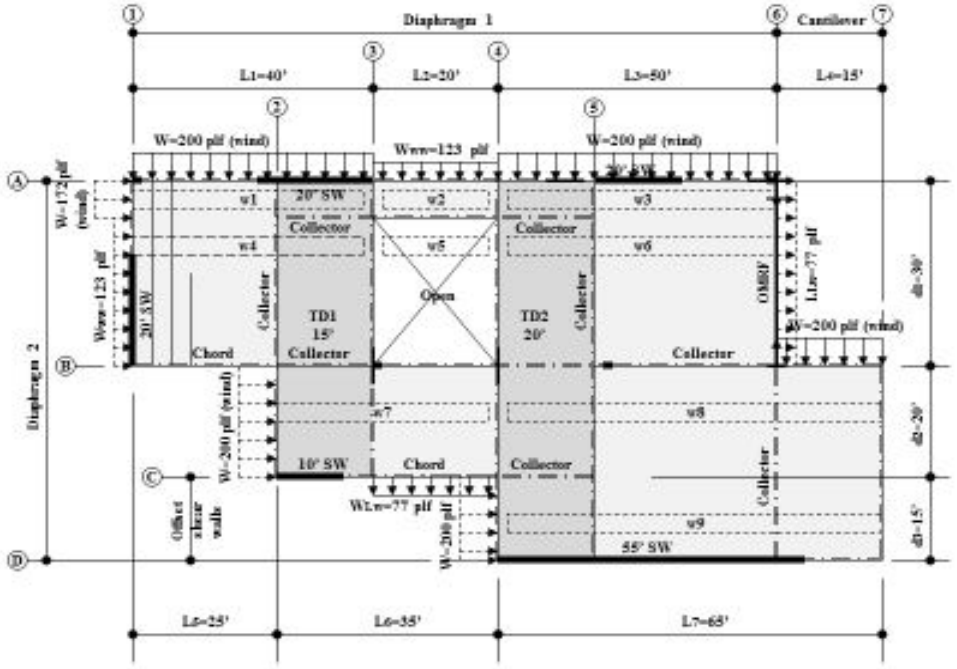
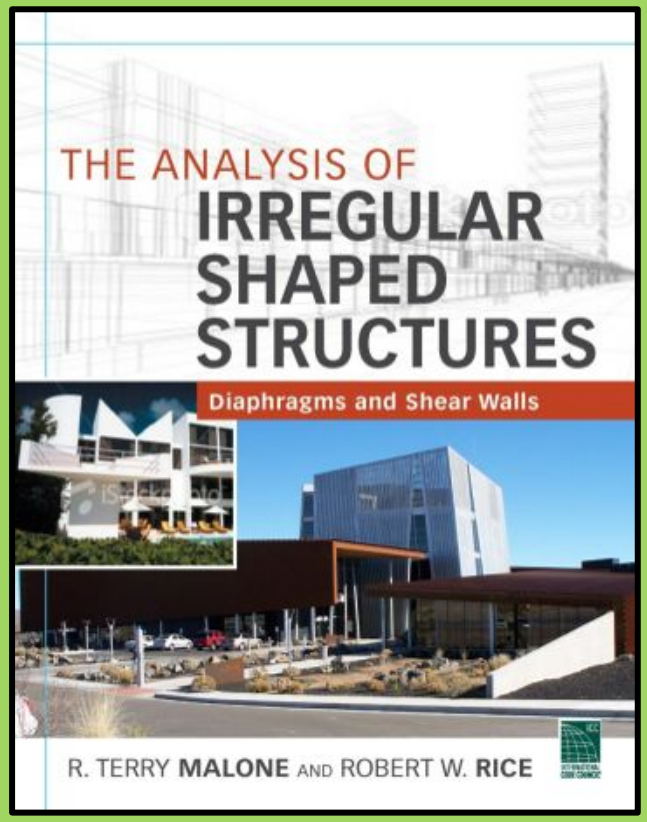
WoodWorks

Part 2-Offset Shear Walls



Example-Complex Diaphragm

Presentation Based On:



Presentation updated to 2012 IBC, ASCE 7-10 2008 SDPWS

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

A continuation from Part 1, this session will cover how to conduct a preliminary breakdown of a complex diaphragm to better understand the distribution of forces within the diaphragm and assure that complete load paths are being established. Examples will be provided illustrating how to analyze in-plane and out-of-plane offset shear walls that are typically created by these diaphragms.

Learning Objectives

- **Segmentation of a Complex Diaphragm**

  Discuss methods of breaking down and analyzing complex diaphragms into manageable segments.

- **In-plane and Out-of-plane Offset Shear Walls**

  Discuss the various types of offset shear wall conditions.

- **Out-of-plane Offset Shear Walls**

  Examine a method of analyzing a diaphragm with offset shear walls for loading in the longitudinal direction.

- **In-plane Offset Shear Walls**

  Examine a two story offset shear wall with varying width.

Presentation Assumptions

Flexible wood sheathed or un-topped steel deck diaphragms

(Can also apply to semi-rigid and rigid diaphragms)

- Loads to diaphragms and shear walls
  - Strength level or allowable stress design
  - Wind or seismic forces (UNO).
- The loads are already factored for the appropriate load combination.

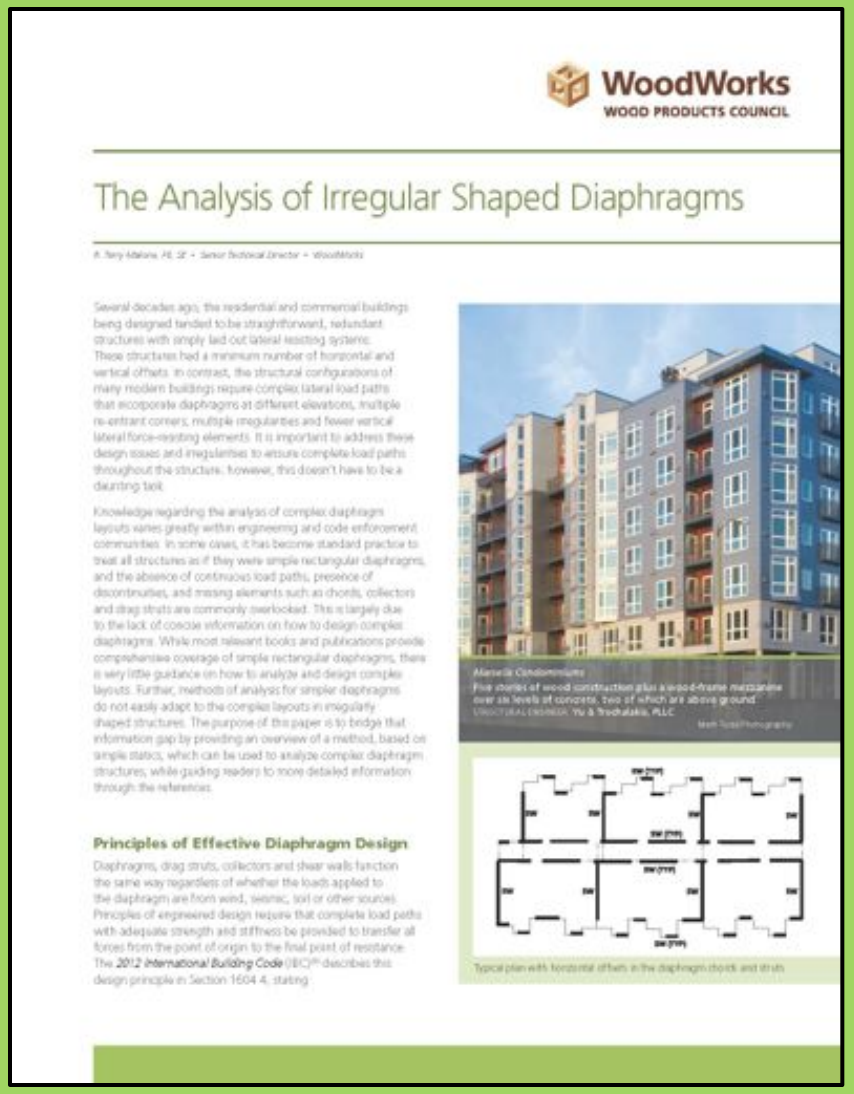
Code References:

- ASCE 7-10 "Minimum Design Loads for Buildings and Other Structures"
- 2012 IBC

Analysis and Design references:

- The Analysis of Irregular Shaped Structures: Diaphragms and Shear Walls- Malone, Rice
- WoodWorks- The Analysis of Irregular Shaped Diaphragms
- Design of Wood Structures- Breyer, Fridley, Pollock, Cobeen
- SEAOC Seismic Design Manual, Volume 2
- Wood Engineering and Construction Handbook-Faherty, Williamson
- Guide to the Design of Diaphragms, Chords and Collectors-NCSEA

Complete Example with narrative and calculations



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The Analysis of Irregular Shaped Diaphragms

R. Terry Malone, PE, SE • Senior Technical Director • WoodWorks

Several decades ago, the residential and commercial buildings being designed tended to be straightforward, redundant structures with simply laid out lateral resisting systems. These structures had a minimum number of horizontal and vertical offsets. In contrast, the structural configurations of many modern buildings require complex lateral load paths that incorporate diaphragms at different elevations, multiple re-entrant corners, multiple irregularities and fewer vertical lateral force-resisting elements. It is important to address these design issues and irregularities to ensure complete load paths throughout the structure; however, this doesn't have to be a daunting task.

Knowledge regarding the analysis of complex diaphragm layouts varies greatly within engineering and code enforcement communities. In some cases, it has become standard practice to treat all structures as if they were simple rectangular diaphragms, and the absence of continuous load paths, presence of discontinuities, and missing elements such as chords, collectors and drag struts are commonly overlooked. This is largely due to the lack of concise information on how to design complex diaphragms. While most relevant books and publications provide comprehensive coverage of simple rectangular diaphragms, there is very little guidance on how to analyze and design complex layouts. Further, methods of analysis for simpler diaphragms do not easily adapt to the complex layouts in irregularly shaped structures. The purpose of this paper is to bridge that information gap by providing an overview of a method, based on simple statics, which can be used to analyze complex diaphragm structures, while guiding readers to more detailed information through the references.

Marsella Condominiums
Five stories of wood construction plus a wood-frame mezzanine over six levels of concrete, two of which are above ground.
STRUCTURAL ENGINEER: Yu & Trivedulaka, PLLC

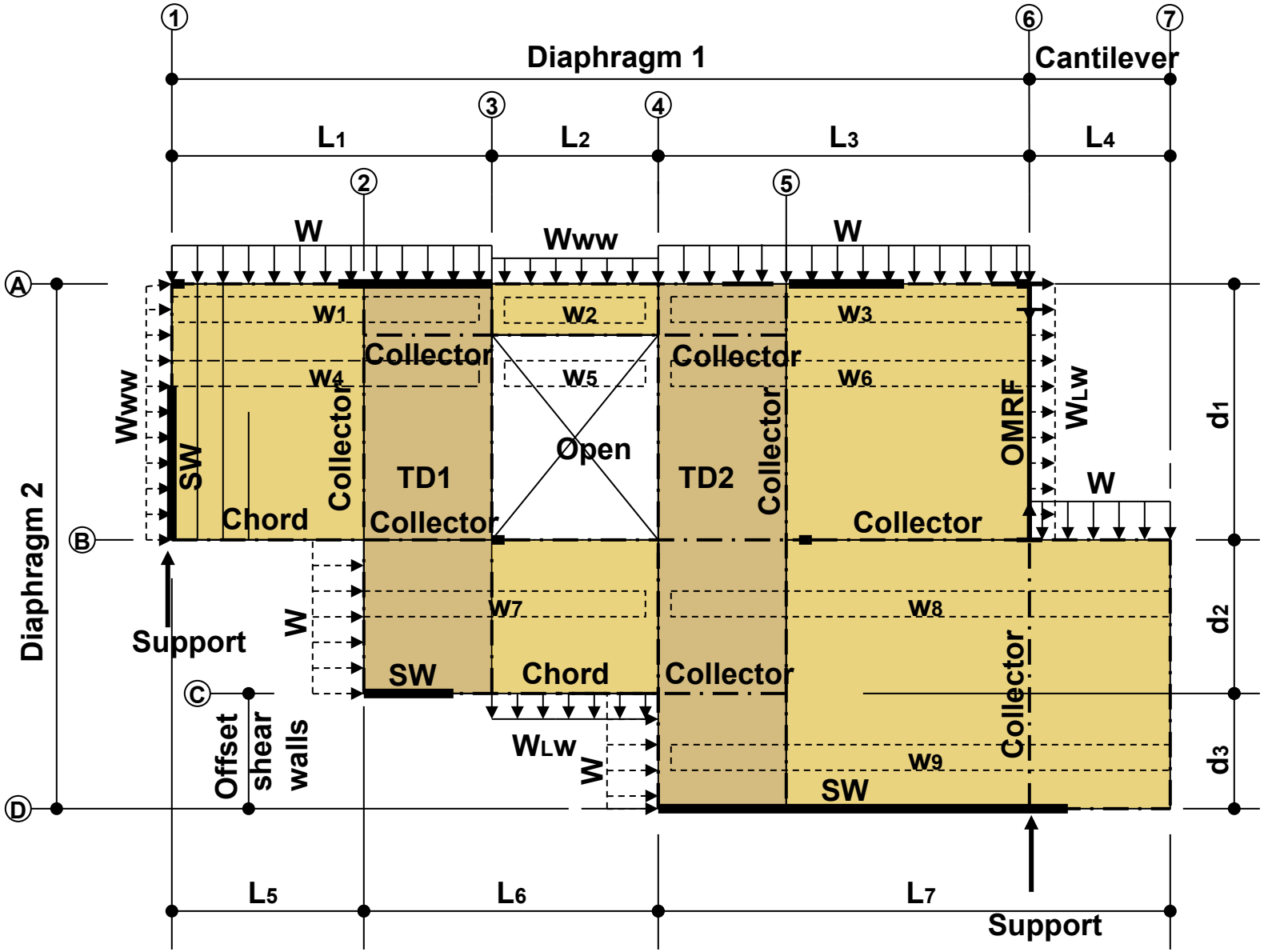
Typical plan with horizontal offsets in the diaphragm chords and struts

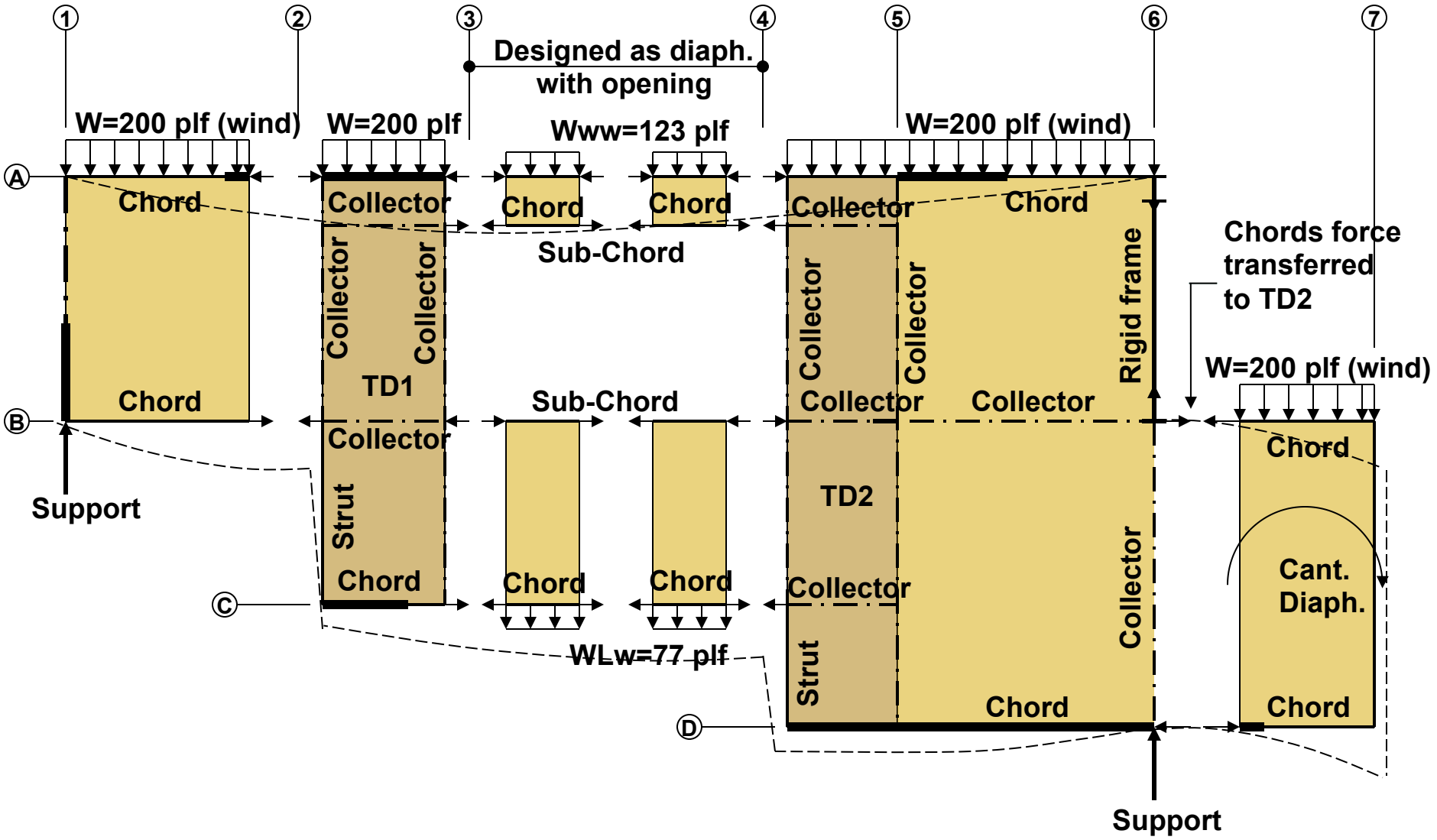
Principles of Effective Diaphragm Design

Diaphragms, drag struts, collectors and shear walls function the same way regardless of whether the loads applied to the diaphragm are from wind, seismic, soil or other sources. Principles of engineered design require that complete load paths with adequate strength and stiffness be provided to transfer all forces from the point of origin to the final point of resistance. The *2012 International Building Code* (IBC)[1] describes this design principle in Section 1604.4, stating:

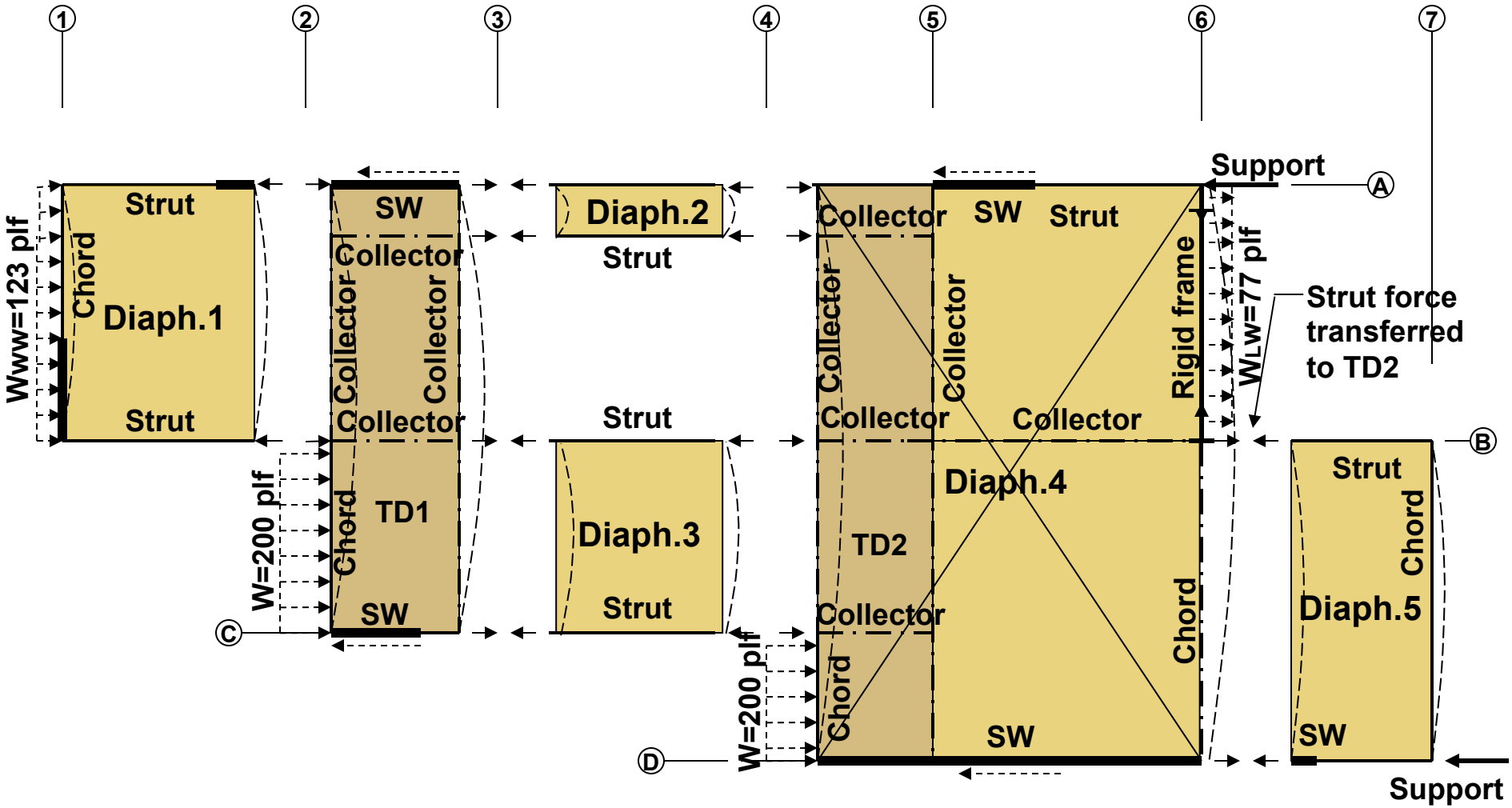
http://www.woodworks.org/education-publications/research-papers/#

A Quick Note on Segmenting and analyzing Complex Diaphragms-Ch.8



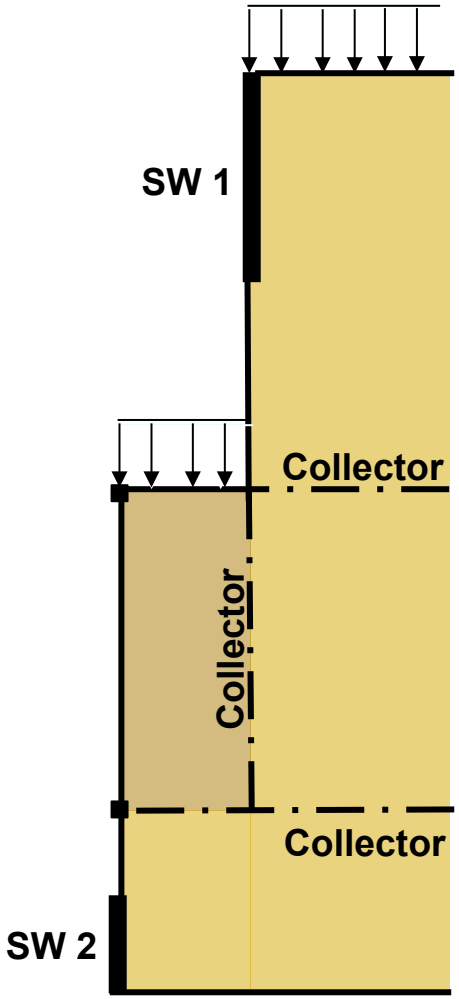


Segmentation of the Diaphragm for Transverse Loading

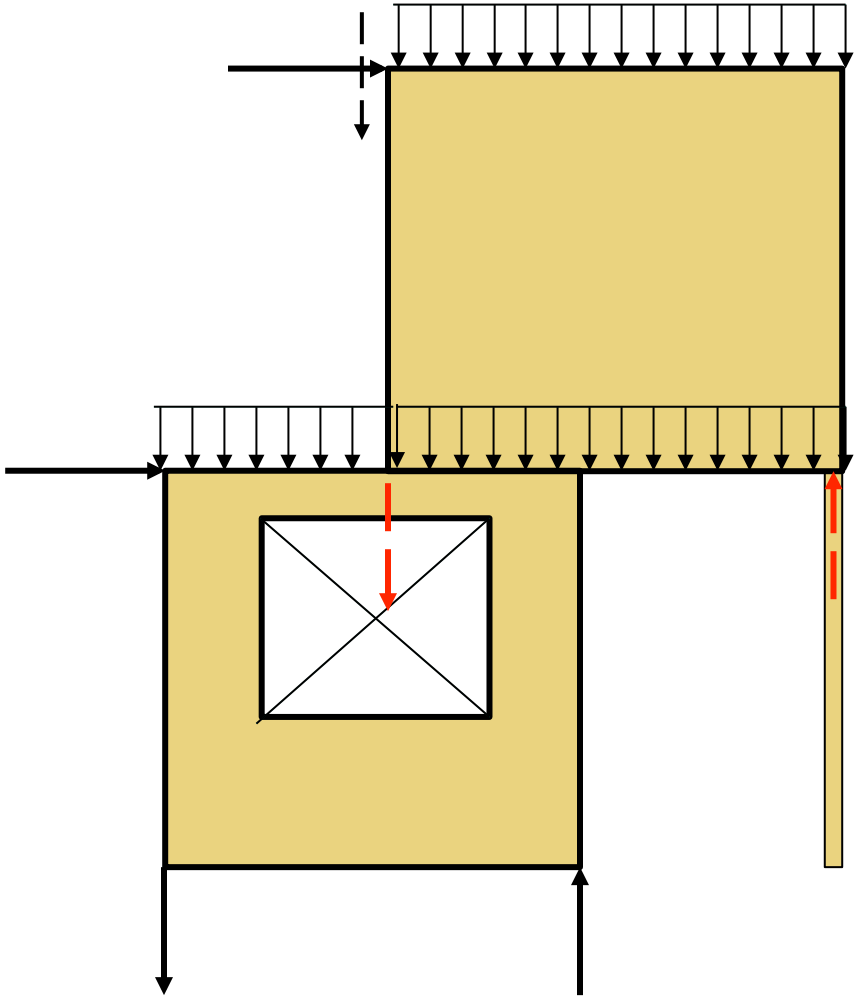


Segmentation of the Diaphragm for Longitudinal Loading

Offset Shear Walls



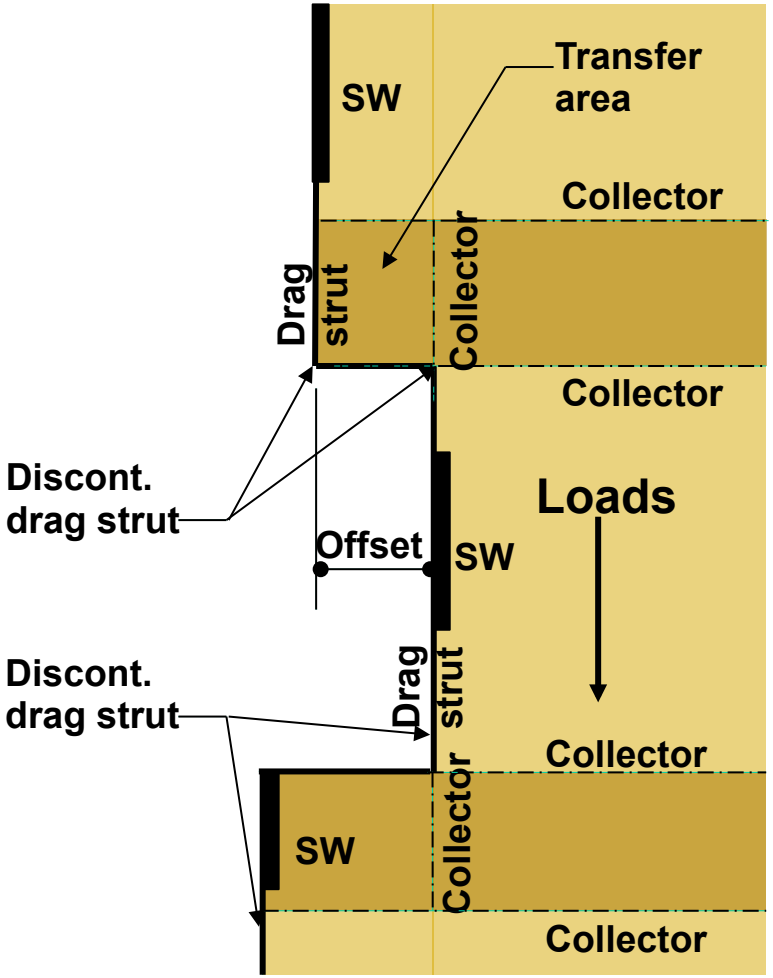
Out-of-plane Offsets



In-plane Offsets

Out-of-Plane Offset Shear Walls

Assumed to act in the Same Line of Resistance



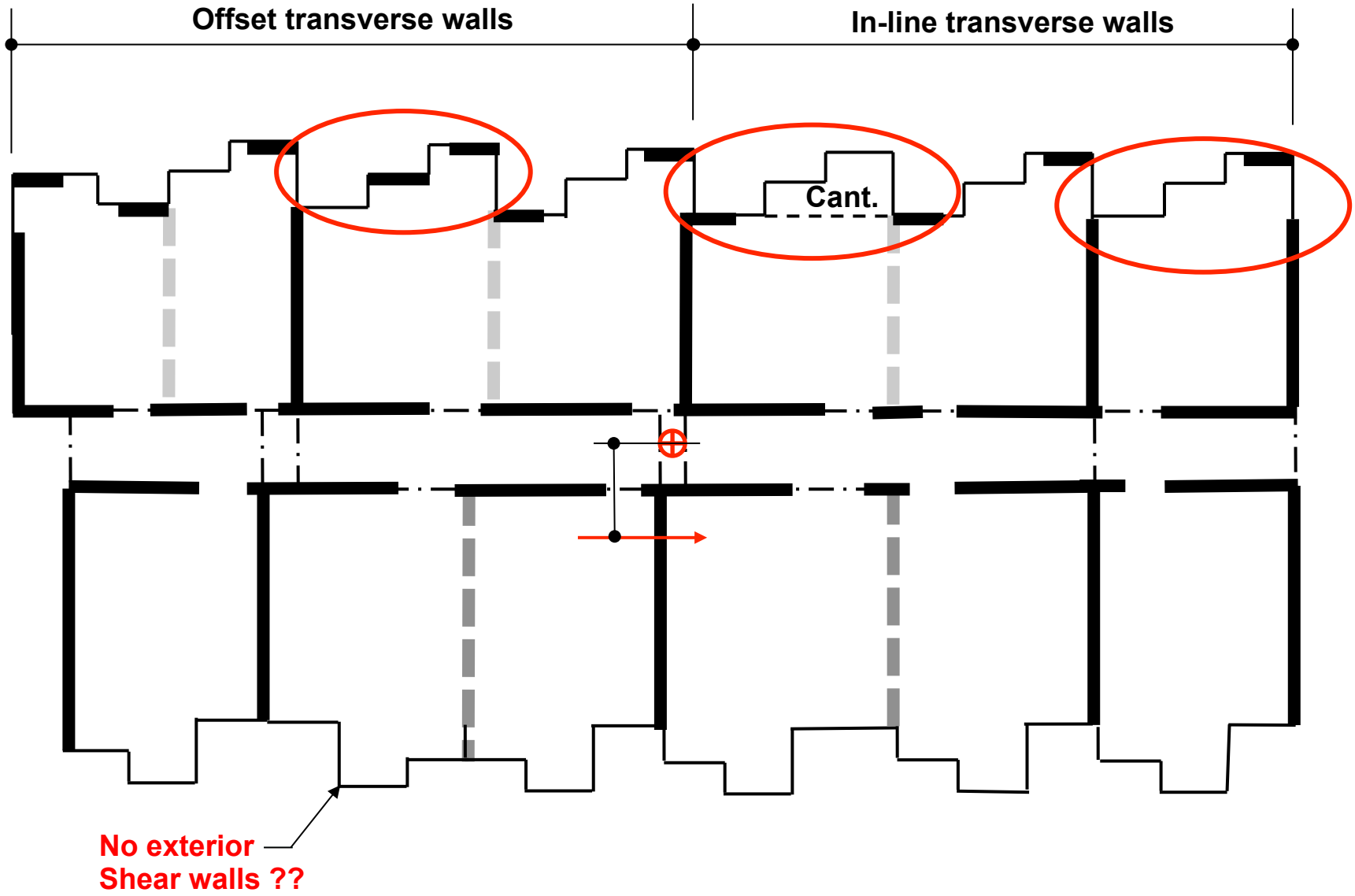
Typical mid-rise multi-family structure at exterior wall line

- Offset walls are often assumed to act in the same line of lateral-force-resistance.
- Calculations are seldom provided showing how the walls are interconnected to act as a unit, or to verify that a complete lateral load path has been provided.
- Collectors are required to be installed to transfer the disrupted forces across the offsets.

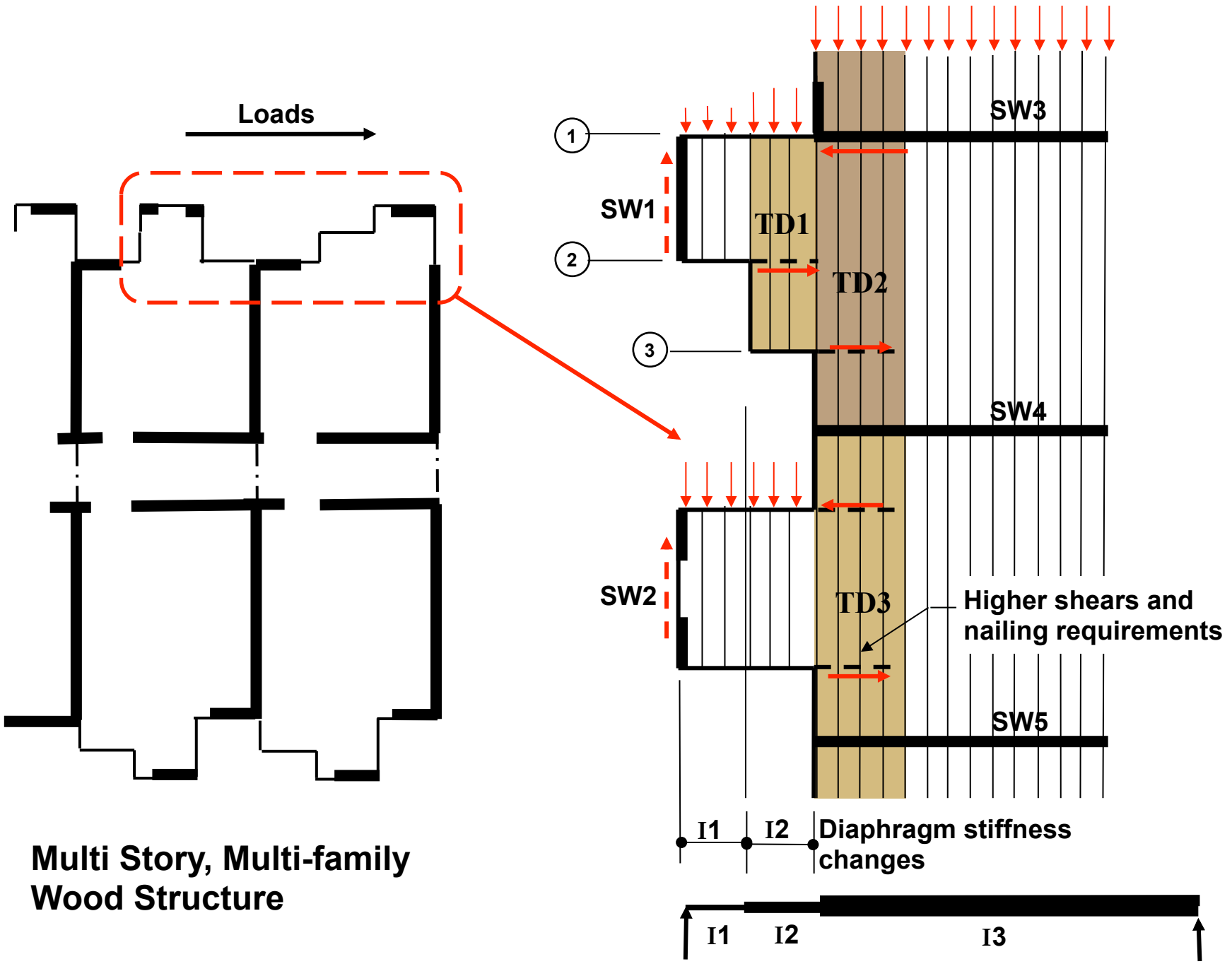
ASCE 7-10 Section 14.5.2
Where offset walls occur in the wall line, the shear walls on each side of the offset should be considered as separate shear walls unless provisions for force transfer around the offset are provided.

Check for Type 2 horizontal irregularity
Re-entrant corner irregularity

Longitudinal Loading



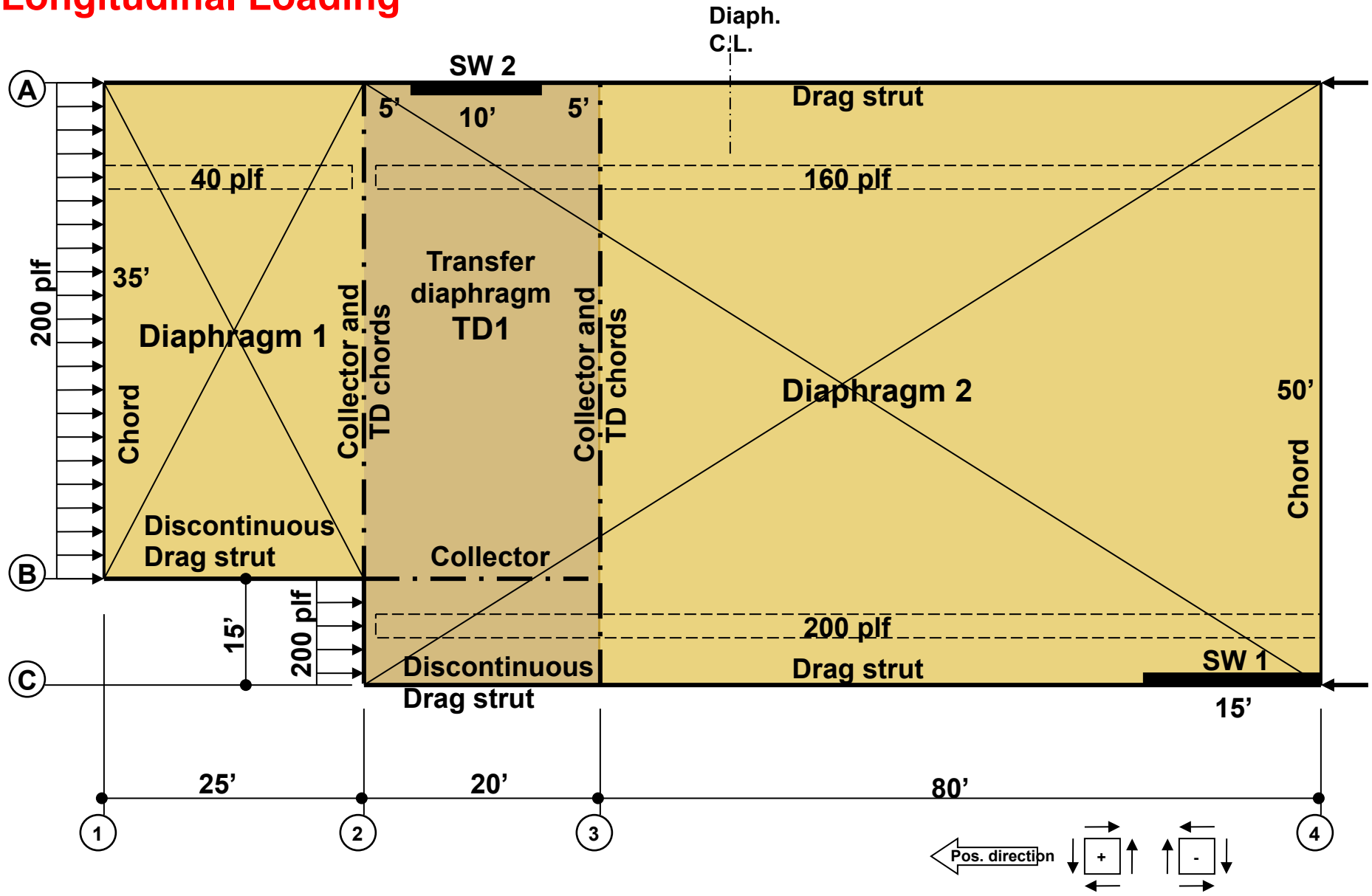
Flexible, semi-rigid, or rigid???

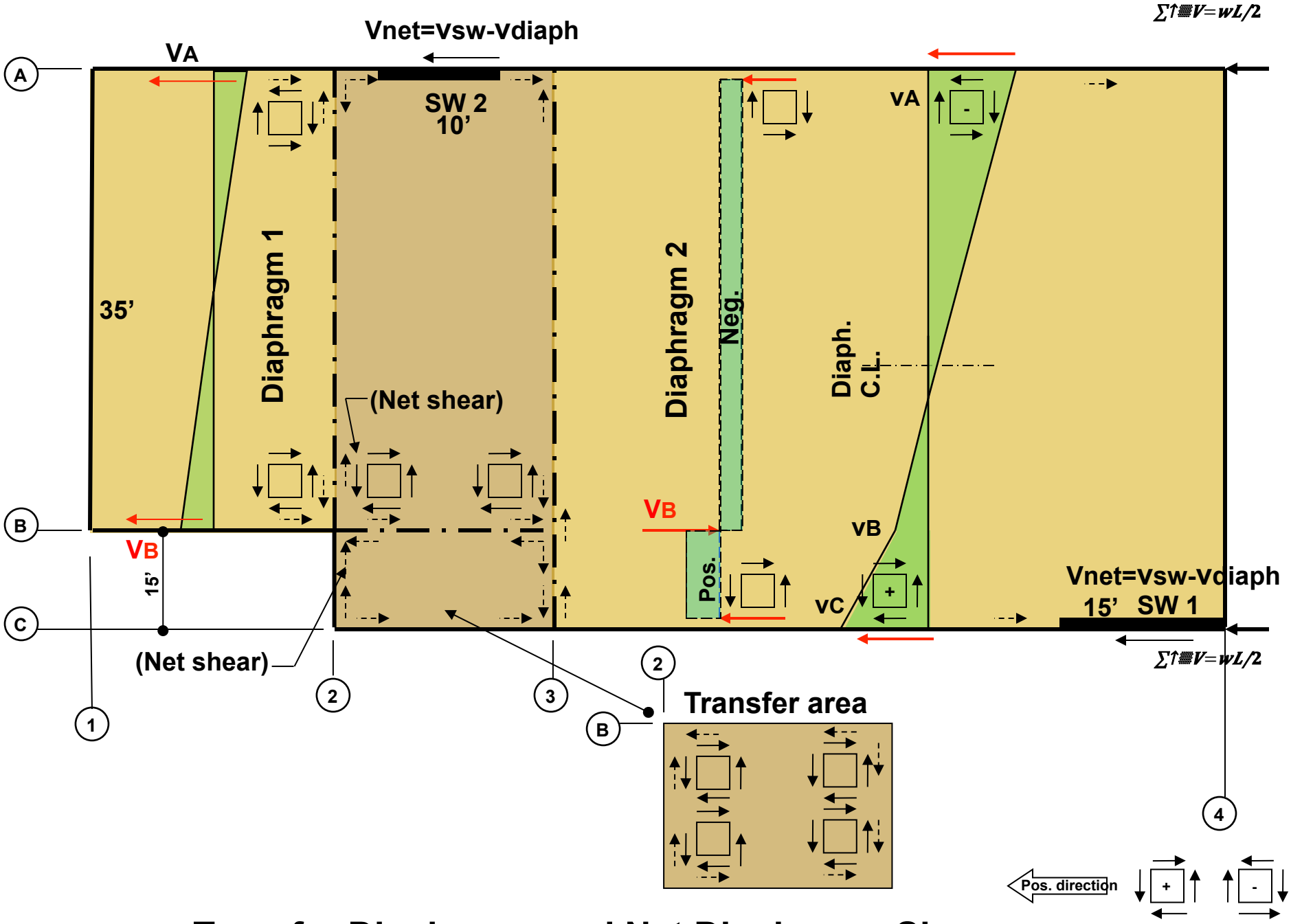


Multi Story, Multi-family Wood Structure

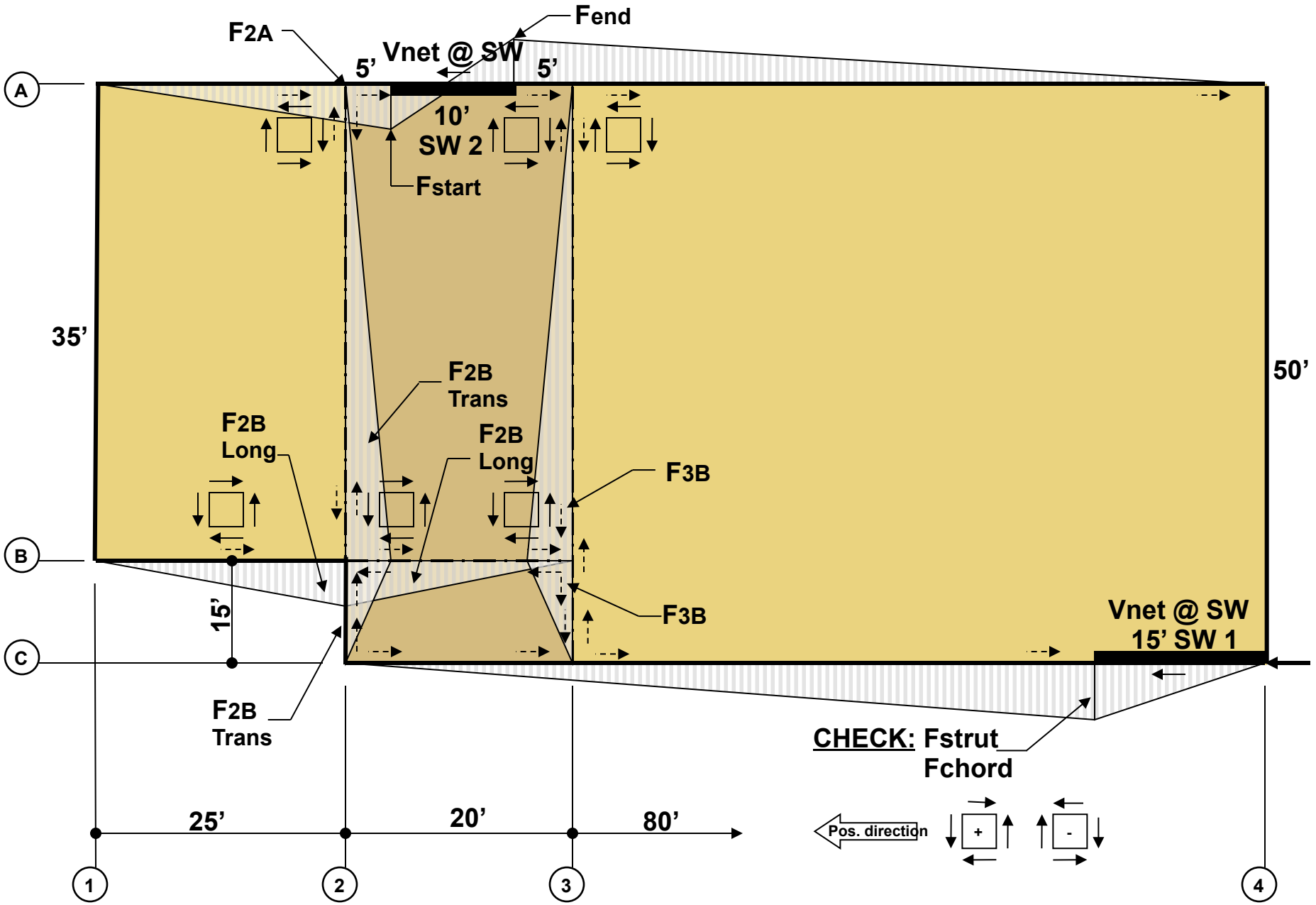
Example 2-Diaphragm with Horizontal End Offset

Longitudinal Loading





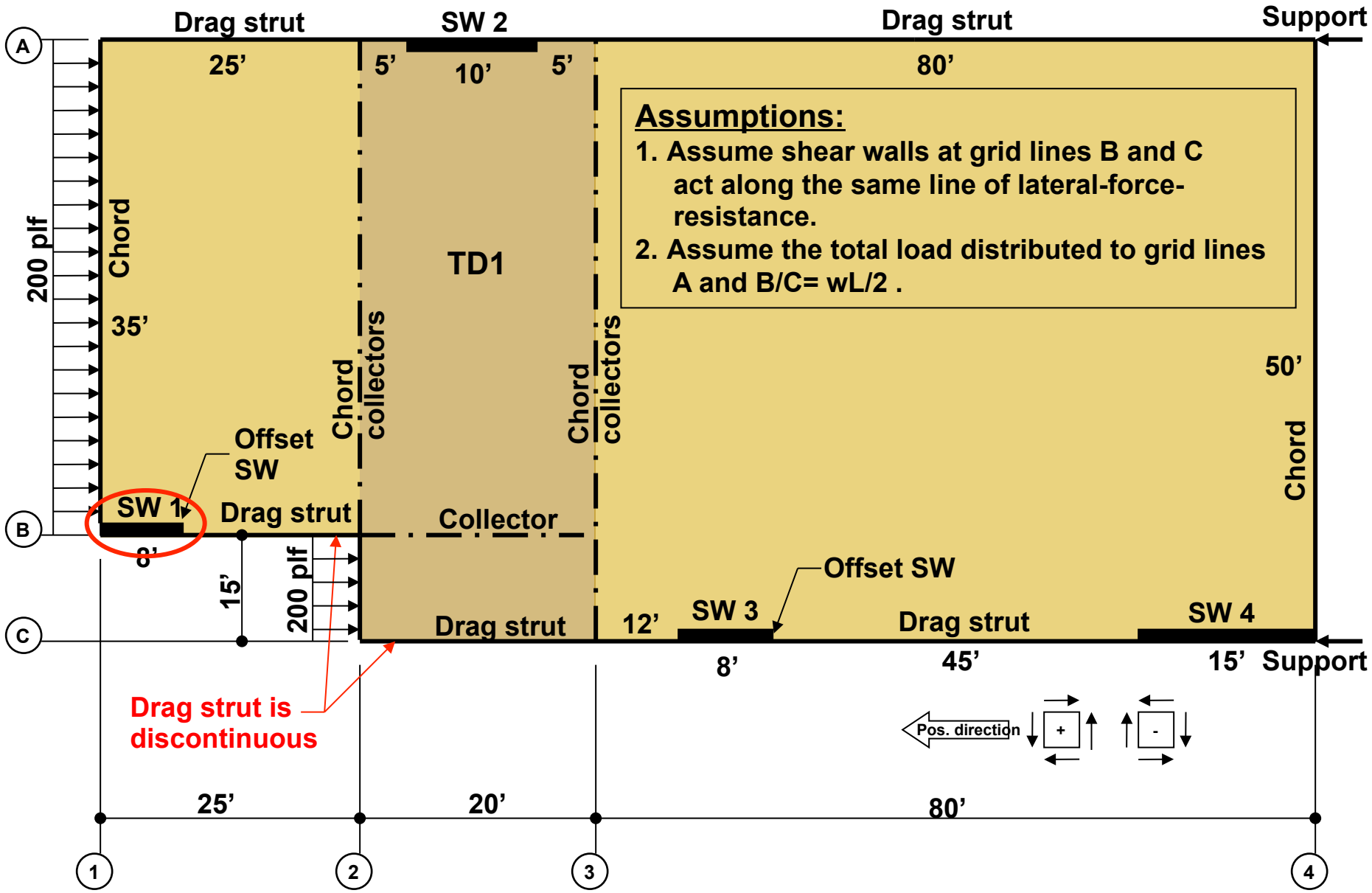
Transfer Diaphragm and Net Diaphragm Shear



Longitudinal and Transverse Collector/Strut Force Diagrams

Example 3-Diaphragm with Horizontal End Offset

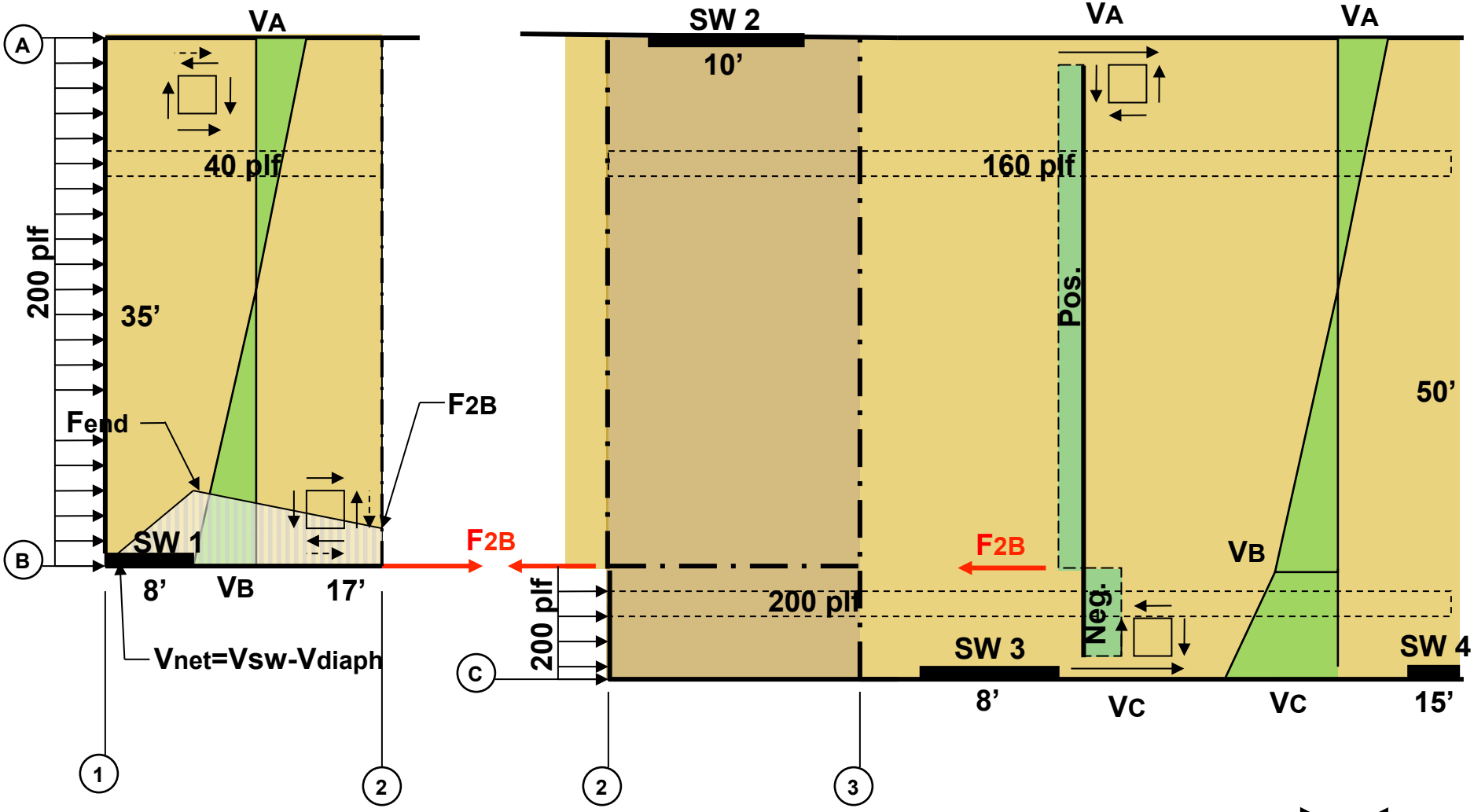
Longitudinal Loading-Offset Shear Walls



Total Shear to Shear Walls (Assumed)

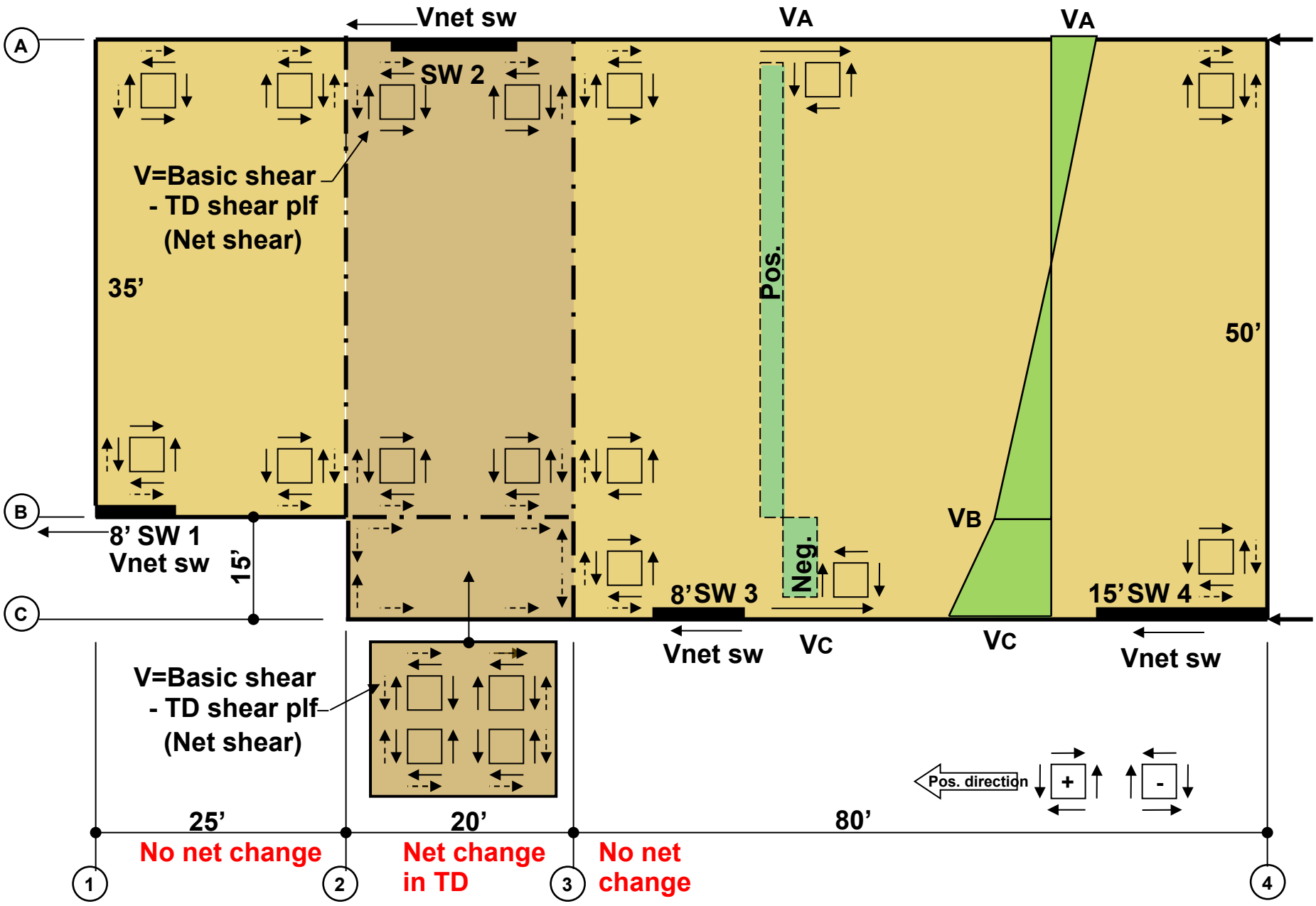
Vsw2=wL/2 plf

∑ Vsw1, sw3, sw4=wL/2, vsw=∑V1,3,4/(Lsw1+Lsw3+Lsw4) plf

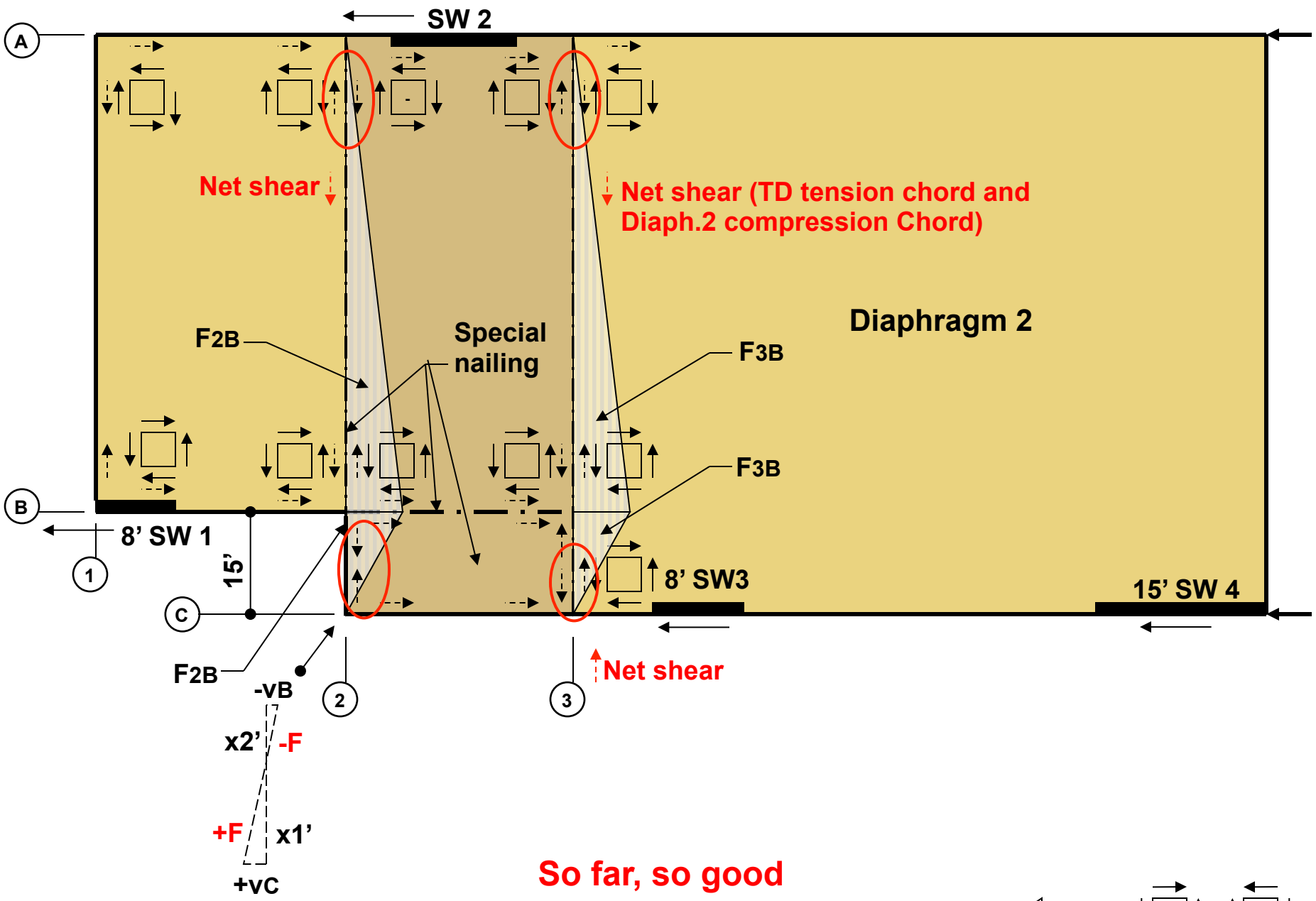


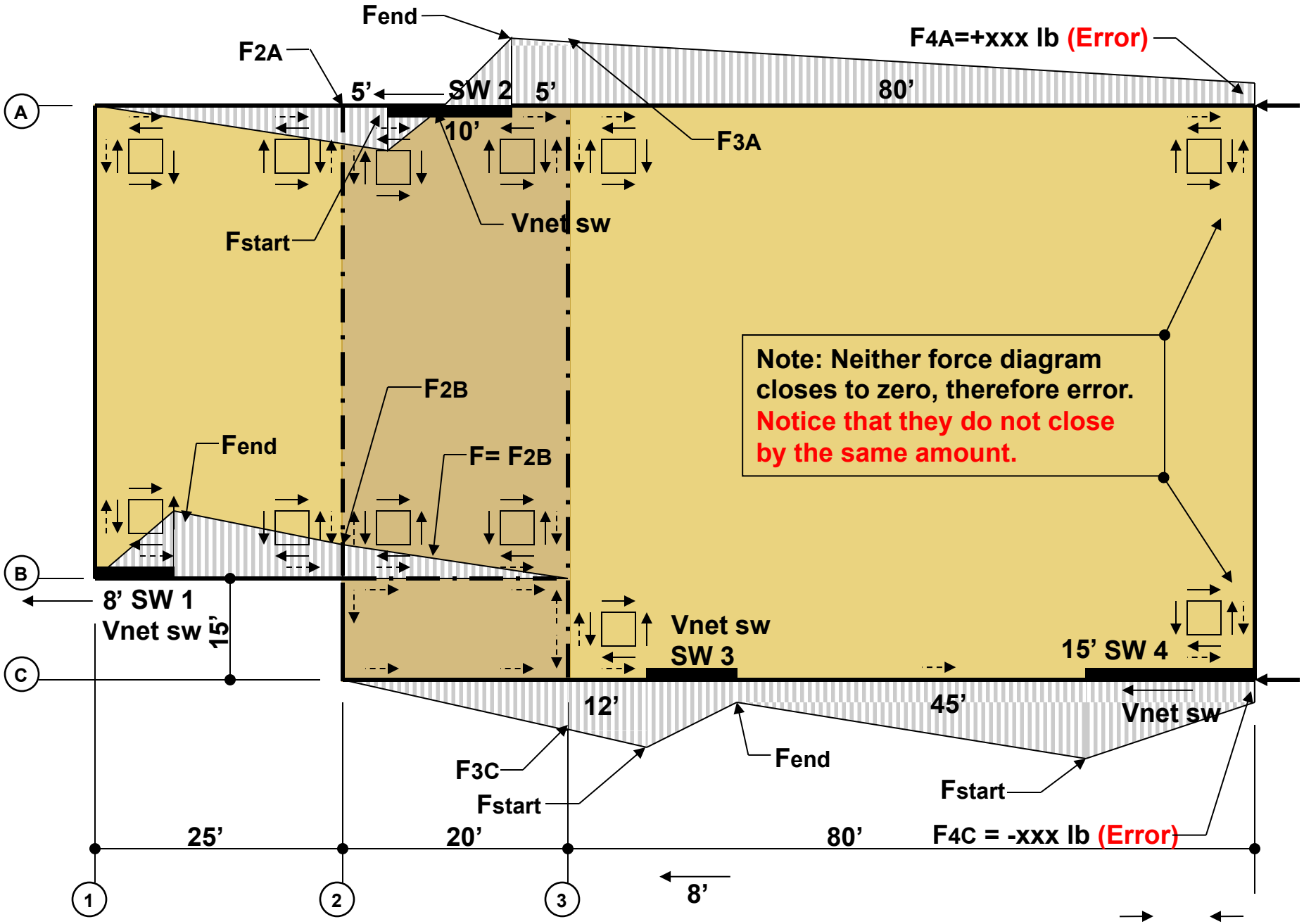
Determine Force transferred Into Transfer Diaphragm

Basic Diaphragm Shears and Transfer Diaphragm Shear

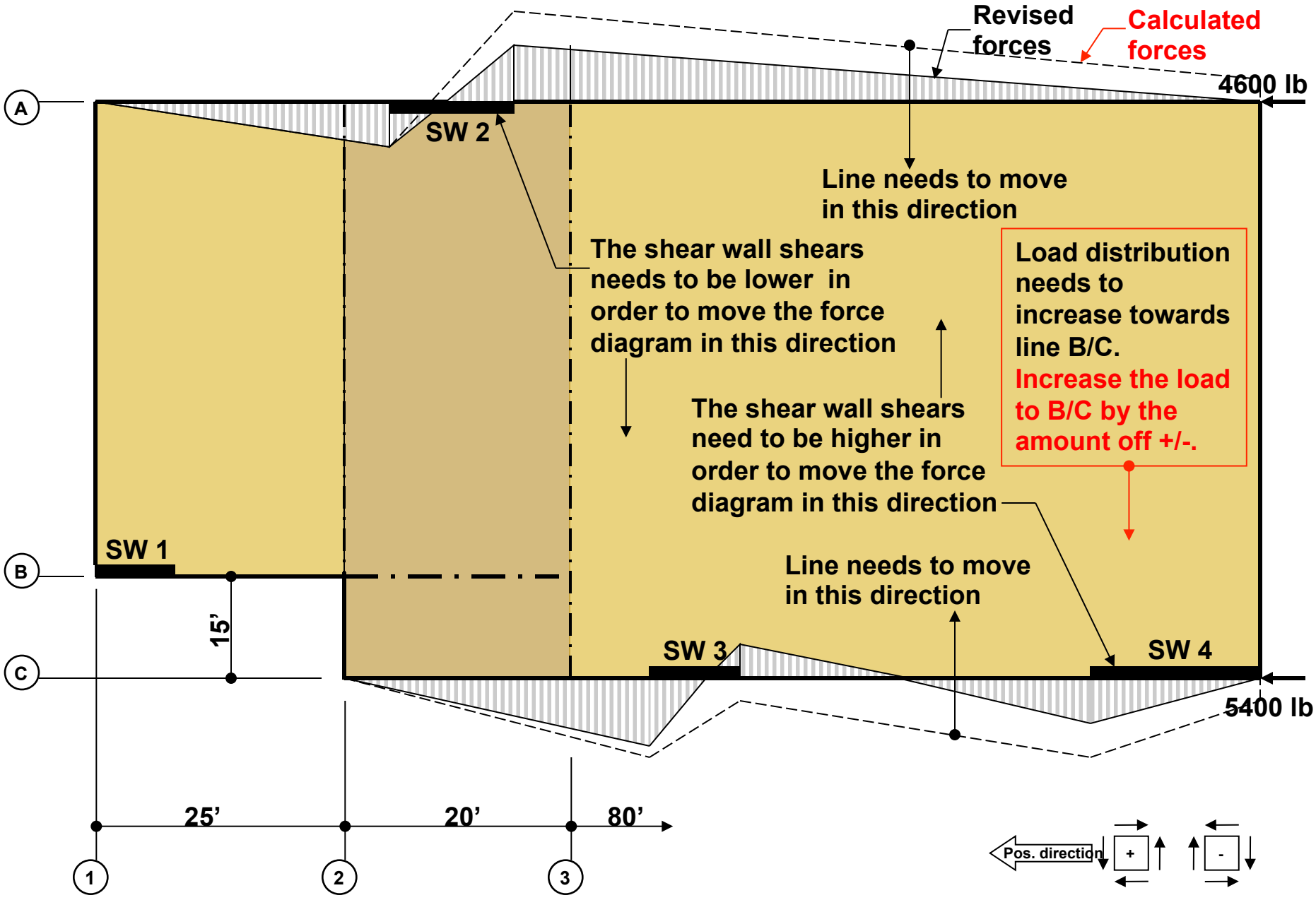


Net Diaphragm Shears


SW 2
A
B
C
1
2
3
Net shear
Net shear (TD tension chord and Diaph.2 compression Chord)
Diaphragm 2
F2B
Special nailing
F3B
F3B
8' SW 1
15'
8' SW3
15' SW 4
F2B
-vB
Net shear
x2'
-F
+F
x1'
+vC
So far, so good
Transverse Collector Force Diagrams
Pos. direction
+
-



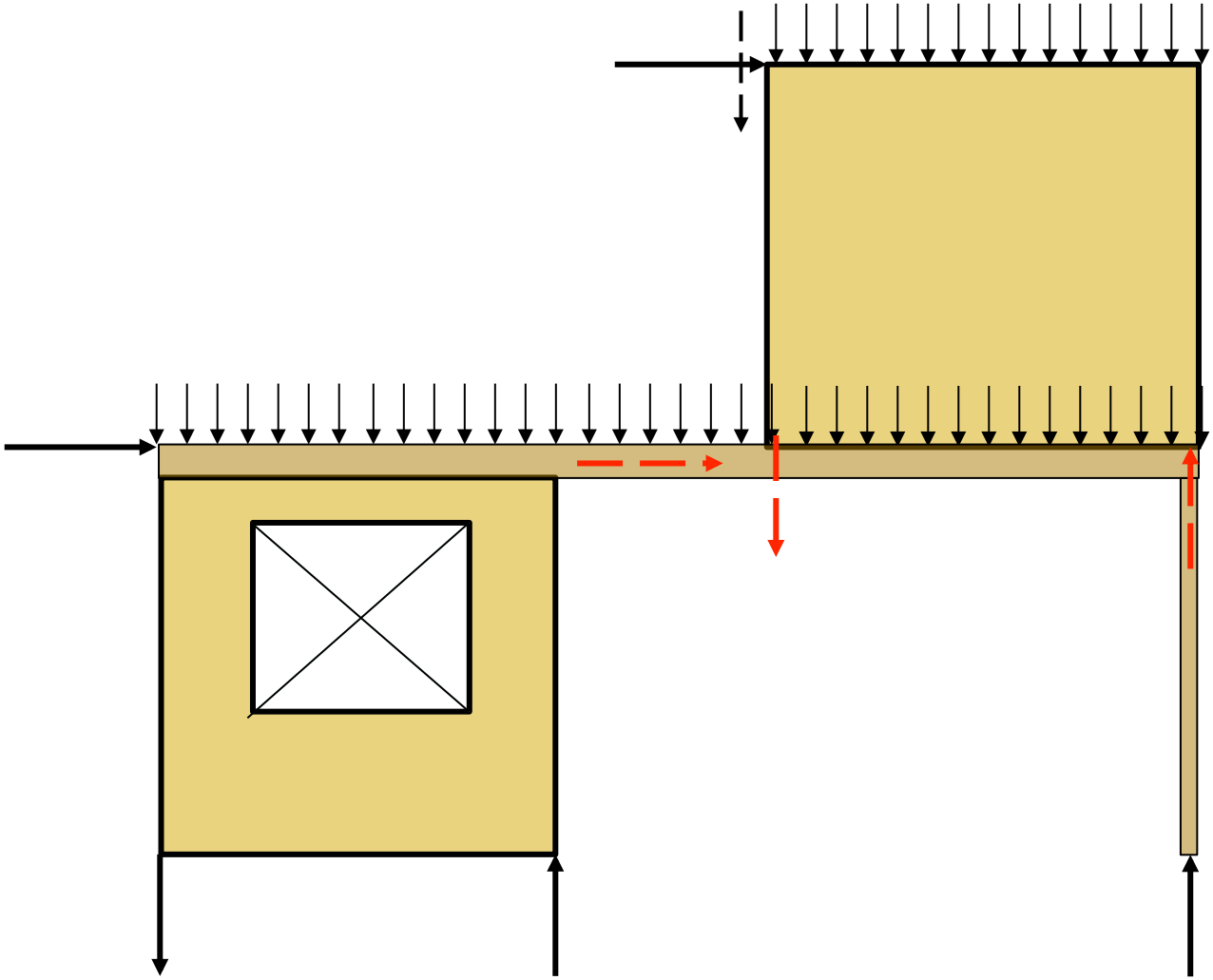
Longitudinal Strut Force Diagrams

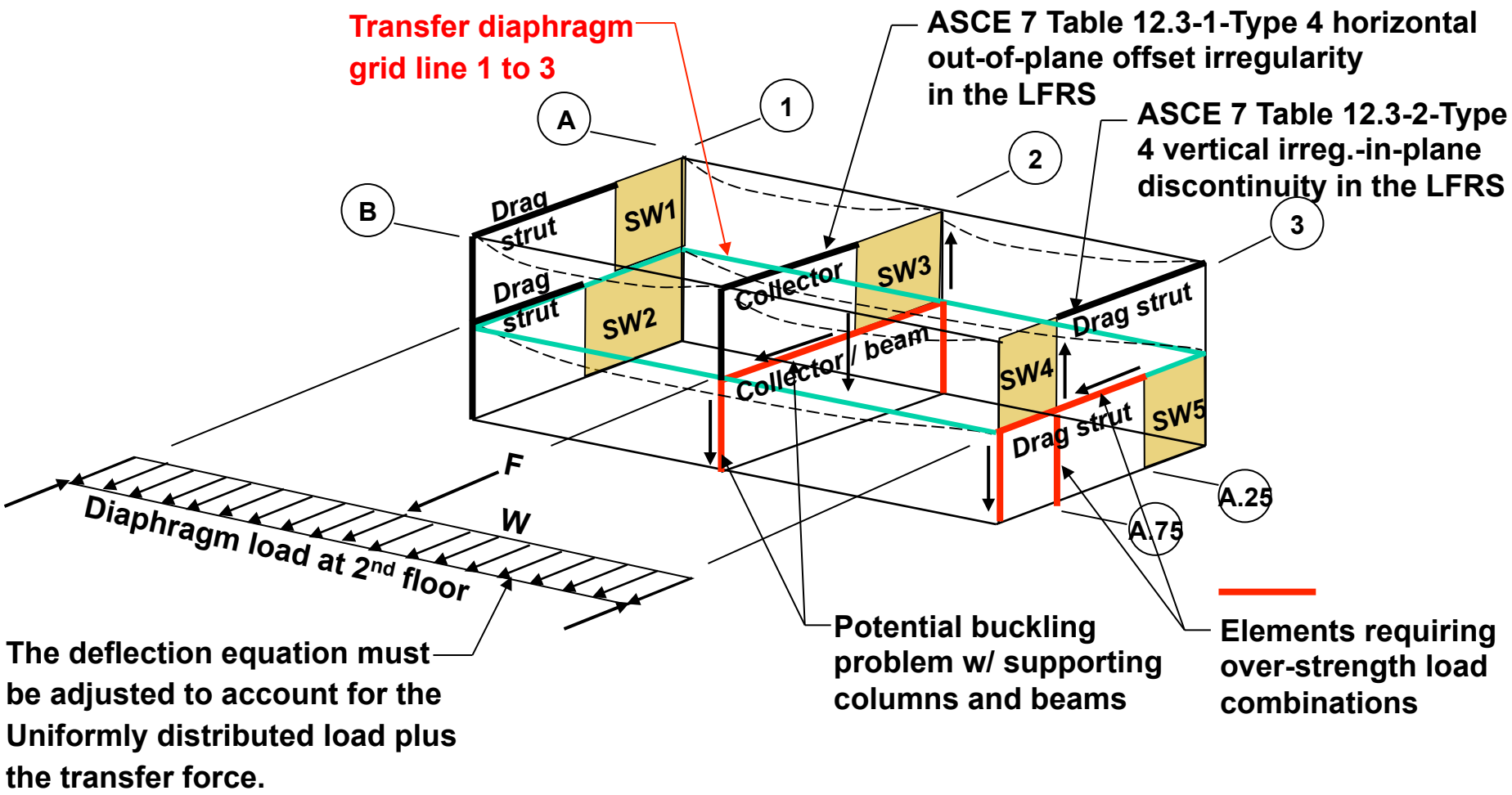


Adjusted Longitudinal Strut Force Diagrams (8% to 20% increase to B/C)

[Amount shifted to B/C depends on the offset to span ratio of the transfer diaphragm]

In-plane Offset Shear Walls



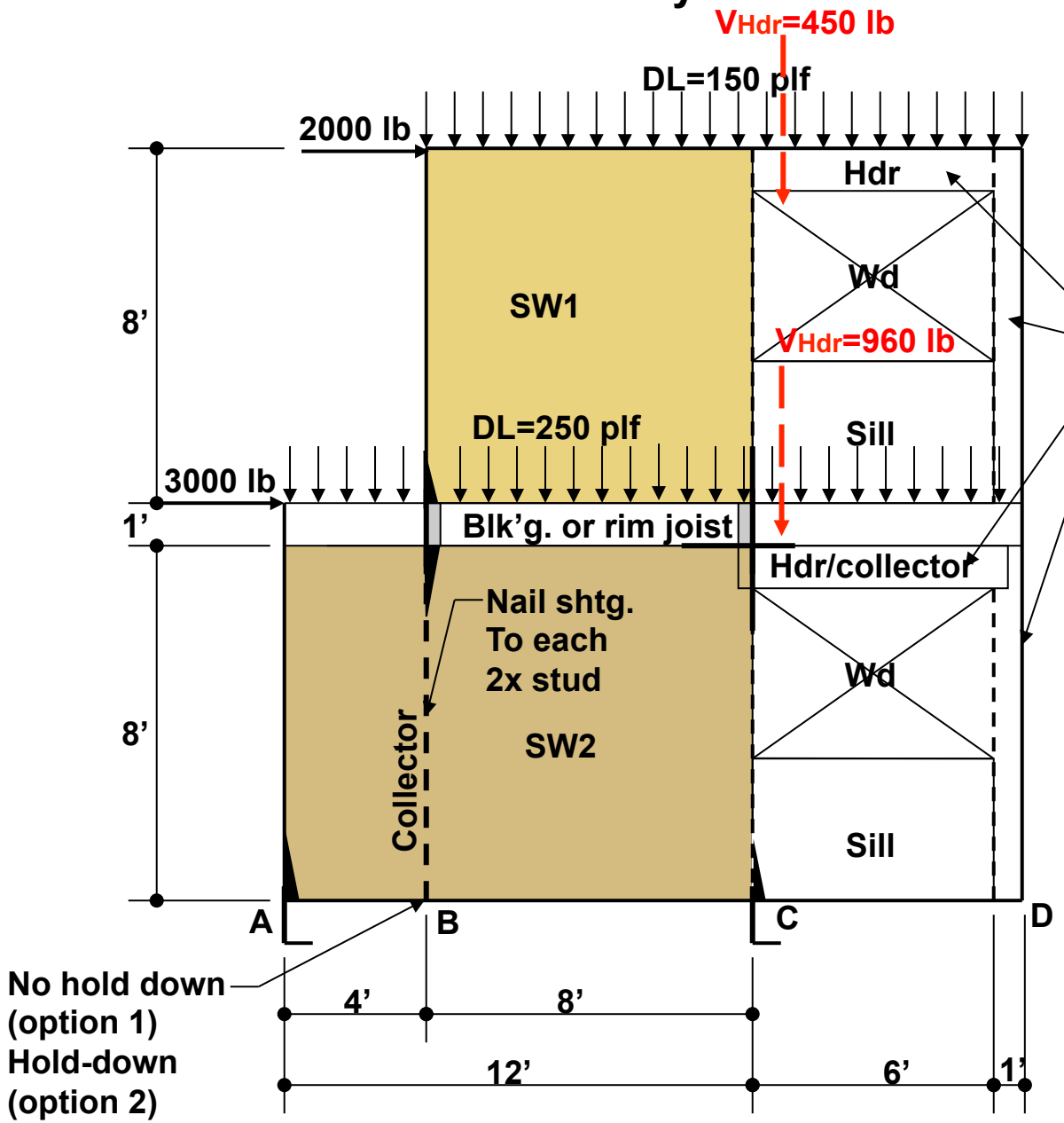


ASCE 7 section 12.3.3.3

Elements supporting discontinuous walls and frames (Check requirements for Rho)

Example 4-In-plane Offset Segmented Shear Wall

-with Gravity Loads



Section does not comply with the required aspect ratio for a perforated or FTO shear wall.

ASCE 7 Table 12.3-2-Type 4 vertical irreg.- in-plane discontinuity in the LFRS

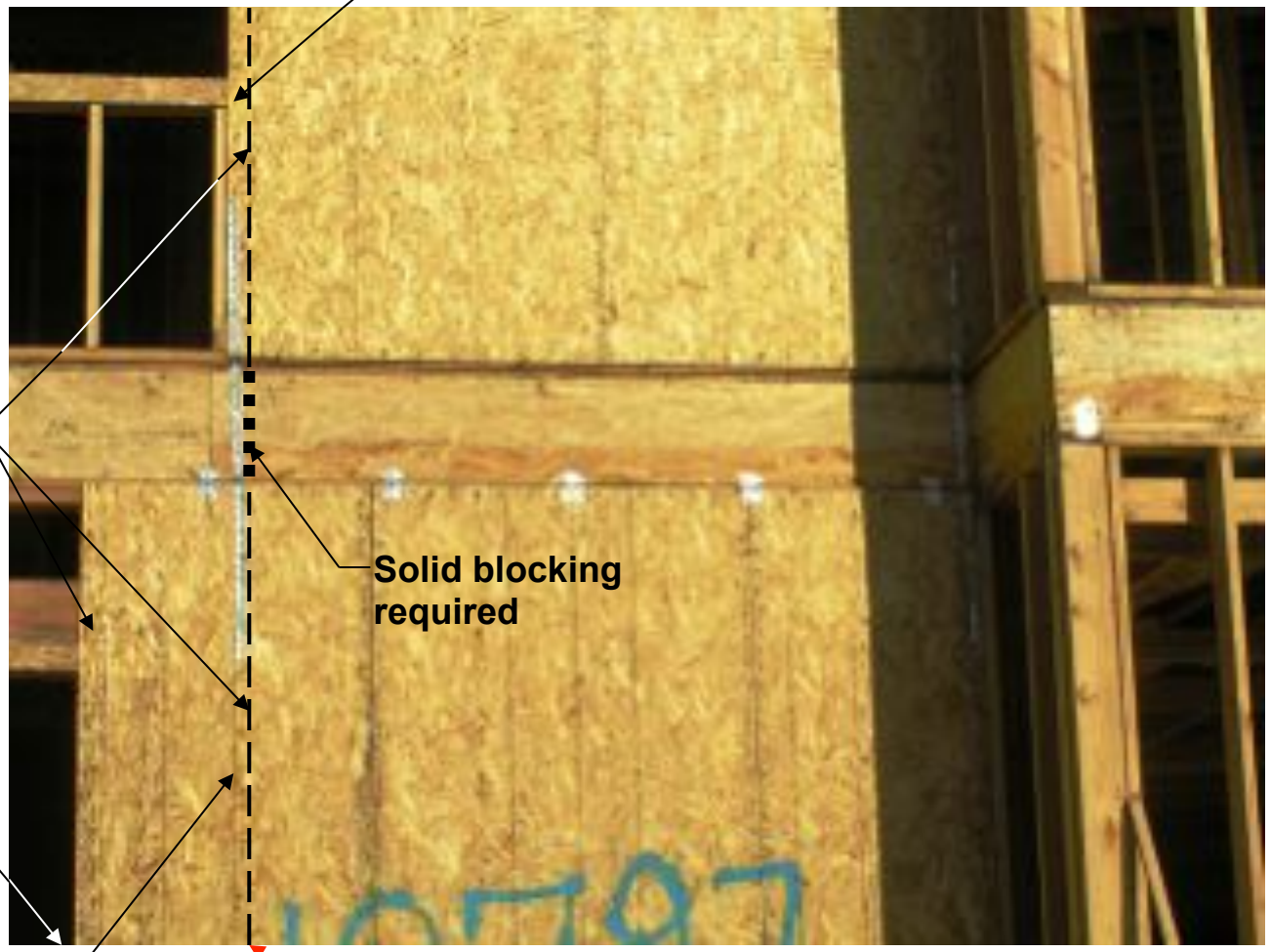
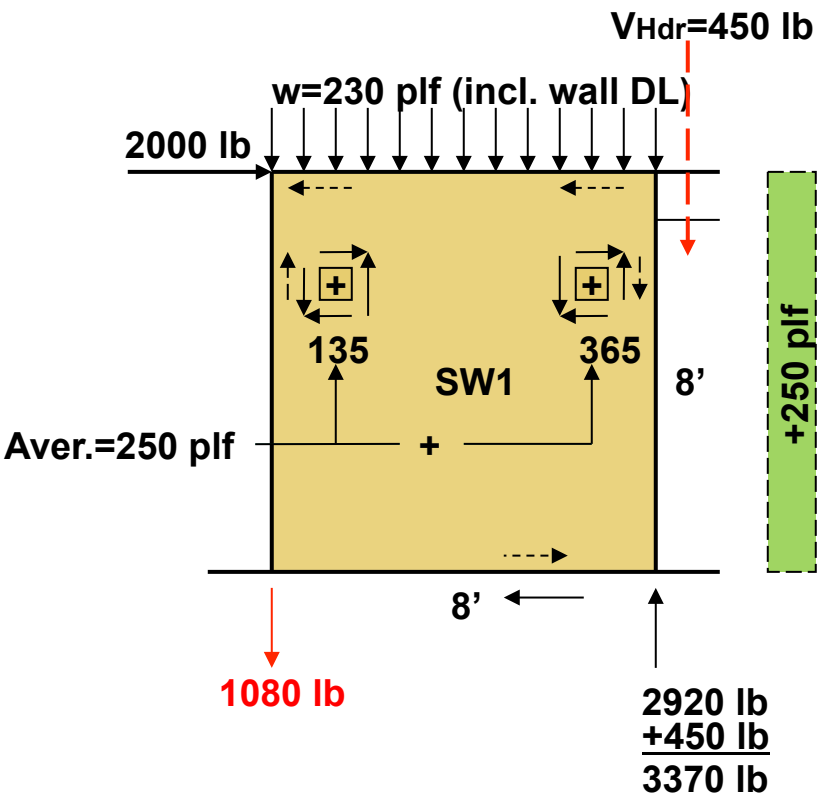
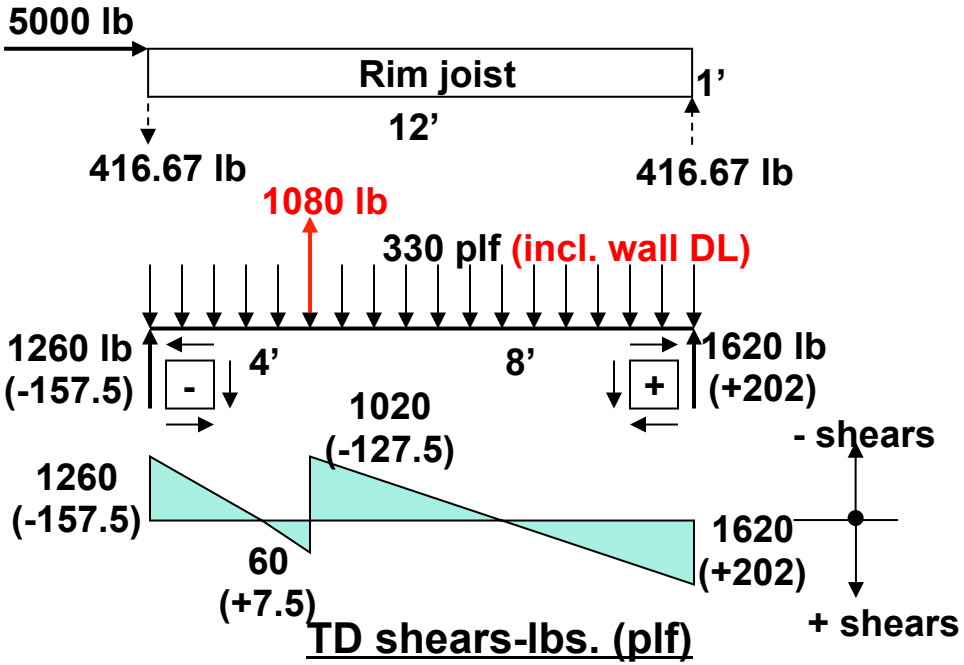


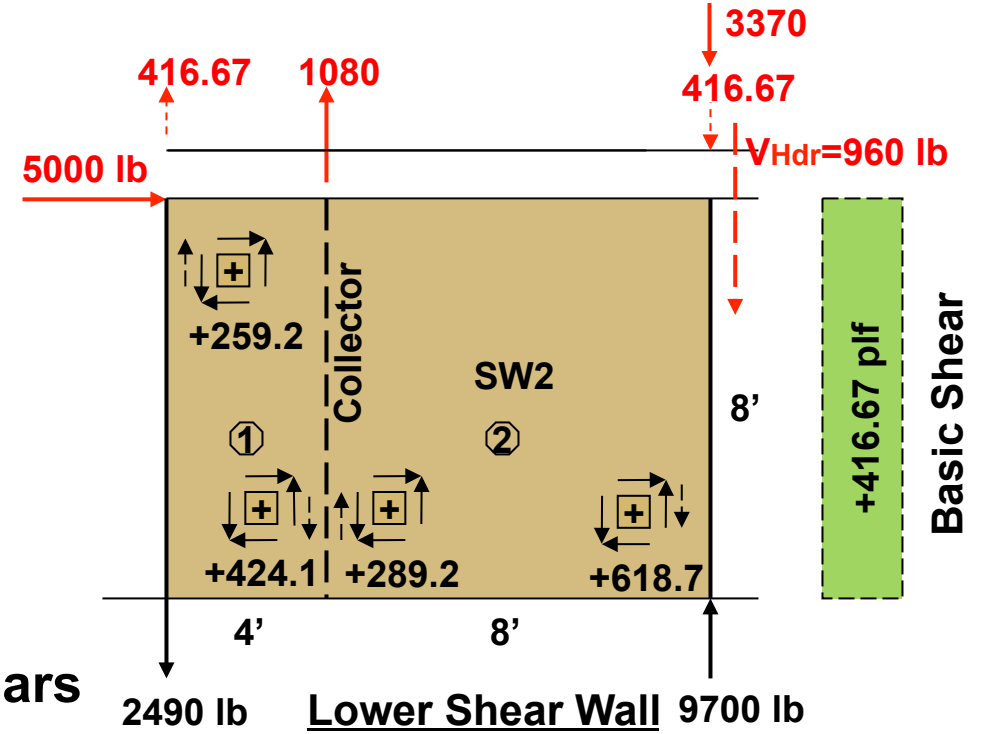
Photo-In-plane Offset Segmented Shear Walls

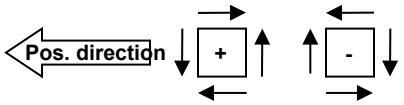


Upper Shear Wall



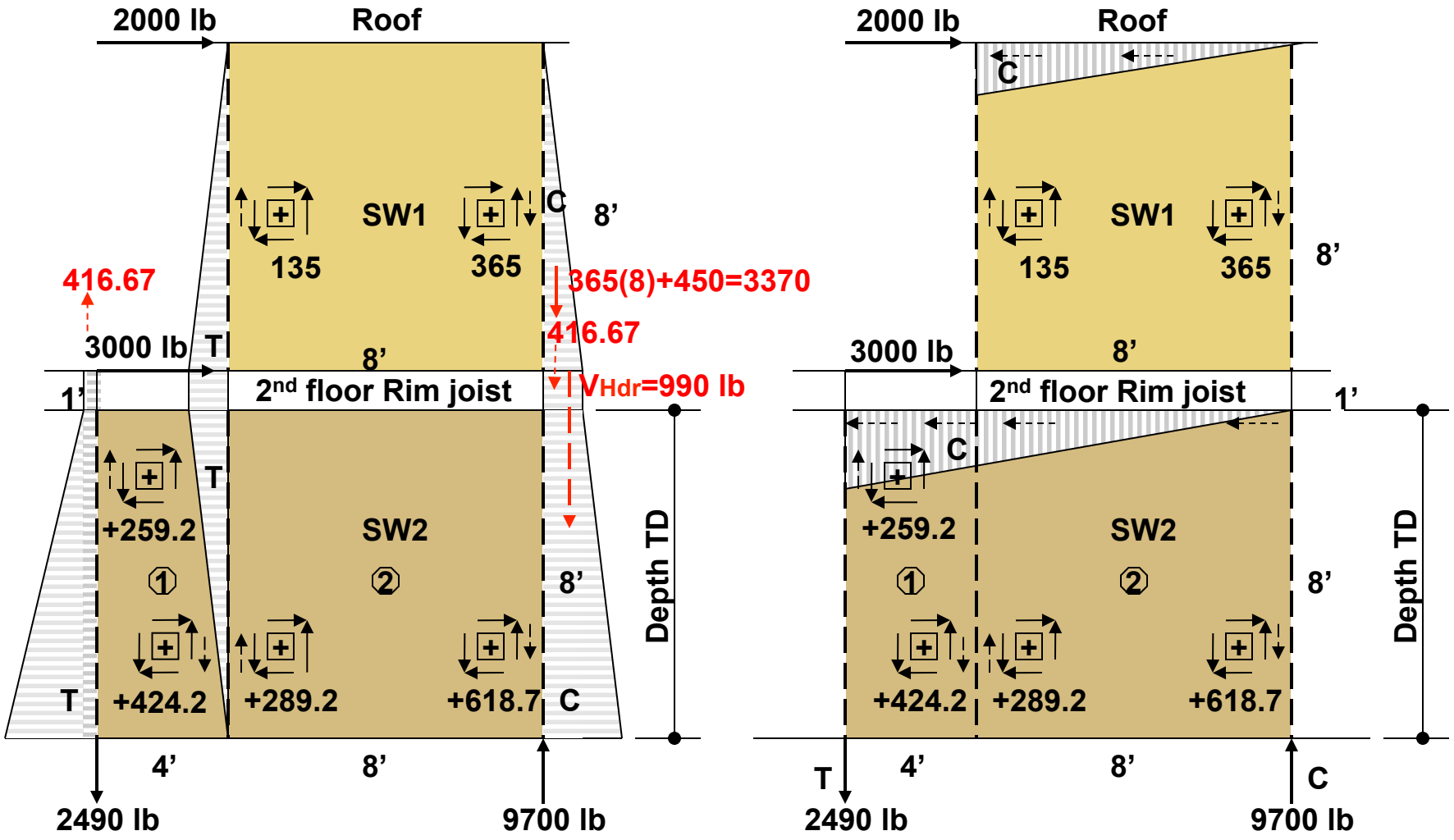
TD shears-lbs. (plf)





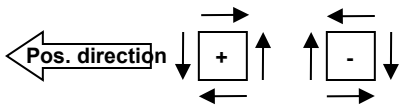
Sign Convention

Wall and Transfer Diaphragm Shears



Vertical Collector Forces

Horizontal Collector Forces



Sign Convention

Collector Force Diagrams

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

Part 2- Offset Shear Walls

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