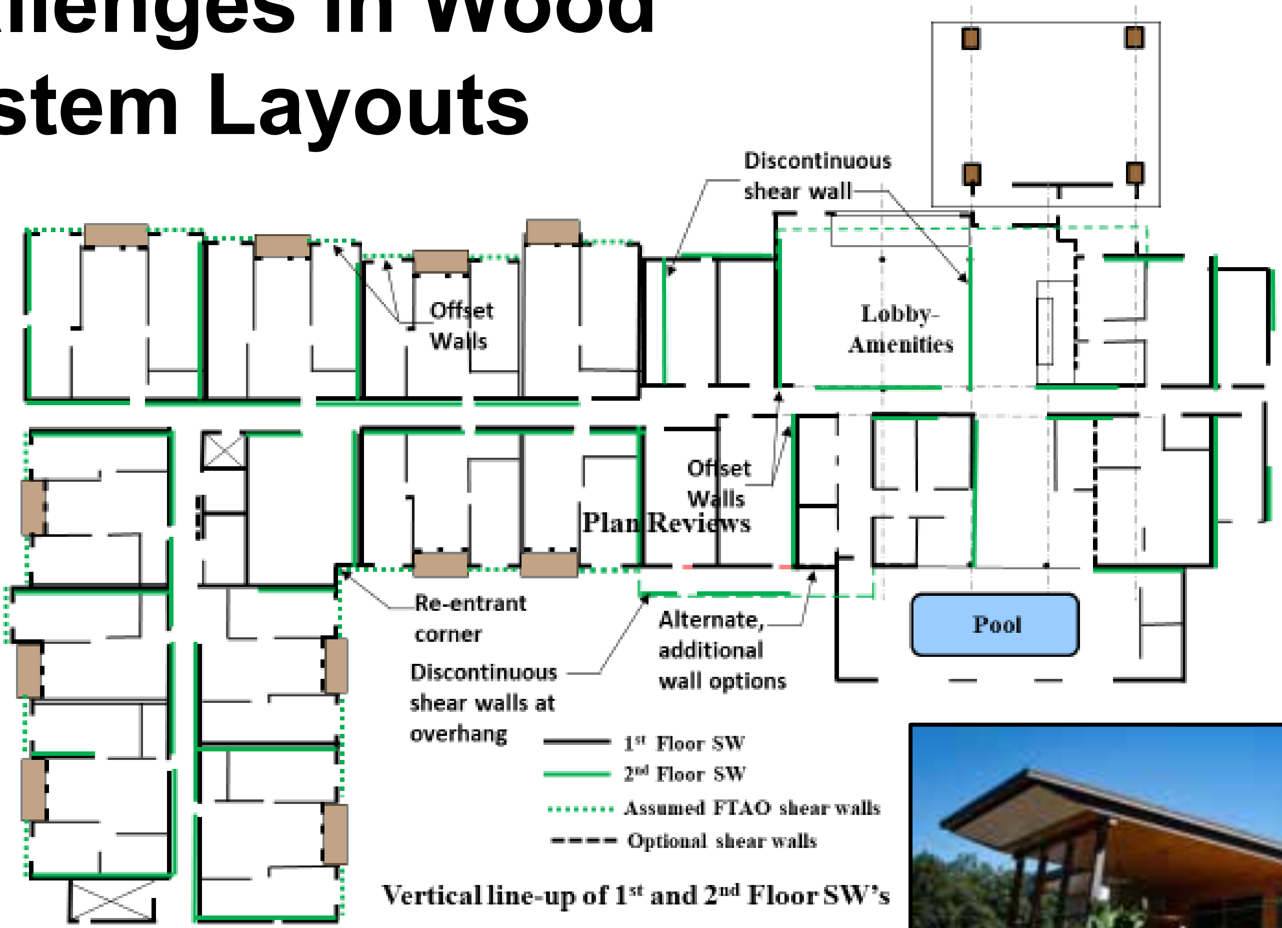
WoodWorks

Common Challenges in Wood Lateral System Layouts

Crescent Terminus
Lord Aeck Sargent
Photographer: Richard Lubrant

Mid-rise



Low-rise

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Senior Technical Director
www.woodworks.org

Photo courtesy of McGraw-Hill-ICC

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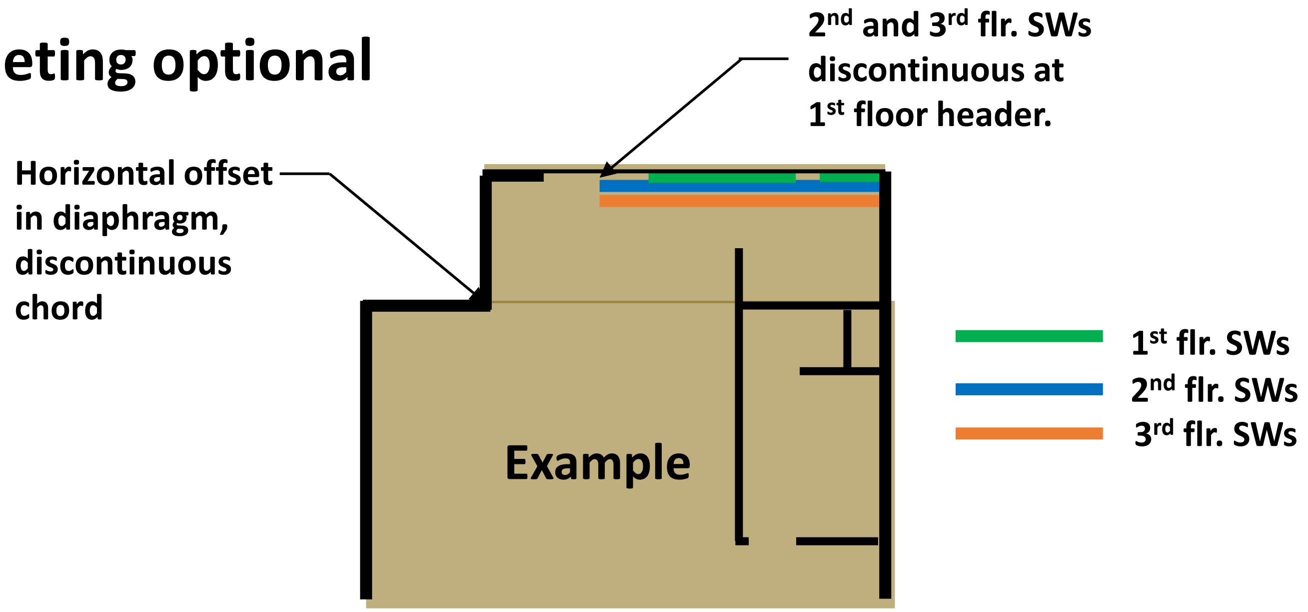
Course Description

Creative structures are becoming increasingly common to differentiate projects in the highly competitive commercial and multi-family construction markets. However, their aesthetically pleasing shapes can create challenging lateral load paths and structural irregularities that are difficult to define and resolve. This presentation will explore lateral system layout challenges that often occur during the schematic design of wood framed buildings.

Topics will include cantilever diaphragm design, impacts of large openings at elevators and stairs, discontinuous shearwalls, relative stiffness issues between shear walls and diaphragms, vertical and horizontal offsets in lateral force-resisting systems, and combinations of different lateral systems (such as masonry shearwalls and wood sheathed shearwalls). Actual design examples will be included throughout the presentation to give real world context for these common challenges.

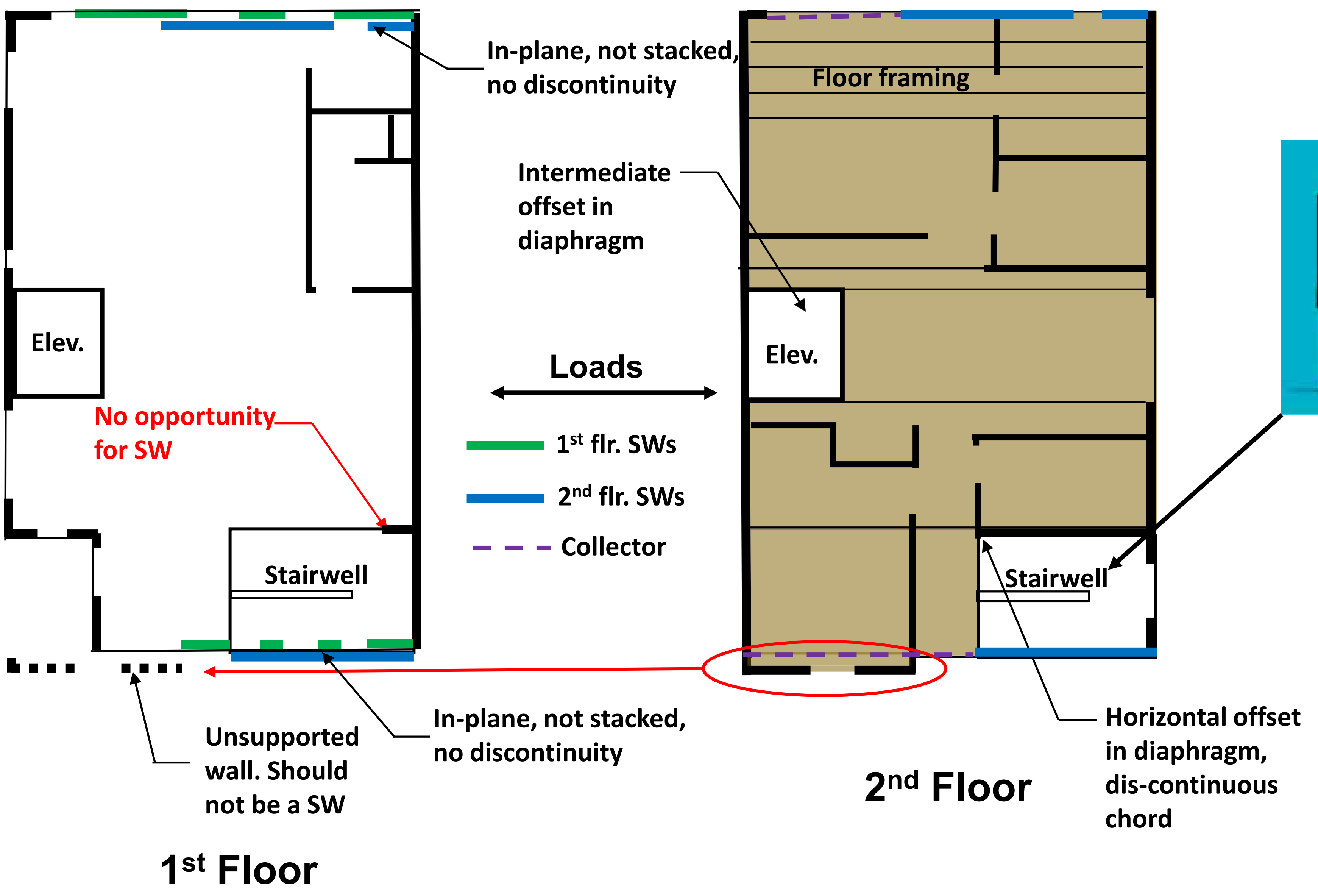
Typical Review Process

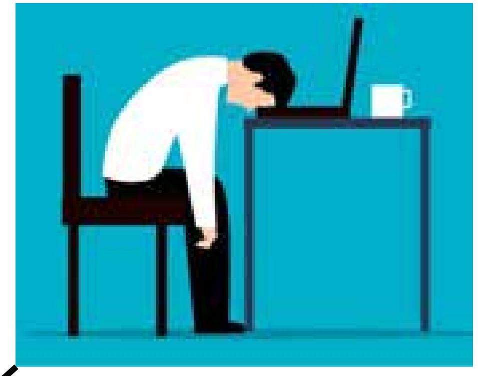
- Overlay shear walls from floor to floor to see if they stack or are discontinuous.
- Determine the diaphragm boundary, including the effects of openings and location of supporting walls (most important task).
- Identify irregularities and load path challenges (offset walls and /or diaphragms, discontinuous chords, etc.).
- Create comments and possible solutions to the issues for consideration.
- Zoom meeting optional



PDF Markup

Example 1-Stairwells and elevator Shafts





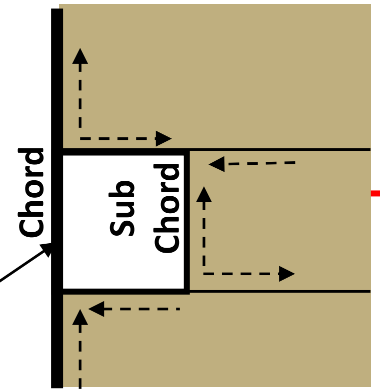
Stairs !!!!!

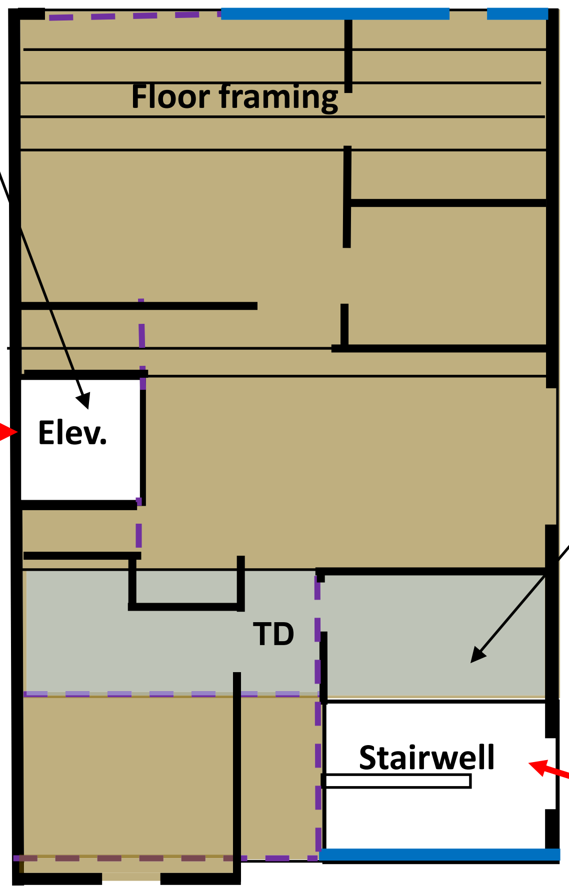
Example 1-Possible solutions

First determine if opening is small enough to ignore.
Can ignore if all 4 items are met:

Opening size criteria
1. 0.15W diaph.
2. 0.15L diaph.
3. Edge dist. 3x
4. A.R all 4 sides

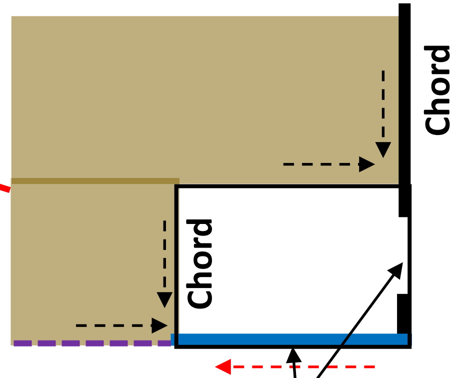
No shear acting on member.





2nd Floor

Solution: Since there is no opportunity to create SWs below, use TD (No new members)



No diaphragm shear acting on member. Can't be part of diaphragm chord

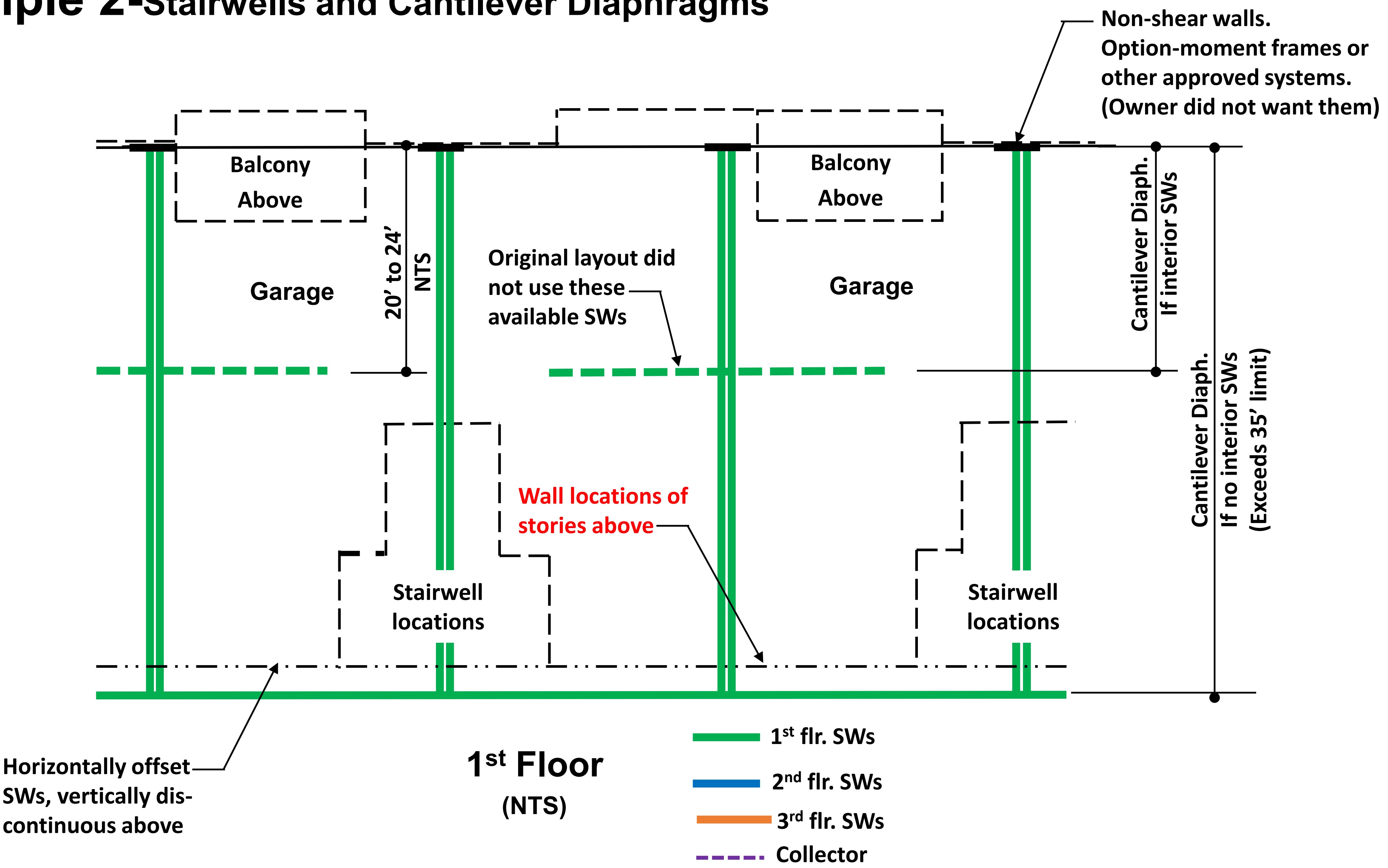
Loads

1st flr. SWs

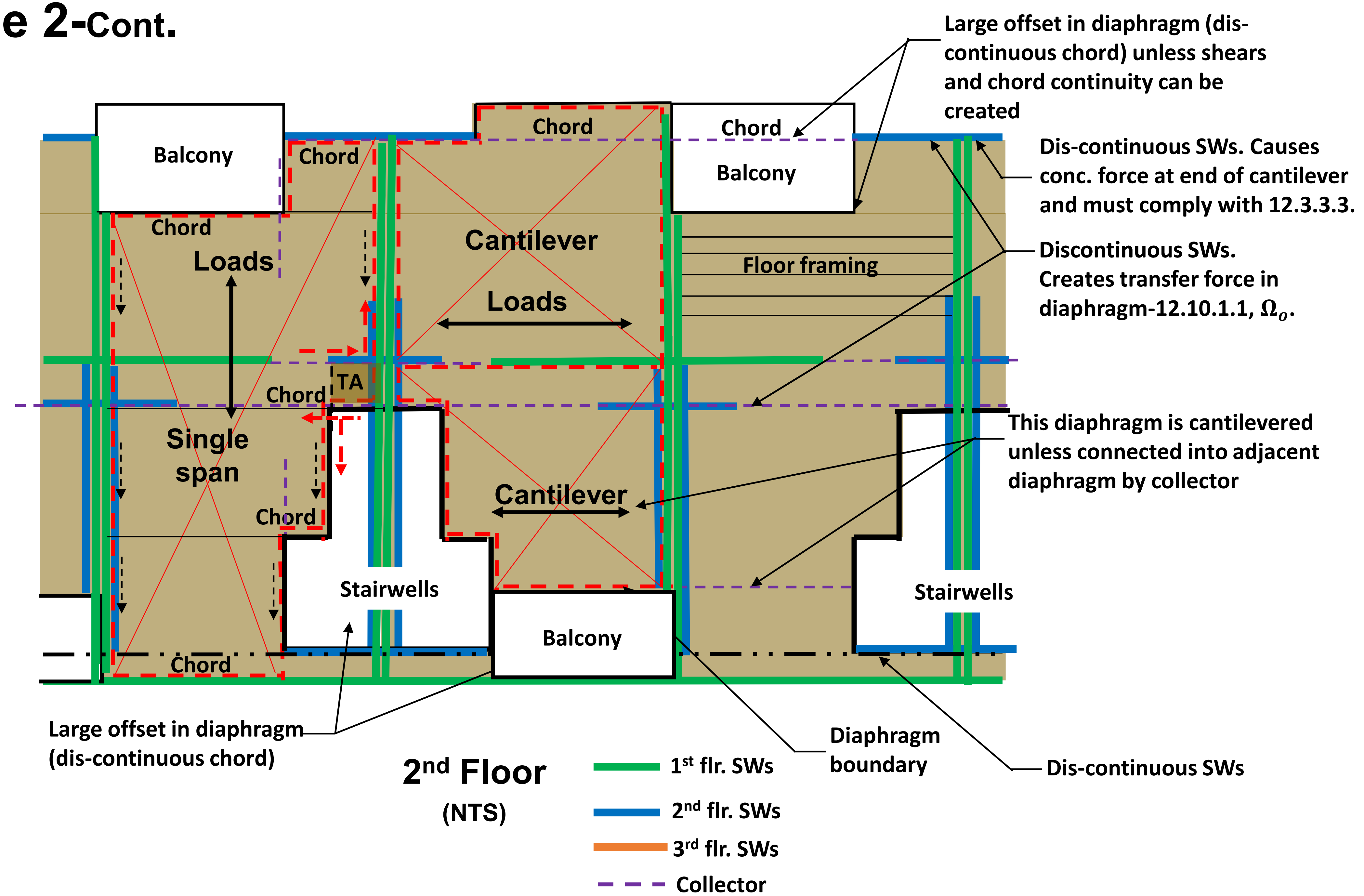
2nd flr. SWs

Collector

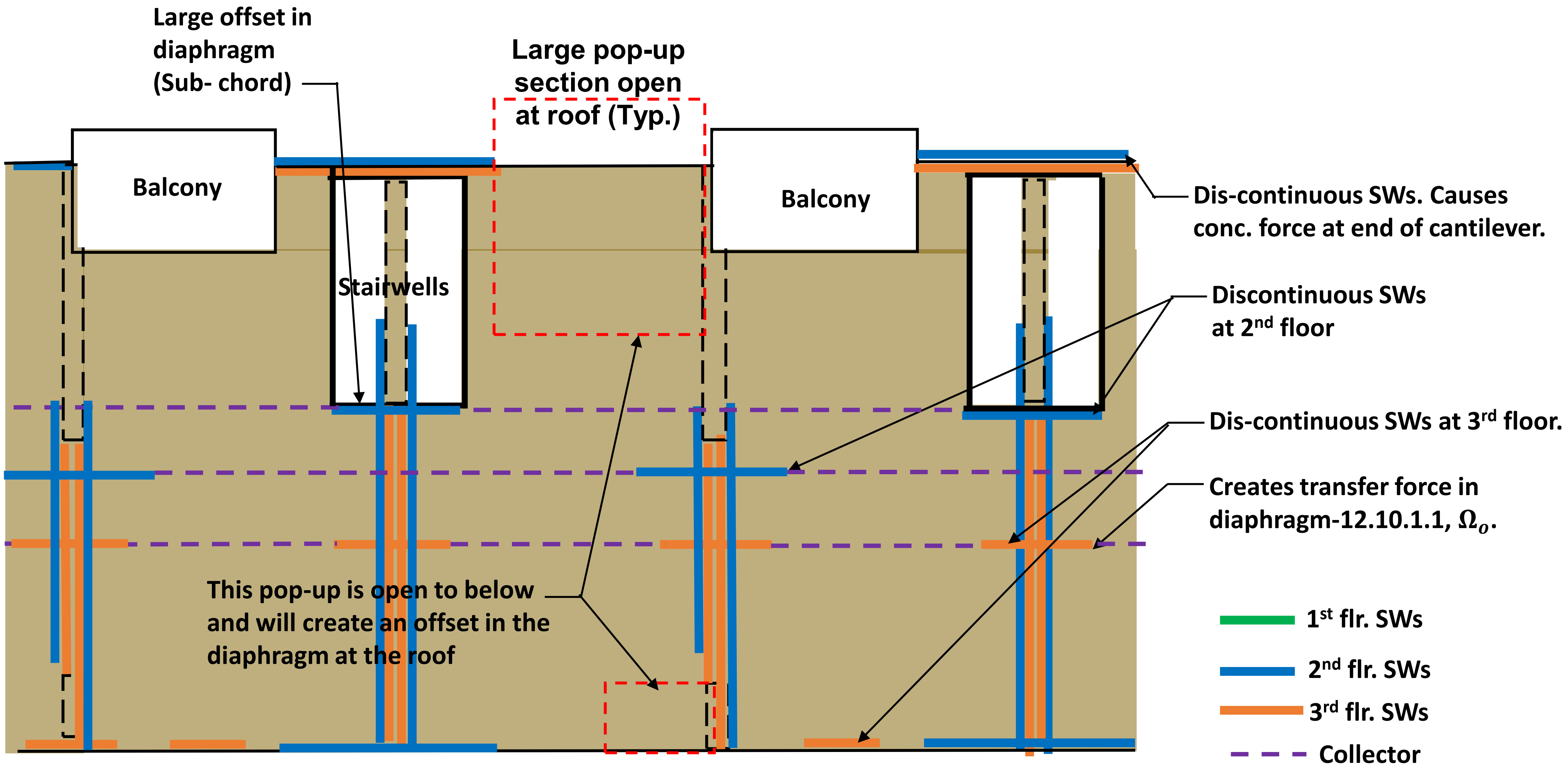
Example 2-Stairwells and Cantilever Diaphragms



Example 2-Cont.



Example 2-Cont.

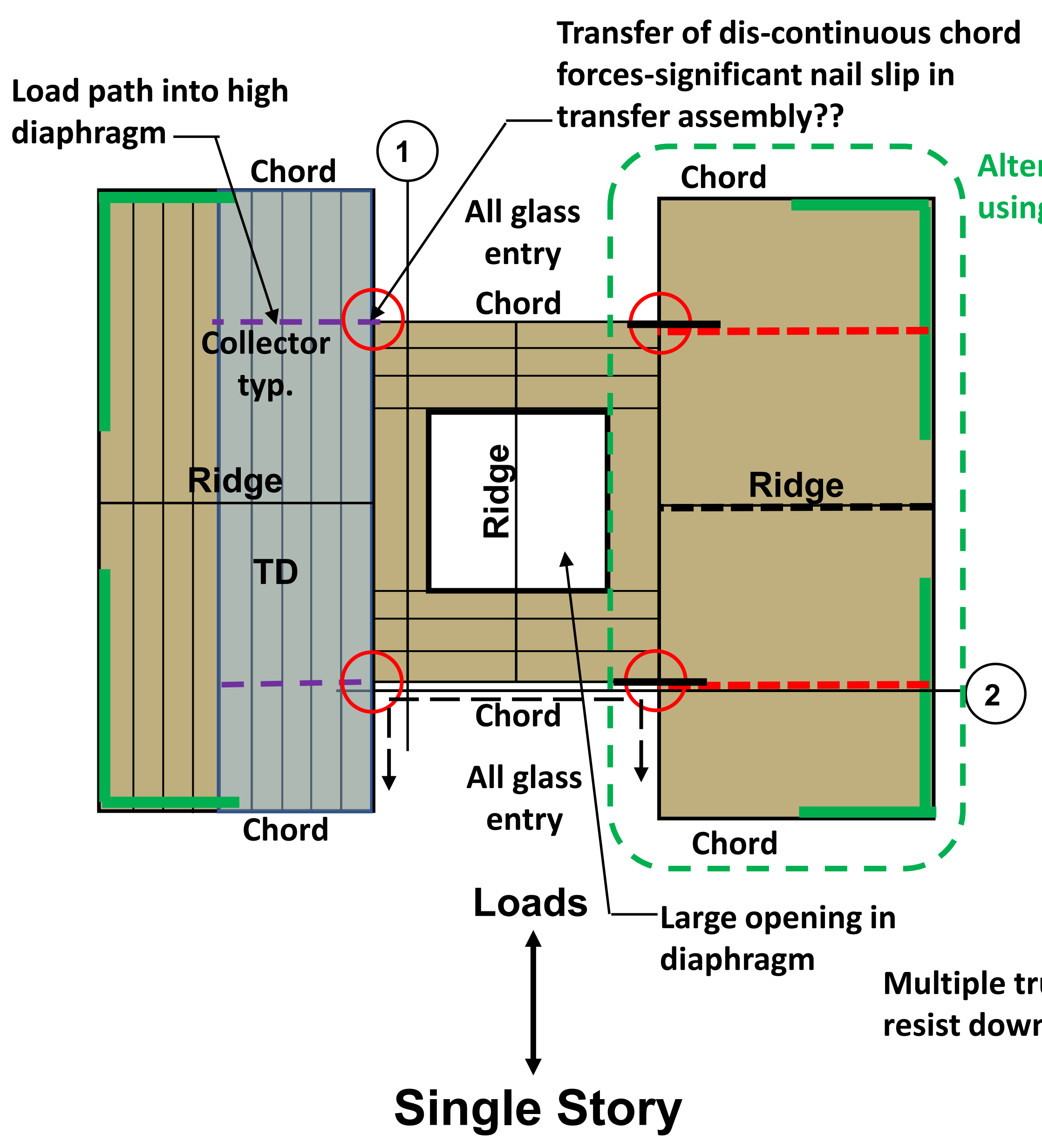


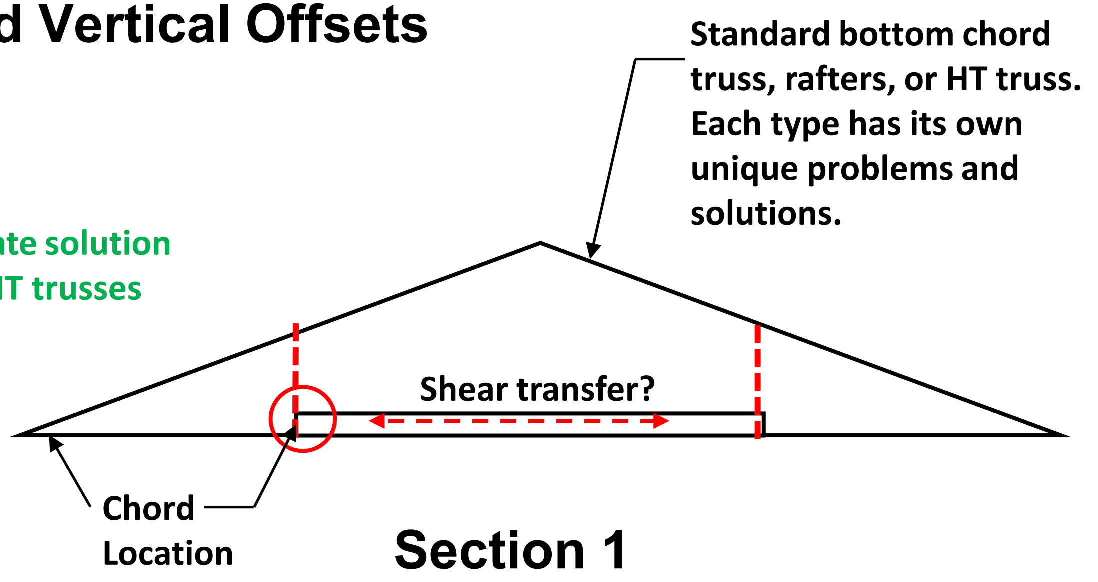
3rd Floor

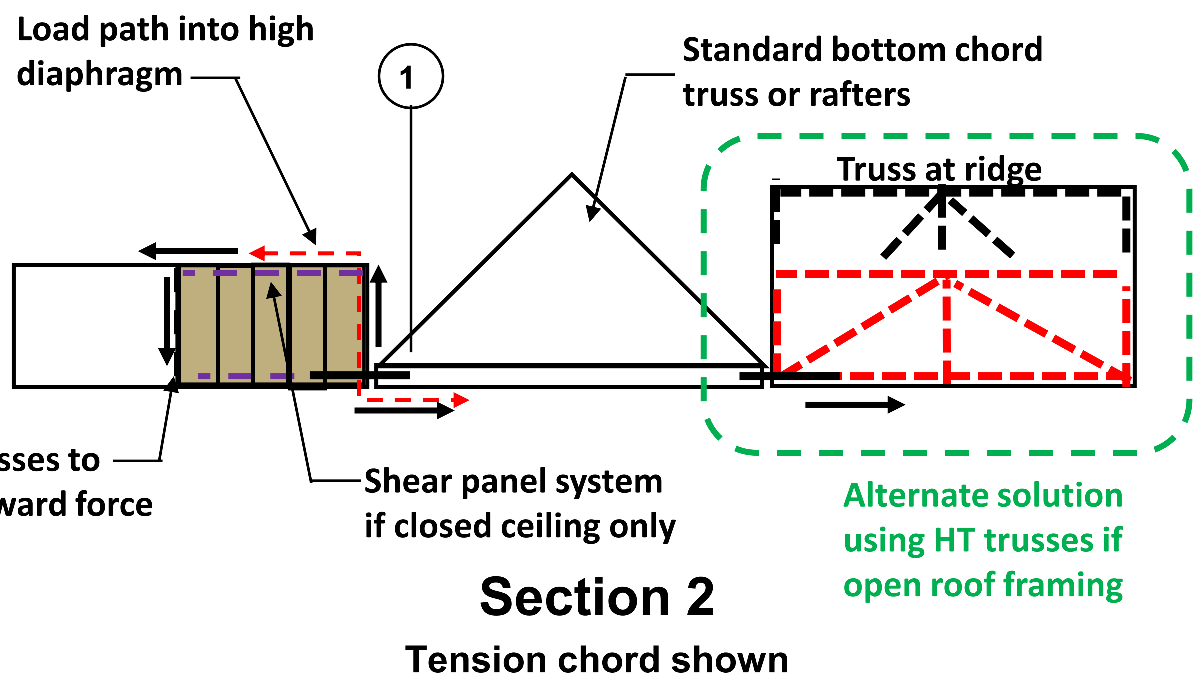
(NTS)

Vertical Offset and Cantilever Diaphragms

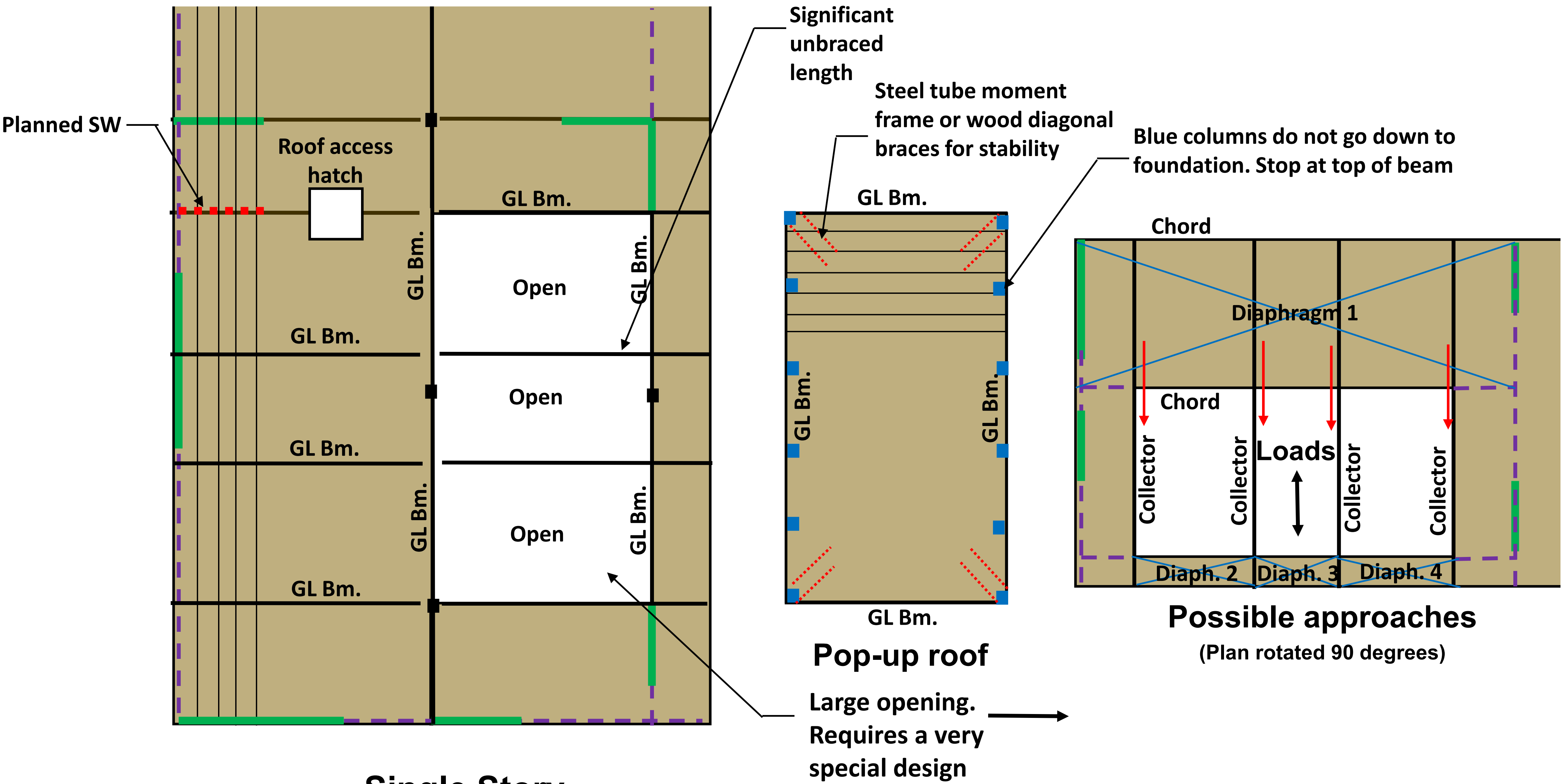
Example 3- Diaphragm Multiple Horizontal and Vertical Offsets







Example 4- Large Openings and Pop-up Roof

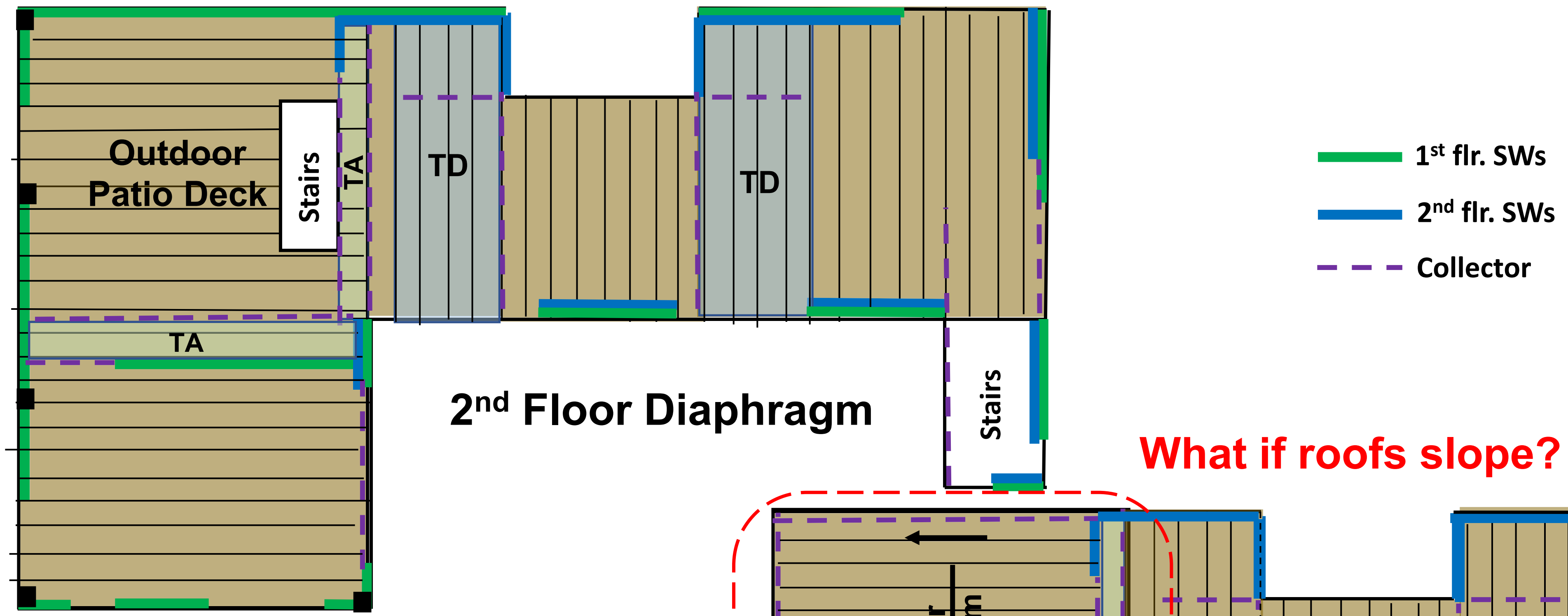


Single Story

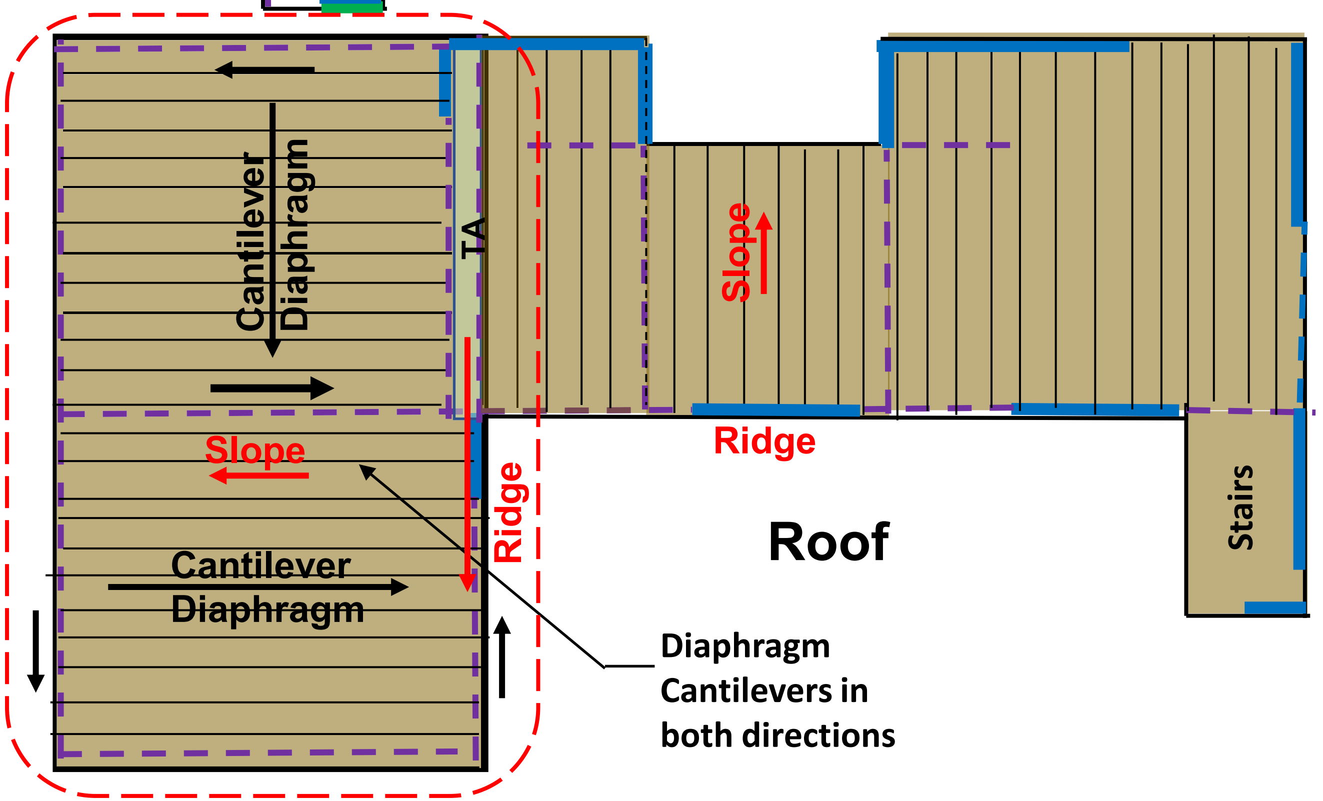
Pop-up roof

Possible approaches

(Plan rotated 90 degrees)



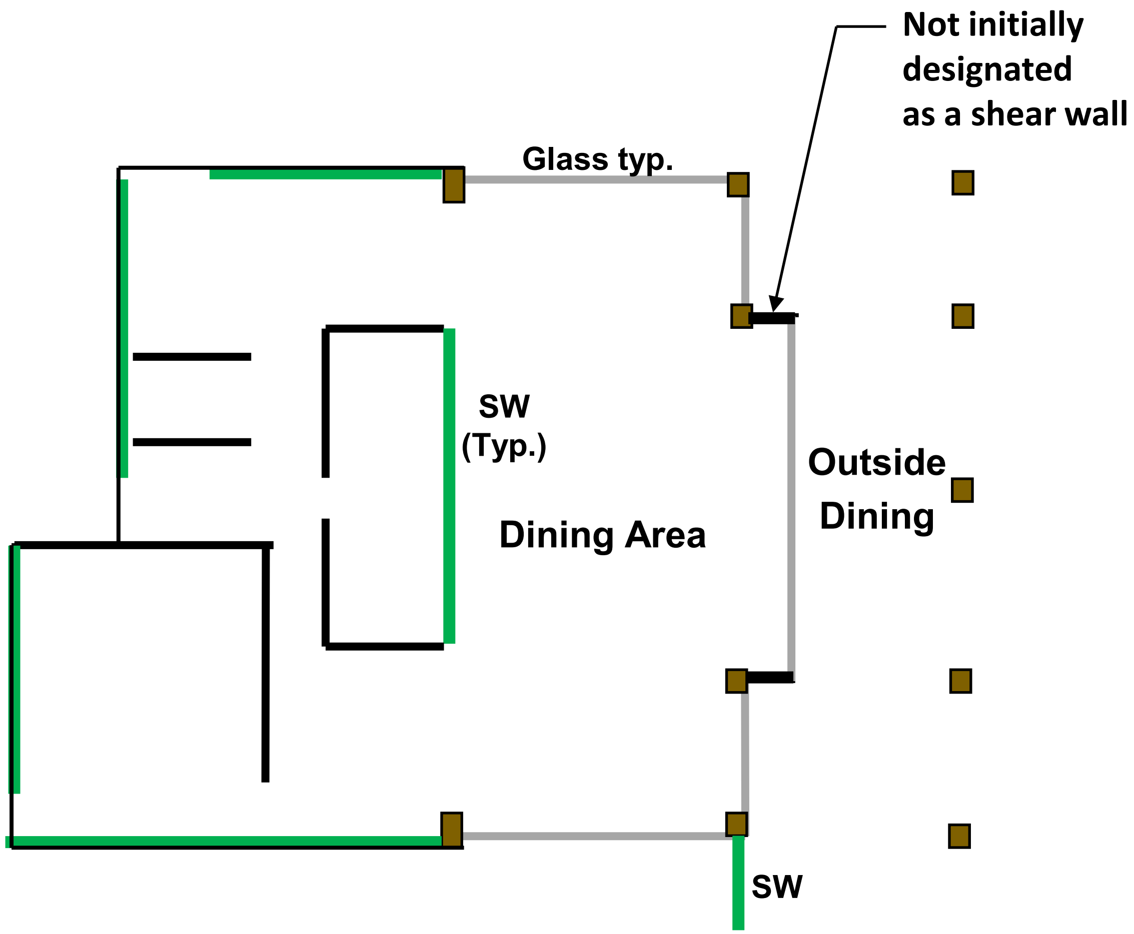
What if roofs slope?



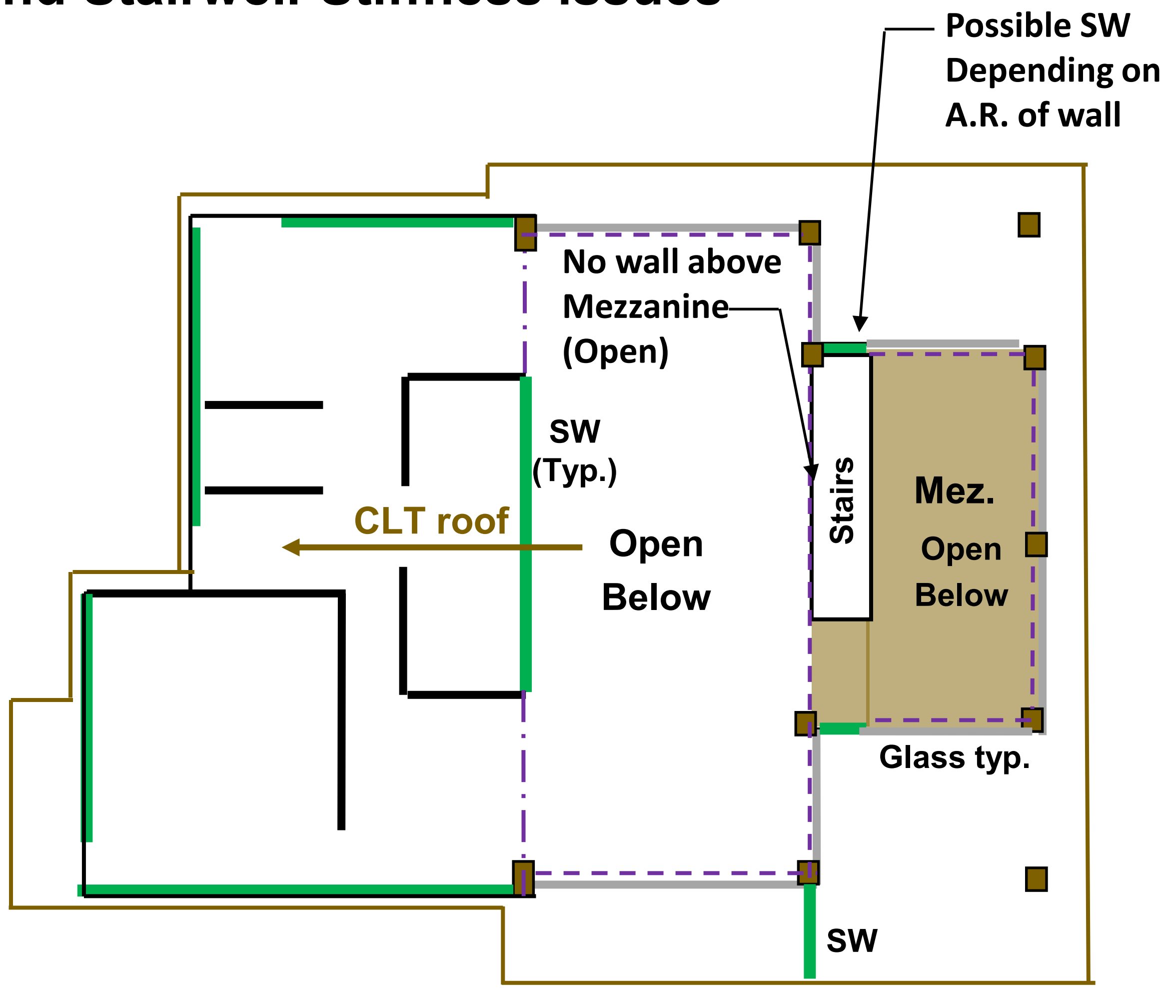
Example 5

Large Cantilever Diaphragm, Stairwells, and Diaphragm Horizontal Offset

Example 6- Multiple cantilever Diaphragms and Stairwell-Stiffness issues

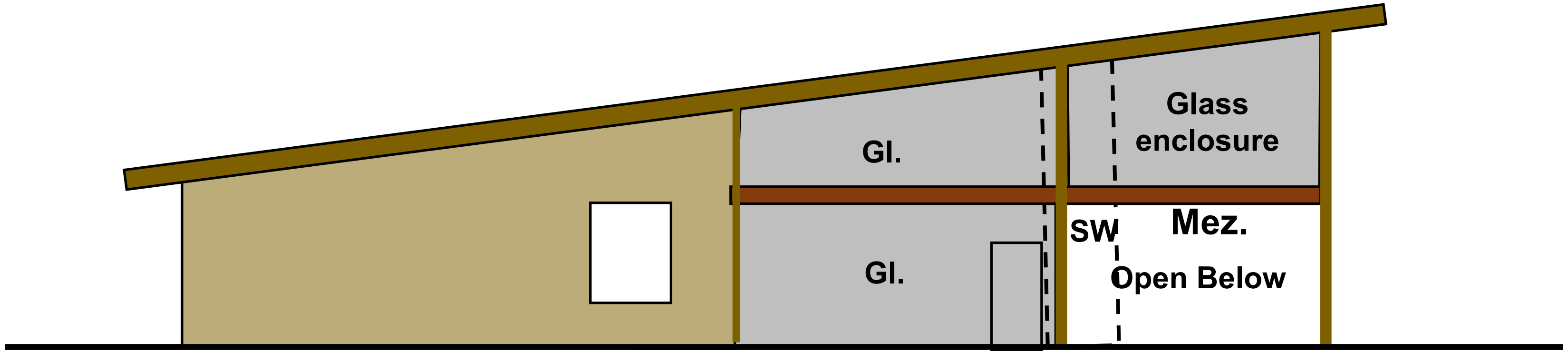


Ground Floor

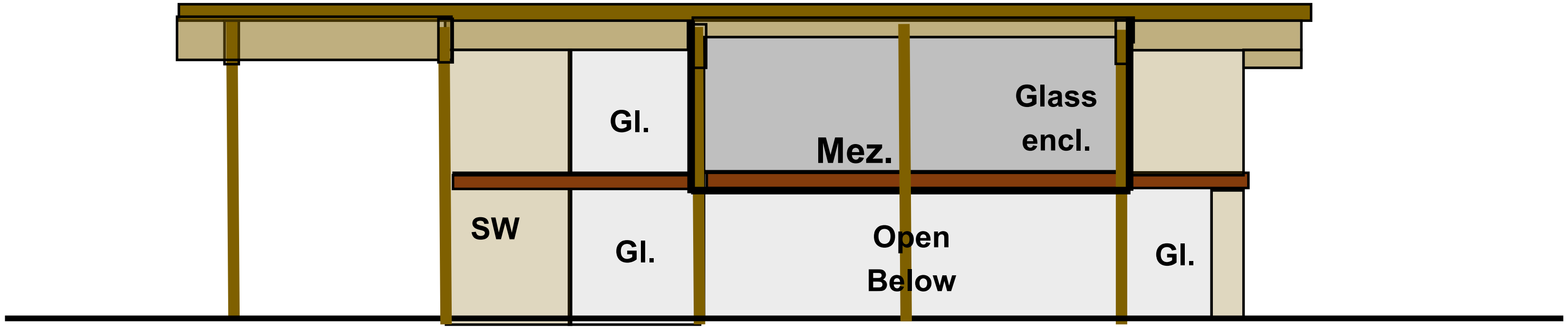


Mezzanine / Roof

Example 6-Cont.

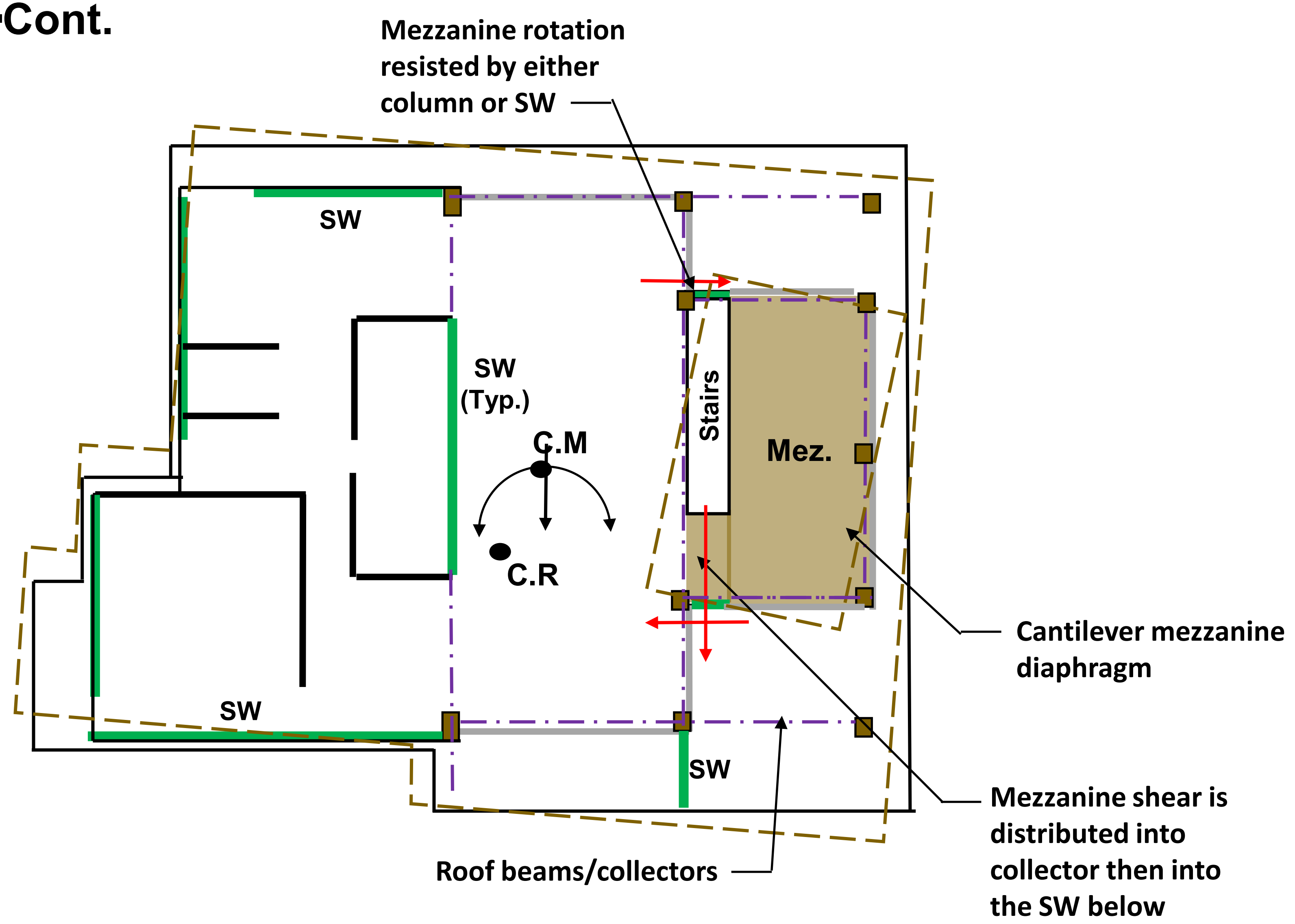


Side Elevation



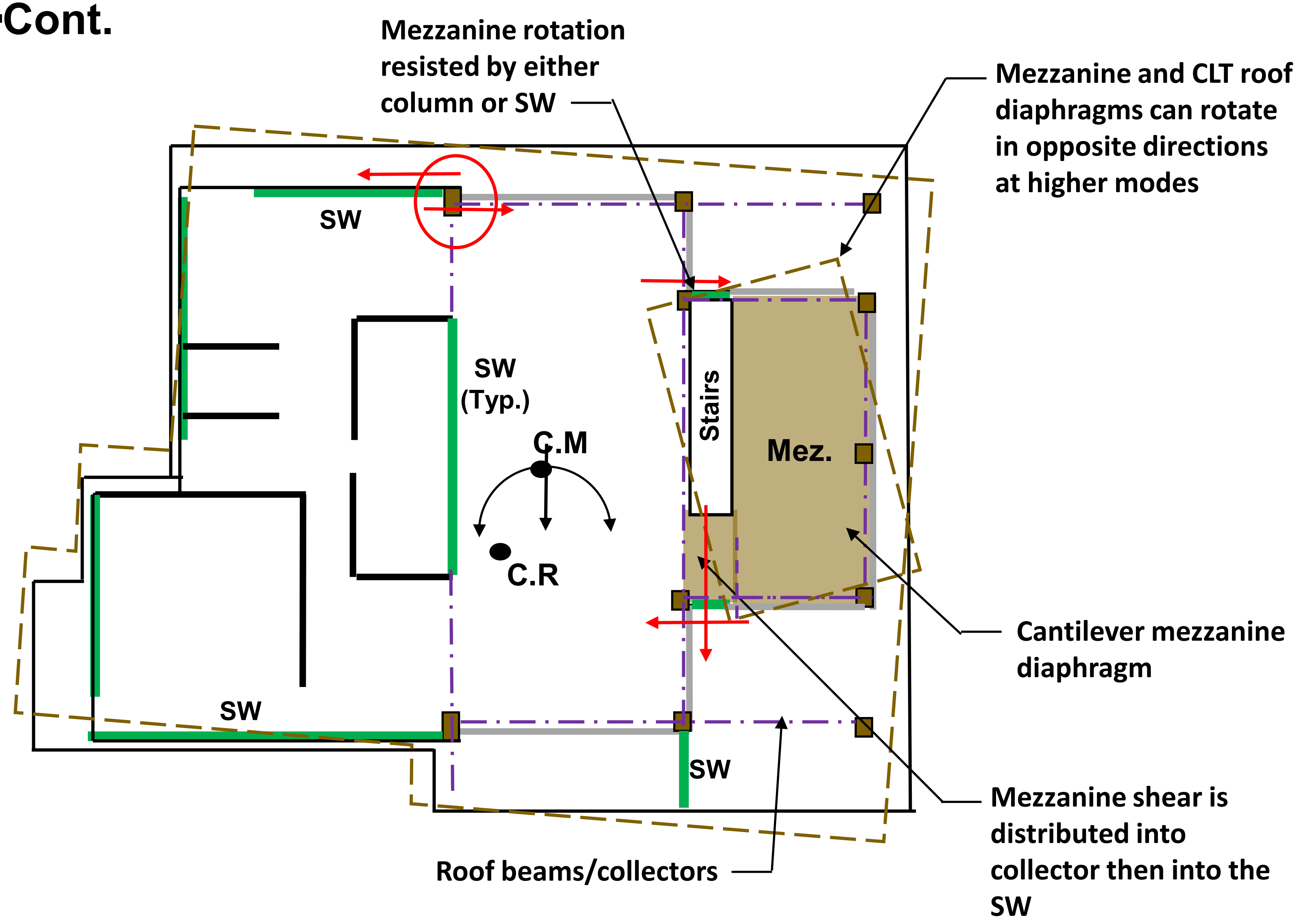
Front Elevation

Example 6-Cont.



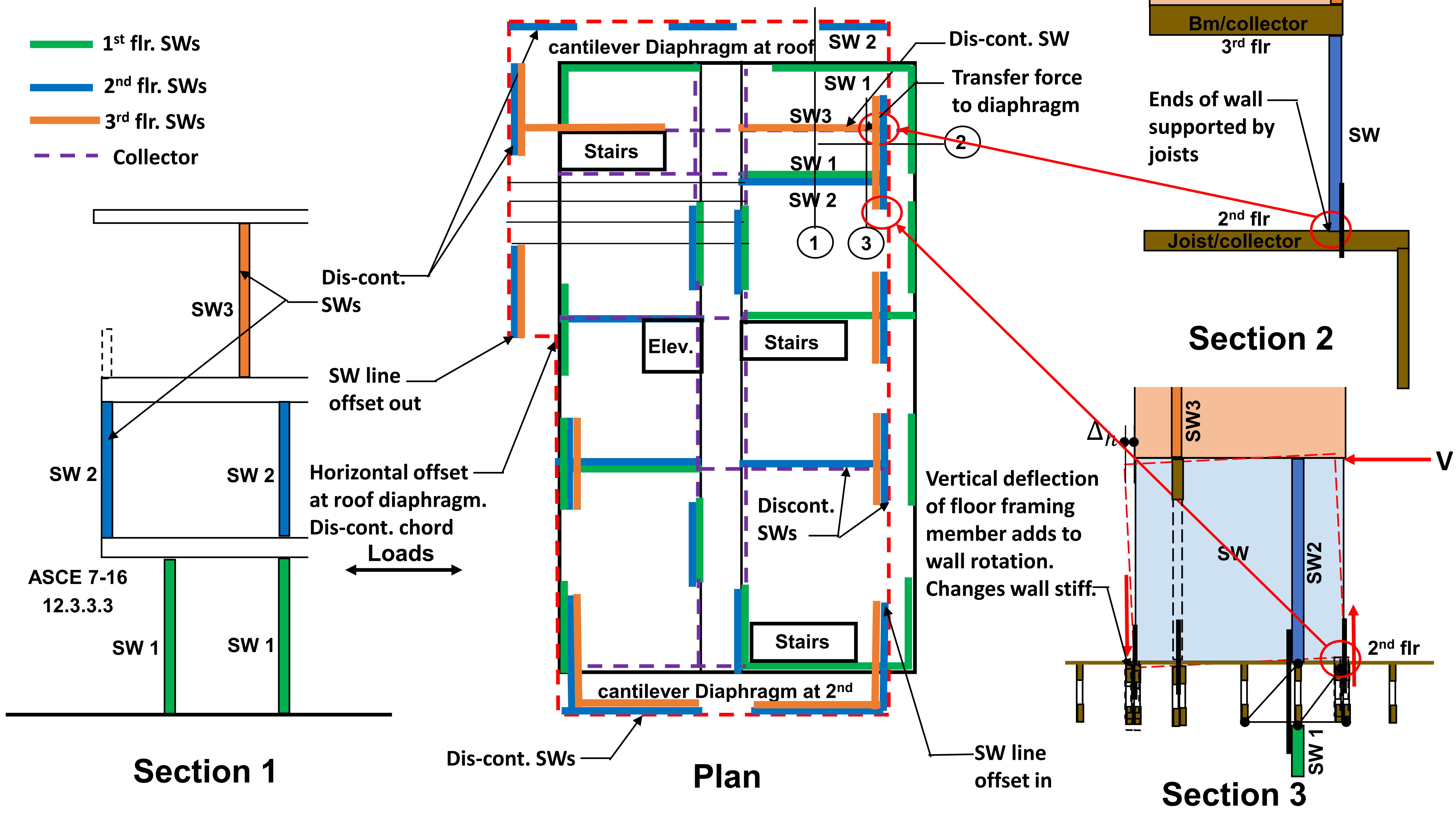
Seismic Response

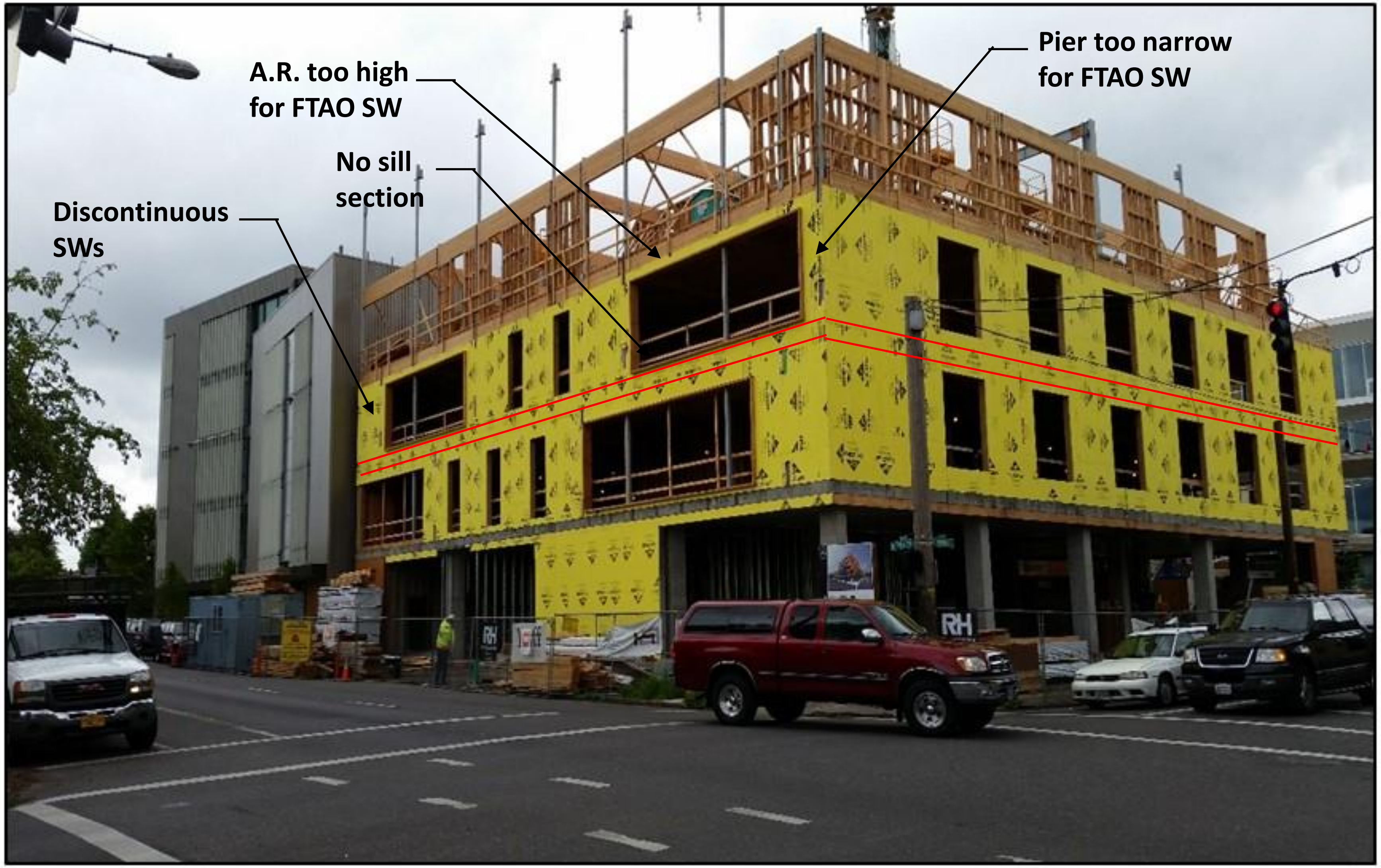
Example 6-Cont.



Seismic Response

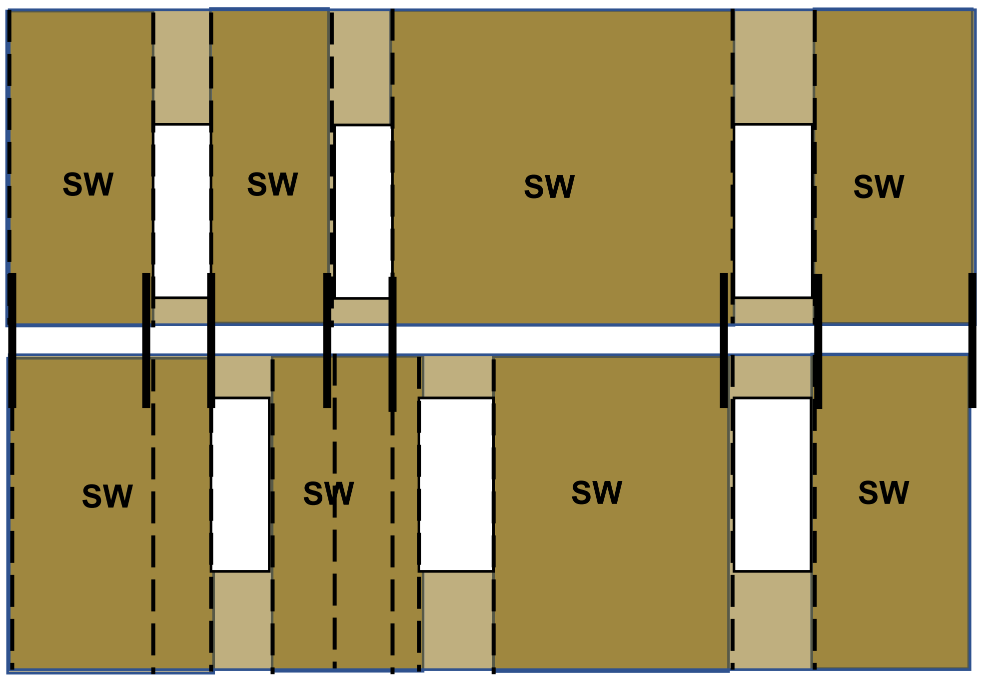
Example 7- Vertically Offset Shear Walls and Cantilever Diaphragm



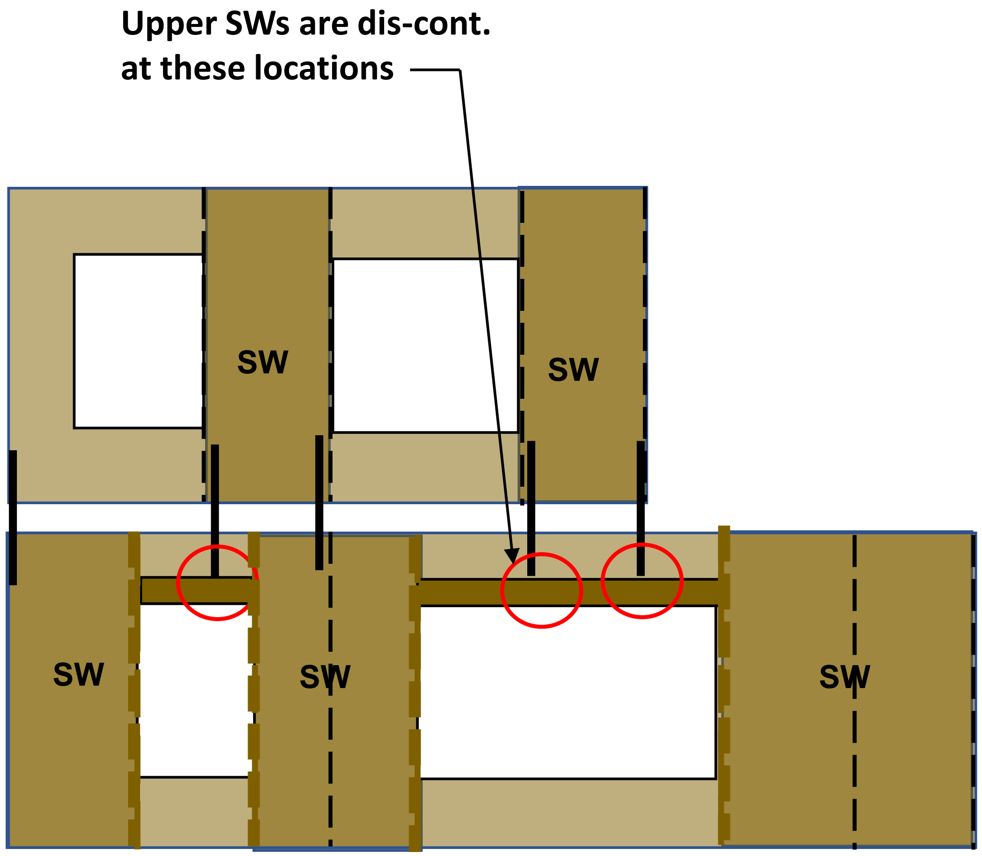


Stacked and Offset SWs

Example 8- In-plane Offset Shear Walls



Non-Discontinuous SWs



Discontinuous SWs

ASCE 7-16

12.3.3.3

Offset Shear Walls

Diaphragm/shear wall relative stiffness issues

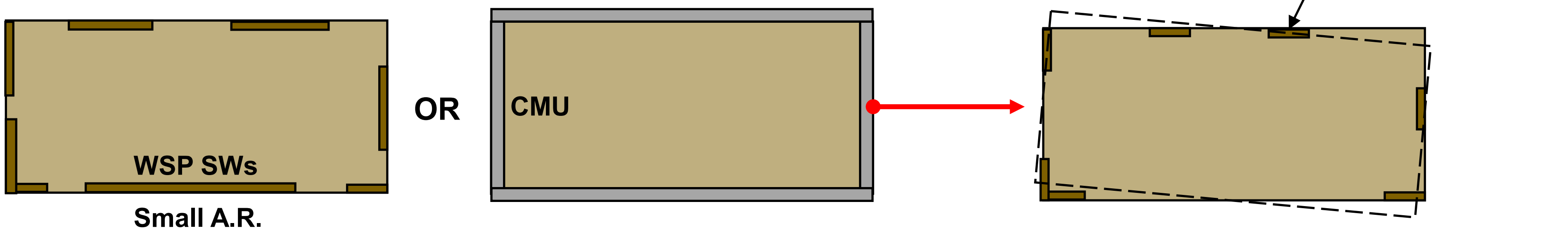
<u>12.3.1 Diaphragm Flexibility: </u>The structural analysis shall consider the relative stiffnesses of diaphragms and the vertical elements of the seismic force-resisting system.

Flexible, Semi-rigid, or Rigid diaphragms?

12.3.1.1 Allows wood diaphragms to be idealized as flexible provided:

1. Vertical elements are stiffer than diaphragm (Steel frames, masonry or concrete).
2. One- and two-family dwellings
3. Light-framed construction where (both):
    a. Non-structural 1 ½” conc. topping over WSP diaphragms.
    b. Each line of vertical elements in of SFRS complies with allowable story drift.

NEHRP Seismic Design Technical Brief No.10, Section 6.3 and ASCE 7-16 commentary: Most light-framed wood diaphragms are semi-rigid.



Rigid walls with flexible diaphragms

Rigid diaphragms with flexible walls

Combined lateral system issues-CMU/WSP, GWB/WSP, steel frames/wood SWs

- 12.2.2-Combinations in different orthogonal directions- use R, Ω_o, C_d for each direction

- 12.2.3-Combinations in same direction- use lowest R, Ω_o, C_d

  Difference in base shear

  R_{wsp} = 6.5

  R_{gwb} = 2 = 3.25 x> Seismic force can be larger than wind force

  $R_{ord\ cmu}$ = 2 = 3.25 x>

  $R_{int\ cmu}$ = 3.5 = 1.88 x>

  $R_{spec\ cmu}$ = 5 = 1.3 x>

R = Response modification factor

Ω_o = Overstrength factor

C_d = Deflection amplification factor

- 12.2.3.1-Vertical combinations:

  1. If lower sys. has lowest R, Ω_o, C_d, use upper R, Ω_o, C_d for upper sys. and lower R, Ω_o, C_d for lower syst. Multiply lower sys. by ratio of upper/lower.
  2. If upper sys. has lower R, Ω_o, C_d, use upper R, Ω_o, C_d for both.

- 12.2.3.3-Horizontal combinations:

  Use lowest R for that direction, Ω_o, and C_d shall be consistent with R value used.

  Exception: Least R value in each independent line of LFR if all three conditions are met:

  1. In Risk Category I or II.
  2. 2-stories or less AGP.
  3. Use of light-framed construction or flexible diaphragm.

  R used for design of the diaphragm shall not be greater than least R value used in that direction.

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This Concludes the Presentation on:

Common Challenges in Wood Lateral System Layouts

Q & A

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Thank You

Harrington Recovery Center
Structural engineer: Pujara Wirth Torke, Inc.
Photographer: Curtis Walz

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