Outline / Learning Objectives

- **Basic Information**
  Discuss boundary elements and related code sections, complete lateral resisting load path requirements and related code sections, and how to establish complete lateral load paths across areas of discontinuity.

- **Discuss the analytical method used for the analysis**
  Discuss analytical method used for solving complex diaphragms and shear walls using “Transfer Diaphragms” and the “Visual Shear Transfer Method.”

- **Horizontally offset Diaphragms**
  Review the analysis of flexible offset diaphragms consisting of structural wood panel sheathing or un-topped steel decking.

- **In-plane and out-of-plane offset shear walls**
  Review the analysis and effects of horizontally out-of-plane and in-plane offset shear walls.
**Code and Basic Information**

- Boundary Elements
- Complete Load Paths

**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.

**Diaphragm Web Discontinuity**

- Still must be distributed into diaphragm.
- What is boundary element?
- Diaphragm 1: Assume angular distribution thru diaphragm (Unsupported edge).
- Diaphragm 2: Assume angular distribution thru diaphragm (Unsupported edge).

**Diaphragm Without Boundary Element At Interior Shear Wall**

- This section is not supported and cannot resist shear
- Acts similar to solid beam notched on tension side
- Splits will occur (See NDS Section 3.4) and Eq. 3.4-3

**Boundary Elements “L” Shaped Buildings-Transverse Loading**

- Re-entrant corner: Tearing will occur if collectors are not installed at re-entrant corner.

- Loads: 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
Complete Continuous Lateral Load Paths

Method of Analysis
The Visual Shear Transfer Method

Shears Applied to Sheathing Elements

Shears Transferred Into Boundary Elements

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.
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.

Framing members, blocking, and connections shall extend into the diaphragm a sufficient distance to develop the force transferred into the diaphragm.

Transfer Mechanism

Partial length collectors do not constitute a complete load path. This force must be transferred out to the main chords. A complete load path is required.

Transfer area without transverse collectors

NOTE: Collector must extend the full depth of the transfer diaphragm

Transfer using beam concept

Basic Procedure
Method by Edward F. Diekmann

Basic Shear Diagram at transfer diaphragm
Analogous to a beam with a concentrated Load.
Diaphragms with Horizontal Offsets

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

Example 1-Diaphragm with Horizontal End Offset
Transverse Loading

Transfer Diaphragm and Net Diaphragm Shear

Sign Convention
Callout all nailing on drawings:
- Standard diaphragm nailing
- Boundary nailing
- Collector nailing

Offset Shear Walls

Out-of-Plane Offset Shear Walls
Assumed to act in the same Line of Resistance

- Whenever there are offset walls, they are typically assumed to act in the same line of lateral-force-resistance.
- Calculations are rarely 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 rarely installed to transfer the disrupted forces across the offsets.

ASCE 7-10, Section 12.1.3
A continuous load path shall be provided to transfer all forces from their point of origin to the lateral force resisting elements (includes members and their connections and splices).

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.

ASCE 7-10 Section 14.5.2 Where offset walls occur in the wall line, portions of the shear wall on each side of the offset shall be considered as separate shear walls unless provisions for force transfer around the offset are provided.
Example 4-Diaphragm with Horizontal End Offset

Longitudinal Loading-Offset Shear Walls

Assumptions:
1. Assume shear walls at grid lines B and C act along the same line of lateral-force-resistance.
2. Assume the total load distributed to grid lines A and B/C = wL/2.

Total Shear to Shear Walls (Assumed)

Vsw2 = wL/2 = 200(50)/2 = 5000 lb, vsw2 = 5500/10 = 550 plf
Vsw1, sw3, sw4 = wL/2 = 200(50)/2 = 5000 lb, vsw = 5000/(8+8+15) = 161.3 plf

Determine Force transferred Into Transfer Diaphragm

Basic Diaphragm Shears and Transfer Diaphragm Shear

Note: Neither force diagram closes to zero, therefore error. Notice that they do not close by the same amount.
Example 4-In-plane Offset Segmented Shear Wall

- with Gravity Loads

Adjusted Longitudinal Strut Force Diagrams (8% increase to B/C) [Amount shifted to B/C depends on the offset to span ratio of the transfer diaphragm]
Questions?

This concludes The American Institute of Architects
Continuing Education Systems Course

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