Introduction

• Design Requirements
• Framing Systems
• Accommodation of Building Movements
• Challenges with Accommodating Lateral Drift
Design Requirements

• Design Forces and Criteria
  – Wind Loads
  – Seismic Loads
  – Deflection Limitations

• Accommodation of Building Movements
  – Isolate the Wall System from the Structure
  – Vertical
  – Lateral
Wind Design Loads

- 1997 Uniform Building Code (or ASCE-7 9.6.2.4) Wind Loads
  \[ P = C_e C_q q_s I_w \]
  
  \[ C_q = 1.2 \text{ (Elements not in areas of discontinuity)} \]
  
  \[ C_q = 1.5 \text{ (Elements in areas of discontinuity)} \]

- Loads Remain Constant with Building Height
Seismic Design Loads

• 1997 Uniform Building Code Seismic Loads

\[ F_p = \frac{a_p C_a I_p}{R_p} \left( 1 + 3 \frac{h_x}{h_r} \right) \]

- \( a_p = 1.0 \)
- \( R_p = 3.0 \) (Members and bodies of connections)
- \( R_p = 1.0 \) (Fasteniers in the connecting system)

• Loads Increase with Building Height
Deflection Limitations

• Out-of-plane deflection limitations are based upon limiting distress to finishes based on curvature of wall system.
  – Metal Panels: L/180 to L/240
  – EIFS: L/240 to L/360
  – Cement Plaster: L/360
  – Brick Veneer: L/360 to L/600 or more
  – Stone Veneer: L/480 to L/600

• Out-of-plane deflections for cold formed wall systems are most always governed by wind loading.
Accommodation of Building Movements

- Accommodation of Building Movements
  - Isolate the Wall System from the Structure
  - Vertical Deflection of Perimeter Beams
  - Lateral Drift of Building Frame System

- Isolate Relatively Light Building Exterior from Inadvertent Loads caused by Expected Building Deformation.
System Description

- Balloon Framed Systems
- Floor to Floor Framed Systems
- Spandrel Framed Systems
- Panelized Systems
Balloon Framed Systems
Balloon Framed Systems

Vertical Slip Connection

Bearing Connection
Balloon Framed Systems

Vertical Slip Connections
Floor to Floor Framed Systems
Floor to Floor Framed Systems

Concrete Slab

Bearing Connection Each Floor

Expansion Joint for Vertical and Lateral Movement
Floor to Floor Framed Systems

Track within a Track

Slotted Slip Track

Slip Connections at Bottom of Deck
Spandrel Framed Systems
Spandrel Framed Systems

Isolation Joint
Allowing Vertical / Lateral Movement
Spandrel Framed Systems

Rigid Connection

1" (4" TOTAL) 1/8" ELEVATION 'A'
STUDS NOT SHOWN FOR CLARITY

(4) #10 S.M.S.

1/2" LONG

\(\angle 2\times 6\times 14GA\times\)

CLOSURE ANGLE BY OTHERS, CAPABLE OF WITHSTANDING LOADS

1" CLR. MAX.
Spandrel Framed Systems

Kicker Connection
Accommodation of Vertical Deflection

• With exception of one or two story balloon framed systems, walls are vertically supported by the structure at the building’s perimeter. Vertical Deflection of building perimeter due to creep and live loads should be limited. Limits are based upon method of attachment to the wall system, wall finish, and joint detailing.
Accommodation of Lateral Deflection

1633.2.4.2 Exterior Elements. Exterior nonbearing, nonshear wall panels or elements that are attached to enclose the exterior shall be designed to resist the forces per Formula (32-1) or (32-2) and shall accommodate the movements of the structure based upon $D_M$ and temperature changes. Such elements shall be supported by means of cast-in-place concrete or by mechanical connections and fasteners in accordance with the following provisions:

1. Connections and panel joints shall allow for relative movement between stories of not less than two times the story drift caused by wind, the calculated story drift based on $D_M$ or $\frac{1}{2}$ inch whichever is greater.

2. Connections to permit movement in the plane of the panel for story drift shall be sliding connections using slotted or oversize holes, connections that permit movement by bending of steel or other connections providing equivalent sliding and ductility capacity.
Accommodation of Lateral Deflection

Building Deformed Shape

Wall Moves with Floor Below and Slips Past Floor Above

$D_M$ Total

$D_M$ Interstory

Building Original Shape
SEAOC “Blue Book” Commentary

Structures designed in conformance with these recommendations should, in general, be able to:

1. Resist a minor level of earthquake motion without damage;
2. Resist a moderate level of earthquake ground motion without structural damage, but possibly experience some nonstructural damage.
3. Resist a major level of earthquake ground motion having intensity equal to the strongest either experienced or forecast for the building site, without collapse, but possibly with some structural as well as nonstructural damage.
The primary function of these recommendations is to provide minimum standards for use in building design regulation to maintain public safety in the extreme earthquakes likely to occur at the building’s site. These recommendations primarily are intended to safeguard against major failures and loss of life, not to limit damage, maintain functions, or provide for easy repair. It is emphasized that the purpose of these recommended design procedures is to provide buildings that are expected to meet this life safety objective.
Building Systems vs. Finish System

BUILDING SYSTEMS
- Steel Moment Frames
- Concrete Moment Frames
- Eccentric Braced Frames
- Concentric Braced Frames
- Concrete Shear Walls

FINISH SYSTEMS
- EIFS Systems
- Cement Plaster Systems
- Adhered Veneer Systems
- Anchored Veneer and Stone Systems

RIGID SYSTEMS
FLEXIBLE SYSTEMS
Accommodating Lateral Drift - Floor to Floor Framing -

Floor to Floor Framing w/ Joint Below Floor Line

$D_M$ Total

$D_M$ Interstory

Joint at Underside of Floor
Floor to Floor Framing - In Plane Movement –

Floor to Floor Framing w/ Joint Below Floor Line

$D_M$ Total

$D_M$ Interstory

Joint at Underside of Floor
Floor to Floor Framing - Out of Plane Movement

Floor to Floor Framing w/ Joint Below Floor Line

$D_M$ Total

$D_M$ Interstory
Accommodating Lateral Drift - Spandrel Framing -

Spandrel Framing w/ Joint at Head of Window

$D_M$ Total

$D_M$ Interstory

Joint at Head of Window

Floor Beyond
Spandrel Framing w/ Joint at Head of Window

\[ D_M \text{ Total} \]

\[ D_M \text{ Interstory} \]

Joint at Head of Window
Spandrel Framing - Out of Plane Movement –

Spandrel Framing w/ Joint at Head of Window

$D_M$ Total

$D_M$ Interstory
Challenges with Accommodating Lateral Drift

At Building Corners:

- Floor to Floor Framing
- Spandrel Framing
Challenges with Accommodating Lateral Drift

Avoid Beams in Wall Space or Vertically Offset Joints:
Challenges with Accommodating Lateral Drift

Avoid Columns in Wall Space:

$D_M$ Interstory
Challenges with Accommodating Lateral Drift

Utilities in Walls can Cross Joints and Must be Designed to Prevent Locking Joint
Bearing Walls?
Real World