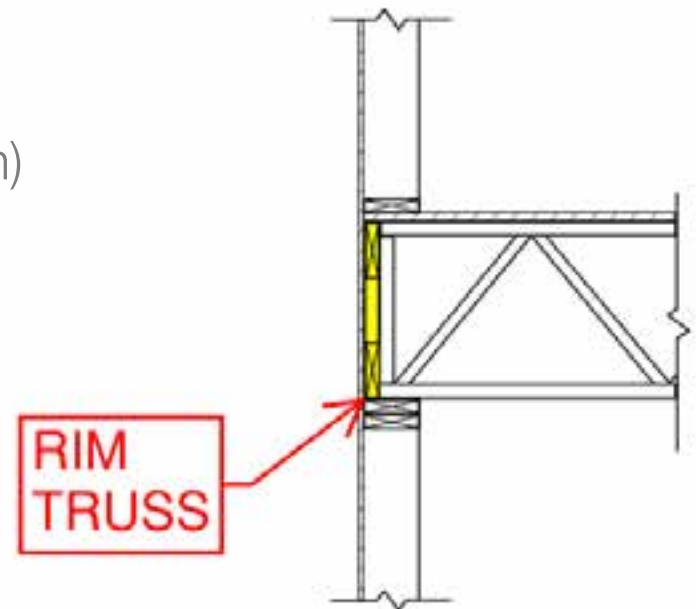
- > Stud load transfers through bottom plate and floor sheathing into rim truss
- > Rim truss spans to misaligned studs below

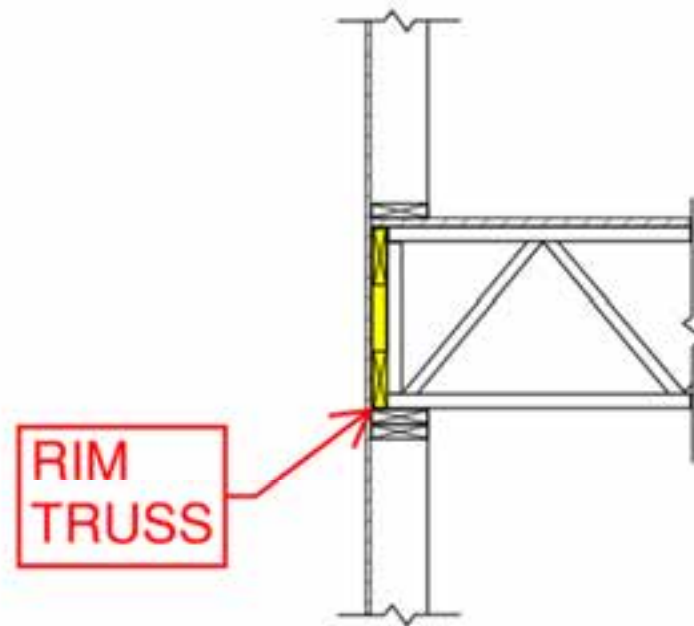
## PROS

- > Part of the truss package (economy + coordination)

## CONS

- > Coordinate mechanical penetrations, loads + vertical web spacing with truss designer
- > Note: does not provide fire blocking





misaligned bearing studs | alternate details

# misaligned bearing studs | alternate details

## top + bottom ribbon boards

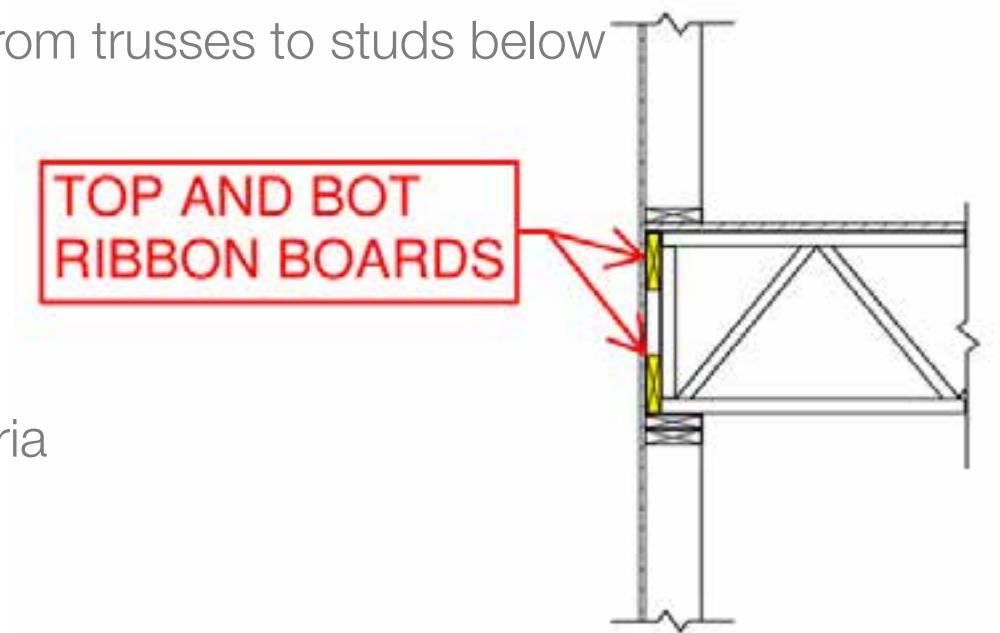
- > Load transfers through bottom plate and floor sheathing into top ribbon board
- > Top ribbon board spans to trusses
- > Bottom ribbon board distributes loads from trusses to studs below

## PROS

- > 2x framing economy

## CONS

- > Review with architect for assembly criteria
- > Does not transfer lateral load



# misaligned bearing studs | alternate details

## larger solid top plate member

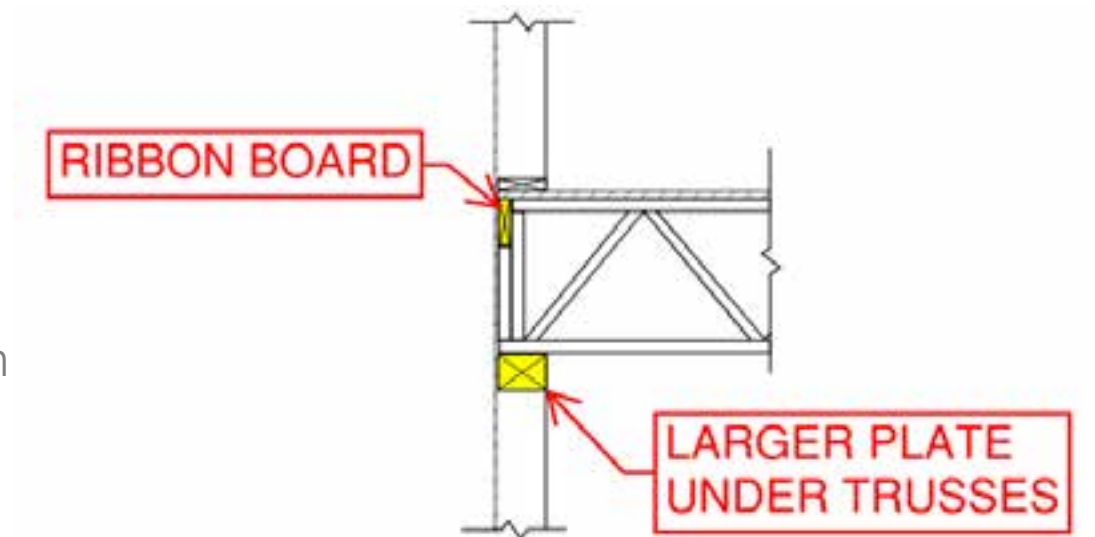
- > Load transfers through bottom plate and floor sheathing into ribbon board
- > Ribbon board spans to trusses
- > Larger top plate spans distributes load to misaligned studs below

## PROS

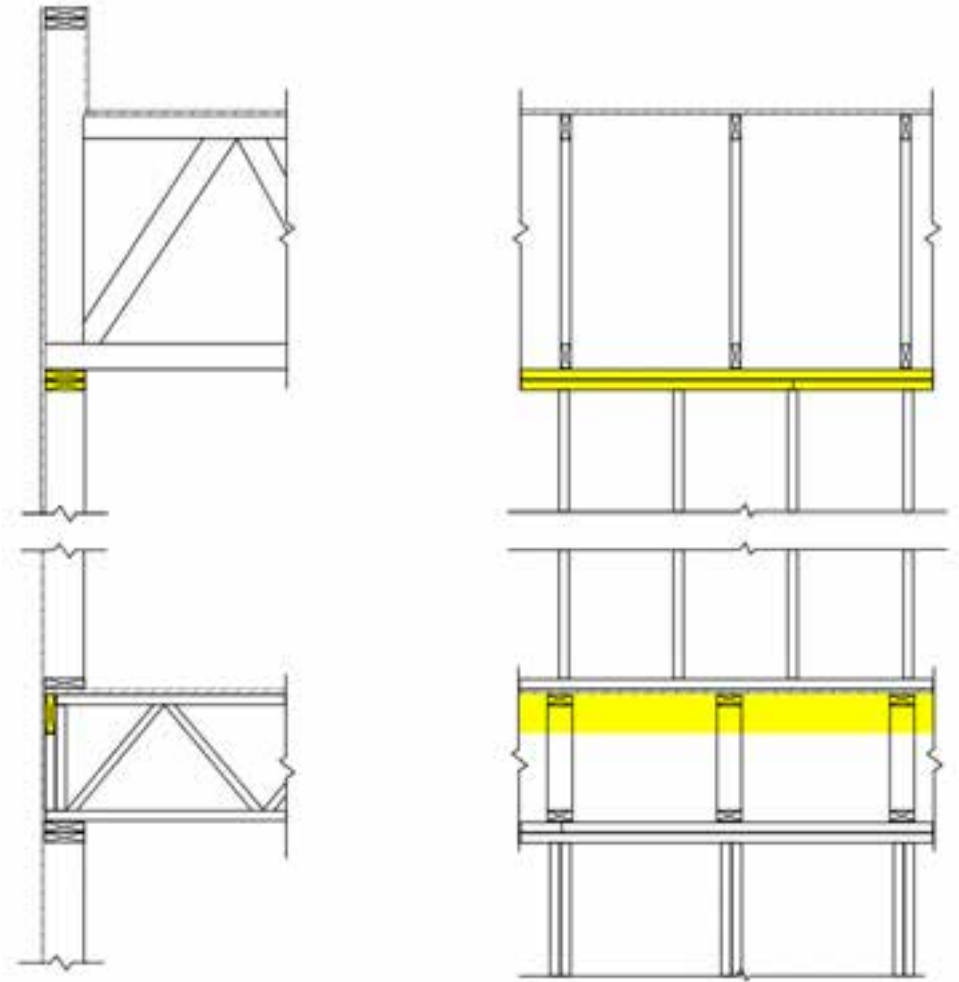
- > 2x framing economy

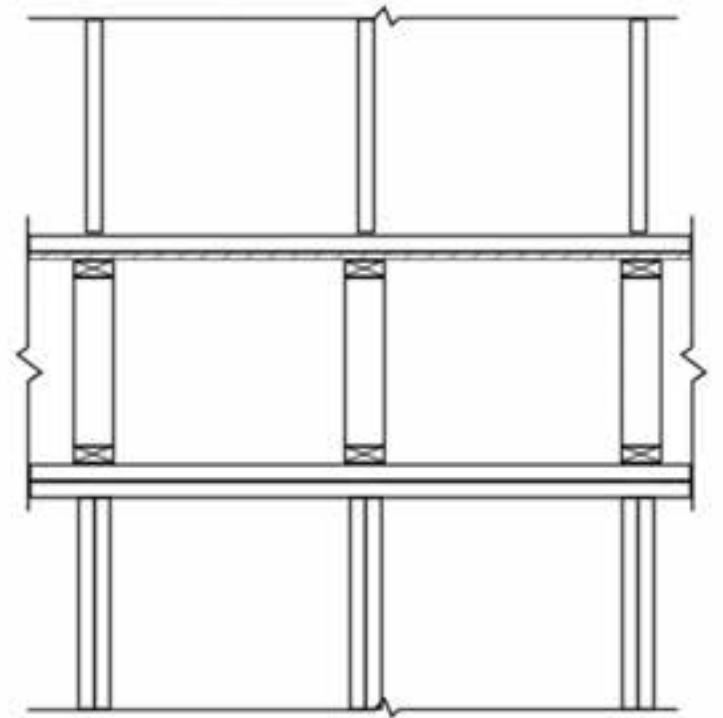
## CONS

- > Limited gains
- > Cost + availability of solid 4x+ section
- > Does not transfer lateral load



# load bearing wall design | aligned bearing studs



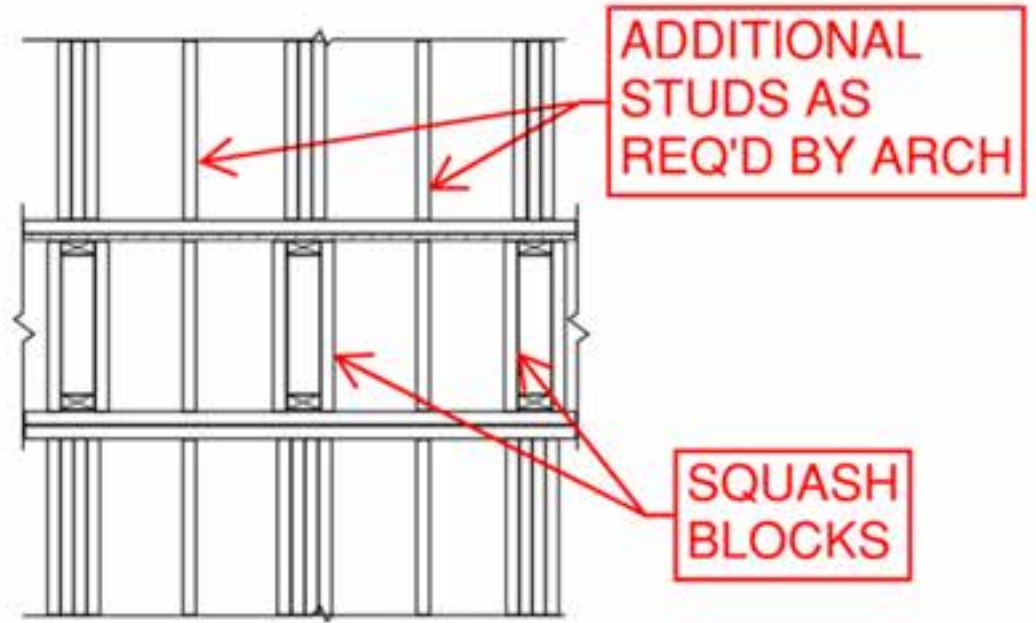


load bearing wall design | aligned bearing studs

# load bearing wall design | aligned bearing studs

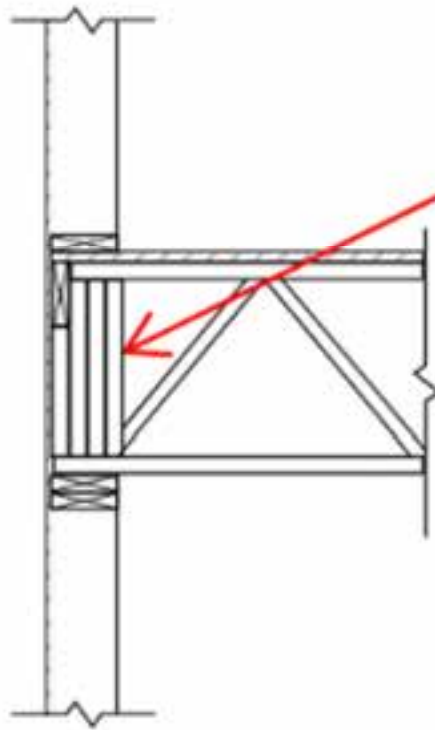
*Keep in mind when aligning studs + trusses:*

- > Truss/joist spacing is often 24"oc
- > Stud spacing often will be tighter for fire ratings or architectural finishes
- > Squash blocks may be required if stud packs are wider than the floor truss/joist
- > Trusses may require additional vertical truss webs at bearing for full width of stud



load bearing wall design | aligned bearing studs

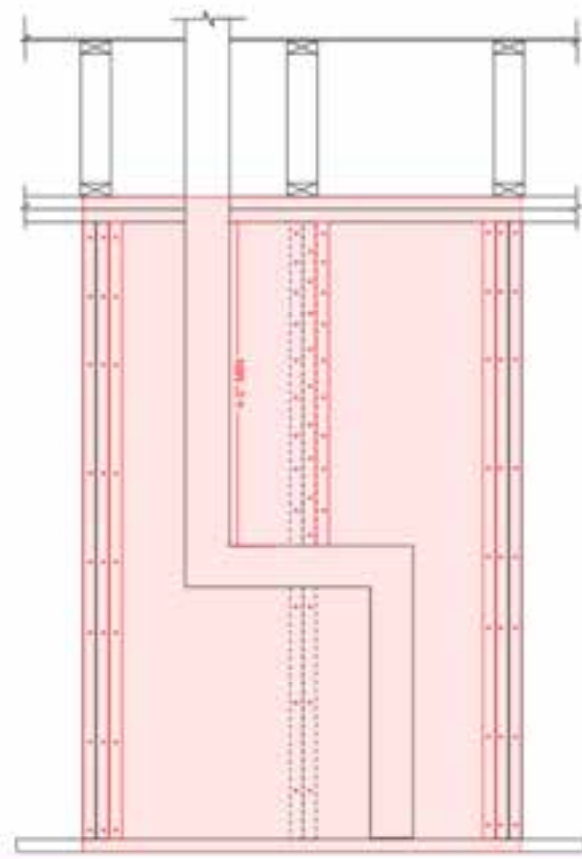
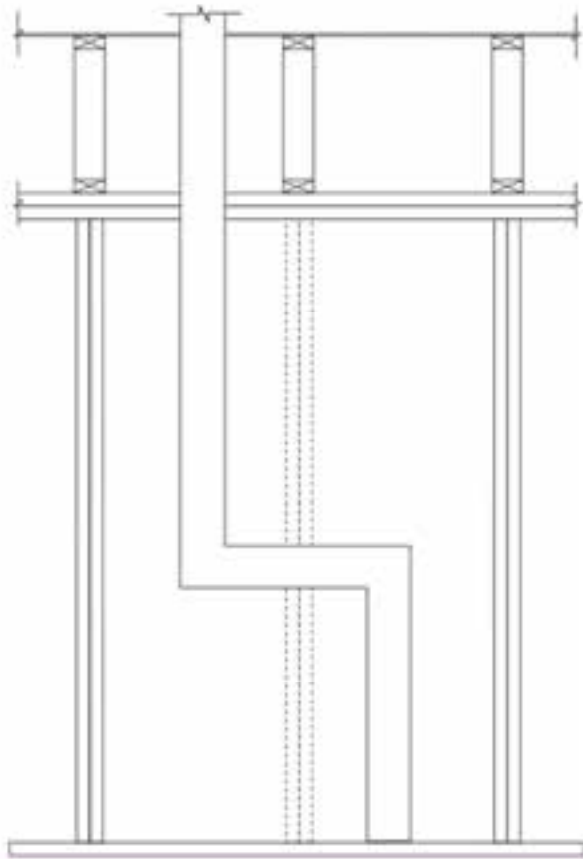




ADDITIONAL TRUSS  
END WEBS AS REQ'D  
TO TRANSFER LOAD  
FROM STUDS ABOVE



load bearing wall design | plumbing stack conflicts



load bearing wall design | plumbing stack conflicts

# shrinkage |

> See WoodWorks article:  
“Accommodating Shrinkage in  
Multi-Story Wood-Frame Structures”



### Accommodating Shrinkage in Multi-Story Wood-Frame Structures

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In wood-frame buildings of three or more stories, cumulative shrinkage can be significant and have an impact on the function and performance of doors, openings, mechanical/electrical/hydraulic (MECH) systems, and structural connections. However, as codes designers and the wood-frame construction community have learned that accommodating wood shrinkage is actually not straightforward.

Wood is hygroscopic, meaning it has the ability to absorb and release moisture. As the moisture is able to be absorbed or released dimensionally, following time and when wood dries and swells, codes designers design their buildings to minimize related effects.

Wood shrinkage occurs perpendicular to grain, meaning that a solid panel would shrink in three joint sets: across its width, across its thickness, and along its length. Longitudinal shrinkage is negligible, meaning the length of a stud in floor joist assemblies remain unchanged. In multi-story buildings, wood shrinkage is therefore concentrated at the wall plates, floor joist-end joints, and the beams. Depending on the materials and details used at floor-to-wall and wall-to-wall connections, shrinkage in light-frame wood construction can range from 0.08 inches to 0.8 inches per foot.

This publication will describe procedures for estimating wood shrinkage and provide detailing options that minimize its effects on building performance.

#### Wood Science & Shrinkage

Understanding the relative shrinkage of wood allows an architect to understand how moisture and wood plates and identify the joints that shrinkage typically occurs. Shrinkage occurs most often in two forms: (1) free water in cell cavities, and (2) bound water in cell walls. Simultaneously, wood is a cellular structure that has arranged an assembly of stretching stresses held together with a ribbon (cell), with each ribbon representing



• Longitudinal joint in the wood frame can be free water stored in the wood cavity or bound water absorbed by the wood cells. As high moisture content, water levels in each direction. As the wood dries, the free water is released from the cell cavities before the bound water is released from the cell walls. After wood has no free water within the cell wall is still saturated. It is not so as in the free water joint (FSP). Imagine a sponge that has just been taken out of a bucket filled with water. As the sponge is lifted from the bucket, water comes out of the pores. When the sponge is laid down, only water comes out of the pores. The moisture within the sponge can be squeezed out of the sponge but not if the sponge is saturated to the FSP. The moisture retained in the sponge is the bound water and water that has been absorbed into the free water.

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questions?



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