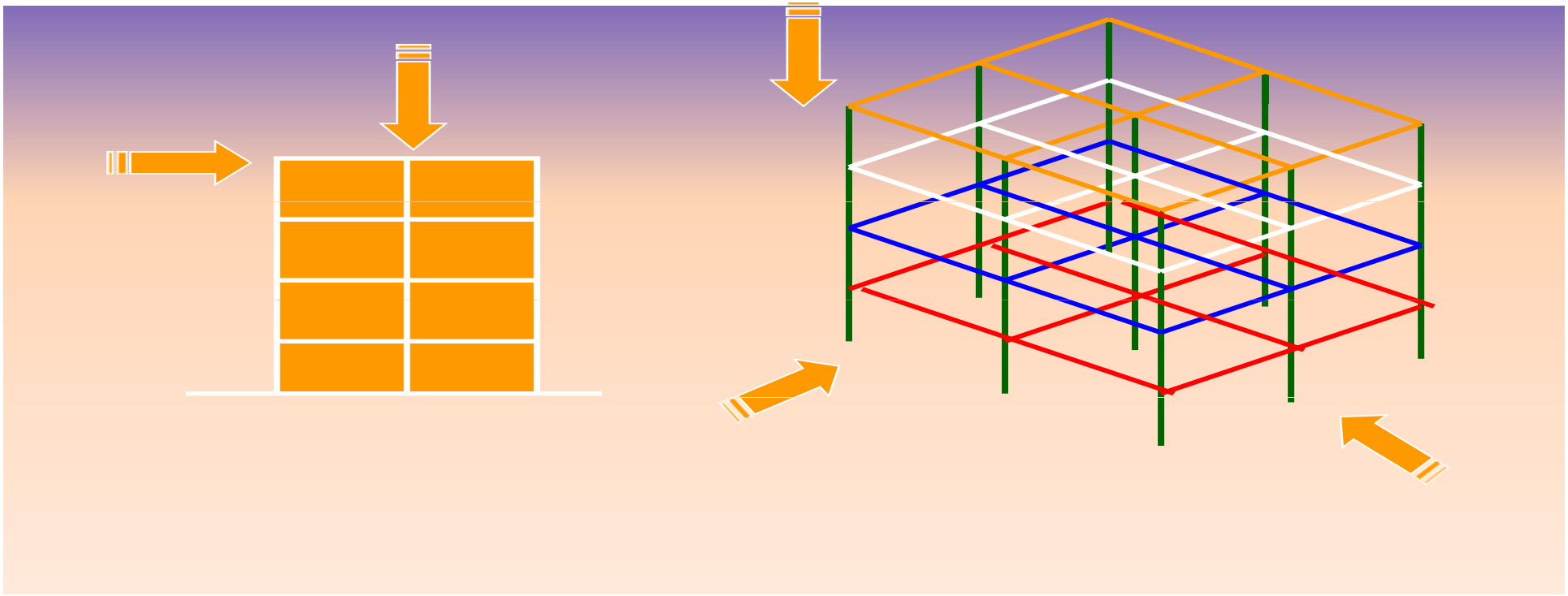
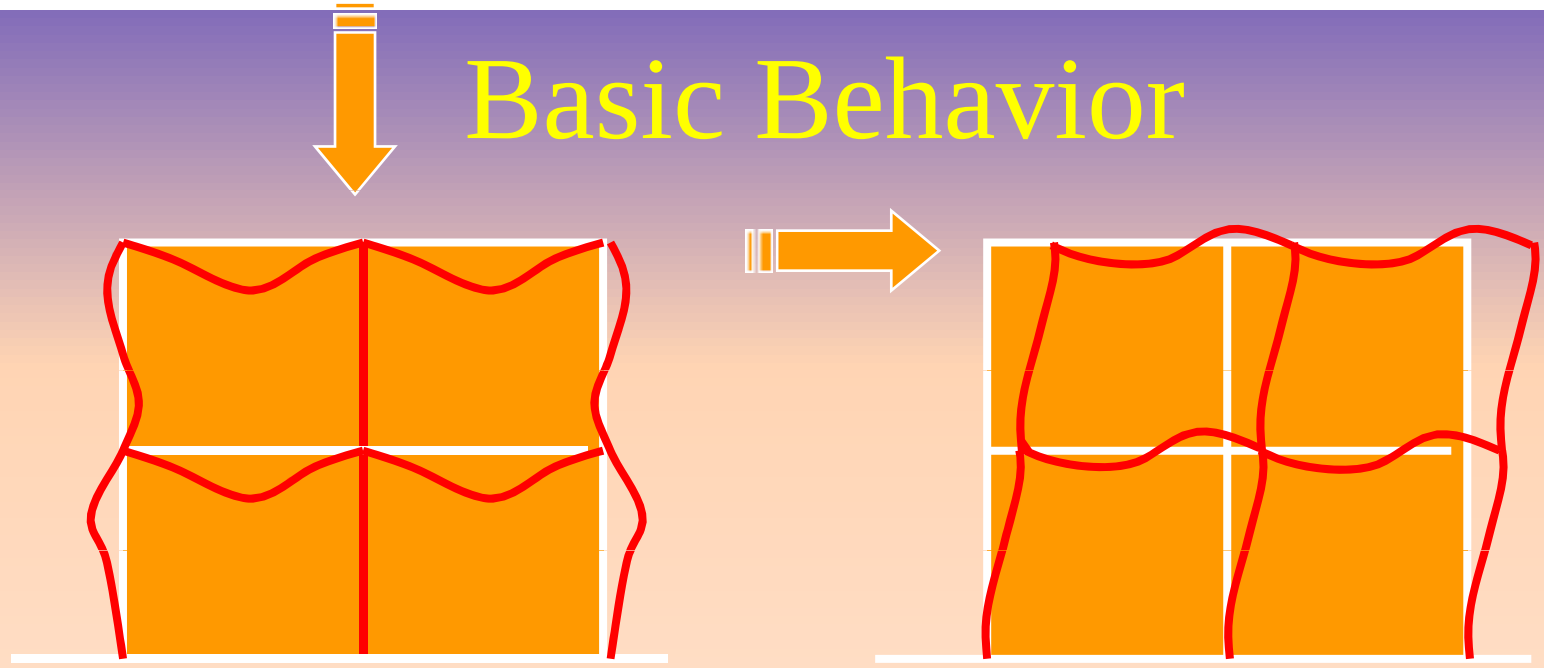
B. Lateral Load Systems

- Frame Overview
- Flat plate (& slab)-column (w/ and w/o drop panels and/or capitals) frame systems
- Beam-column frame systems
- Shear wall systems (building frame and bearing wall)
- Dual systems (frames and shear walls)

Frame: Coplanar system of beam (or slab) and column elements dominated by flexural deformation



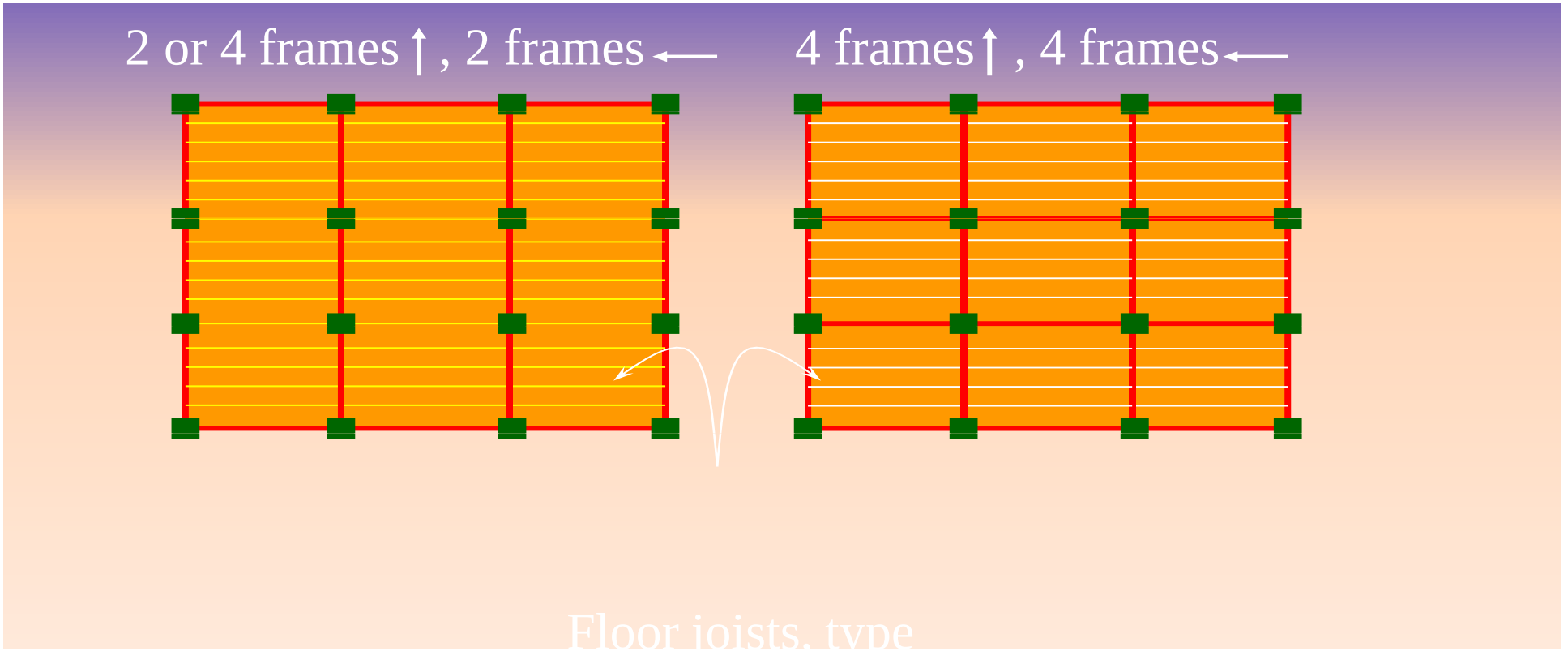
Basic Behavior



Gravity Load

Lateral Loading

2D vs. 3D Frames (Plan)



Frame Advantages

- Optimum use of floor space, ie. optimal for office buildings, retail, parking structures where open space is required.
- Relatively simple and experienced construction process
- Generally economical for low-to mid-rise construction (less than about 20 stories)
- In Houston, most frames are made of reinforced concrete.

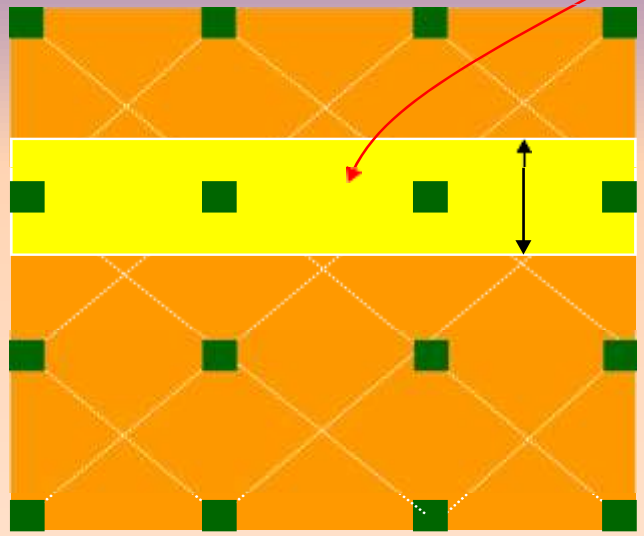
Frame Disadvantages

- Generally, frames are flexible structures and lateral deflections generally control the design process for buildings with greater than about 4 stories. Note that concrete frames are about 8 times stiffer than steel frames of the same strength.
- Span lengths are limited when using normal reinforced concrete (generally less than about 40 ft, but up to about 50 ft). Span lengths can be increased by using pre-stressed concrete.

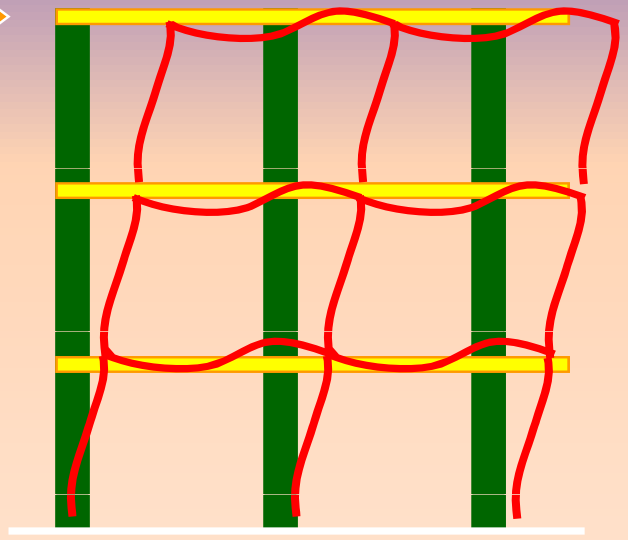
Frame Lateral Load Systems

Flat plate-column frame:

Effective slab width



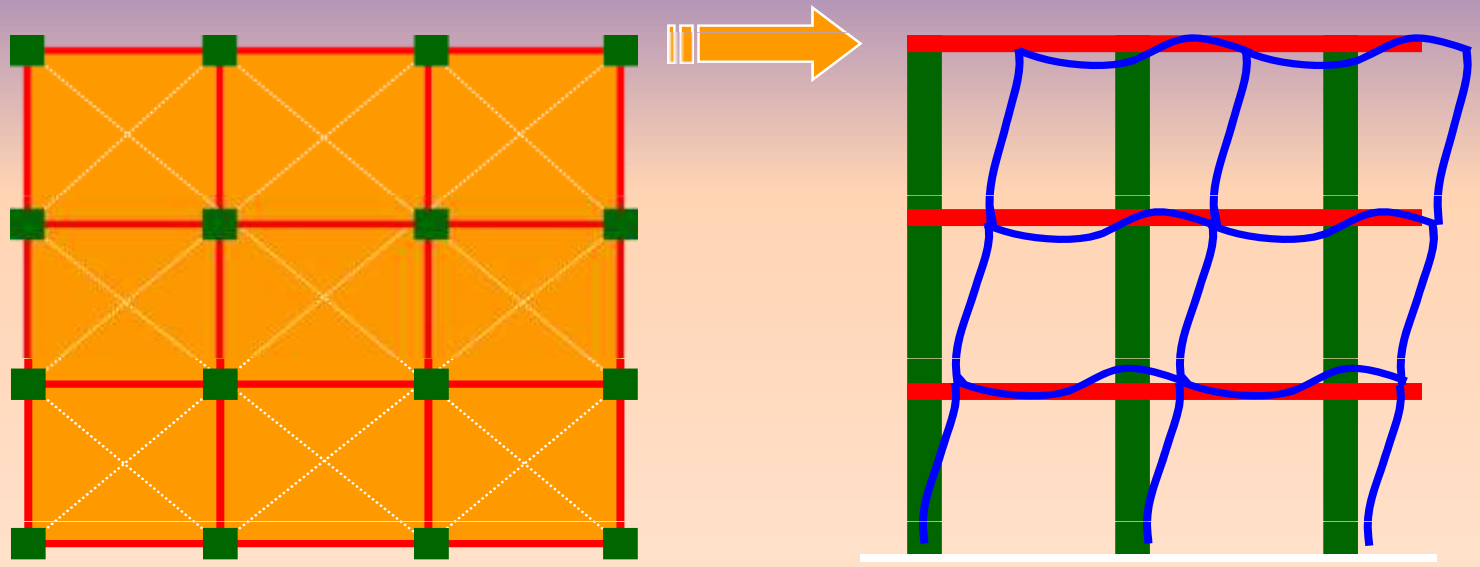
Plan



Elevation

Frame Lateral Load Systems

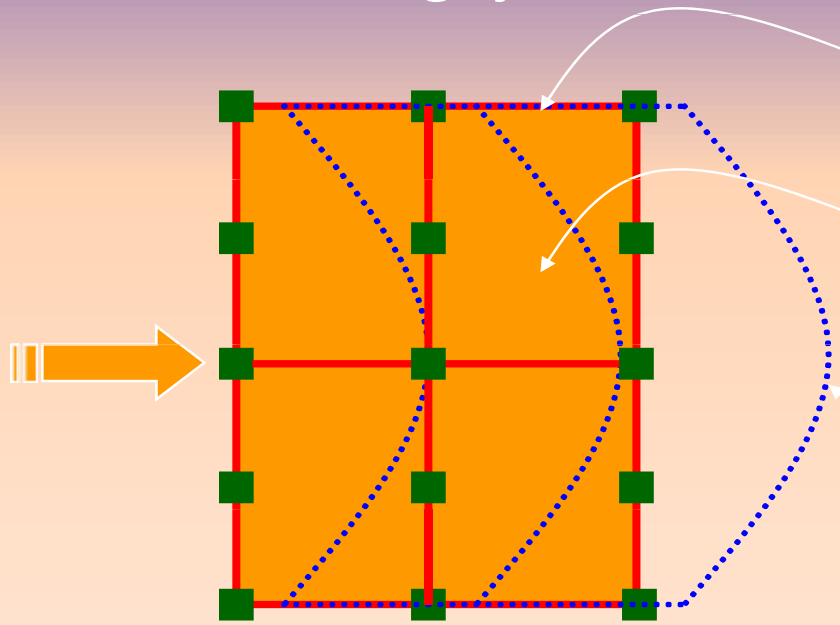
Beam-column frame:



Elevation

Frame Lateral Load Systems

Diaphragm (shear) element: Carries lateral loading to the lateral load resisting system



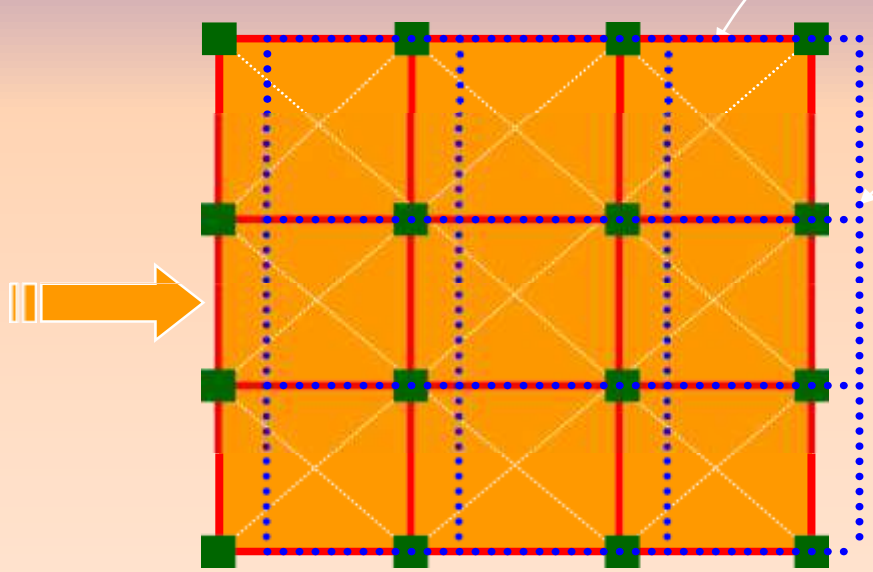
Lateral load frame, type.

Plate element

Deformed shape - Lateral load distributes to frames proportional to tributary area

Frame Lateral Load Systems

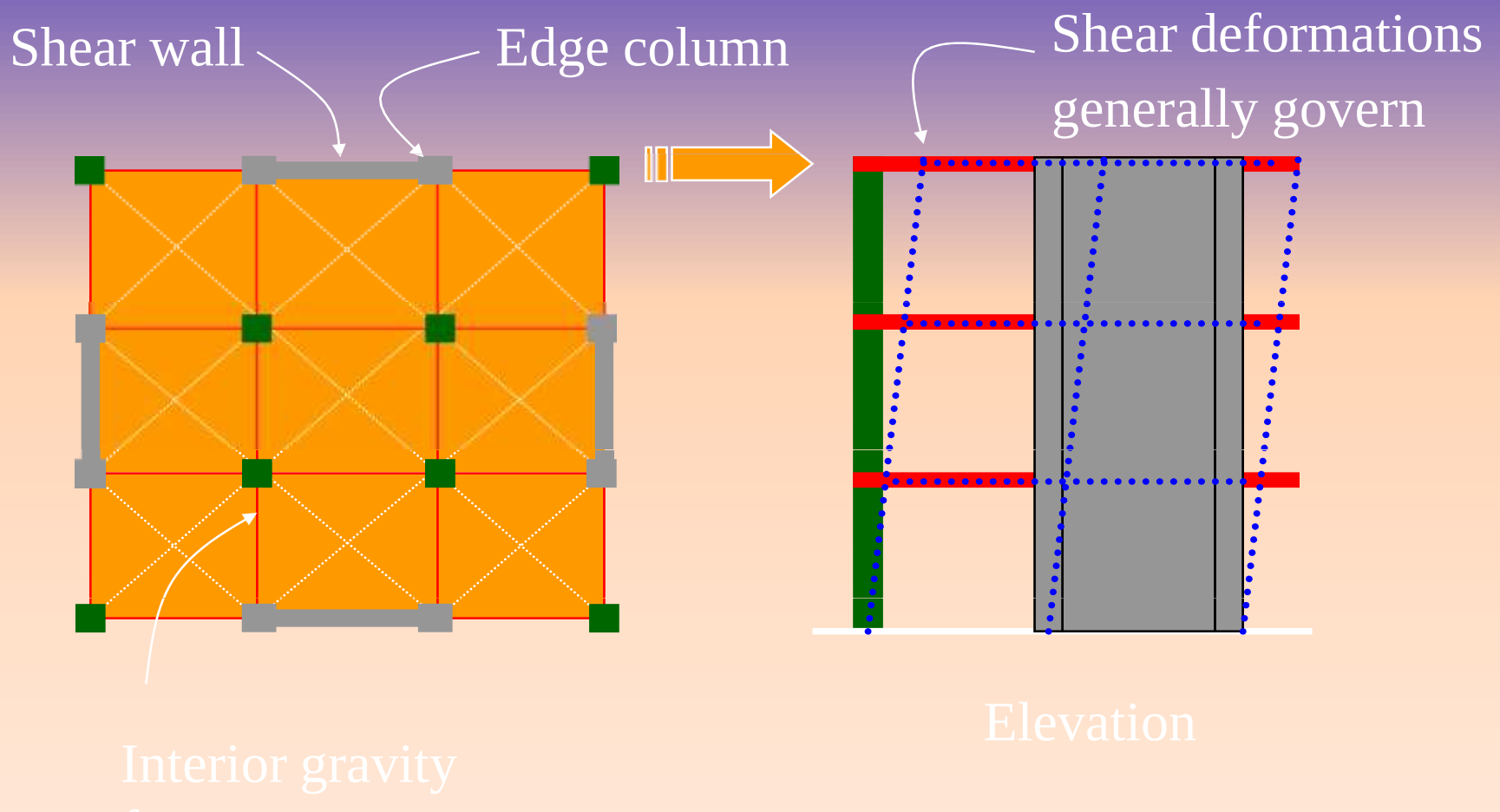
For relatively square plans, diaphragms are generally considered rigid



Space frame with square plan

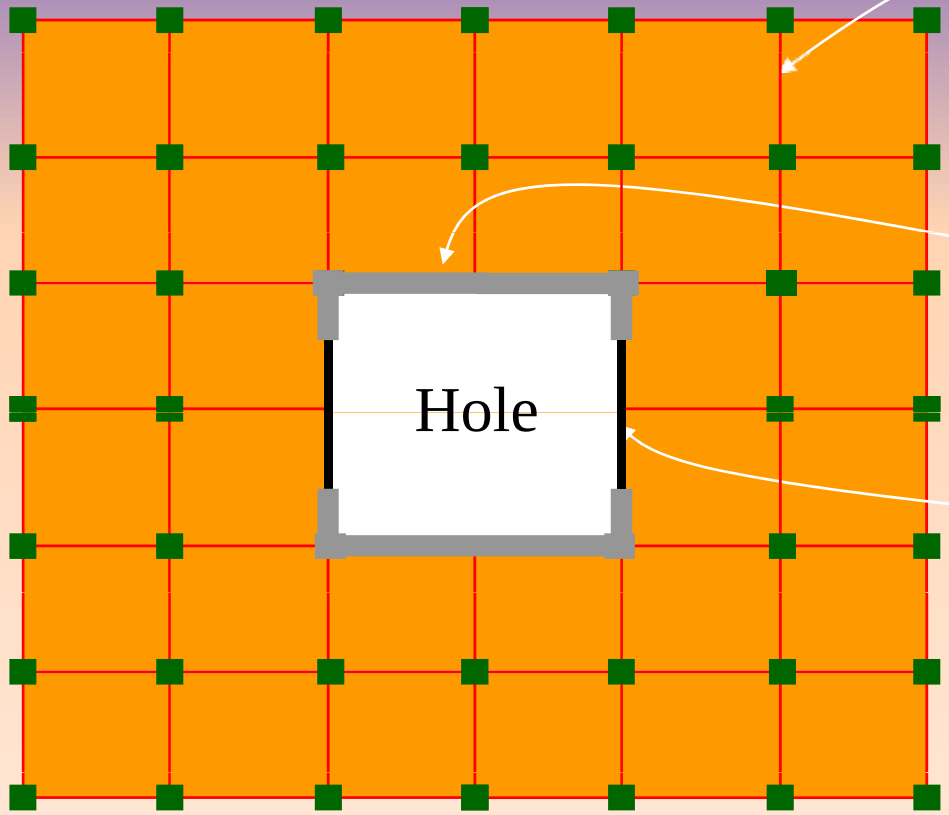
Deformed shape has constant lateral displacement - No diaphragm flexibility, ie. lateral load distributes to frame proportional to frame stiffness

Shear Wall Lateral Load Systems



Shear Wall Lateral Load Systems

Elevator shaft configuration



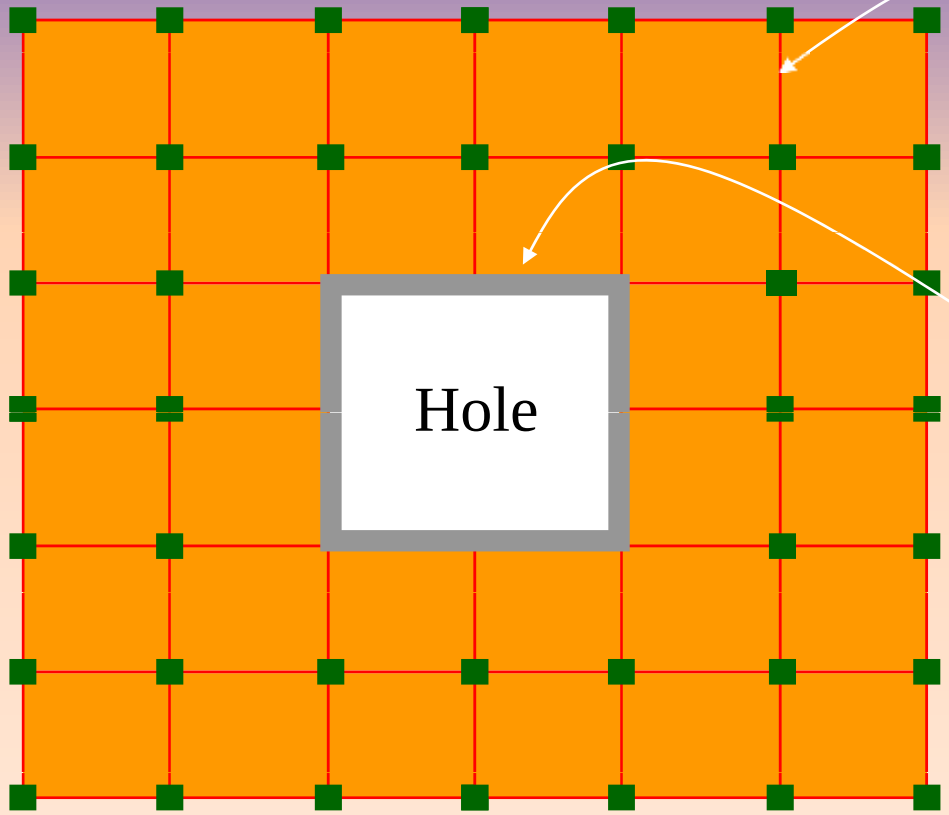
Gravity frames

Shear walls

Coupling beams

Dual Lateral Load Systems

Wall-Frame Dual System:



Lateral frames – 25% of lateral load, minimum

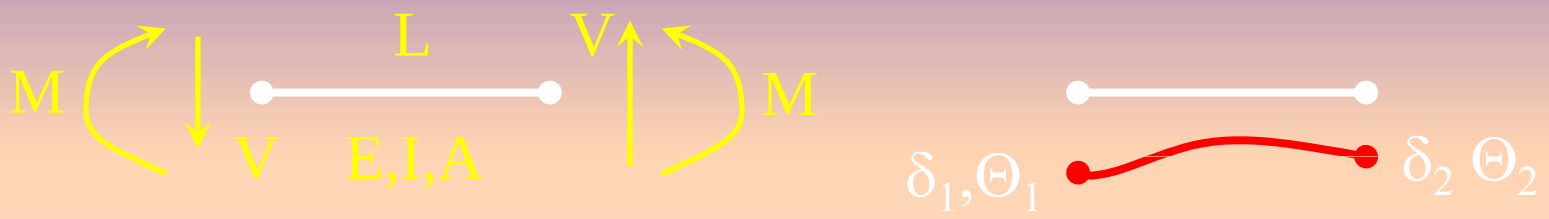
Shear walls

4. Structural Members

- Beams
- Columns
- Slabs/plates/shells/folded plates
- Walls/diaphragms

Beam Elements

Defn: Members subject to bending and shear



Elastic Properties:

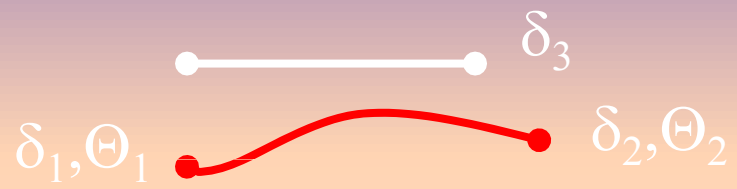
$k_b = f (EI/L^n)$ (bending) $\sigma = My/I$ (normal stress)

$k_s = GA/L$ (shear) $v = VQ/Ib$ (shear stress)

δ_b = f (load, support conditions, L, E, I) (bending)

Column Elements

Defn: Members subject to bending, shear, and axial



Elastic Properties:

$k_a = EA/L$ (axial) $\sigma_a = F/A$ (normal stress)

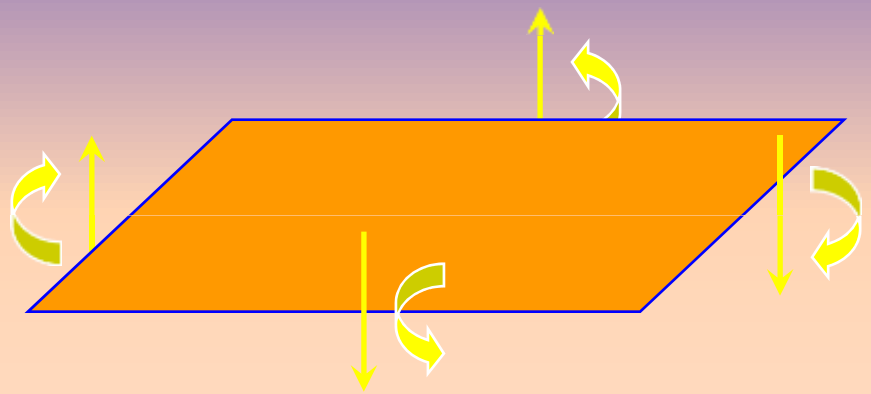
$k_b = f\,(EI/L^n)$ (bending) $\sigma_b = My/I$ (normal stress)

$k_s = GA/L$ (shear) $v = VQ/Ib$ (shear stress)

$\delta_b =$ (load, support conditions, L, E, I, A) (normal)

Slab/Plate Elements

Defn: Members subject to bi-directional bending & shear

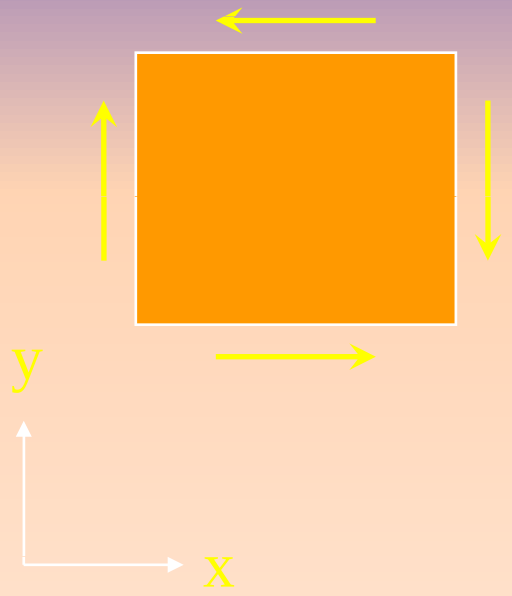


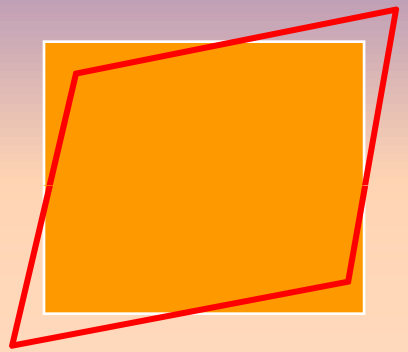
M_x, M_y, and V_z

Θ_x, Θ_y, and δ_z

Wall/Diaphragm Elements

Defn: Members subject to shear





V_x and V_x

δ_x and δ_y