Diaphragms 2

Design Process

• Diaphragms are the roofs and floors of the upper stories

• They are assumed to act as a beam (usually a deep beam with substantial shear deformation)

Design Process

• Sheathing thickness is usually based on vertical loading (vertical live and dead loads – i.e., bending action)

• Sheathing nailing schedule is usually based on the lateral shears (assuming uniform distribution of shear across the diaphragm)
Design Process

• Chord members are designed to resist the couple forces associated with the bending moment

• Struts are designed to transfer the reaction shears

• Collectors (Drag Struts) may be part of the Diaphragm, but usually are part of the walls

Design Process

• The diaphragm deflection is checked for 2 reasons
  – To determine if the building meets the allowable drift requirements
  – The determine if the diaphragm is rigid or flexible for distribution of forces to the vertical elements in the story below

• Anchorage is designed to tie the diaphragm to the vertical elements

Diaphragm Components

• Roof or Floor Sheathing

• Framing members supporting the sheathing

• Boundary struts and chords (chords carry the moment and struts carry the reactions)
Drag Struts / Collectors

• Drag Strut or Collectors “Drag” forces introduced at openings to the resisting elements at the sides of the opening.

• These function in both Tension and Compression.
Design Concepts

- Diaphragm Capacity is governed by nail capacity or shear through the thickness of the sheathing
- Two “types” of diaphragms are included in design aide tables
  - Blocked (All edges of sheathing panels supported and nailed to framing)
  - Unblocked (2 edges are fully supported)

Diaphragm - Blocked

- Symmetric nailing is important
- Number of nails in a nail line is more important than spacing
Diaphragm Unblocked

Diaphragm Panel Unblocked

- Maintain Symmetric nailing (numbers of nails in line)
- This is weakest configuration and prone to damage of roofing.
- Use sheathing clips (Plywood clips)

Minimum Nailing

- 6-inches o.c. for supported edges
- 12-inches o.c. for intermediate supports (field nailing) when framing is spaced < 48 inches o.c.
- 6-inches o.c. for field nailing when framing is spaced 48 inches o.c. of greater
Minimum Nailing

• The same requirements are set for blocked diaphragms, but all of the edges are supported and therefore nailed at a minimum of 6 inches o.c.

• Nail size is determined by the panel thickness and minimum penetration requirements for the nail size

Minimum Nailing

• Nails MUST be a minimum of 3/8 inch from the edges of the panel

• Increasing the edge distance increases the toughness of the diaphragms, but does not increase the strength much

Minimum Nailing

• The load Case is determined by the direction of the continuous panel joint with respect to the unblocked or blocked edge and the direction of the load (not panel direction)

• Each panel has 2 load cases depending on the direction being analyzed
Diaphragm Table

- Tabulated unit shears are based on Douglas-fir-larch or southern pine framing
- The values must be modified if the species (i.e., density) of the framing is different
- The design values are for short-term loading (i.e., wind and seismic durations)

Diaphragm Tables

- Be careful which table is being used!!!! Some building codes allow for a 40% increase in design value for wind. Some tables are already factored to include this increase. Others are not.
- Need to reduce values for durations other than wind and seismic
Diaphragm Tables

• The nail schedule includes spacing requirements for the following locations in the diaphragm
  – Boundary regions of diaphragm
  – Continuous panel joints
  – Other panel edges
  – Intermediate framing or field regions

Diaphragm - Blocked

Field Nailing

Diaphragm Unblocked

Partial Roof or Floor Plan
**Diaphragm Considerations**

- The nail size and panel thickness can not be changed independently

- If blocking or main framing do not have thickness or depth required for full penetration of nails, unit shears must be reduced

**Diaphragm Considerations**

- Tongue and Groove (T&G) edges DO NOT provide shear transfer and therefore can not be used to replace blocking

**Chord Design**

- Determine the couple to resist the moment
  \[ T = C = M/b \]

- Tension force typically controls the design (design values are usually higher for compression than tension)
Chord Design

- Usually tension splices (i.e., the connections) are the weak link
- Magnitude of the chord force is directly proportional to the moment
- 1.6 ASD (1.0 LRFD) usually applies to the design of members and connections

Chord Design

- Chord can act as other part of structure as well (e.g., double top plate of wall, reinforcing or bond beam in masonry, band joist on floor)
- DO NOT USE LEDGERS AS CHORDS

Chord Design Wood
Chord Design Masonry

General Consideration

• The nailing schedule and blocking requirements can change in large diaphragms, but drawings must show the changes clearly and inspection of construction MUST include this item