To gain a better understanding of diaphragms, chords and collectors, and how to account for irregularities.

**Course Outline**

- Diaphragms.
- Chords.
- Collectors.
- Irregularities.
Course Limitations

- The course provides a simplified approach to diaphragms, chords, collectors, and irregularities.
- This course will discuss limitations of conventional construction and when additional analysis is required.
- This course will cover basic, common situations in light-framed construction (flexible diaphragms).
- Similar principles can be applied to larger structures as long as the diaphragm is flexible. Only basic structures will be discussed.

Diaphragms

Gravity (Vert.) Loads

- Dead
- Live
- Snow
- Vertical Seismic/Wind Loads
Gravity Load Path

- Gravity-Resisting Elements:
  - Vertical:
    - Trimmers
    - Columns
    - Posts
    - Etc.
  - Horizontal:
    - Headers/Beams
    - Joists
    - Girders

Wind/Seismic Loads

Wind Basics
- Lift
- Pressure or Suction
- Reaction
Lateral Load Path

- Lateral-Resisting Elements:
  - Vertical:
    - Shear Walls
    - Braced Frames
    - Moment Frames
    - Cantilevered Columns
    - Several more…
  - Horizontal:
    - Floor Diaphragm
    - Roof Diaphragm

The diaphragm acts like a joist, beam, or girder.
The lateral force resisting system acts like the post, column, or trimmer.
Incomplete Load Path

- Disruption in the gravity load path.
- What is the problem here?
- Why?
  - What does this do to the shear capacity?
  - Bending?

Industry has accounted for this in some instances.
Code address this for diaphragms as well.

Diaphragm Openings

- Prescriptive openings in beams.
- Prescriptive openings in diaphragms IBC 2308.4.4.1.
  - Openings > 4 ft.
  - 16 gage
  - Extend no less than the dimension of the opening.
**Diaphragm Openings**

- Prescriptive openings in diaphragms IBC 2308.4.4.1.
  - Opening length no greater than 50% of the distance between shear walls.
  - No greater than 25% of the area between shear walls.

**Diaphragm Openings**

- If opening exceeds the prescriptive requirements an analysis of the diaphragm is required.

**Diaphragm Openings**

- What do we do about it?
  - Collectors
  - Additional Shear Walls
  - Open Front Structures
**Open Front Structures**

- Open Front Requirements
  - \( \frac{L}{W} < 1.5:1 \) (must be torsionally regular)
  - Must meet story drift requirements (idealized as rigid or semi-rigid)
  - \( L < 35 \) feet

**Incomplete Load Path**

Gravity load path is pretty easy to follow.

- What is the problem here?
  - Lack of load path.

**Diaphragm Offsets**

- Shall not be vertically offset such that the framing members on either side of the offset cannot be lapped or tied together (IBC 2308.4.4.2)
  - Lack of load path.
Diaphragm Offsets

- Lack of load path.
  - What do we do about it?

Diaphragm Offsets

- Provide collector to shear wall per Section 12.10.2 of ASCE 7-10.
- Out-of-plane offset irregularity. Table 12.3-1 of ASCE 7-16
  - Detail connection to lower roof diaphragm, increase forces in the diaphragm for irregularity, and verify the diaphragm is adequate.

Lateral Load Path
Chords

- Compression or tension member that resists bending. Often associated with top and bottom chord of a truss.

- Also occurs in beams and joists.
- Also needed in a floor or roof diaphragm.
  - Top Plates
  - Ledger Angles
  - Bond Beams
  - Channel Chords
  - Etc.
Chords

- Chord in light framed construction typically occurs at the double top plate.
- Splice in top plate.

- More of a problem in long, narrow buildings.
- Breaks or jogs in the top plate can cause a stress concentration in the diaphragm.
- Section 12.10.1 of ASCE 7-16

Chord force:
- $T = C = \frac{M}{d}$
- $M = w l^2 / 8$
  - Can also be determined for more complicated situations with a shear/moment diagram
- $w =$ wind or seismic load to the diaphragm
- $l =$ distance between shear walls.
Diaphragm Design

- Check the unit shear in the diaphragm at the location of concern (chord and shear forces)
- Provide strap where required for chord and drag forces.

Collectors

- Collector elements shall be provided that are capable of transferring the seismic forces originating in other portions of the structure to the element providing resistance to those forces. Section 12.10.2 ASCE 7-16
Collectors

- Collector should be provided where the diaphragm is not adequate to resist the lateral forces.
- Collectors should be designed to transfer the load in tension/compression of forces tributary to them.

Collectors

- Trusses which have been designed for a lateral load can be used as a collector.
  - Provide lateral load for truss design.
  - Verify that boundary nailing is sufficient to transfer forces into the collector.
  - Field nailing may not be adequate.

Collectors

- Provide sufficient length of collector into the diaphragm until diaphragm is adequate to resist the lateral forces.
  - Unit shear in the shear wall greater than diaphragm capacity.
- Verify that the blocking is adequate to resist compression forces.
  - Forces increase with proximity to LFRS.
Collectors

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  - Forces increase with proximity to LFRS.

Irregularities

- Out-of-Plane Offset
  - Table 12.3-1
  - Section 12.3.3.3 of ASCE 7-16
    - Vertical elements designed for the overstrength factor.
    - This includes tension/compression loads on hold downs, beams, and columns/posts.
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Irregularities

- Out-of-Plane Offset
  - Section 12.3.3.4 of ASCE 7-16
    - Diaphragm shear forces increased by 25%

Questions?