common challenges in light wood-frame gravity structural design
big picture gravity questions at kickoff

construction type

> Type VA or VB
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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?
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construction type

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

Figure 1A: Example detail for Type III-A exterior wall-floor intersection with rim board and blocking

- Two-hour fire-resistance-rated exterior wall assembly, rated for exposure from interior side (and from exterior side as required by IBC 705.5)
- FRTW wall framing (studs, plates, blocking, etc.)
  - Untreated wood rim board, designed to support full wall load (with a minimum thickness of 1 1/4" if wall is required to be rated from exterior per IBC 705.5)
  - Untreated wood blocking with minimum thickness of 1 1/4" (Case A), 1 1/2" (Case B) or 1 3/4" (Case C). Blocking must be designed to support full wall load if wall is required to be rated from exterior per IBC 705.5.
  - FRTW sheathing (as required)
  - FRTW wall framing (studs, plates, blocking, etc.)
  - Exterior fire protection (as required to achieve fire-resistance rating per IBC 705.5)
  - Two-hour fire-resistance-rated exterior wall assembly, rated for exposure from interior side (and from exterior side as required by IBC 705.5)

- One-hour fire-resistance-rated floor/ceiling assembly made with untreated framing members and floor sheathing
  - Ceiling membrane (as required for one-hour floor assembly):
    - Case A: Two layers of min 1/4" Type X GWB or equivalent (used in conjunction with min 1 1/2" blocking)
    - Case B: Two layers of min 1/4" Type X GWB or equivalent (used in conjunction with min 1 1/2" blocking)
    - Case C: One layer of min 1/4" Type X or Type C GWB (used in conjunction with min 1 1/2" blocking and min 1 1/2") 2.5 pcf (nominal) mineral wool batt insulation resting on furring or resilient channels
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?
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
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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?
Table 8.3.1.1—Minimum thickness of nonpre-stressed two-way slabs without interior beams (in.)\textsuperscript{[1]}

<table>
<thead>
<tr>
<th>$f_y$, psi\textsuperscript{[2]}</th>
<th>Without drop panels\textsuperscript{[3]}</th>
<th>With drop panels\textsuperscript{[3]}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exterior panels</td>
<td>Interior panels</td>
</tr>
<tr>
<td></td>
<td>Without edge beams</td>
<td>With edge beams\textsuperscript{[4]}</td>
</tr>
<tr>
<td>40,000</td>
<td>$\ell_n/33$</td>
<td>$\ell_n/36$</td>
</tr>
<tr>
<td>60,000</td>
<td>$\ell_n/30$</td>
<td>$\ell_n/33$</td>
</tr>
<tr>
<td>75,000</td>
<td>$\ell_n/28$</td>
<td>$\ell_n/31$</td>
</tr>
</tbody>
</table>
podiums below light framed residential

> For a 30-foot bay, minimum thickness is approximately 11-inches
  • Some stop here and move on
podiums below light framed residential

Table 24.2.2—Maximum permissible calculated deflections

<table>
<thead>
<tr>
<th>Member</th>
<th>Condition</th>
<th>Deflection to be considered</th>
<th>Deflection limitation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flat roofs</td>
<td>Not supporting or attached to nonstructural elements likely to be damaged by large deflections</td>
<td>Immediate deflection due to maximum of L, S, and R</td>
<td>L/180[1]</td>
</tr>
<tr>
<td>Floors</td>
<td></td>
<td>Immediate deflection due to L</td>
<td>1/360</td>
</tr>
<tr>
<td>Roof or floors</td>
<td>Supporting or attached to nonstructural elements</td>
<td>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[2]</td>
<td>L/480[2]</td>
</tr>
<tr>
<td></td>
<td>Likely to be damaged by large deflections</td>
<td></td>
<td>L/240[4]</td>
</tr>
<tr>
<td></td>
<td>Not likely to be damaged by large deflections</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

[1] 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.

[2] 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.

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

[4] Limit shall not exceed tolerance provided for nonstructural elements.
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> Podium thickness typically governed by deflection
  • L/480 long term DL + LL at light Framed Wood Above
    – For a 30’x30’ grid, ∆ ≈ 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
why does it matter?

Load Path,
Load Path,
Load Path.
Double top plate transfers load to stud.

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

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

**Align Studs**

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

**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

lager 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”