Lateral Load Resistance

- stability important for any height
- basic mechanisms
  - shear walls
  - diaphragms
  - diagonal bracing
  - frame action
- resist any direction laterally without excessive movement

Load Direction

- layout

Lateral Load Resistance

- deformations
- load transfer & in-plane forces
Rectangular Buildings

- short side (in red)
  - needs to resist most wind
  - bigger surface area
  - shear walls common
- long side
  - other mechanisms
- long & low
  - may only need end bracing
- symmetry important
  - avoid distortions, ex. twisting

Shear Walls

- resist lateral load in plane with wall

Shear Walls

- lateral resistance

Lateral Load Design 5
Lecture 14
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Shear Walls

- masonry
- concrete

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Lateral Load Design 7
Lecture 14
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Lateral Load Design 8
Lecture 15
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http://nisee.berkeley.edu/godden
Shear Walls

- timber
  - wall studs with sheathing
  - vertical trusses

Shear Walls

- steel

Shear Walls

- insulated concrete forms (ICF)

Diaphragms

- roof and floor framing and decks
- relative stiffness
- necessary in pin connected beam-column frames with no horizontal resisting elements
Diaphragms

- connections critical
- drag struts

Braced Frames

- pin connections
- bracing to prevent lateral movements

Braced Frames

- types of bracing
  - knee-bracing
  - diagonal
  - X (cross)
  - K, V or chevron
  - shear walls

Rigid Framing and Bracing
Rigid Framing and Bracing

Frame Action

- choice influenced by ease of rigid joint construction by system
  - concrete
  - steel
  - timber braces
- bending moments mean larger members

Shear Walls & Diagonal Bracing

- use with pin connected members
  - steel common
  - concrete rare
- solid shear walls
  - concrete
  - masonry
- wide spaced shear walls or diagonal bracing requires floor diaphragms
  - timber, steel or composite

Member Orientation

- strong axis
  - biggest I in a non-doubly-symmetric section
  - resists bending better
- frame action & narrow dimension buildings
  - deep direction parallel to long is typical
  - very narrow parallel to short
Member Characteristics

• long span members preclude frame action

• shear walls can be combined with bearing walls
  – use determines orientation

Building Height and Resistance

• low-medium rise
  – easier to accommodate
  – ex. residential
    • shear walls
    • diagonal bracing
    • floor diaphragms (panels)

• high rise
  – shear walls & bracing hinder functions
  – frames useful or with shear walls

Multistory Buildings

• strength design
  – frame action efficient up to ~ 10 stories
  – steel systems
  – reinforced concrete
    • flat plate & columns
      – lower lateral capacity
      – edge moments can’t be resisted
      – end walls offer shear resistance
    • flat slab
    • one-way
    • two-way
      – higher resistance
  – elevator cores
Strength Design

• moments like cantilever beam
• tube action – bigger I
• elements
  – rigid at exterior resist lateral loads
  – interior can only carry gravity loads
• “stiffen” narrow shaped plans with shape

Deflection and Motion Control

• serviceability issues
  – vibration
  – deflection
  – displacement
• mechanisms
  – stiffness
  – tuned mass dampers
• rule of thumb:
  – limit static wind load deflections to h/500

Wind Design

• codes
  – based upon minimum wind speed with 90% probability of 50 yr non-exceedance
• loads
  – pressure
  – drag
  – rocking
  – harmonic
  – uplift
  – torsion

Wind Design Loads

• exposure
  – non-linear
  – equivalent static pressure based on wind speed

\[ F_W = C_d q_h A \]
\[ = pA \]
**Flood Design**

- **know your risk**
  - **zone A**
    - 100 year flood, no data available
  - **zone AE**
    - 100 year flood, detailed analysis
  - **zone E**
    - outside 100 year flood, minimal depths

- **loads**
  - hydrostatic pressure
    - up, down, lateral
  - impact velocities
    - scour
  - impact from debris

- **design**
  - elevation, proper site
  - shear walls with caution
  - concrete recommended