Structural System Overview

DESIGN OF MULTISTOREY SRUCTURES

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Presentation Overview

1. Building system primary functions
2. Types of load
3. RC structural systems
4. RC structural members

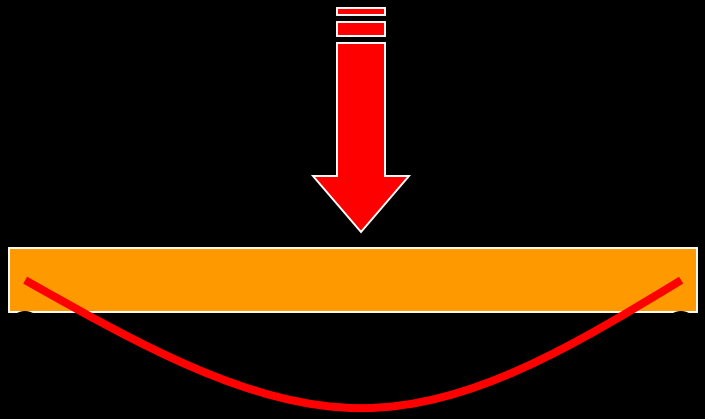
1. Basic Building System Functions

Support gravity loads for strength and serviceability during:

1. Normal use (service) conditions
2. Maximum considered use conditions
3. Environmental loading of varying intensities

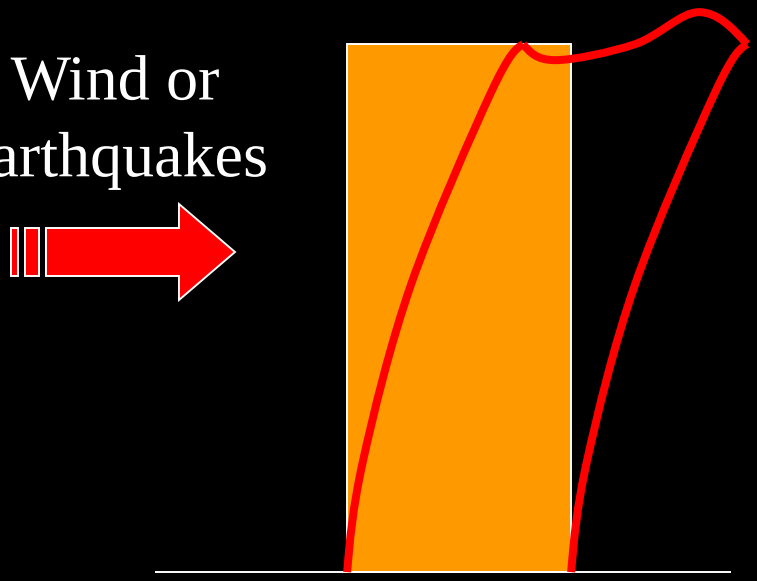
Vertical deflection (sag)

Dead, Live, etc.



Lateral deflection (sway)

Wind or earthquakes



Performance-Based Design: Control displacements within acceptable limits during service loading, factored loaded, and varying intensities of environmental loading

2. Types of Load

Gravity:

Dead

Live

Impact

Snow

Rain/floods

Lateral

Wind

Earthquake

Soil lateral pressure

Thermal

Centrifugal

3. RC Structural Systems

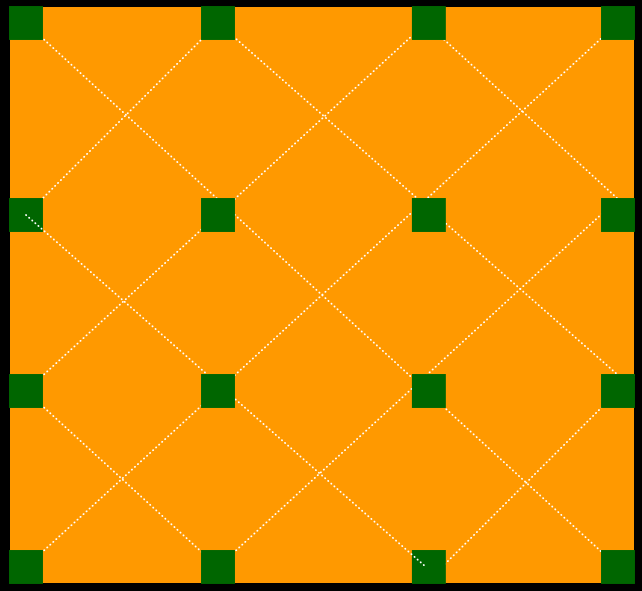
A. Floor Systems
B. Lateral Load Systems

A. Floor Systems

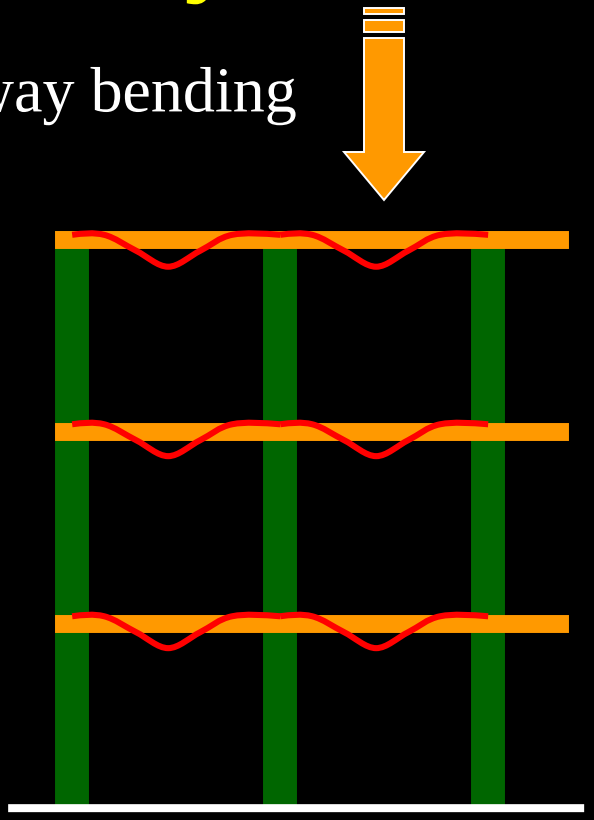
- Flat plate
- Flat slab (w/ drop panels and/or capitals)
- One-way joist system
- Two-way waffle system

Flat Plate Floor System

Slab-column frame system in two-way bending



Plan



Elevation

Flat Plate Floor System

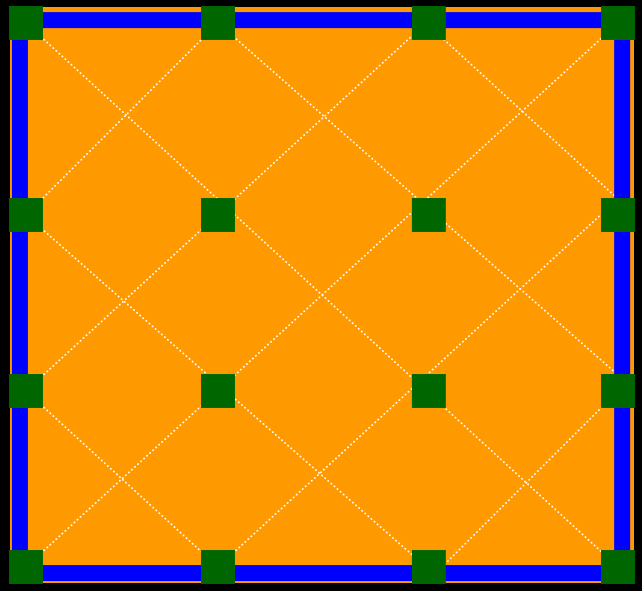
Advantages:

- Simple construction
- Flat ceilings (reduced finishing costs)
- Low story heights due to shallow floors

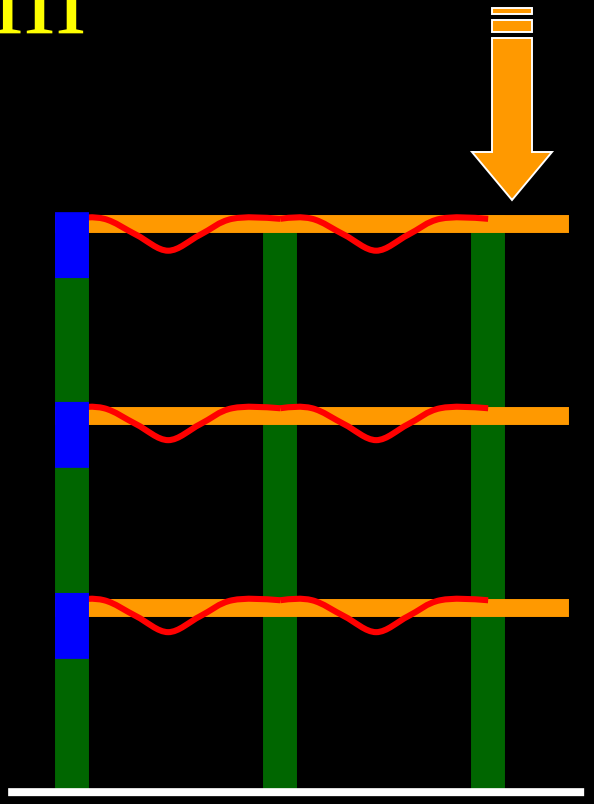
Typical Applications:

- Short-to-medium spans with light loading
- For LL=50 psf 15’ - 30’ spans
- For LL=100 psf, 15’ – 25’ spans

Flat Plate w/Spandrel Beam System



Plan



Elevation

Flat Plate w/Spandrel Beam System

Advantages:

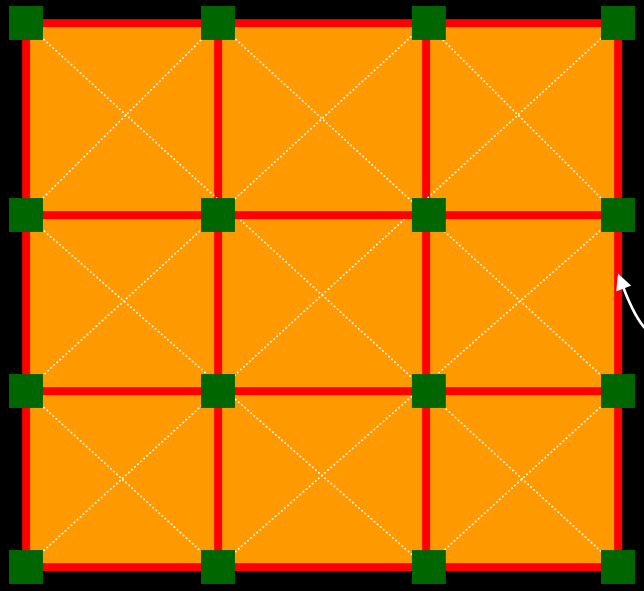
- Same as flat plate system, plus
  - Increased gravity and lateral load resistance
  - Increased torsional resistance
  - Decreased slab edge displacements

Typical Applications:

- Same as flat plate systems

Flat Plate w/Beams Floor System

Two-way bending



Gravity and lateral load frames

Flat Plate w/Beams Floor System

Advantages:

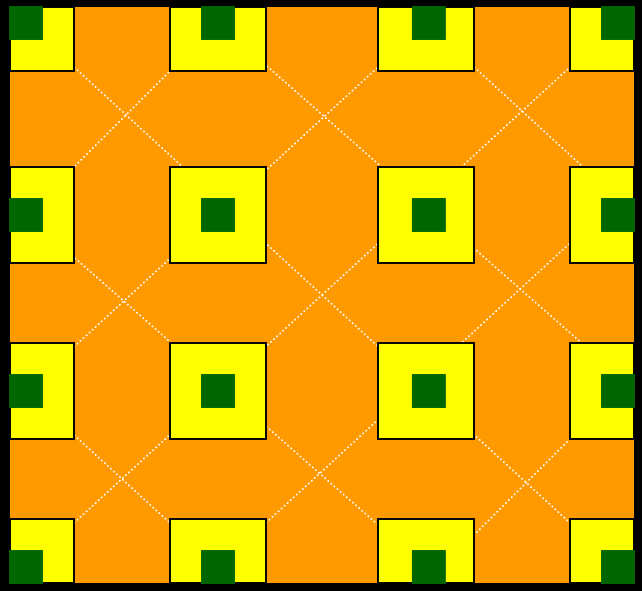
- Increased gravity and lateral load resistance
- Simple construction
- Flat ceilings (reduced finishing costs)

Typical Applications:

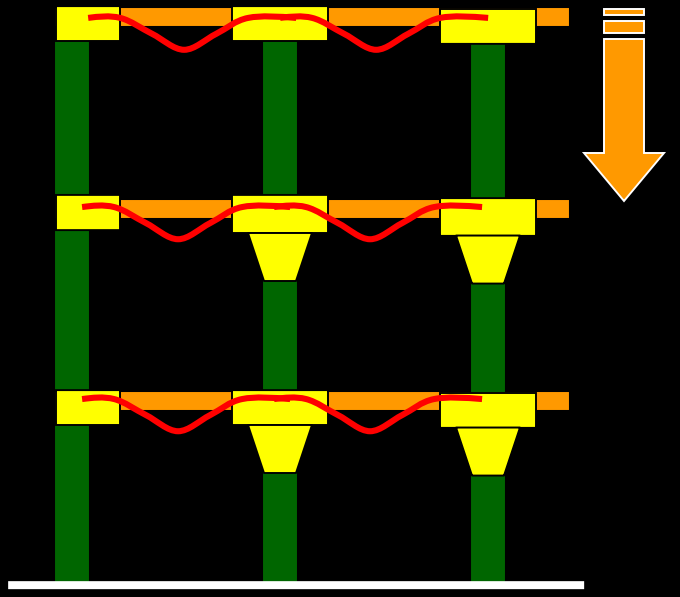
- Medium spans with light loading
- For LL=50 psi, 25’ - 30’ spans
- For LL=100 psi, 20’ – 30’ spans

Flat Slab Floor System

Flat plate with drop panels,shear capitals, and/or column capitals



Plan



Elevation

Flat Slab Floor System

Advantages:

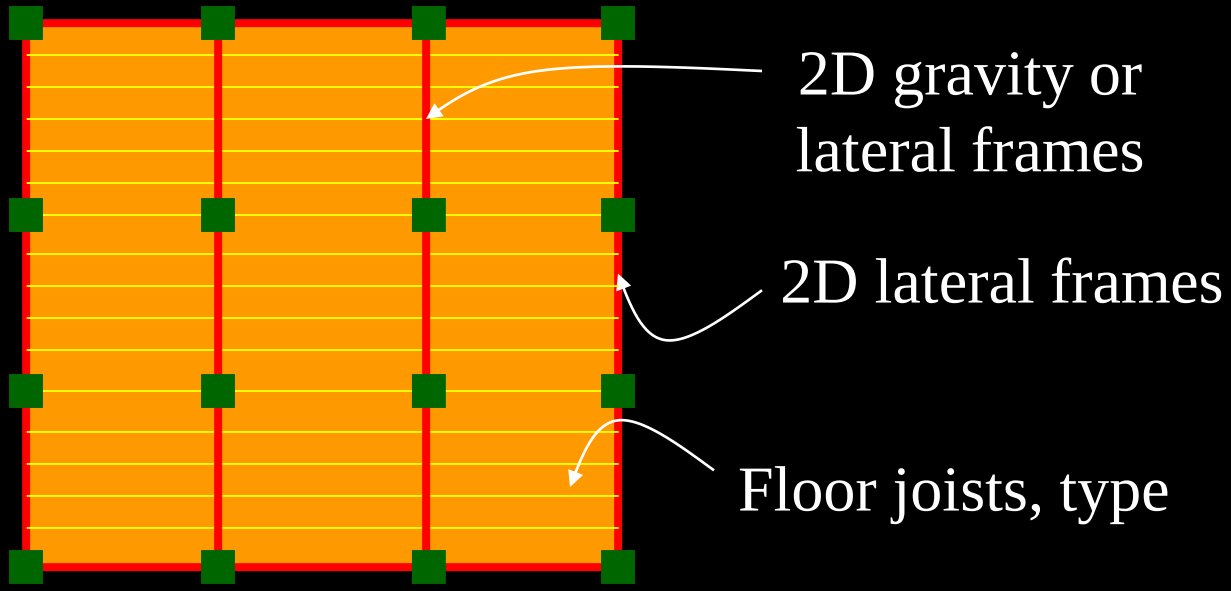
- Reduced slab displacements
- Increased slab shear resistance
- Relatively flat ceilings (reduced finishing costs)
- Low story heights due to shallow floors

Typical Applications:

- Medium spans with moderate to heavy loading
- For LL=50 psi, 30’ – 35’ spans
- For LL=100 psi, 25’ – 35’ spans

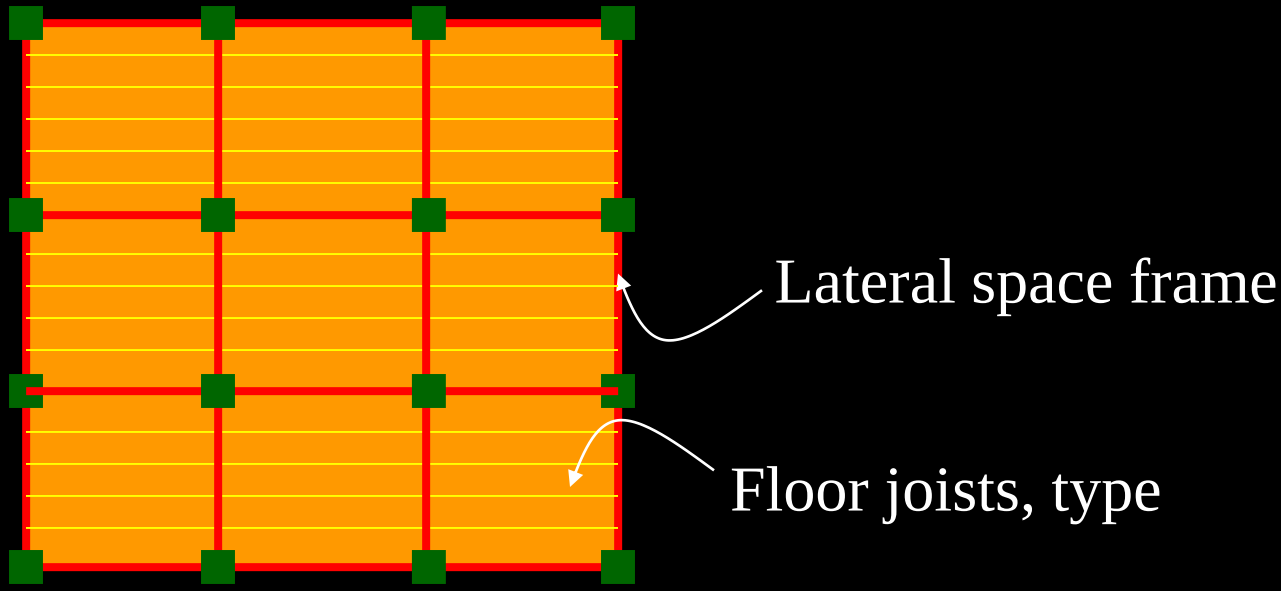
One-Way Joist Floor System

Rib (joist) slab : (One-way bending)



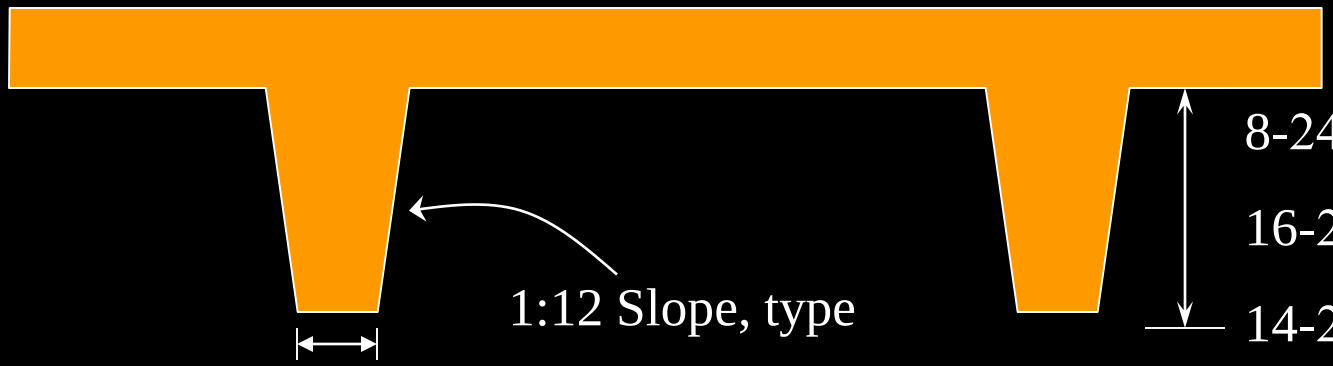
One-Way Joist Floor System

Rib (joist) slab with beams: (One-way bending)



One-Way Joist Floor System

Typical Joist



8-24” for 30” Modules

16-24” for 53” Modules

14-24” for 66” Modules .

- 2’ or 3’ cc. – Joists
- 4’ or 6’ cc. – Skip joists
- 5’ or 6’ cc – Wide-module joists

One-Way Joist Floor System

Advantages:

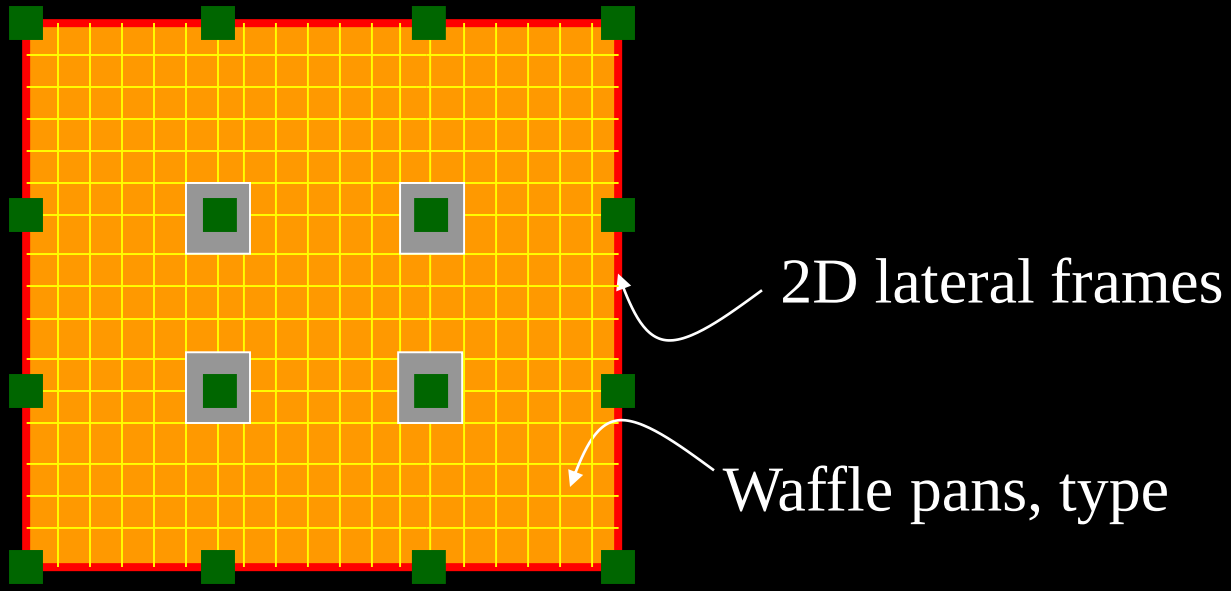
- Longer spans with heavy loads
- Reduced dead load due to voids
- Electrical, mechanical etc. can be placed between voids
- Good vibration resistance

Typical Applications:

- Medium-to-long spans with heavy loading
- For 30” modules, 35’ – 40’ spans
- For 53” & 66” modules, 35’ – 50’ spans

Two-Way Joist Floor System

Waffle slab : (Two-way bending)



Two-Way Joist Floor System

Advantages:

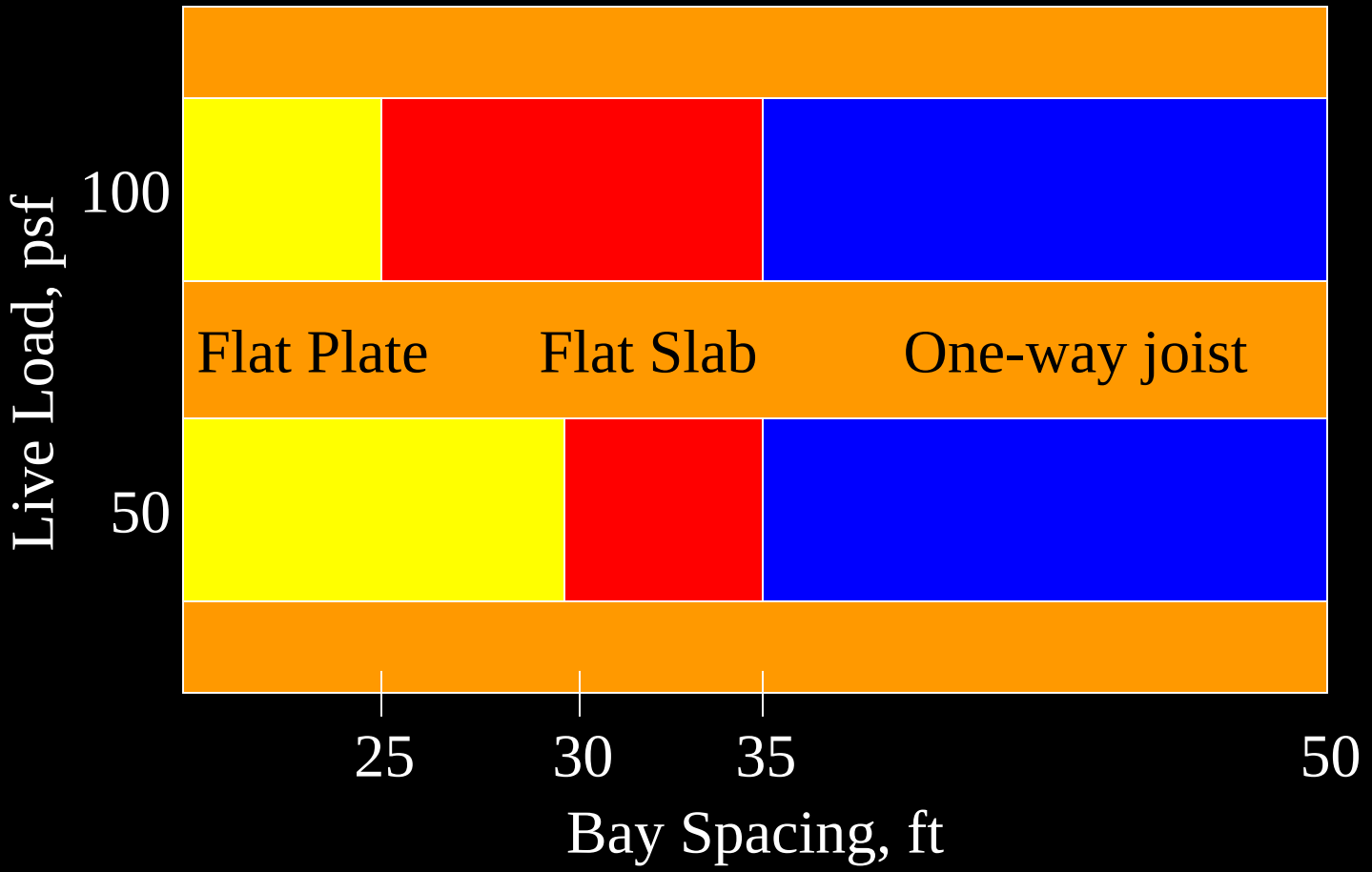
- Longer spans with heavy loads
- Reduced dead load due to voids
- Electrical, mechanical etc. can be placed in voids
- Good vibration resistance
- Attractive Ceiling

Typical Applications:

- Long spans with heavy loading
- For 3’, 4’, and 5’ modules, 40’ – 50’ spans and beyond

Floor System Effective Cost

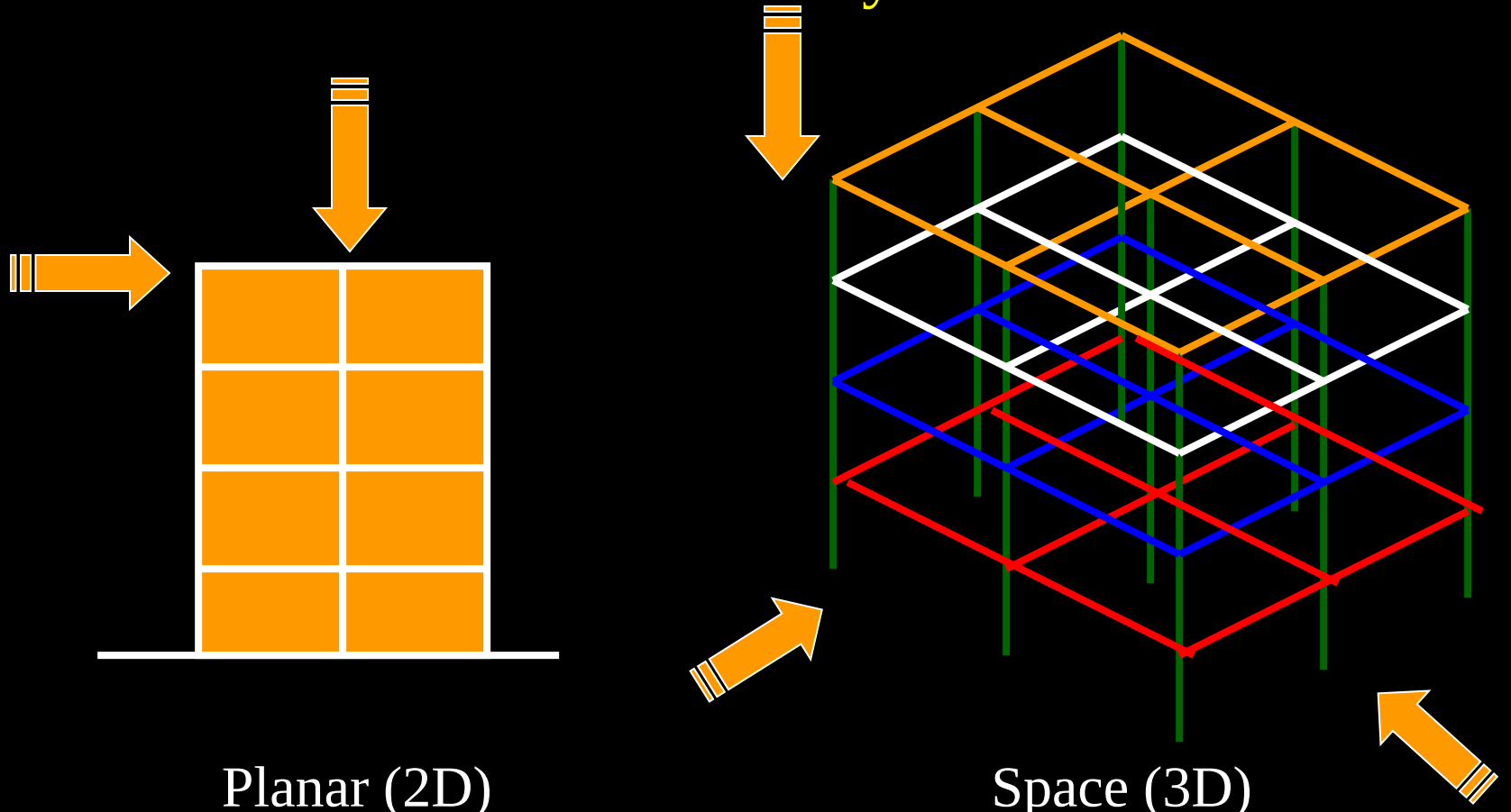
(PCA)



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)

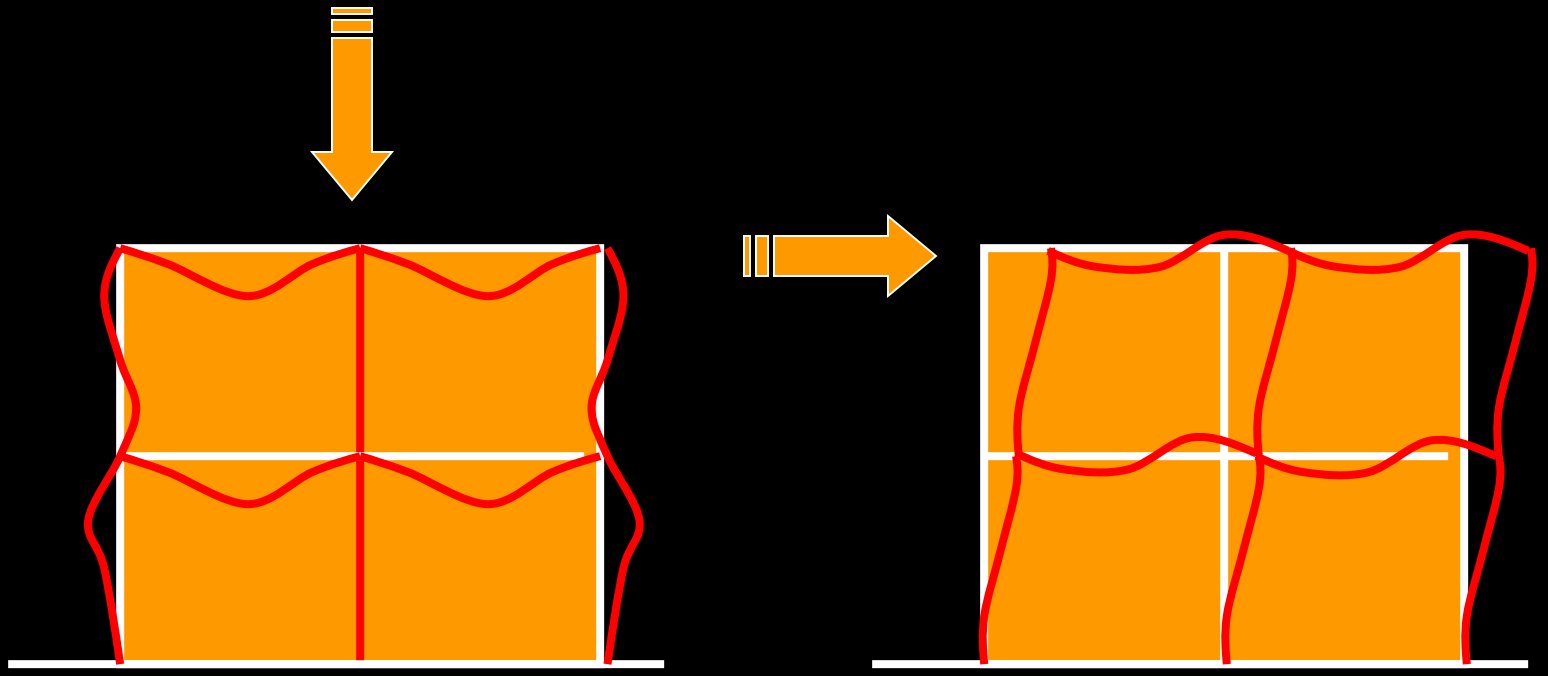
Frame: Coplanar system of beam (or slab) and column elements dominated by flexural deformation



Planar (2D)

Space (3D)

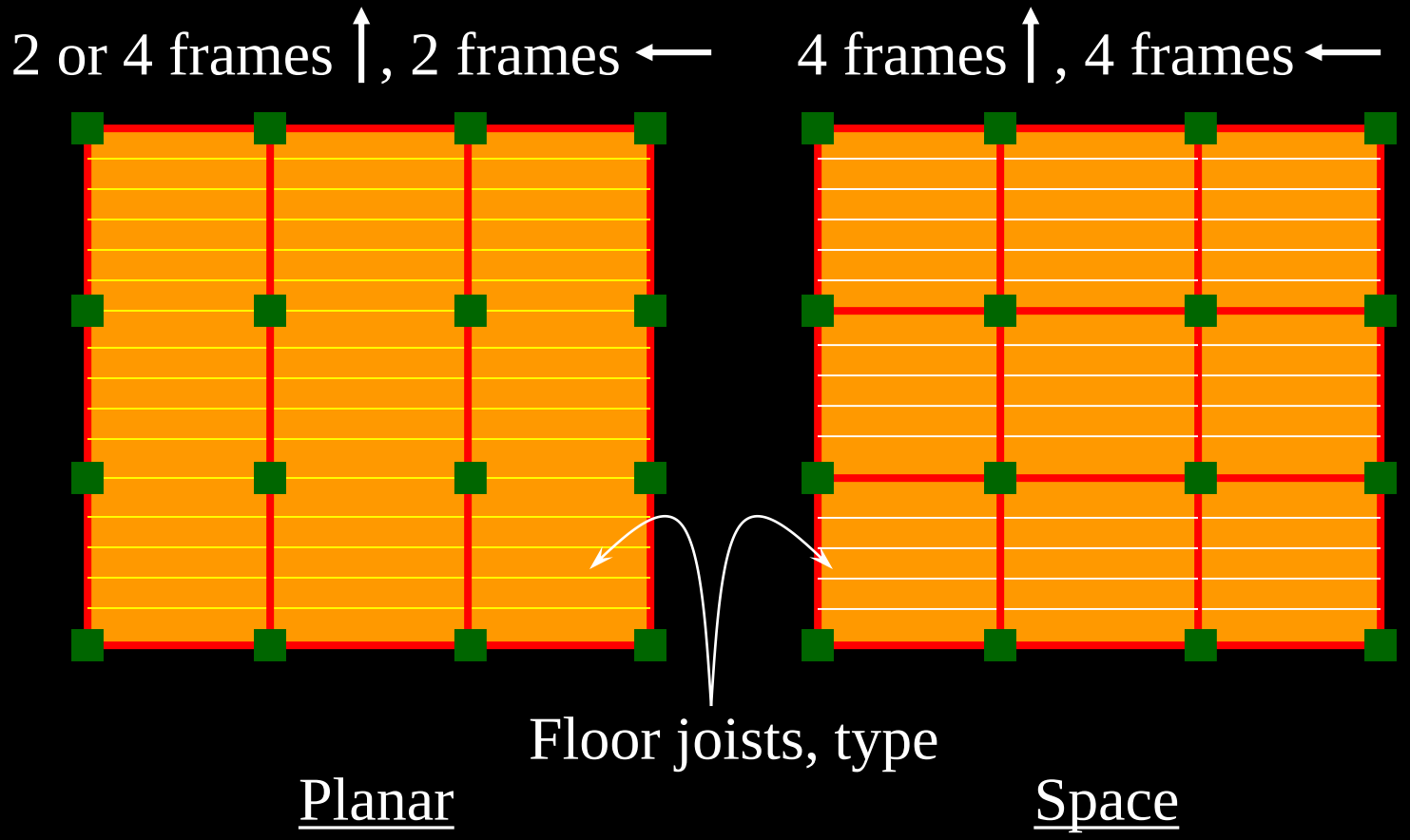
Basic Behavior



Gravity Load

Lateral Loading

2D vs. 3D Frames (Plan)



Frame Advantages

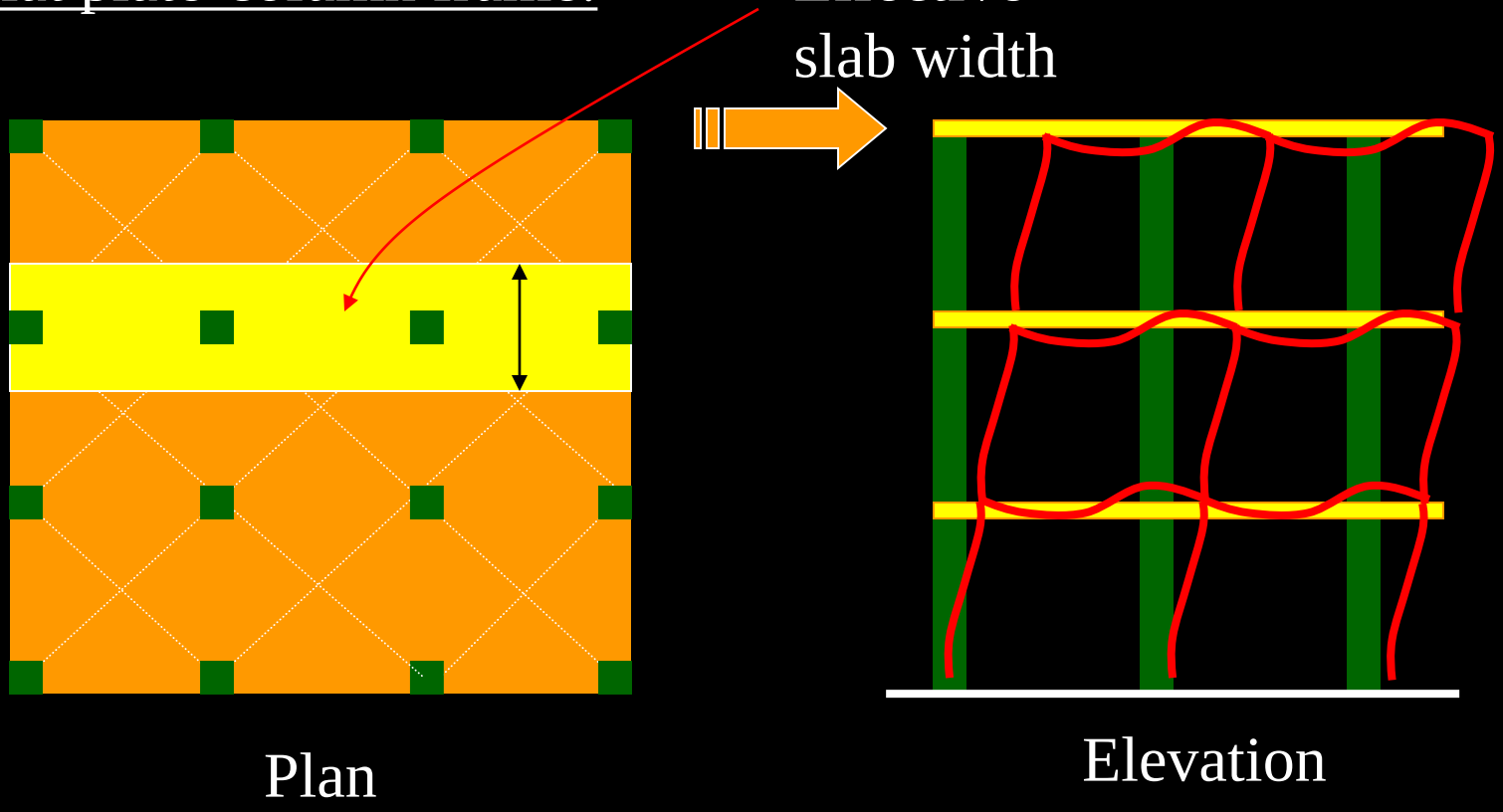
- Optimum use of floor space, ie. optimal for office buildings, retail, parking structures where open space is required.
- Relatively simple and experienced construction process
- Generally economical for low-to mid-rise construction (less than about 20 stories)
- In Pakistan, most frames are made of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

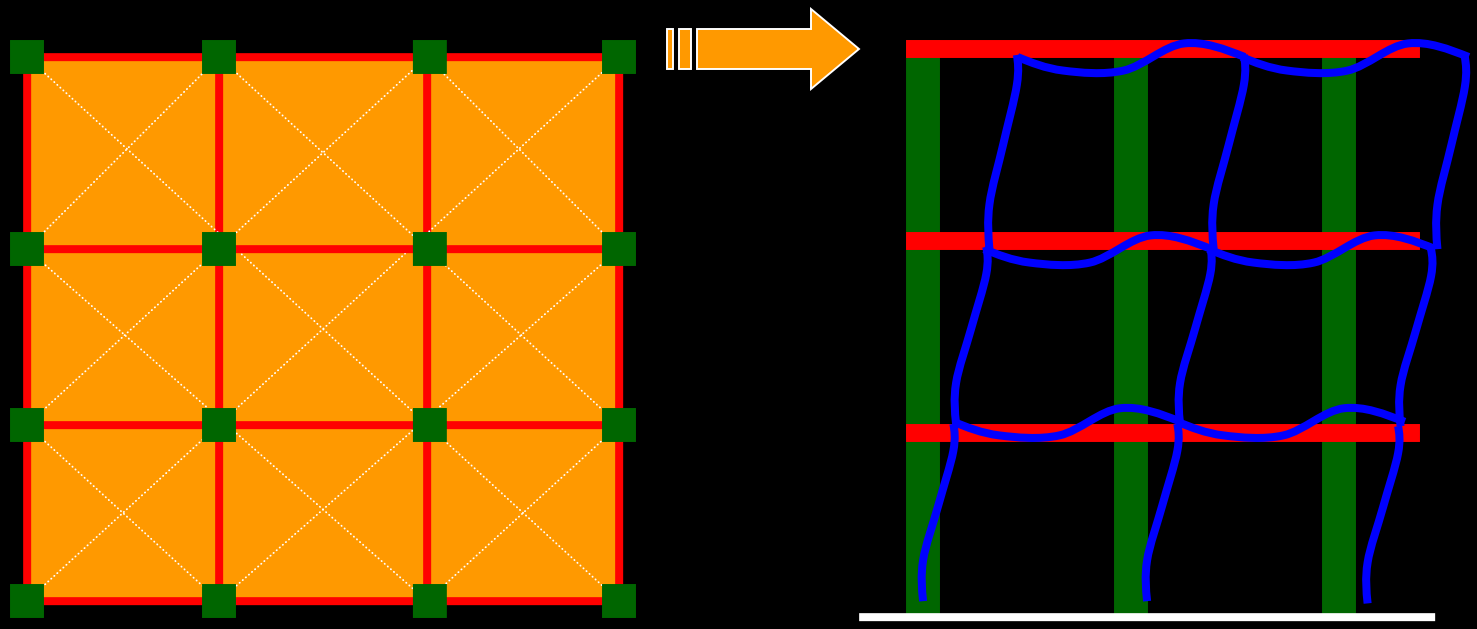
Frame Lateral Load Systems

Flat plate-column frame:



Frame Lateral Load Systems

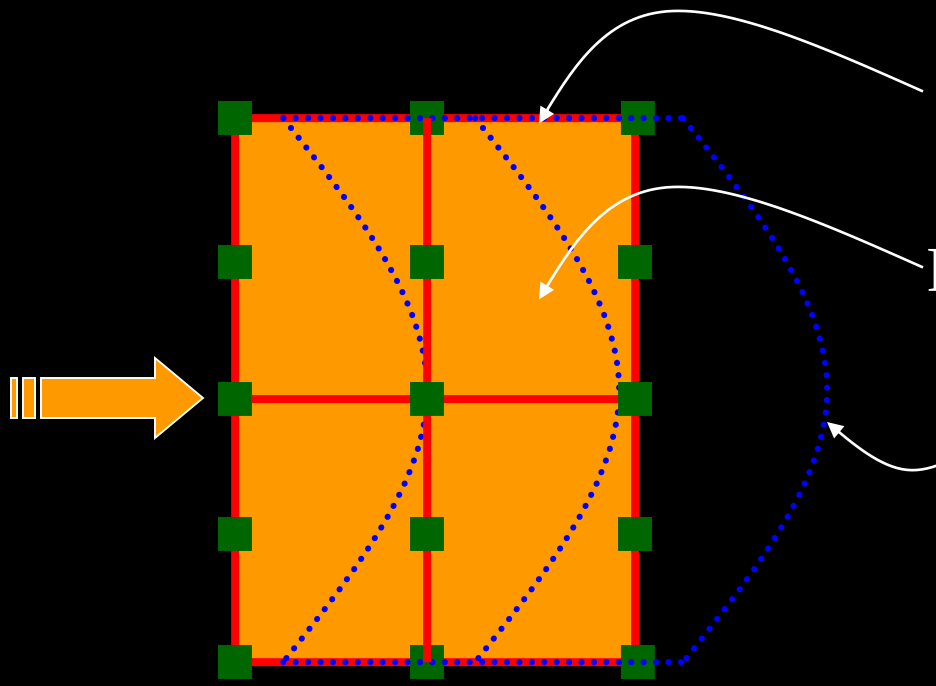
Beam-column frame:



Elevation

Frame Lateral Load Systems

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



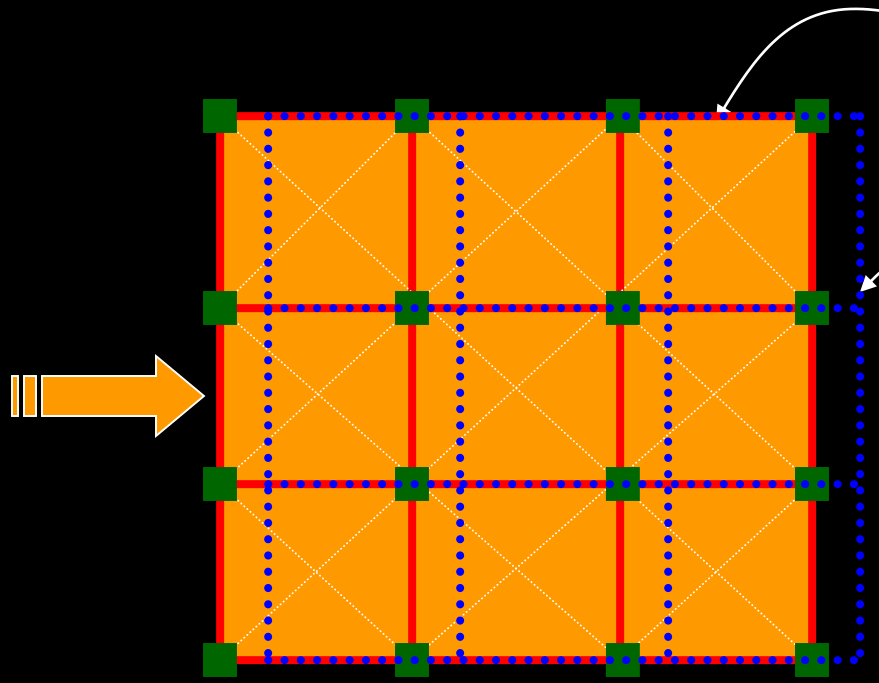
Lateral load frame, type.

Plate element

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

Frame Lateral Load Systems

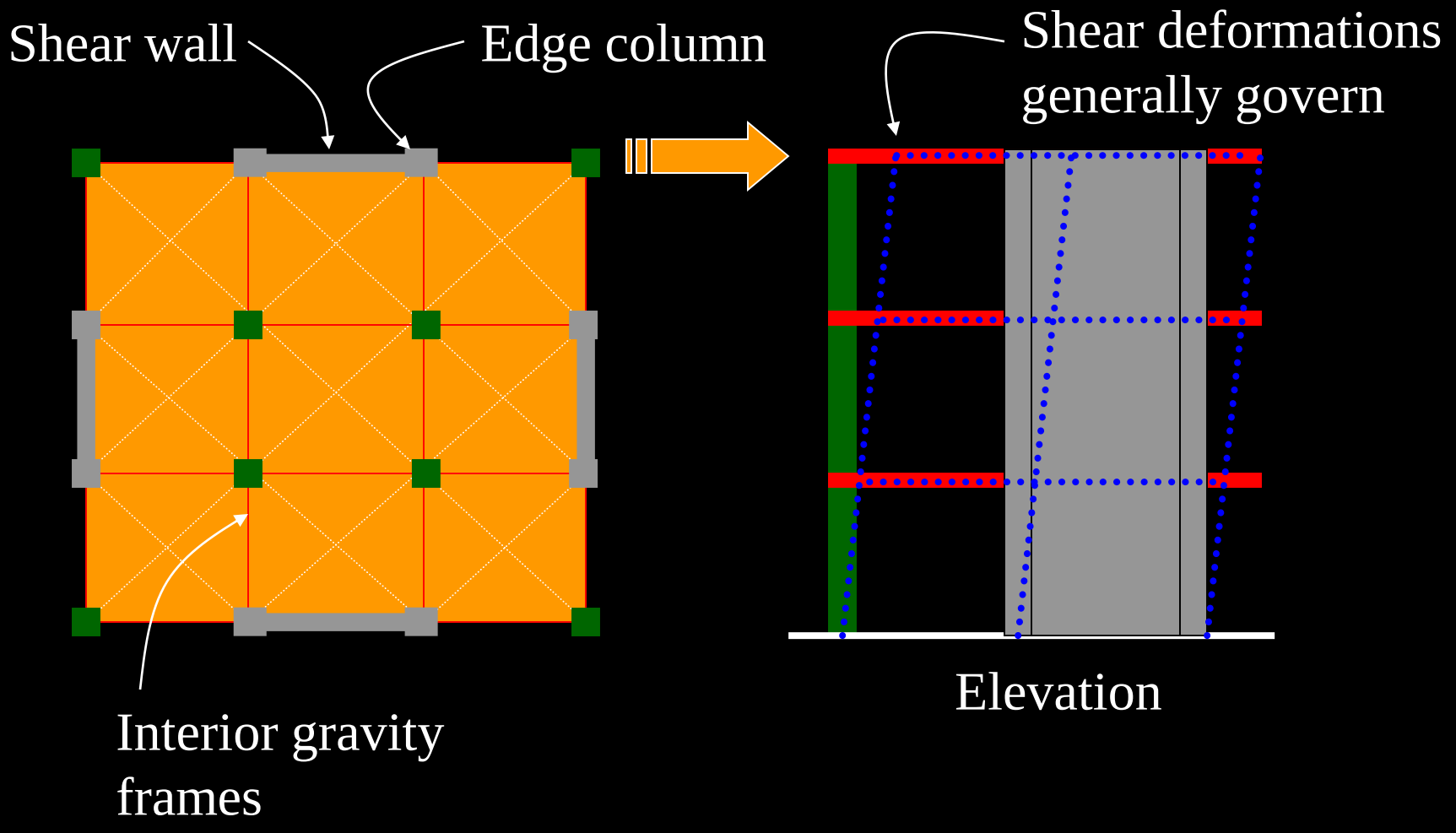
For relatively square plans, diaphragms are generally considered rigid



Space frame with square plan

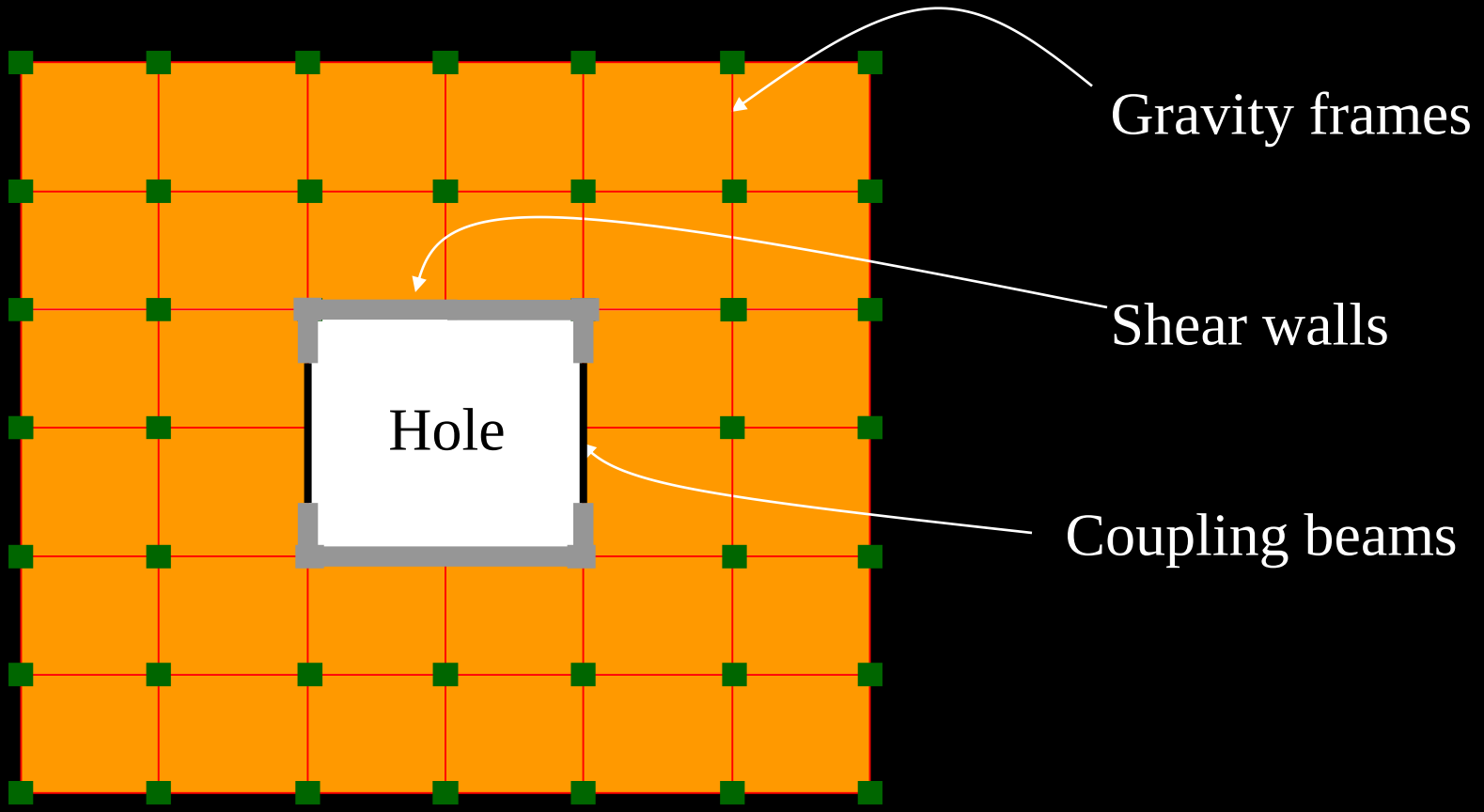
Deformed shape has constant lateral displacement - No diaphragm flexibility, ie. lateral load distributes to frame proportional to frame stiffness

Shear Wall Lateral Load Systems



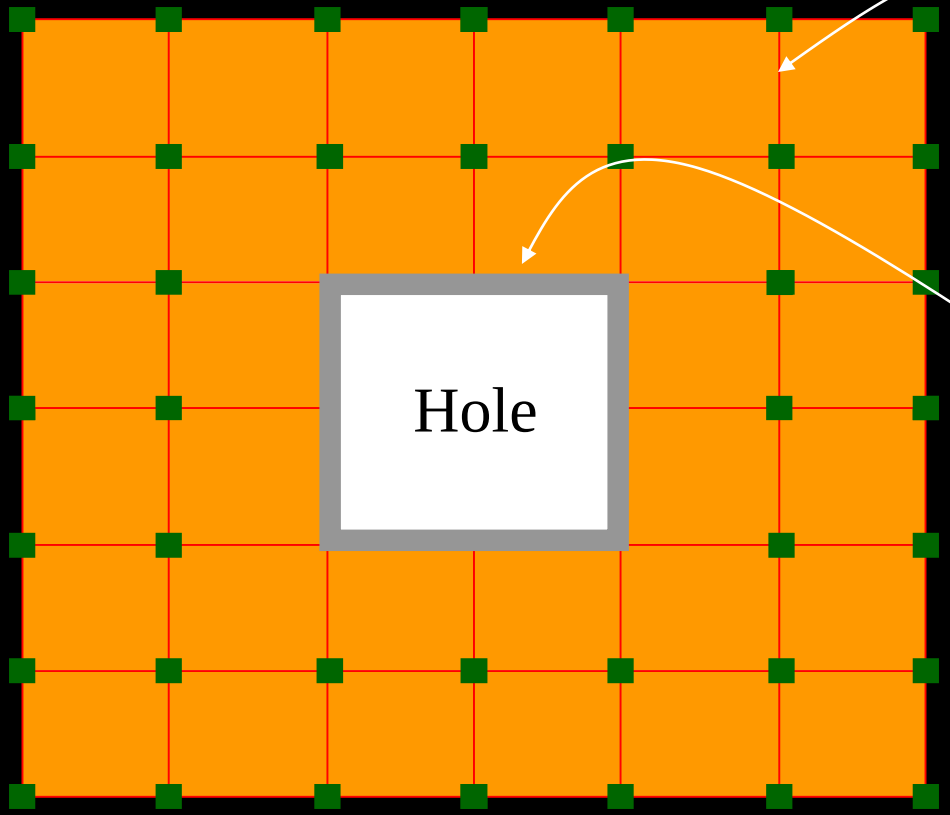
Shear Wall Lateral Load Systems

Elevator shaft configuration



Dual Lateral Load Systems

Wall-Frame Dual System:



Lateral frames – 25% of lateral load, minimum

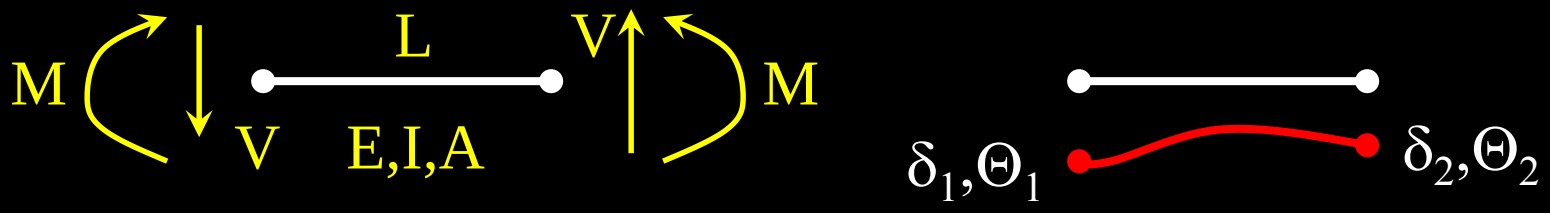
Shear walls

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) $\quad \sigma = My/I$ (normal stress)

$k_s = GA/L$ (shear) $\quad \nu = VQ/Ib$ (shear stress)

$\delta_b = f$ (load, support conditions, L, E, I) (bending)

Column Elements

Defn: Members subject to bending, shear, and axial

Elastic Properties:

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

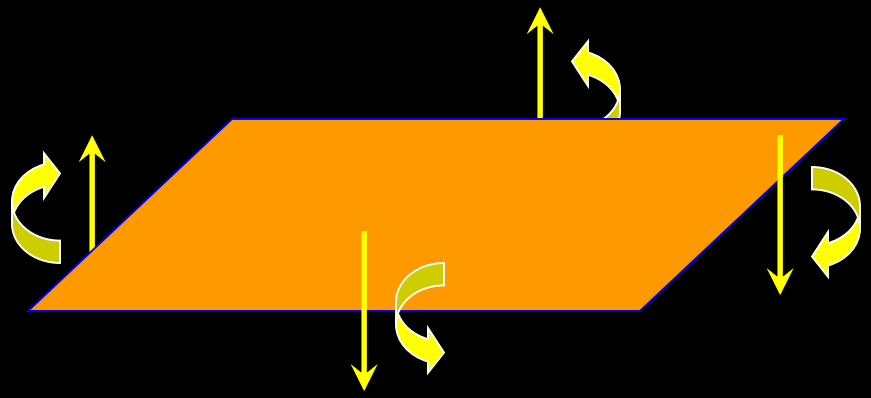
$k_b = f\,(EI/L^n)$ (bending) $\quad \sigma_b = My/I$ (normal stress)

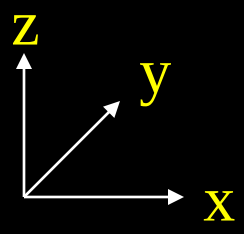
$k_s = GA/L$ (shear) $\quad v = VQ/Ib$ (shear stress)

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

Slab/Plate Elements

Defn: Members subject to bi-directional bending & shear



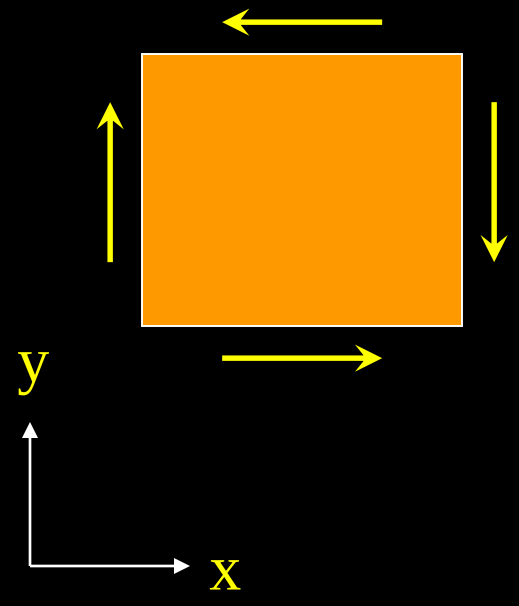


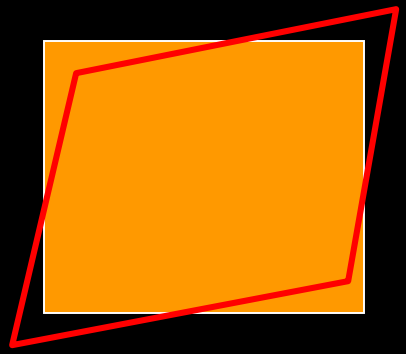
M_x, M_y, and V_z

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