Part 2 - Offset Shear Walls

Excerpts From:

THE ANALYSIS OF IRREGULAR SHAPED STRUCTURES

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Course Description

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

• In-plane Offset Shear Walls
  Examine a two story offset shear wall with varying widths.

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

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

Analysis Option 1-Analyze as Diaphragm with Intermediate offset

Analysis Option 2-Analyzing as separate diaphragms

Assumes small diaphragms are supported off of main diaphragm

Analysis Option 3-Ignoring lower diaphragm sections

Assumes main diaphragm takes all of the load. Lower diaphragms are ignored.
**Transverse Loading Semi-Rigid**

Offset walls | In-line walls
---|---
Not effected | Not effected

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**Offset Shear Walls**

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**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.

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**Example 3-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.

Typical mid-rise multi-family structure at exterior wall line
Total Shear to Shear Walls (Assumed)

\[ V_{sw2} = \frac{wL}{2} = \frac{200(50)}{2} = 5000 \text{ lb}, \quad V_{sw2} = \frac{5000}{10} = 500 \text{ plf} \]

\[ V_{sw1}, \ sw3, \ sw4 = \frac{wL}{2} = \frac{200(50)}{2} = 5000 \text{ lb}, \quad V_{sw3} = \frac{5000}{8+8+15} = 161.3 \text{ plf} \]

**Basic Diaphragm Shears and Transfer Diaphragm Shear**

**Net Diaphragm Shears**

- Net shears (basic shear +/- TD Shears)
- Legend: Basic diaphragm shear, Neat shear (+/- TD Shears), Transfer diaphragm shears

**So far, so good**

Transverse Collector Force Diagrams

**Longitudinal Strut Force Diagrams**

Note: Neither force diagram closes to zero, therefore error. Notice that they do not close by the same amount.
Adjusted Longitudinal Strut Force Diagrams (6% increase to B/C)

The shear wall shears need to be lower in order to move the force diagram in this direction.

The shear wall shears need to be higher in order to move the force diagram in this direction.

The deflection equation must be adjusted to account for the uniformly distributed load plus the transfer force.

ASCE 7 section 12.3.3.4 Type 4 vertical or horizontal irregularity in SDC D, E, F design forces determined from section 12.10.1.1 (Fpk) shall be increased 25%:
- Connections of diaphragms to vertical elements and to collectors.
- Collectors and their connections, including connections to the vertical elements of the lateral force-resisting system.

Exception: Forces calculated using the seismic load effects including over-strength factor of section 12.4.3 need not be increased.

ASCE 7 section 12.3.2.2-Type 4 vertical irregularity-out-of-plane discontinuity in the LFRS

ASCE 7 section 12.3.2.1-Type 4 horizontal irreg, in-plane discontinuity in the LFRS

Diaphragm load at 2nd floor

W (Rhose1)

The shear wall shears needs to be lower in order to move the force diagram in this direction.

Load distribution needs to increase towards line B/C.

Increase the load to B/C by the amount of +/-.

The shear wall shears need to be higher in order to move the force diagram in this direction.

Line needs to move in this direction.

Line needs to move in this direction.

In-plane Offset Shear Walls
Connections shall be adequate to transmit the forces for which the discontinuous element is required to be designed.

**Example 4-In-plane Offset Segmented Shear Wall**

- **V_{hd}=450\ lb**

Transfer diaph. is required on the left side of the opening if sill section is added.

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

Hold down location if Cantilever Method used.

No hold down (option 1)

Hold-down (option 2)

Increased nailing may be required.
Questions?

This concludes

The AIA Part 2-Presentation on Offset Shear Walls

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