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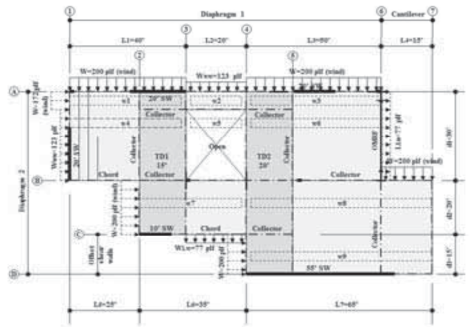
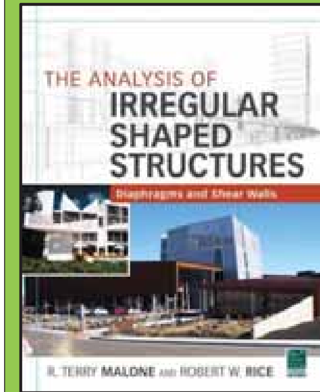
Part I-Offset Diaphragms



Example-Complex Diaphragm

Excerpts From:



Presentation updated to 2012 IBC, ASCE 7-10

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Course Description

Lateral force resisting systems in today's structures are much more complex than they were several decades ago, incorporating multiple horizontal and vertical offsets in the diaphragms, multiple irregularities, and fewer lateral resisting elements. This two part presentation will provide a brief review of the method used to analyzed these complex structures. In part 1, topics will include code requirements, how to recognize diaphragm irregularities and discontinuities, how shears are distributed through complex diaphragms, the method of analysis used to solve the transfer of forces across areas of discontinuity, and the analysis of flexible wood sheathed or untopped steel decking diaphragms with horizontal offsets.

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Learning Objectives

- **Basic Information**

  Discuss boundary elements, complete lateral resisting load path requirements and related code sections.

- **Examine Common Types of Discontinuities**

  Examine common types of discontinuities and irregularities and discuss how to establish complete lateral load paths across areas of discontinuity.

- **Discuss the Analytical Method of Analysis**

  Review an analytical method used for solving complex diaphragms and shear walls using "Transfer Diaphragms" and the "Visual Shear Transfer Method."

- **Offset Diaphragms-Examples**

  Review the analysis of flexible offset diaphragms for loading in the transverse and longitudinal directions.

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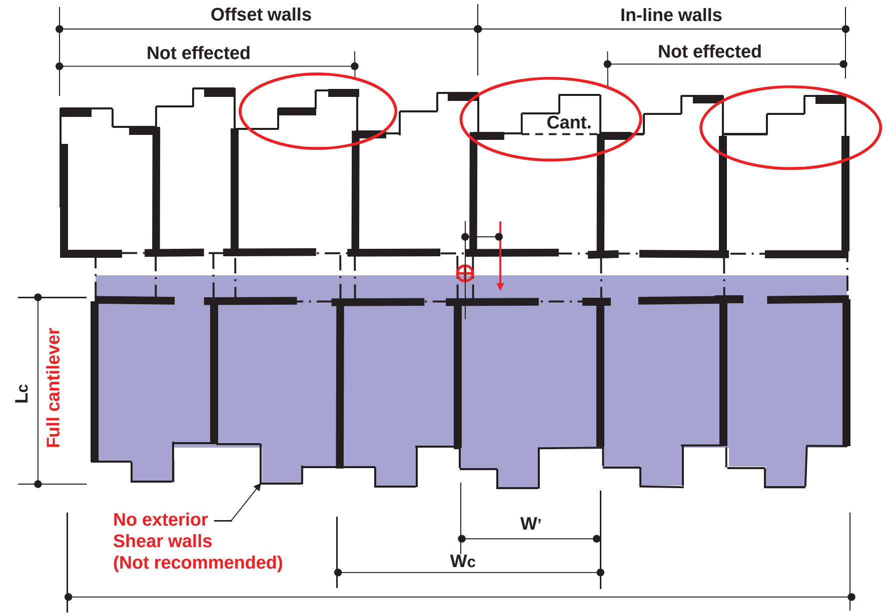
Transverse Loading Semi-Rigid



Presentation Assumptions

Flexible wood sheathed or un-topped steel deck diaphragms

The method of analysis is also relevant to internal load path analysis within semi-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:

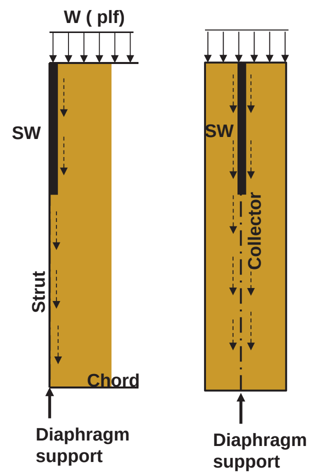
- ASCE 7-10 "Minimum Design Loads for Buildings and Other Structures"
- 2012 IBC

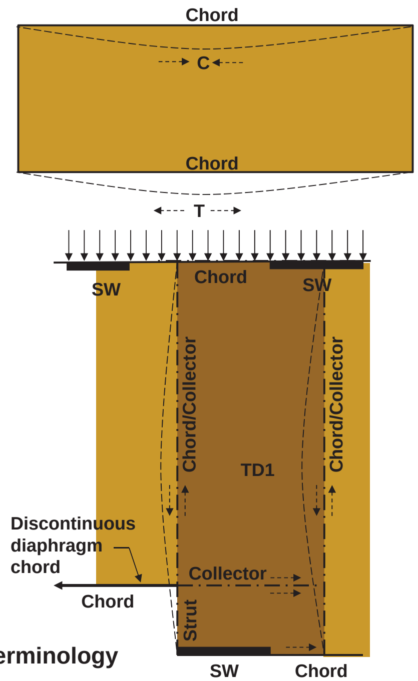
Design references:

- The Analysis of Irregular Shaped Structures: Diaphragms and Shear Walls-Malone, Rice
- 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, Mays

Basic Information

- **Boundary Elements**
- Complete Load Paths
- Method of Analysis





Strut- receives shears from one side only.
Collector- receives shears from both sides.
Chord-perpendicular to the applied load and receives axial tension and compression forces.

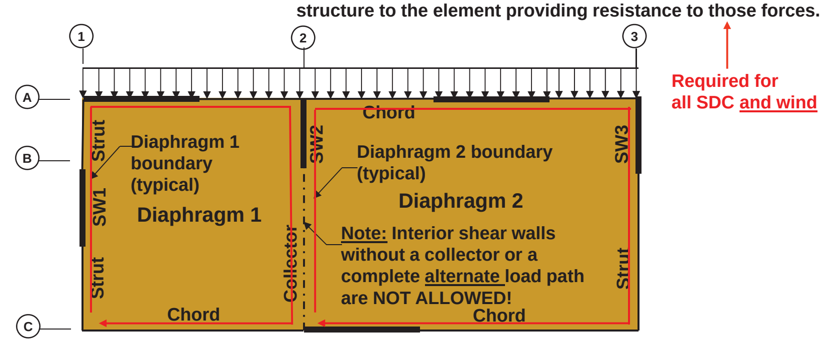
Strut, Collector, and Chord- (my) Terminology

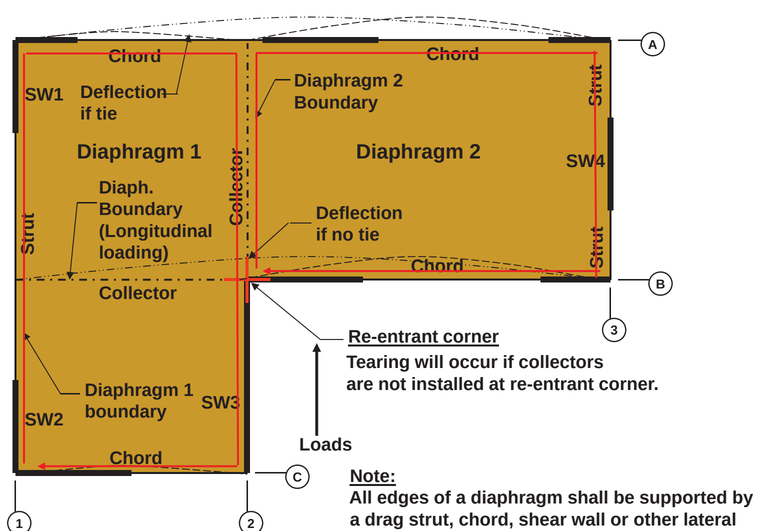
Diaphragm Boundary Elements

Fundamental Principles:
A shear wall is a location where diaphragm forces are resisted (supported), and therefore defines a diaphragm boundary location.

Note: All edges of a diaphragm shall be supported by a boundary element.

- **Diaphragm Boundary Elements:**
  - Chords, drag struts, collectors, Shear walls, frames
  - Boundary member locations:
    - Diaphragm and shear wall perimeters
    - Interior openings
    - Areas of discontinuities
    - Re-entrant corners.
- Diaphragm and shear wall sheathing shall not be used to splice boundary elements.
- Collector elements shall be provided that are capable of transferring forces originating in other portions of the structure to the element providing resistance to those forces.





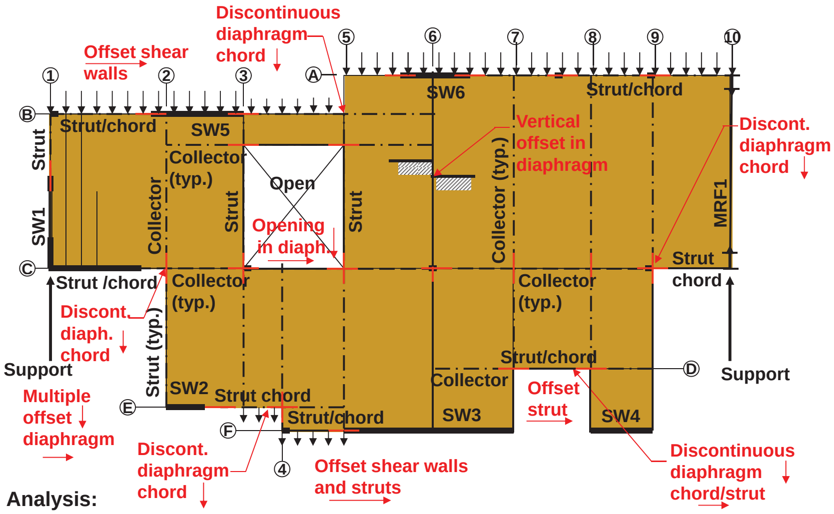
Note:
All edges of a diaphragm shall be supported by a drag strut, chord, shear wall or other lateral resisting element.

------ Deflected curve if proper tie
-·-·-·- Deflected curve if no tie

Boundary Elements "L" Shaped Buildings-Transverse Loading

Basic Information

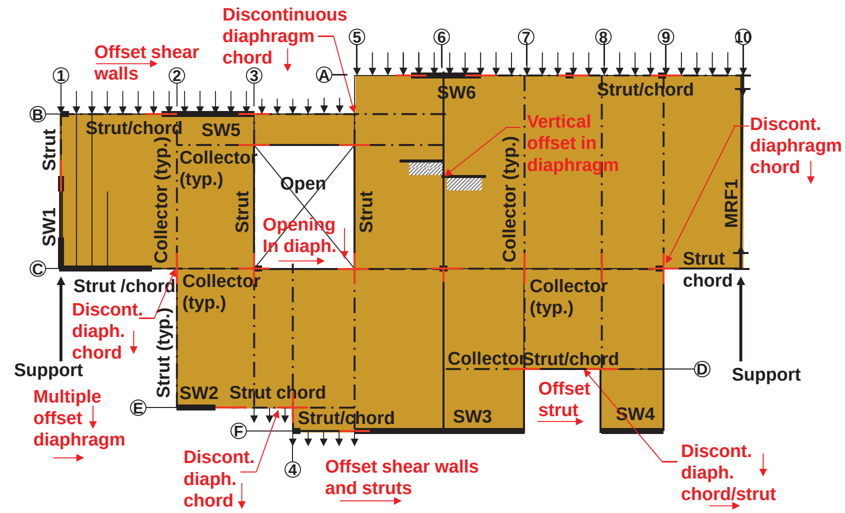
- Boundary Elements
- **Complete Load Paths**
- Method of Analysis



Analysis:

- Design shall be based on a rational analysis
- Complete load path from point of origin to lateral force resisting element (includes members and their connections and splices)
- Openings in shear panels that materially effect their strength shall be fully detailed on the plans and shall have their edges adequately reinforced to transfer all shear stresses.

Complete Continuous Lateral Load Paths



- ASCE 7-10 section 12.10.1-At diaphragm discontinuities such as openings and re-entrant corners, the design shall assure that the dissipation or transfer of edge (chord) forces combined with other forces in the diaphragm is within shear and tension capacity of the diaphragm.

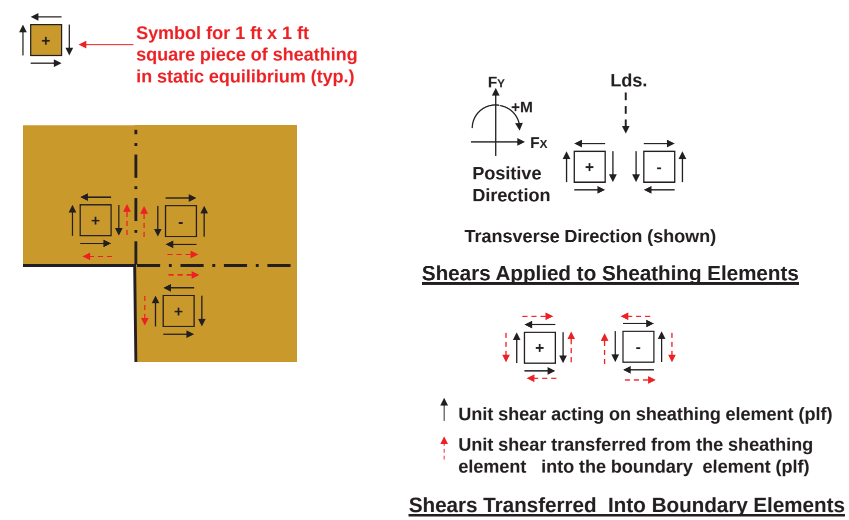
What does this mean?

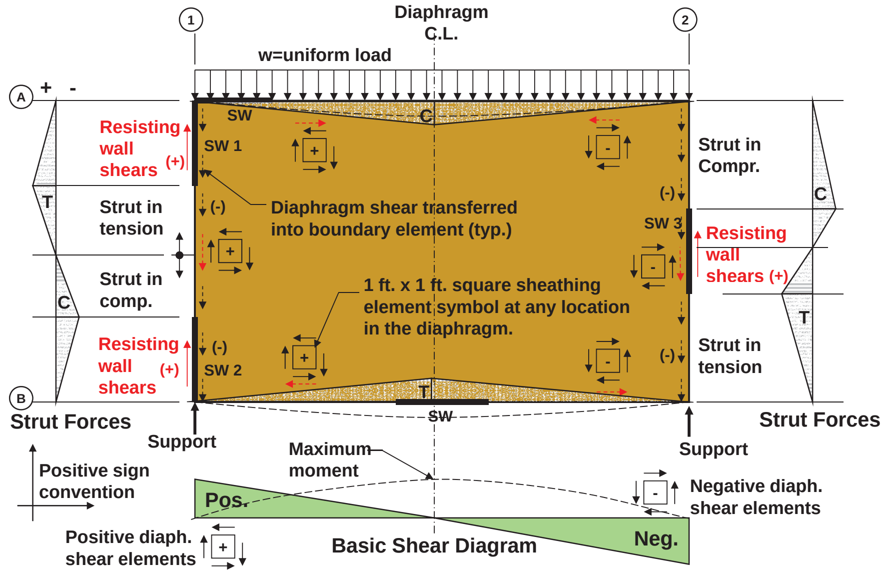
Basic Information

- Boundary Elements
- Complete Load Paths
- **Method of Analysis**

Method of Analysis

The Visual Shear Transfer Method

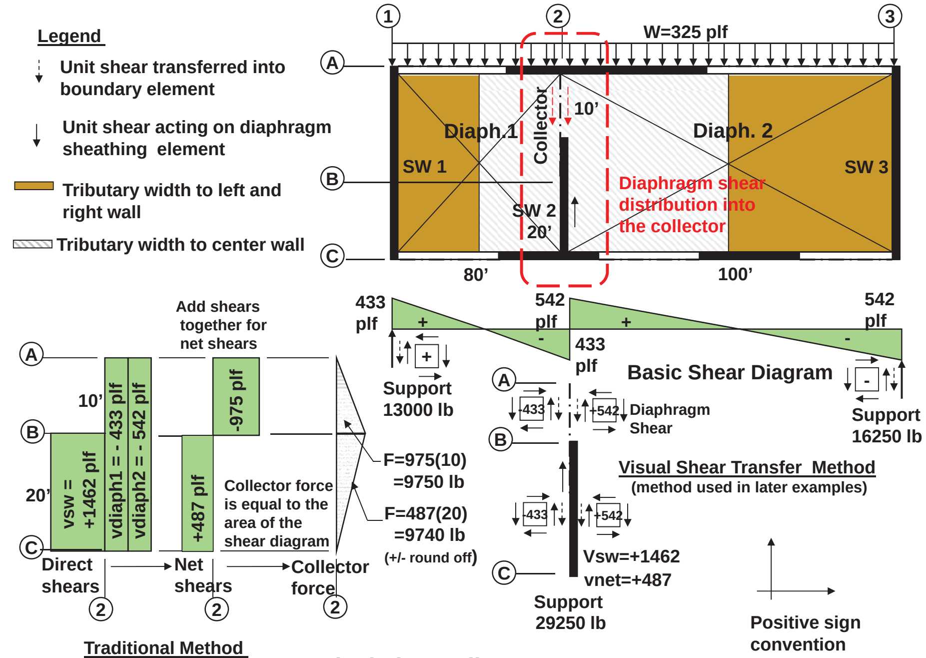




All edges of a diaphragm shall be supported by a boundary element (chord, strut, collector) or other vertical lateral force resisting element (shear wall, frame).

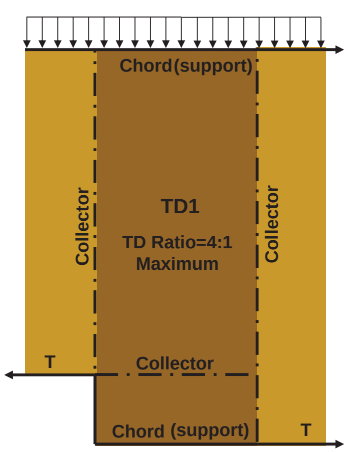
Shear Distribution Into a Simple Diaphragm

The Visual Shear Transfer Method

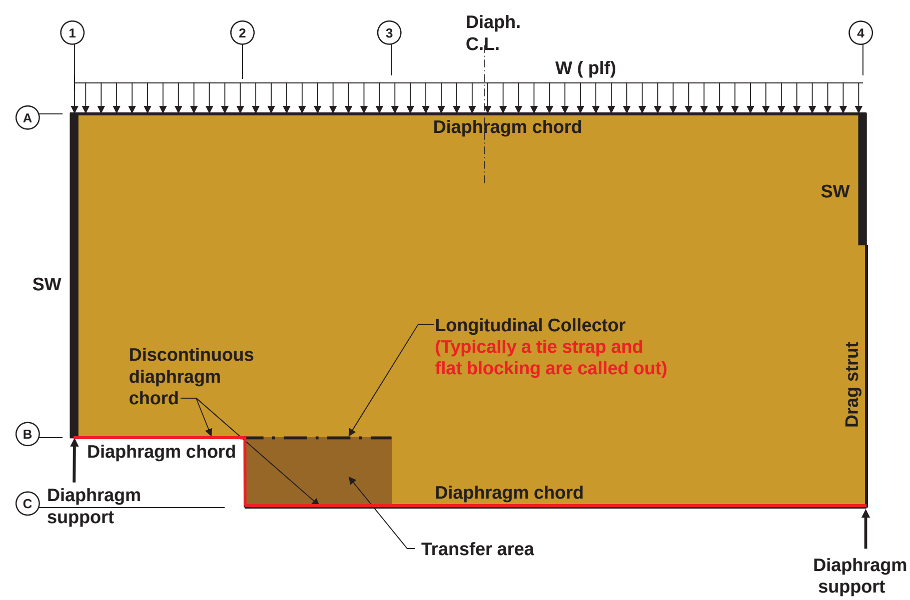


Calculating Collector Forces

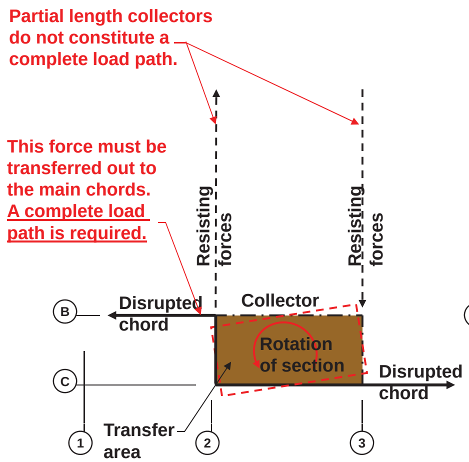
Introduction to Transfer Diaphragms and Transfer Areas



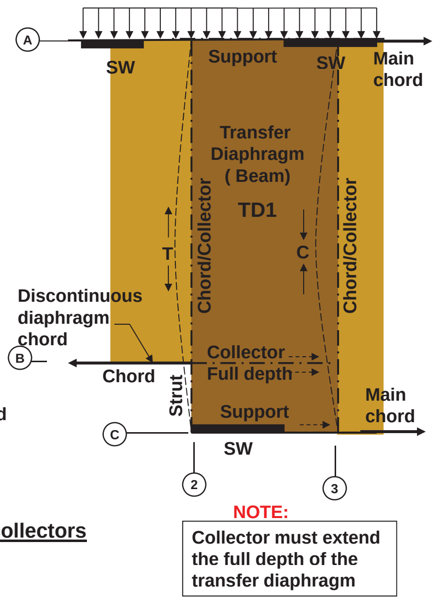
- **Transfer Diaphragm (sub-diaphragm):** A portion of a larger diaphragm designed to anchor and transfer local forces to primary diaphragm chords/struts of the main diaphragm.
- At discontinuities, such as openings or re-entrant corners, the design shall assure that the dissipation or transfer of edge (chord) forces combined with other forces in the diaphragm is within shear and tension capacity of the diaphragm. What does this mean?
- Framing members, blocking, and connections shall extend into the diaphragm a sufficient distance to develop the force transferred into the diaphragm. What does this mean?



Transfer Diaphragm Members and Elements

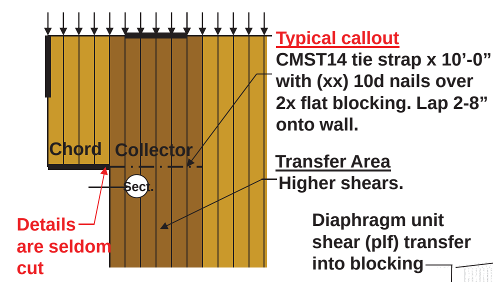


Transfer area without transverse collectors



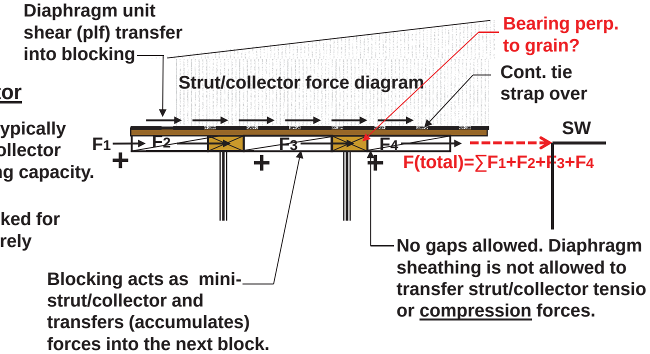
Transfer using beam concept

Transfer Mechanism



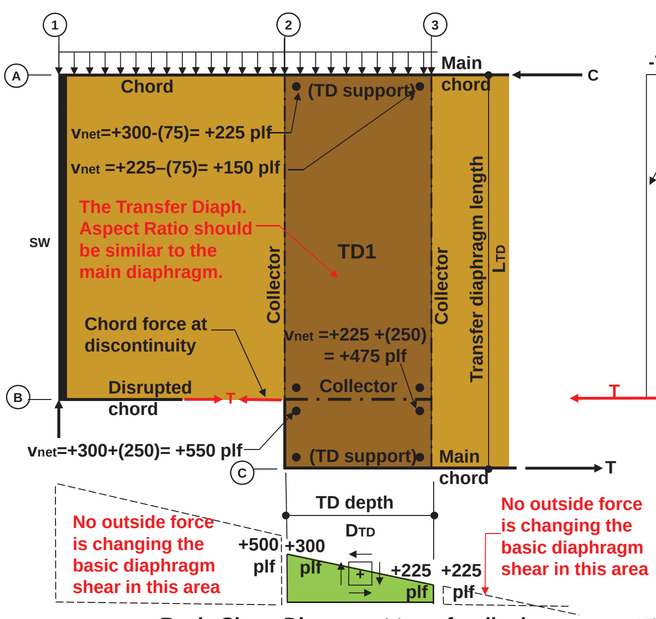
Plan-Partial length collector

- The length of the collector is typically determined by dividing the collector force by the diaphragm nailing capacity. (Wrong!!)
- The collector is typically checked for tension only. Compression rarely checked. (Wrong!!)

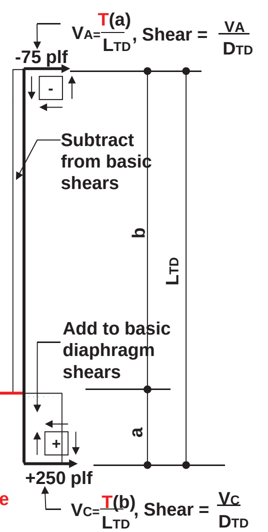


Collector force distribution

Example of Partial Strut/Collector



Basic Shear Diagram at transfer diaphragm



Transfer Diaphragm Shears

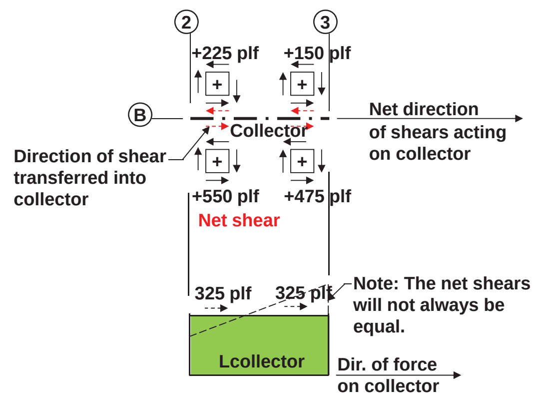
Analogous to a beam with a concentrated Load.

vnet= 300 + (250) = 550 plf

Basic diaph. shear — TD shears — Net shear

Basic Procedure

Method by Edward F. Diekmann



Resulting net shear diagram on collector

- Place the net diaphragm shear on each side of the collector
- Place the transfer shears on each side of the collector
- Sum shears on collector (based upon direction of shears transferred onto collector).

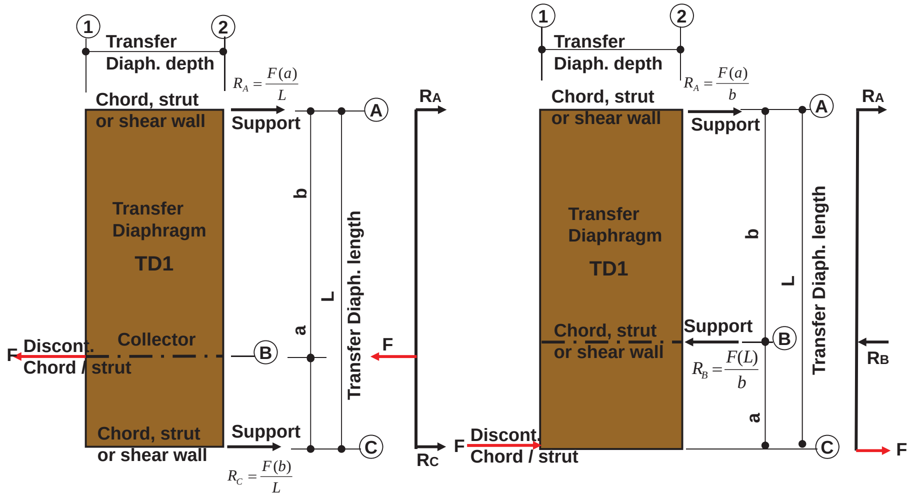
Shear left=+550-225= +325 plf

Shear right=+475-150=+325 plf

- Collector force=area of shear diagram

$$F_{collector} = \frac{(325+325)(L_{collector})}{2}$$

Shear Distribution Into The Collector



Simple Span Transfer Diaphragm

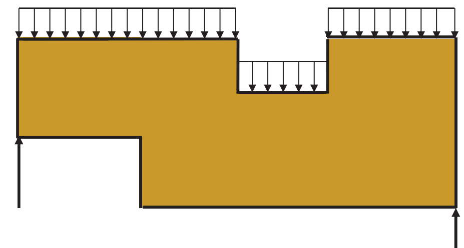
Analogous to a simple span beam with a concentrated load

Propped Cantilever Transfer Diaphragm

Analogous to a propped cantilever beam with a concentrated load

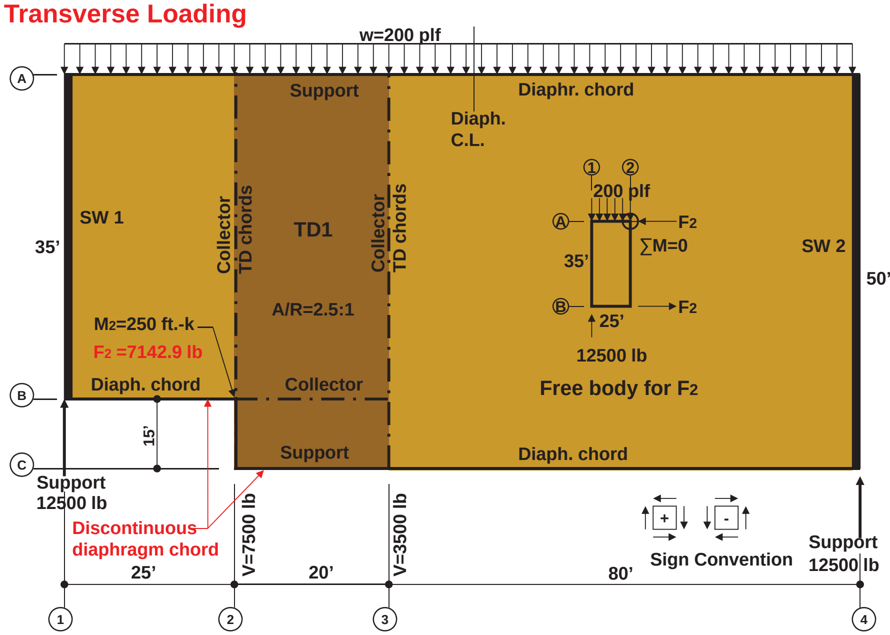
Simple Span and Propped Cantilever Transfer Diaphragms

Diaphragms with Horizontal Offsets

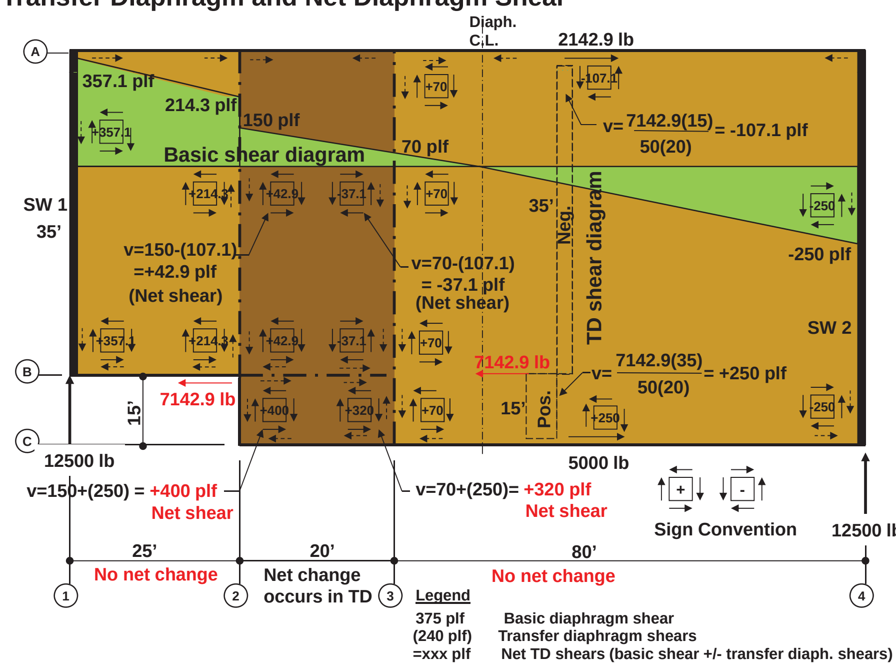


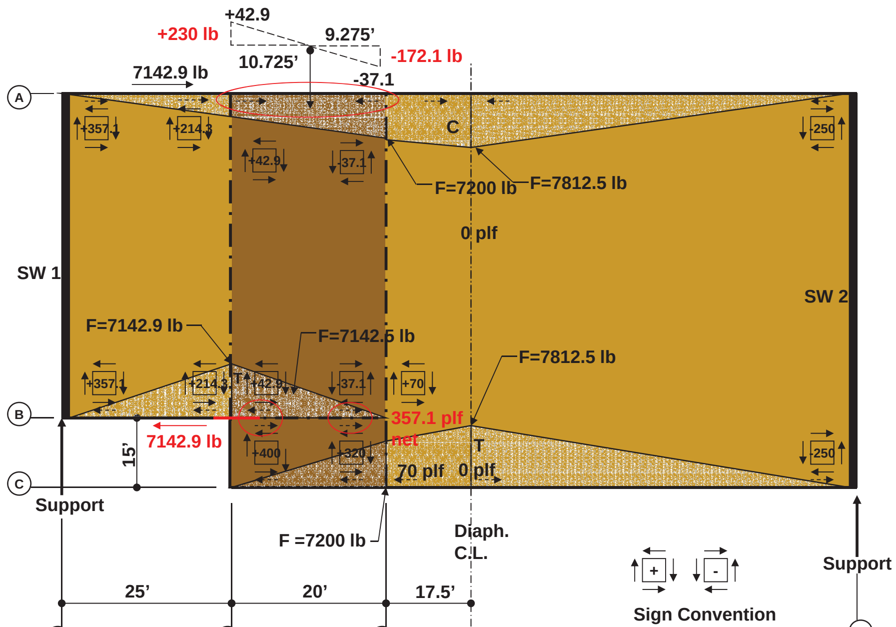
Example 1-Diaphragm with Horizontal End Offset

Transverse Loading

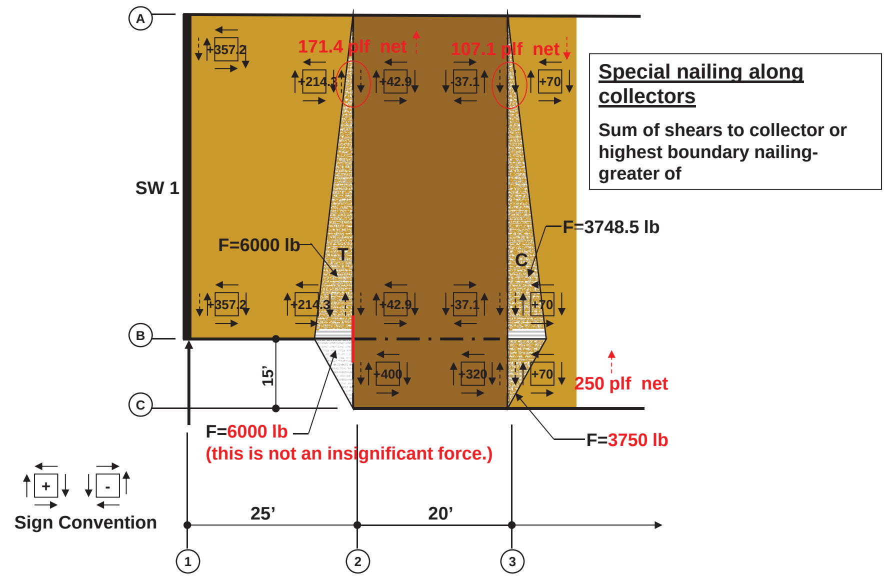


Transfer Diaphragm and Net Diaphragm Shear

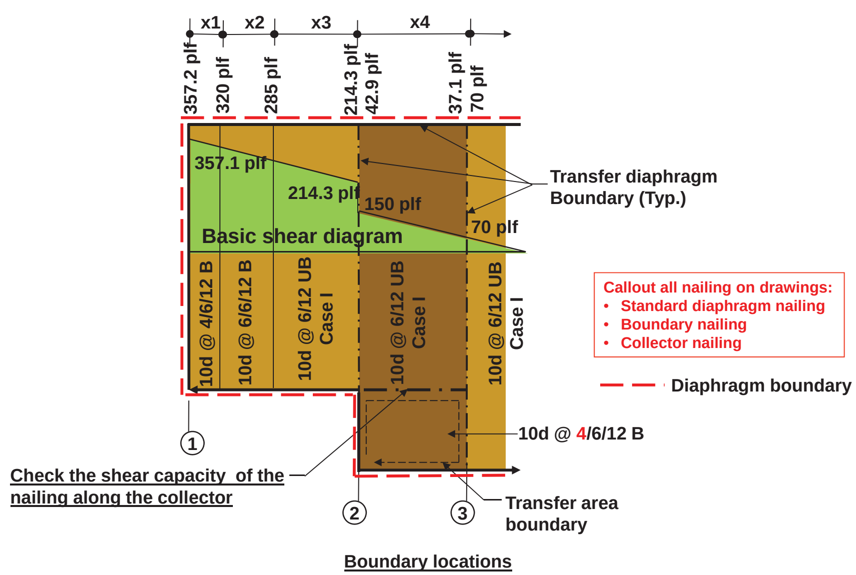




Longitudinal Chord Force Diagrams



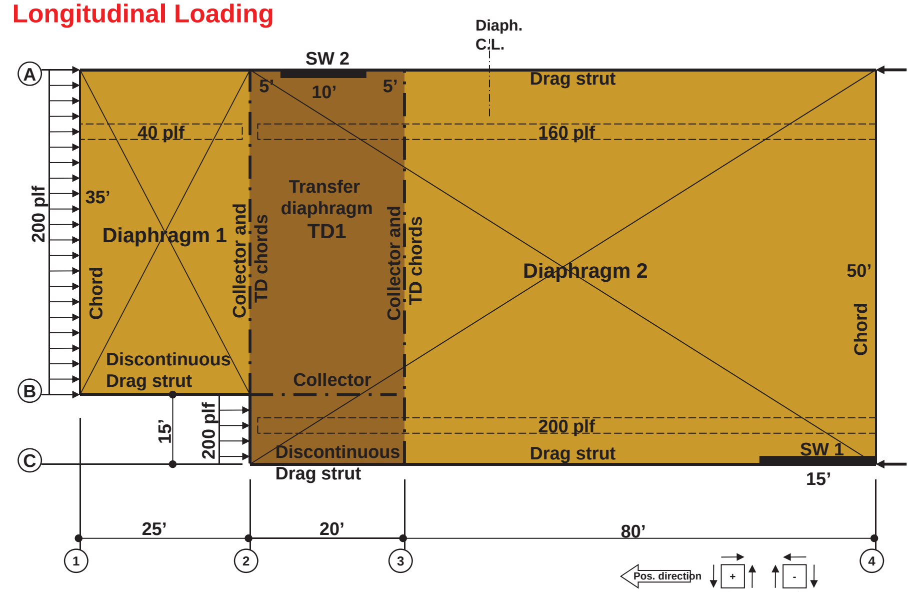
Transverse Collector Force Diagrams

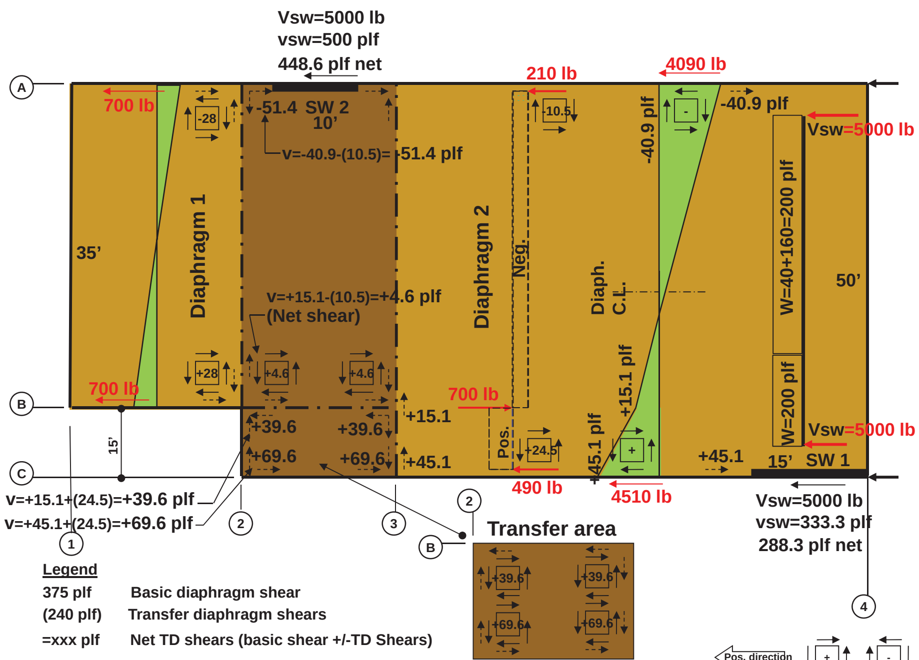


Diaphragm Nailing Callouts

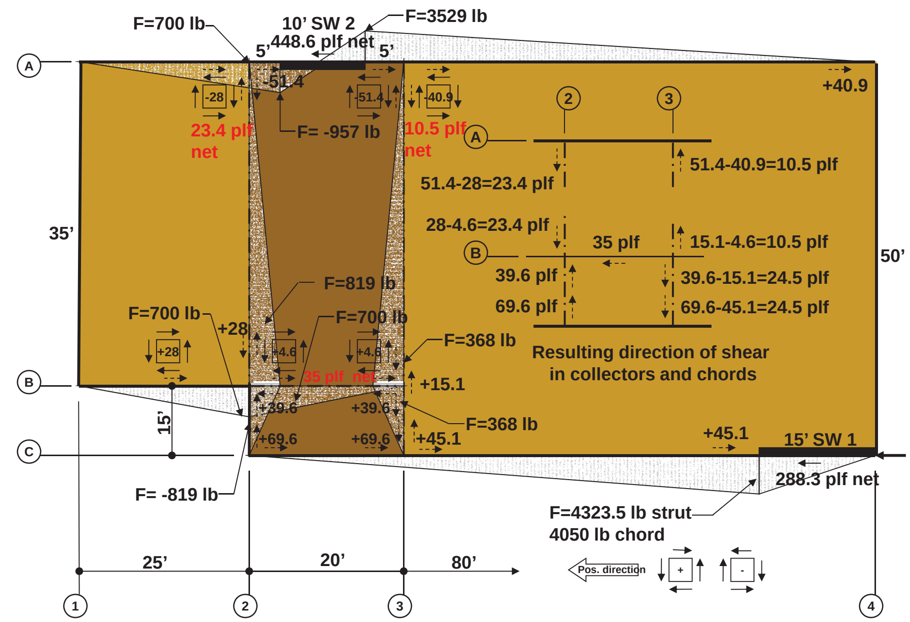
Example 2-Diaphragm with Horizontal End Offset

Longitudinal Loading





Transfer Diaphragm and Net Diaphragm Shear



Longitudinal and Transverse Collector/Strut Force Diagrams

Questions?

This concludes

AIA Presentation Part 1- on Offset Diaphragms

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