ARCHITECTURAL STRUCTURES I:
STATICS AND STRENGTH OF MATERIALS

ENDS 231

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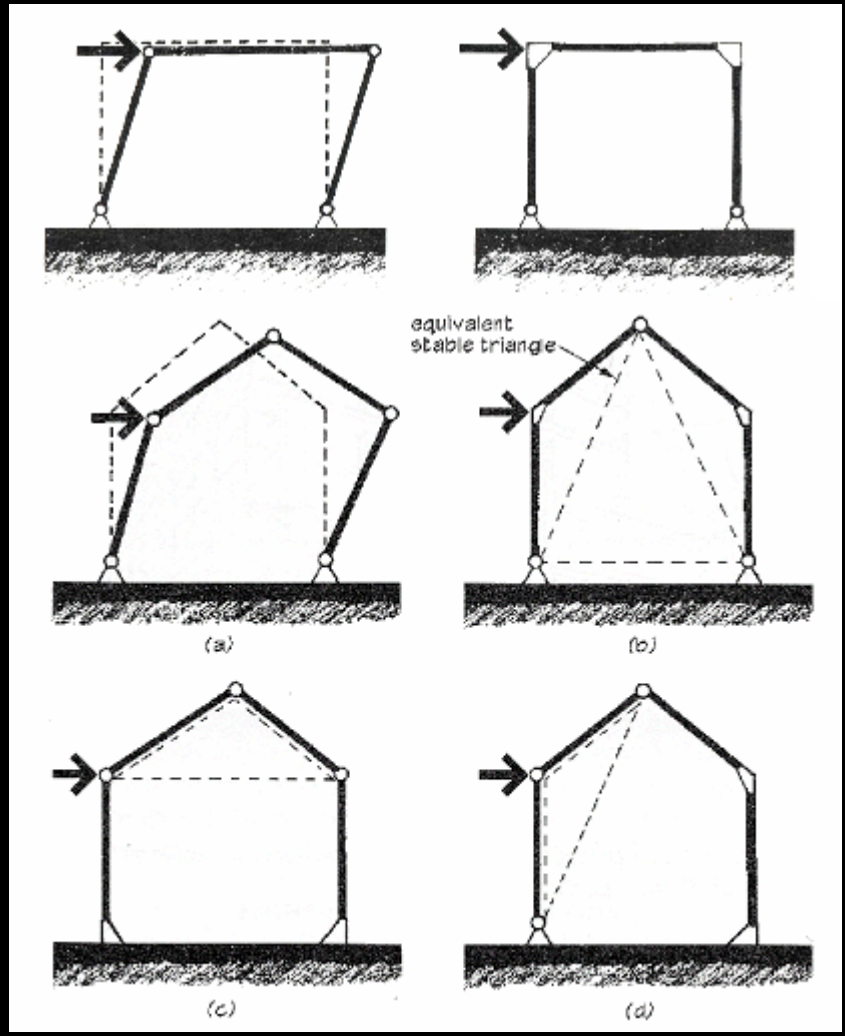
SUMMER 2006

lecture
twenty four

frames:
rigid and braced

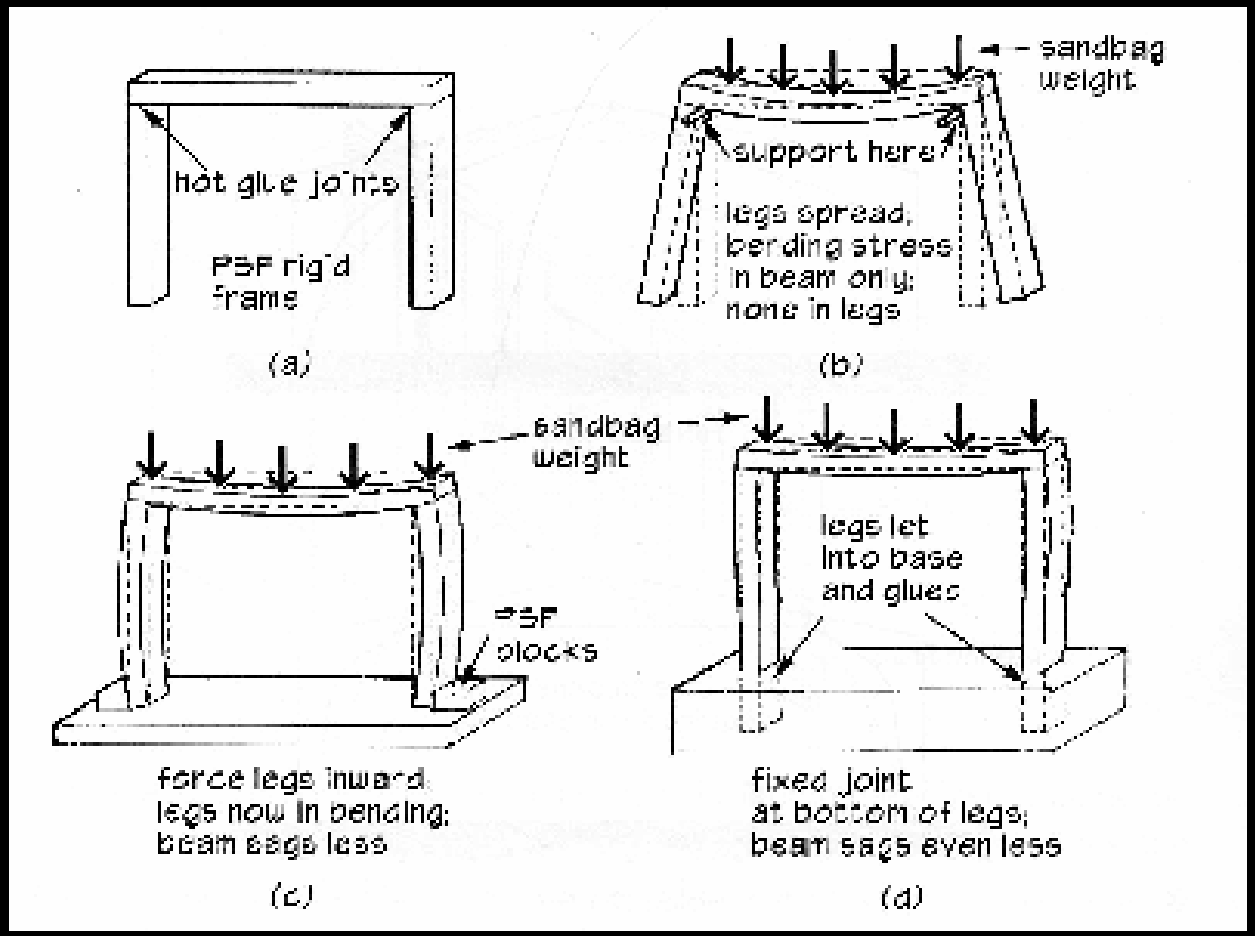
Rigid Frames

- *<u>rigid</u> frames have no pins*
- *frame is all one body*
- *joints transfer <u>moments and shear</u>*
- *typically statically indeterminate*
- *types*
  - *portal*
  - *gable*



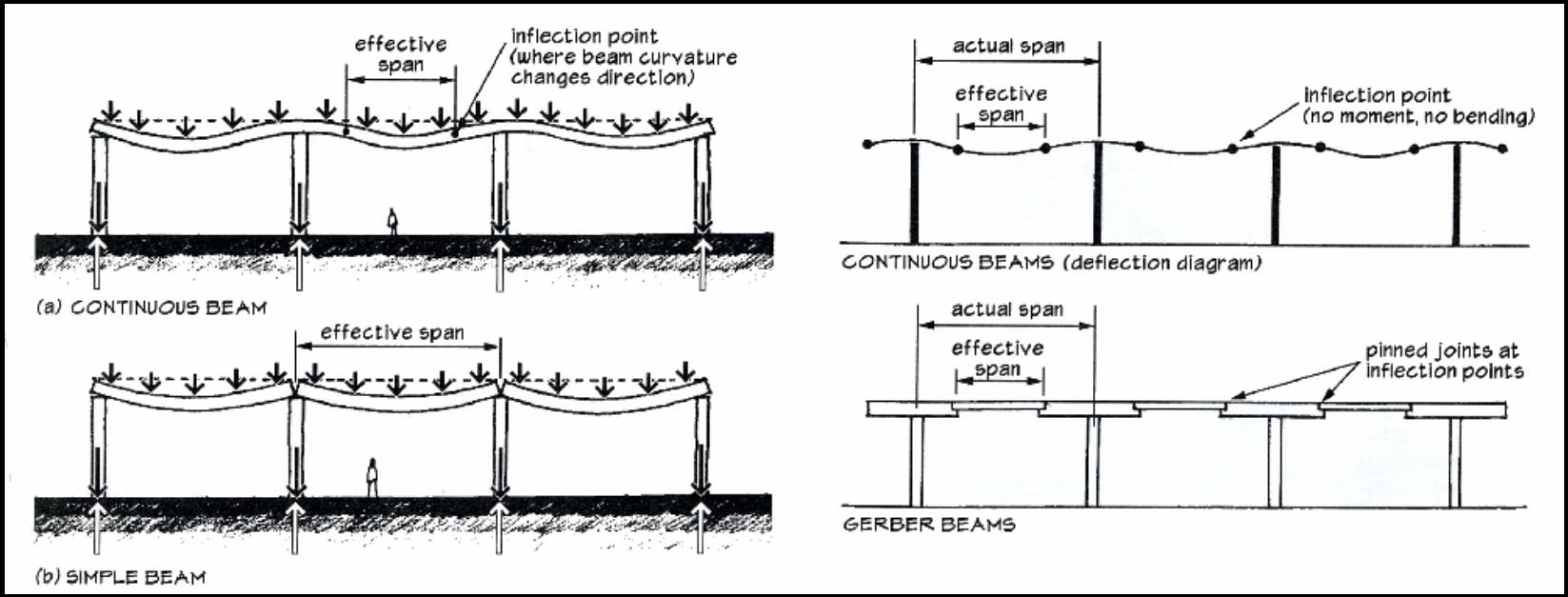
Rigid Frames

- *behavior*



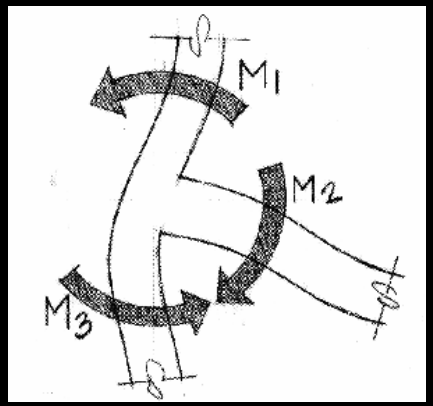
Rigid Frames

- *moments get redistributed*
- *deflections are smaller*
- *effective column lengths are shorter*
- *very sensitive to settling*



Rigid Frames

- *resists lateral loadings*
- *shape depends on stiffness of beams and columns*
- *90° maintained*



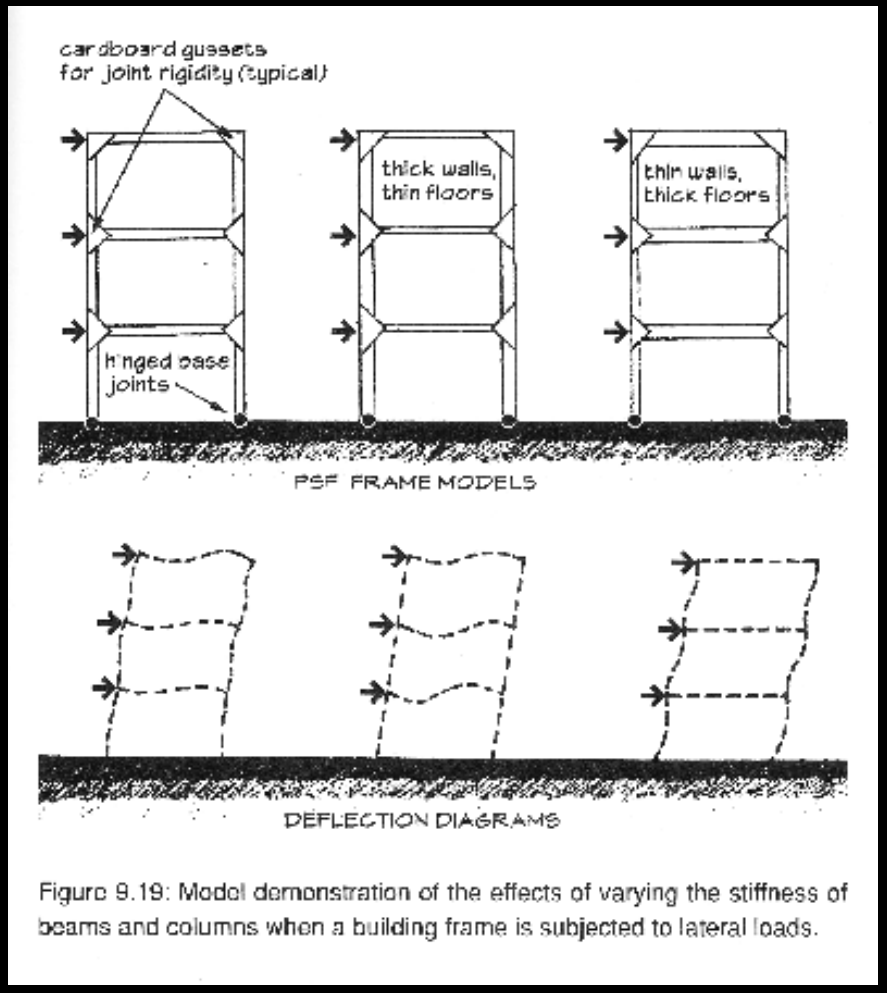
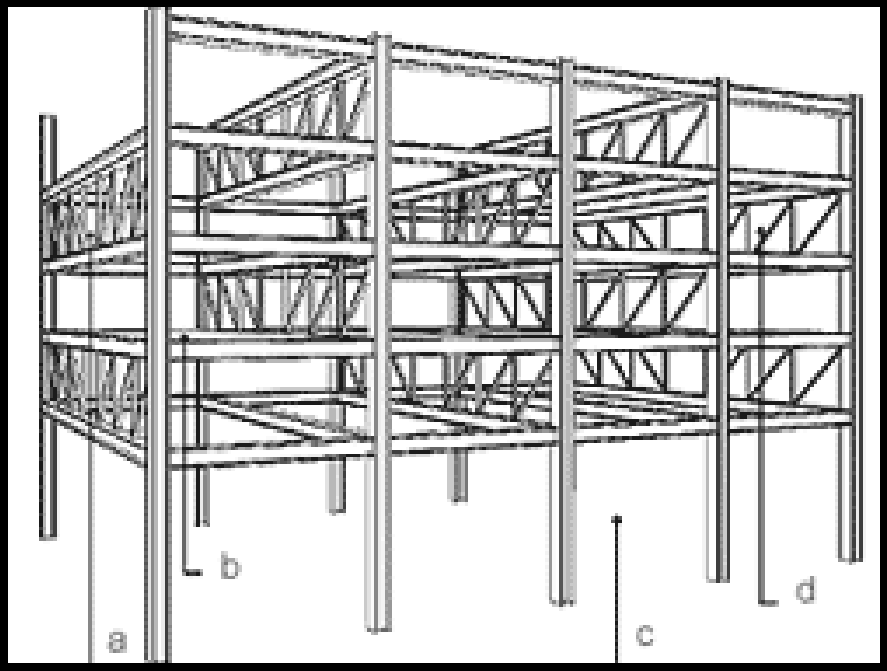


Figure 9.19: Model demonstration of the effects of varying the stiffness of beams and columns when a building frame is subjected to lateral loads.

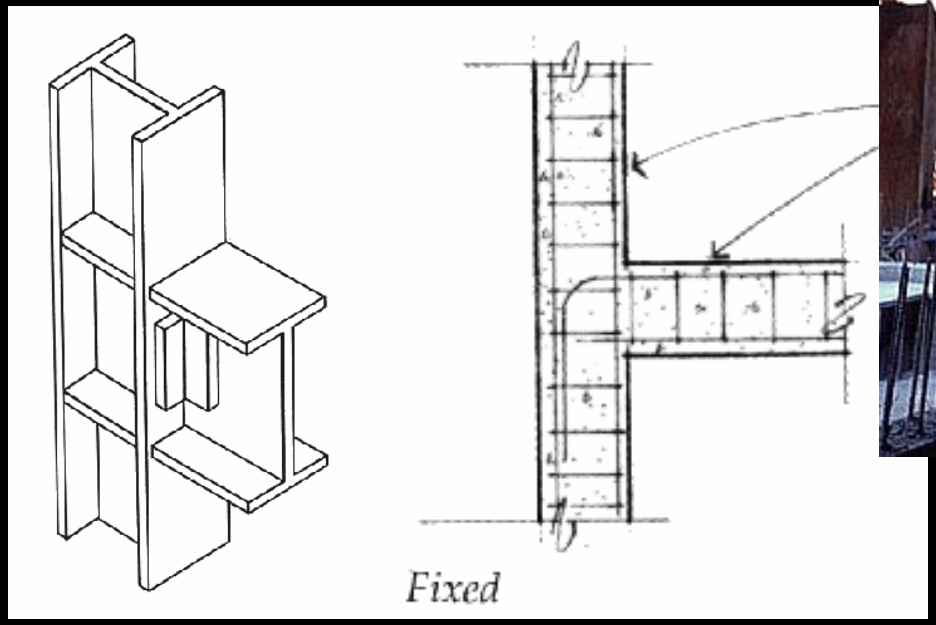
Rigid Frames

- *staggered truss*
  - *rigidity*
  - *clear stories*



Rigid Frames

- connections
  - steel
  - concrete

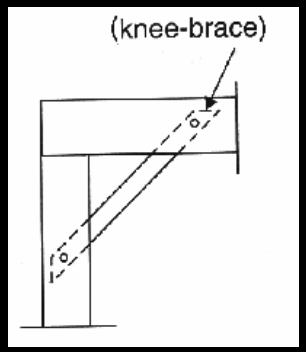


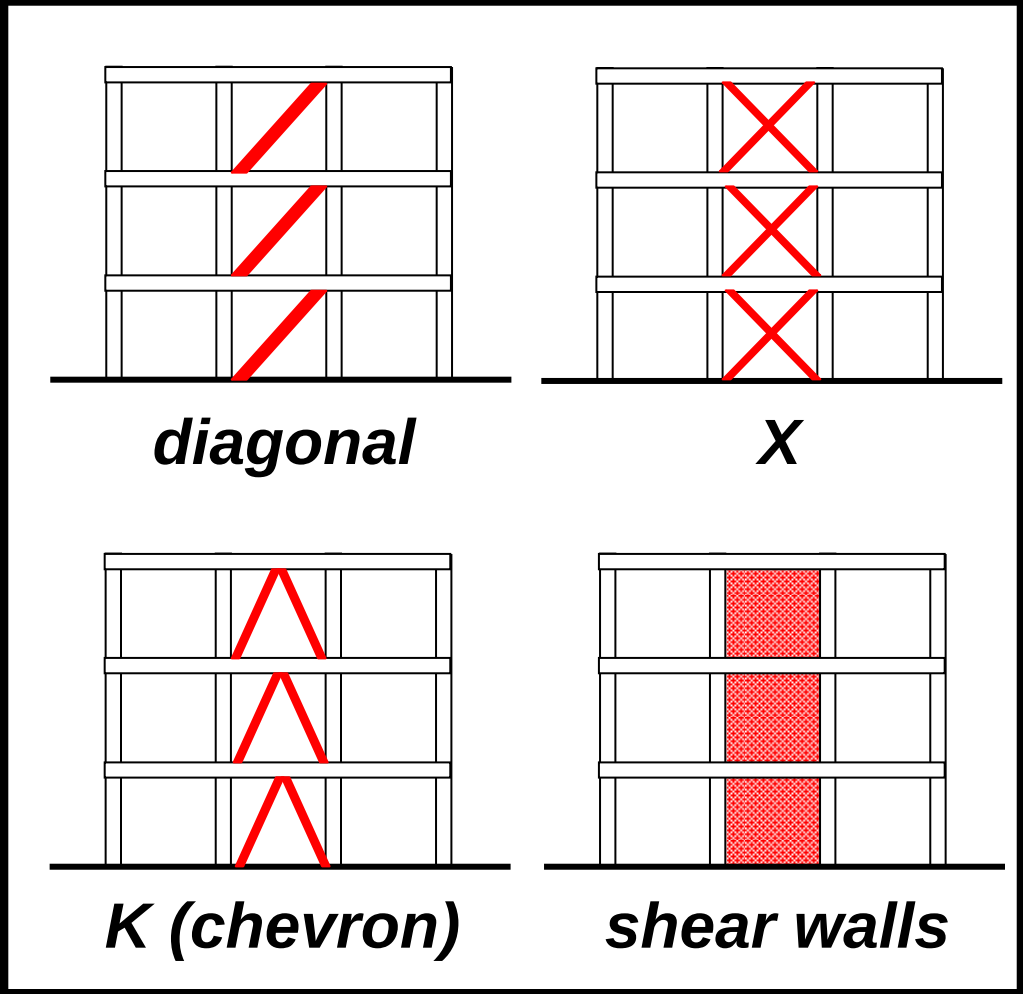
Braced Frames

- *pin connections*
- *bracing to prevent lateral movements*

Braced Frames

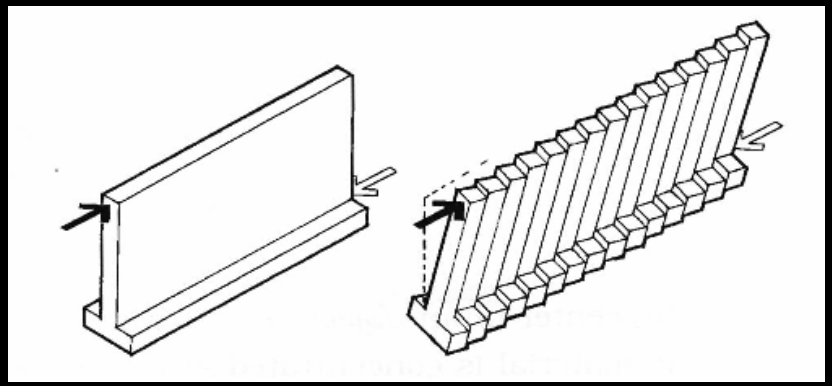
- *types of bracing*
  - *knee-bracing*
  - *diagonal*
  - *X*
  - *K or chevron*
  - *shear walls*

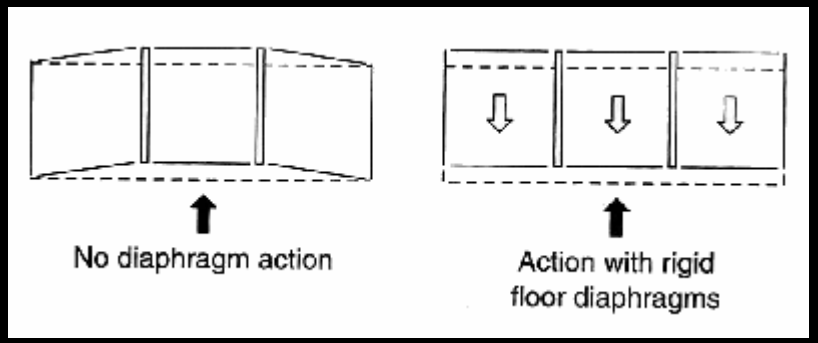


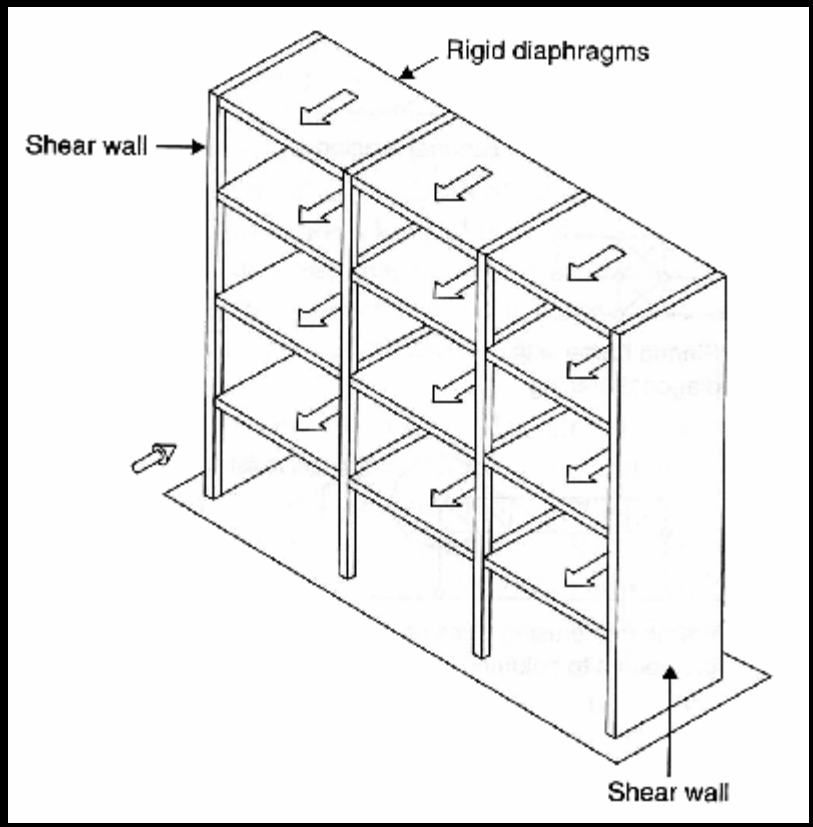


Shear Walls

- *resist lateral load in plane with wall*

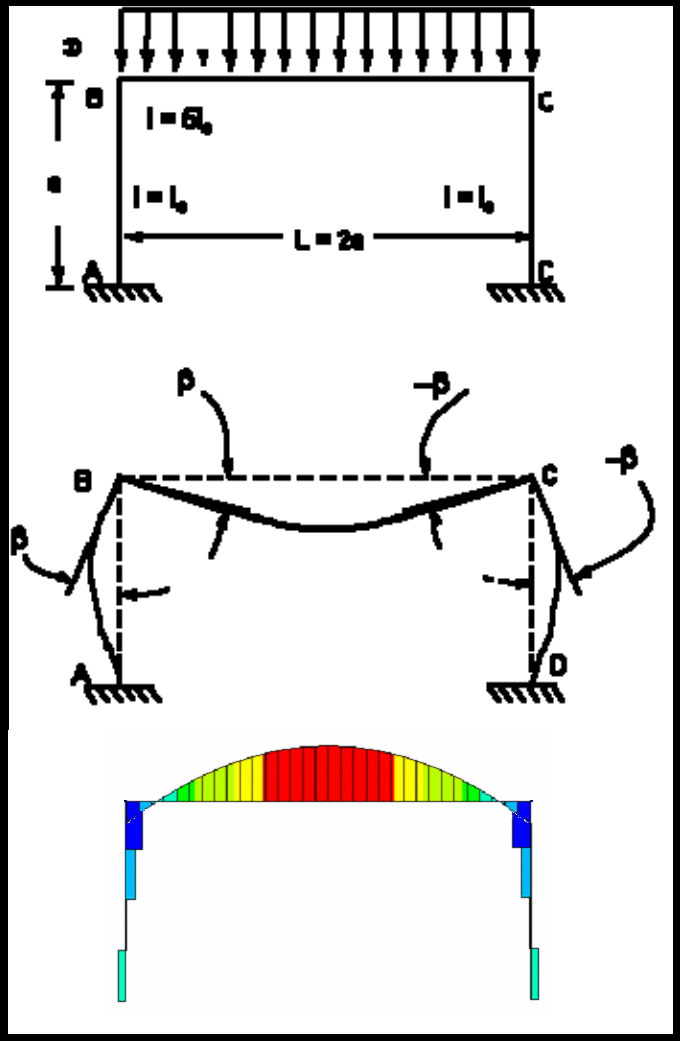






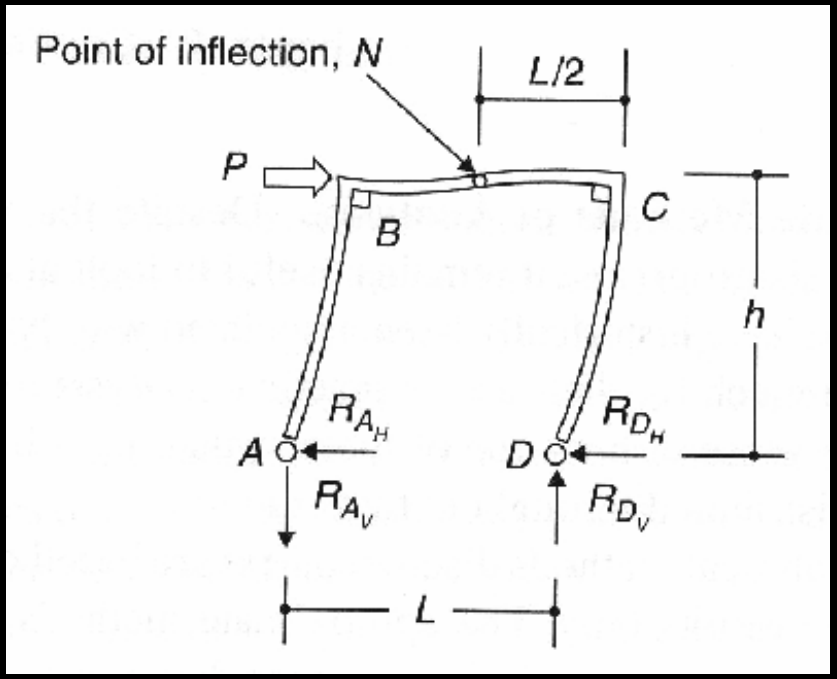
Rigid Frame Analysis

- members see
  - shear
  - axial force
  - bending
- V & M diagrams
  - plot on “outside”



Rigid Frame Analysis

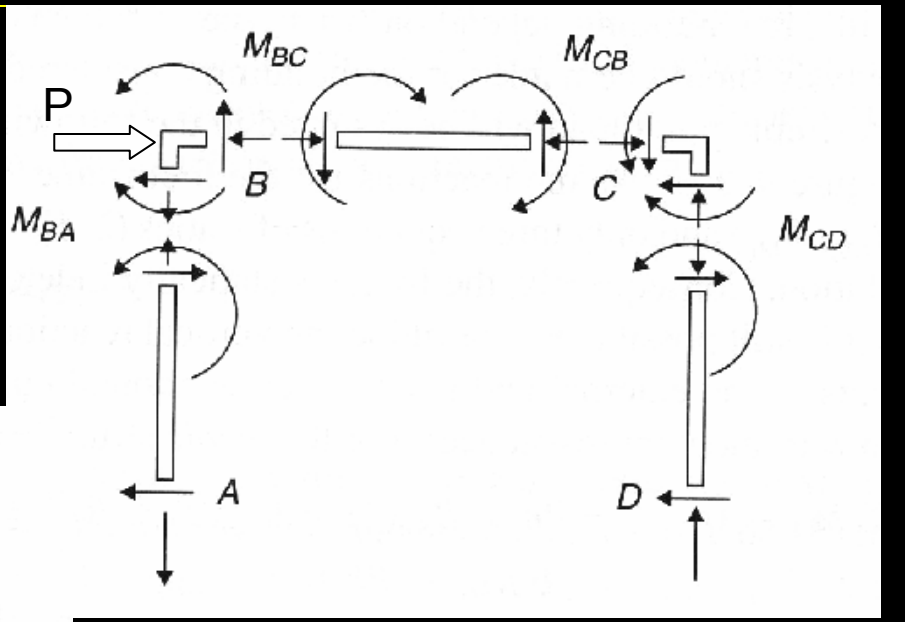
- need support reactions
- free body diagram each member
- end reactions are equal and opposite on next member
- "turn" member like beam
- draw V & M

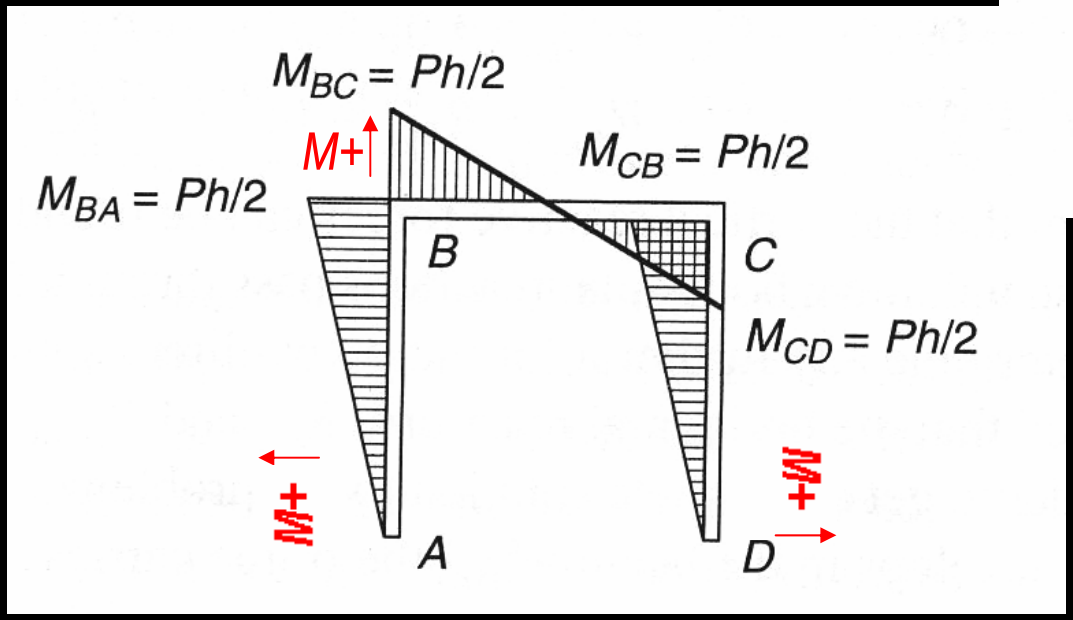


Rigid Frame Analysis

– *FBD & M*

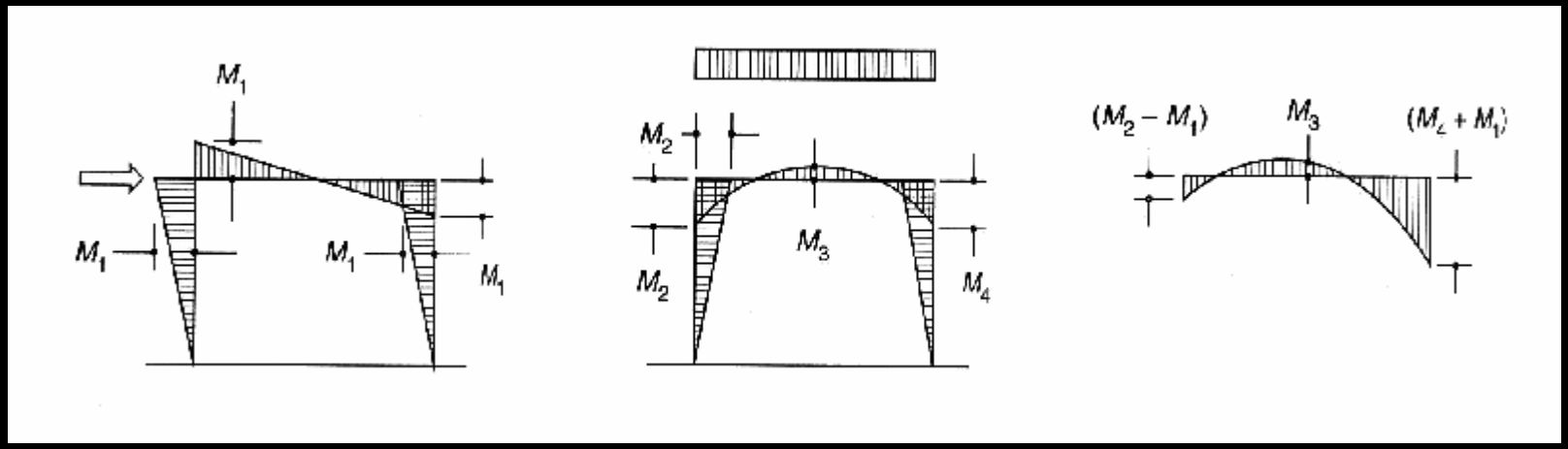
- *opposite end reactions at joints*





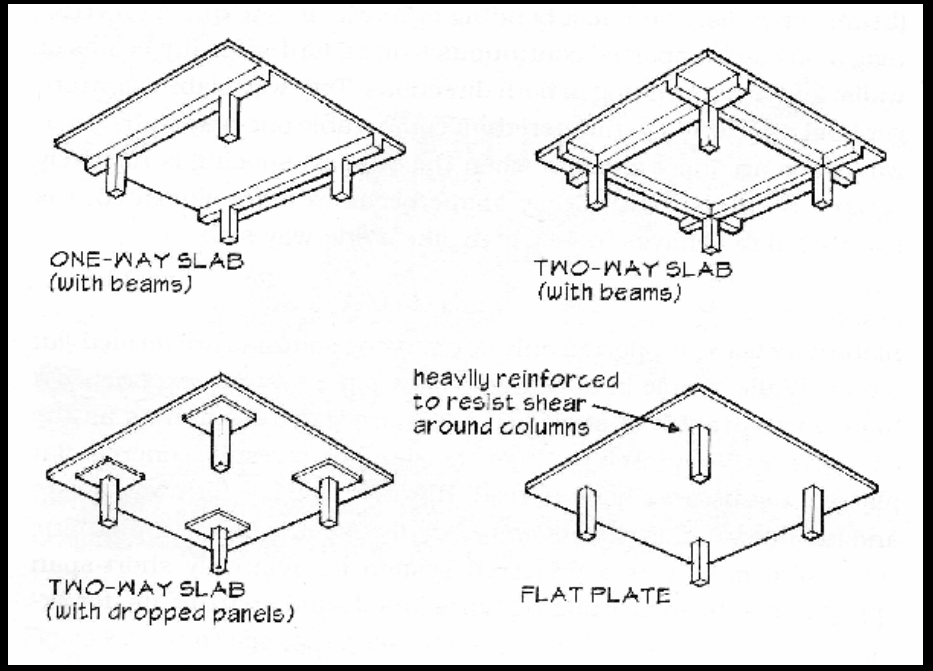
Rigid Frame Design

- *loads and combinations*
  - *usually uniformly distributed gravity loads*
  - *worst case for largest moments...*
  - *wind direction can increase moments*



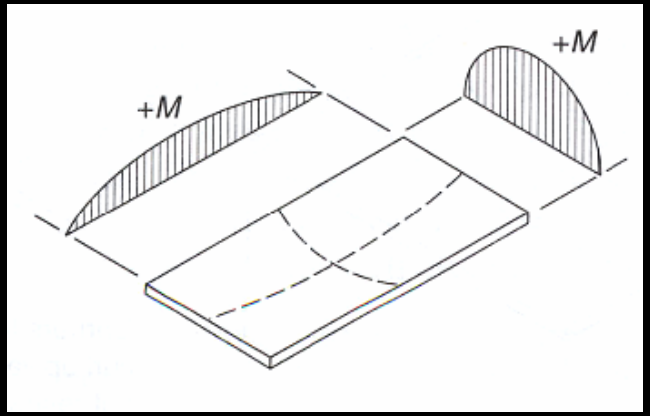
Rigid Frame Design

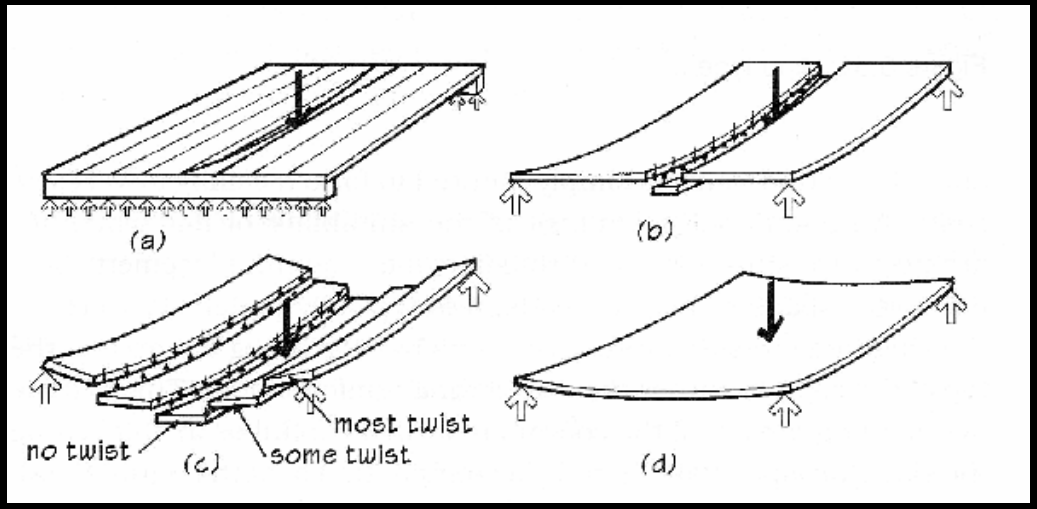
- *frames & floors*
  - *rigid frame can have slab floors or slab with connecting beams*
- *other*
  - *slabs or plates on columns*



Rigid Frame Design

- *floors – plates & slabs*
  - *– one-way behavior*
    - *side ratio > 1.5*
    - *“strip” beam*
  - *– two-way behavior*
    - *more complex*

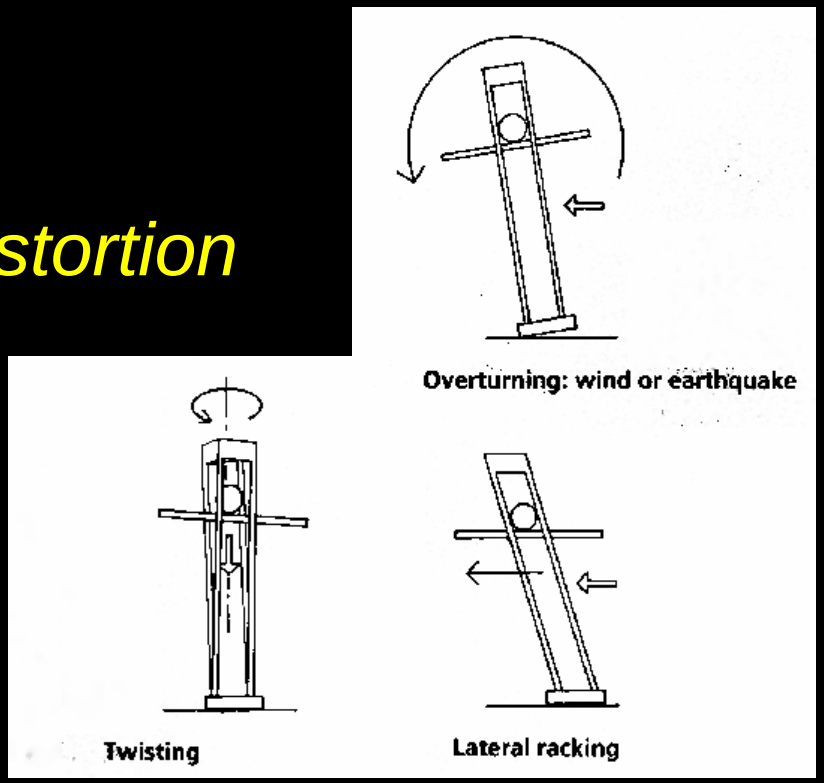




DESIGN CRITERIA	Light-frame timber	Heavy-frame timber	Masonry bearing wall	Steel frame (hinge connections)	Steel frame (rigid connections)	Steel open-web joists	Steel space frame	Steel decking	Site-cast concrete: one-way slab	Site-cast concrete: two-way plate	Site-cast concrete: two-way slab	Site-cast concrete: one-way joists	Site-cast concrete: waffle slab	Precast concrete: solid slab	Precast concrete: hollow-core slab	Precast concrete: single tee	Precast concrete: double tee	RATIONALE
Exposed, fire-resiant construction		■	■						■	■	■	■	■	■	■	■	■	Inherently fire-resistive construction
Irregular building form	■		■						■	■	■							Simple, site-fabricated systems
Irregular column placement										■	■		■					Systems without beams in roof or floors
Minimize floor thickness									■	■				■	■			Precast-concrete systems without ribs
Allow for future renovations	■	■	■	■	■	■	■	■	■			■		■	■			Short-span, one-way, easily modified
Permit construction in poor weather	■	■		■	■	■	■	■						■	■	■	■	Quickly erected; avoid site-cast concrete
Minimize off-site fabrication time	■		■						■	■	■	■	■					Easily formed or built on site
Minimize on-site erection time		■		■	■	■		■						■	■	■	■	Highly prefabricated; modular components
Minimize low-rise construction time	■	■		■	■	■		■										Lightweight, easily formed or prefabricated
Minimize medium-rise construction time				■	■	■		■	■	■	■	■	■	■	■	■	■	Precast, site-cast concrete; steel frames
Minimize high-rise construction time				■	■	■		■										Strong; prefabricated; lightweight
Minimize shear walls or diagonal bracing			■		■				■	■	■	■	■					Capable of forming rigid joints
Minimize dead load on foundations	■	■		■	■	■	■	■										Lightweight, short-span systems
Minimize damage due to foundation settlement	■	■		■		■		■						■	■	■	■	Systems without rigid joints
Minimize the number of separate trades on job	■		■															Multipurpose components
Provide concealed space for mech. services	■					■	■								■			Systems that inherently provide voids
Minimize the number of supports							■											Two-way, long-span systems
Long spans						■	■									■		Long-span systems

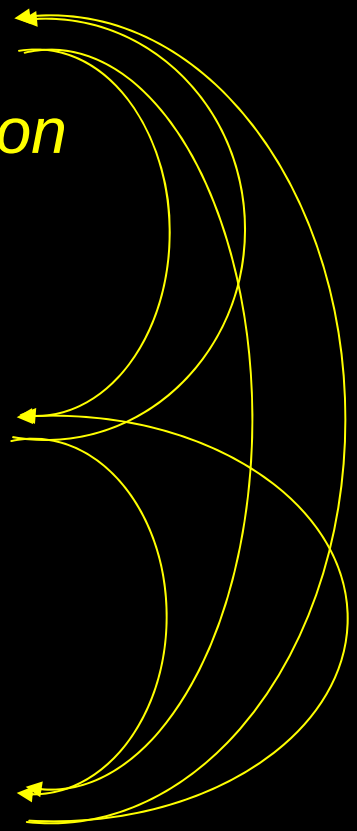
Structural Design Criteria

- *components stay together*
- *structure acts as whole to be stable*
  - *resist sliding*
  - *resist overturning*
  - *resist twisting and distortion*
- *internal stability*
  - *interconnectedness*
- *strength & stiffness*

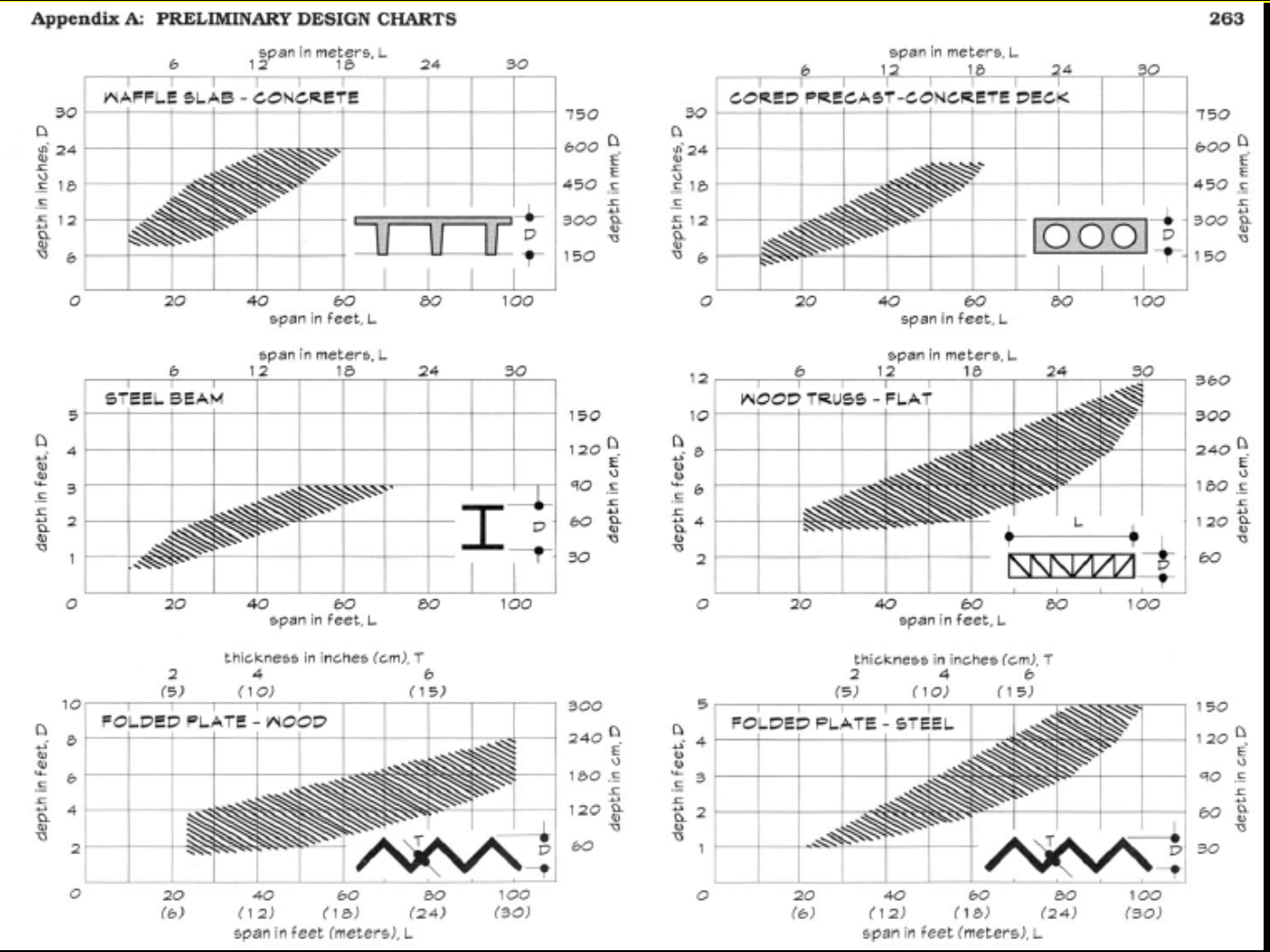


Structural Design Sequences

- *first-order design*
  - *structural type and organization*
  - *design intent*
  - *contextual or programmatic*
- *second-order*
  - *structural strategies*
  - *material choice*
  - *structural systems*
- *third-order*
  - *member shaping & sizing*



Component Design Guides



Final Exam Material

- *my list:*
  - *equilibrium - ΣF & ΣM*
    - *supports, trusses, cables, beams, pinned frames, rigid frames*
  - *materials*
    - *strain & stress (E), temperature, constraints*
  - *beams*
    - *distributed loads, tributary width, V&M, stresses, design, section properties (I & S), pitch, deflection*

Final Exam Material

- *my list (cont'd):*
  - *columns*
    - *stresses, design, section properties (I & r)*
  - *frames*
    - *P, V & M, P-Δ, connection design, tension member design*
  - *design*
    - *ASD*
    - *LRFD*
    - *wood peculiarities*