ARCHITECTURAL STRUCTURES I:
STATICS AND STRENGTH OF MATERIALS

ENDS 231

DR. ANNE NICHOLS

SUMMER 2006
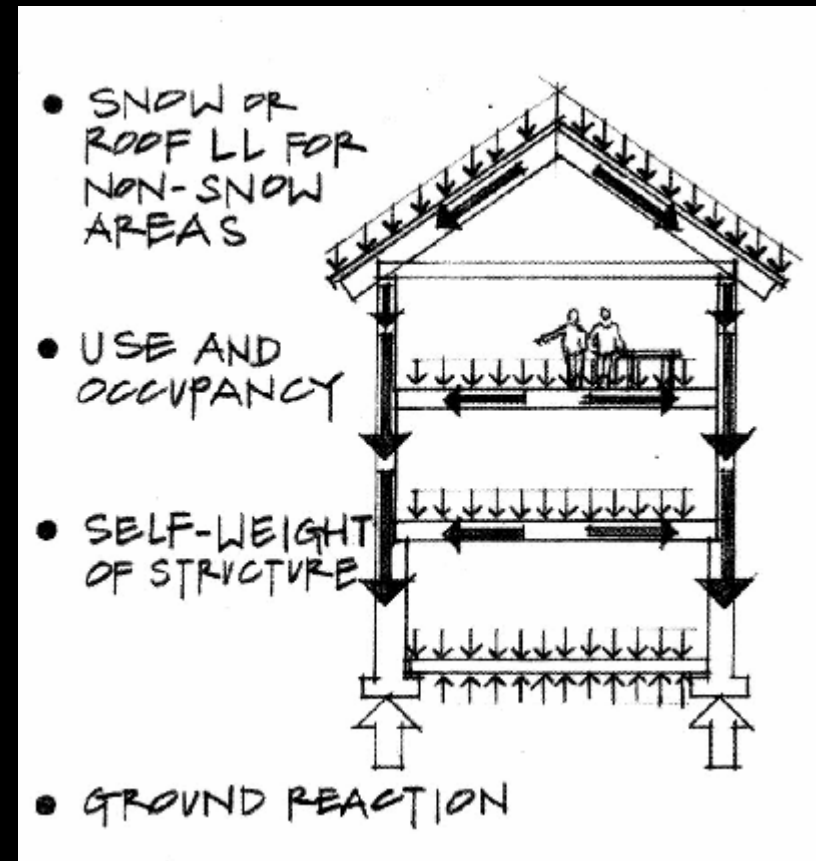
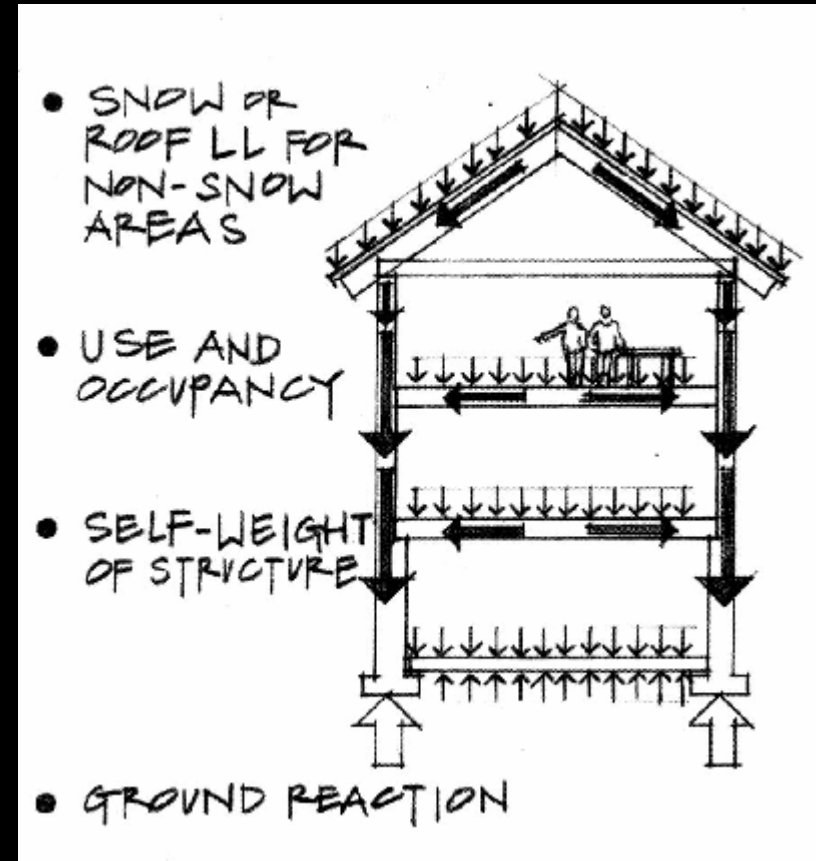lecture
nine

load tracing
and types

Structural Loads

- **gravity acts on mass (F=m*g)**
- **force of mass**
  - acts at a point
    - ie. joist on beam
  - acts along a "line"
    - ie. floor on a beam
  - acts over an area
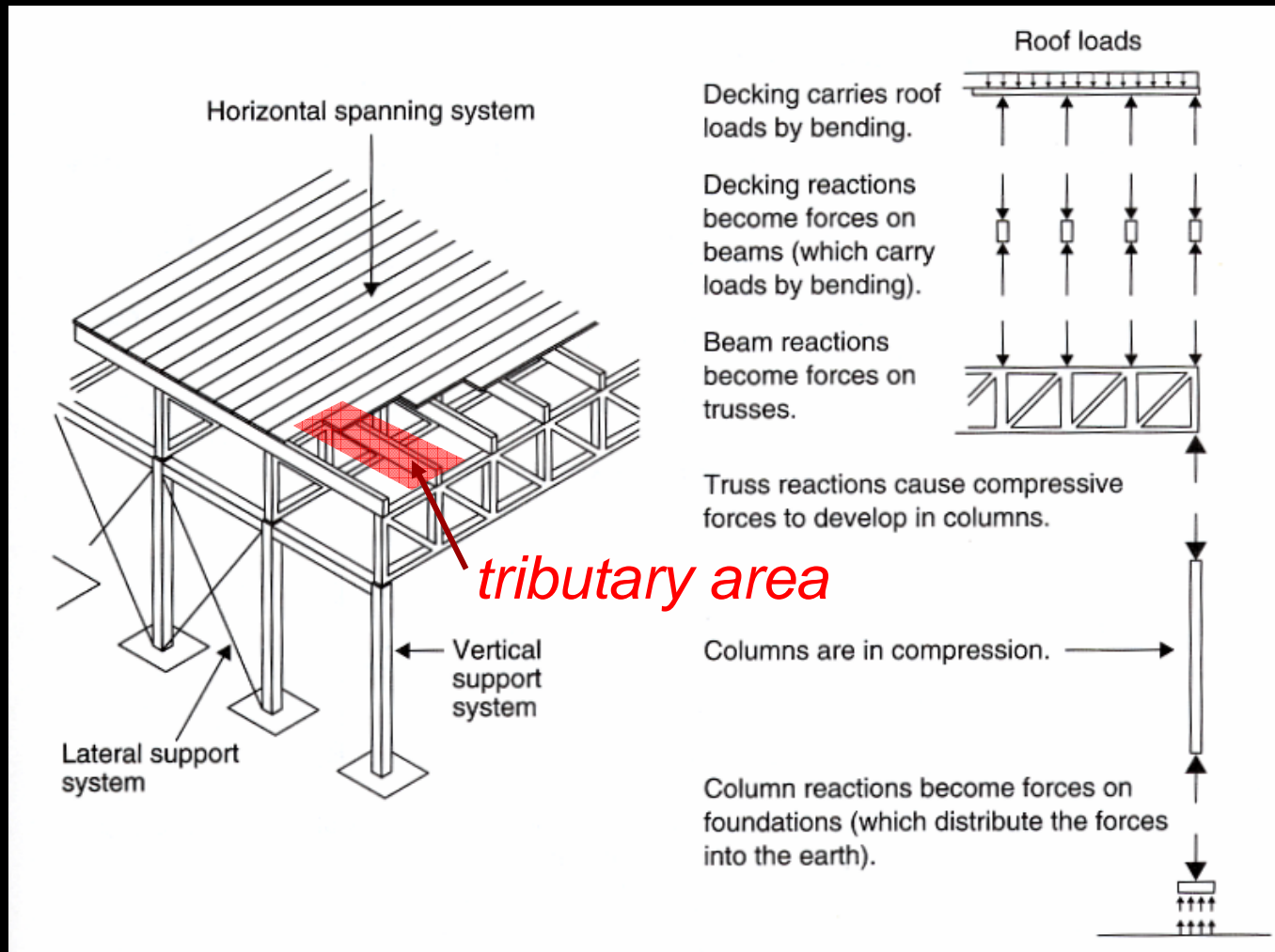   - ie. people, books, snow on roof or floor

- SNOW OR ROOF LL FOR NON-SNOW AREAS
- USE AND OCCUPANCY
- SELF-WEIGHT OF STRUCTURE
- GROUND REACTION

Load Tracing

- **how loads are transferred**
  - *usually starts at top*
  - *distributed by supports as <u>actions</u>*
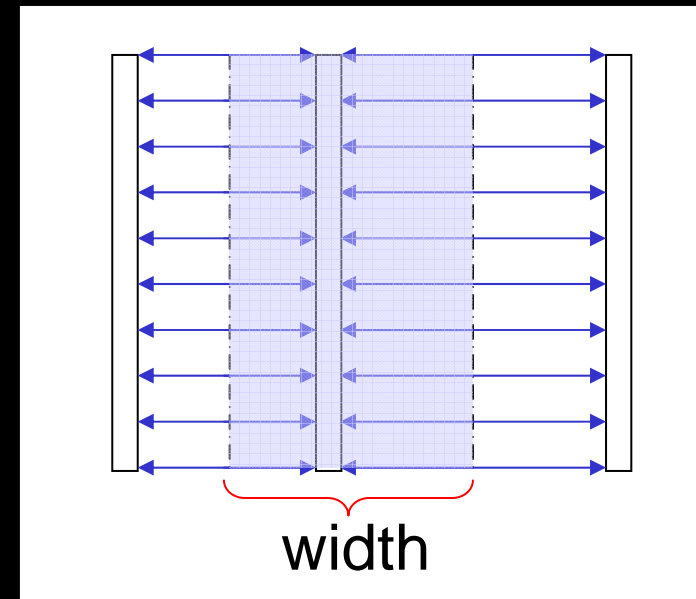 - *distributed by <u>tributary areas</u>*

- SNOW OR ROOF LL FOR NON-SNOW AREAS
- USE AND OCCUPANCY
- SELF-WEIGHT OF STRUCTURE
- GROUND REACTION

Load Tracing

Horizontal spanning system

Vertical support system

Lateral support system

tributary area

Roof loads

Decking carries roof loads by bending.

Decking reactions become forces on beams (which carry loads by bending).

Beam reactions become forces on trusses.

Truss reactions cause compressive forces to develop in columns.

Columns are in compression.

Column reactions become forces on foundations (which distribute the forces into the earth).

Load Tracing

- *tributary load*
  - *think of water flow*
  - *"concentrates" load of area into center*

$$w = \left(\frac{load}{area}\right) \times (tributary\ width)$$

width

Load Tracing

Patcenter
Rogers 1986

primary stays
suspend secondary
stays which support
roof

main masts transfer
vertical loads to
columns and foundations

vertical ties resist
wind uplift only
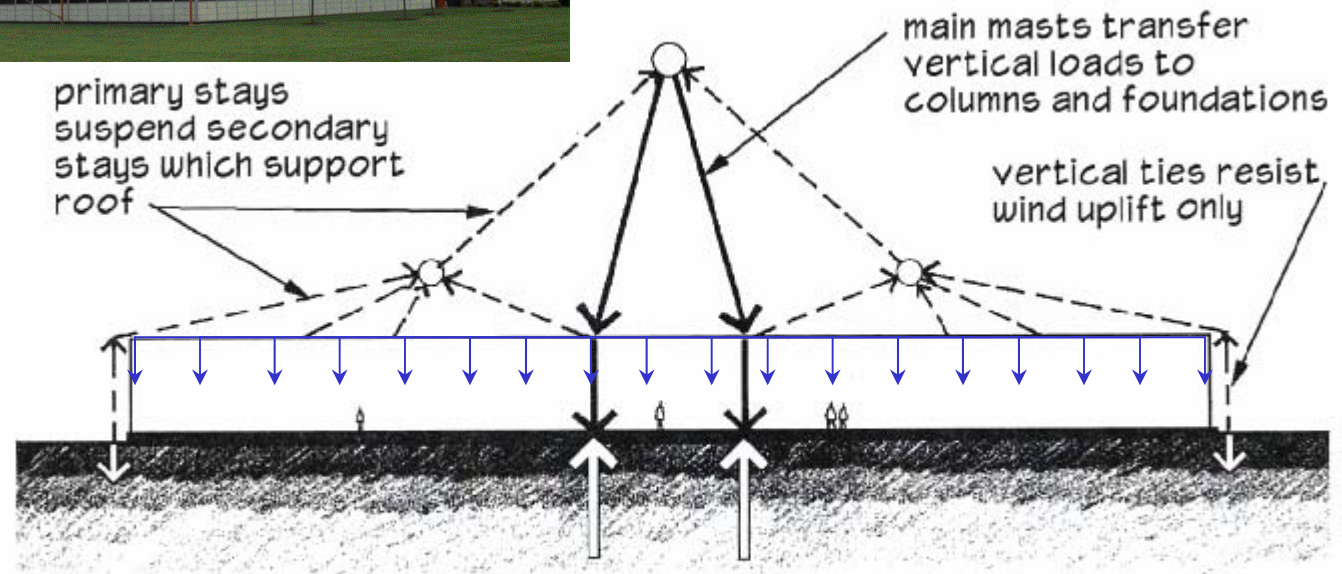
Figure 3.5: Patcenter, load path diagram.

Load Tracing

Alamillo Bridge
Calatrava 1992

diagonal stays support
roadbed and generate
inward thrust

weight of
sloped pylon
resists thrust
due to cable
stays

roadbed transmits
horizontal thrust
to pylon
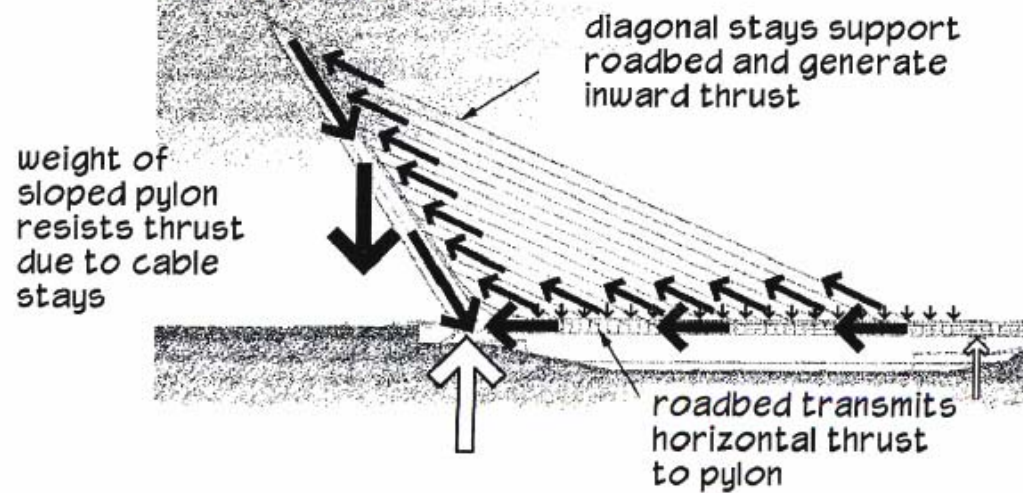
Figure 3.12: Alamillo bridge, load path diagram.

Load Paths
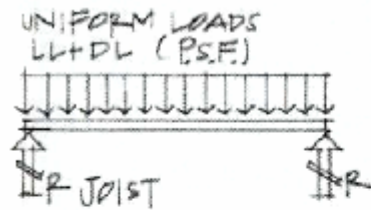
(a) FBD—decking.
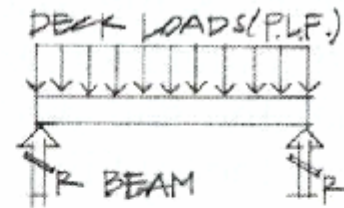
(b) FBD—joists.
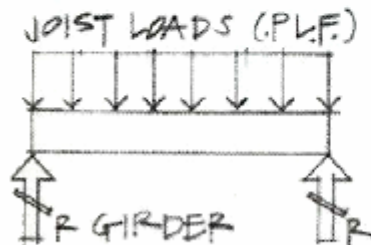
(c) FBD—beams.
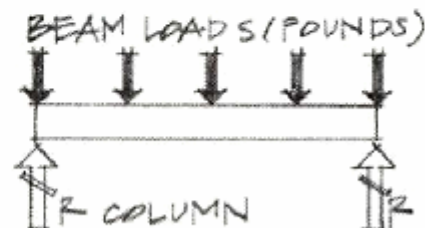
(d) FBD—girder.
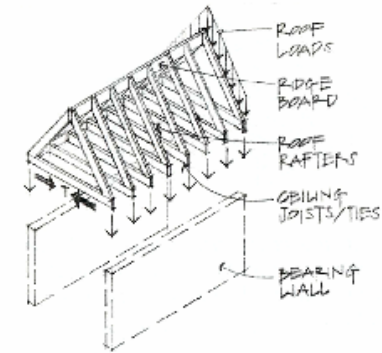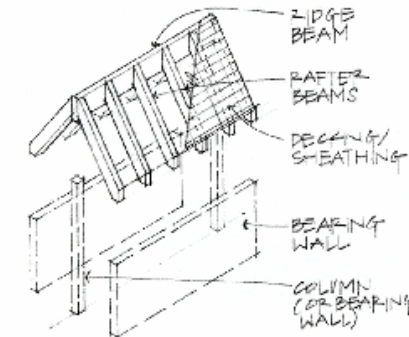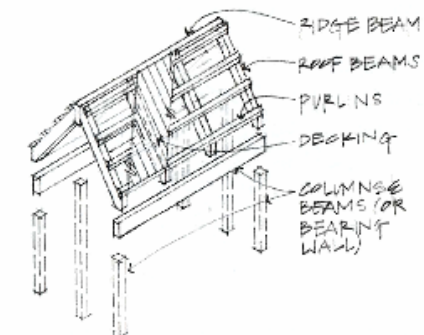
Load Paths

- ## wall systems
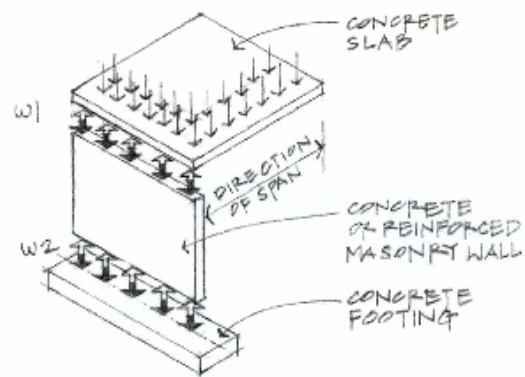
Figure 4.12 Uniform wall load from a slab.
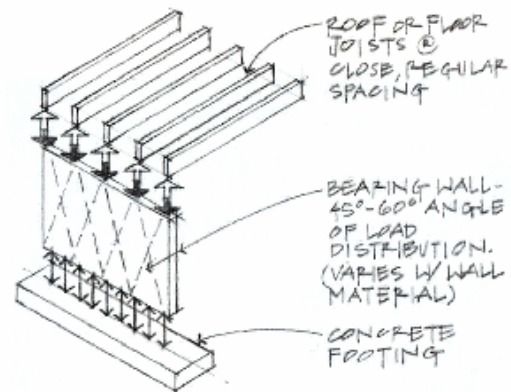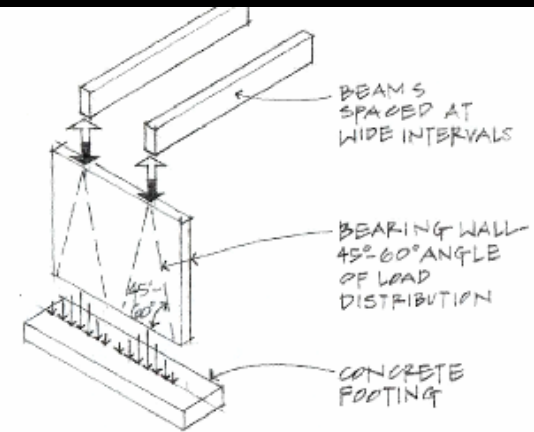
Figure 4.13 Uniform wall load from rafters and joists.

Figure 4.14 Concentrated loads from widely spaced beams.

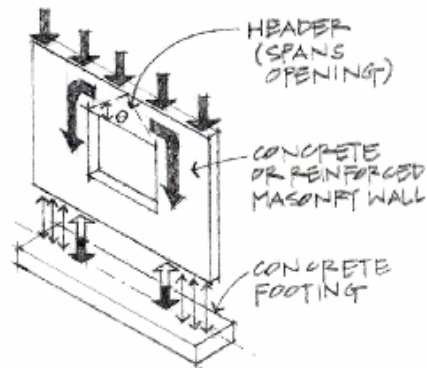# *Load Paths*

- ## *openings & pilasters*
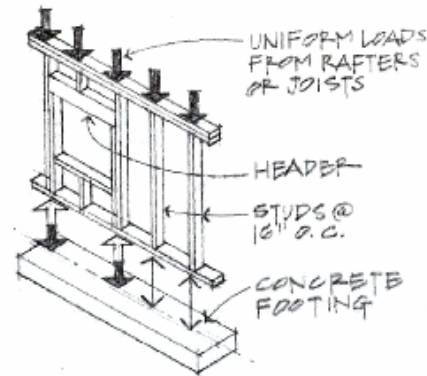

Figure 4.15   Arching over wall openings.
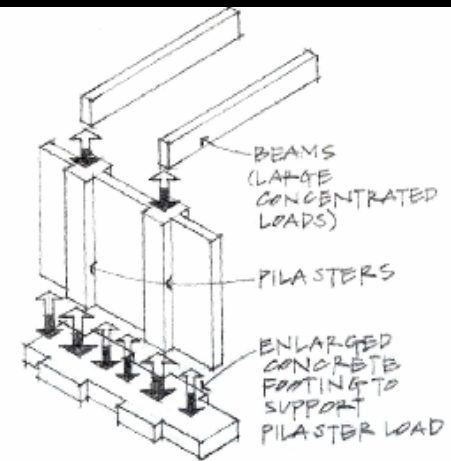
Figure 4.16   Stud wall with a window opening.

Figure 4.17   Pilasters supporting concentrated beam loads.
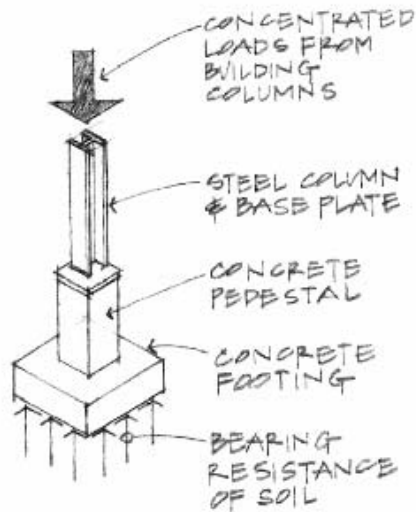
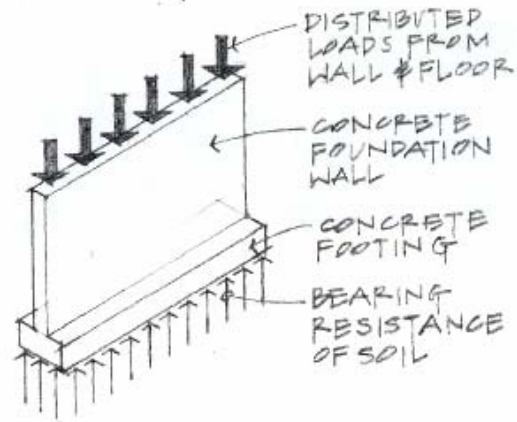# Load Paths

- *foundations*

Figure 4.24 Spread footing.

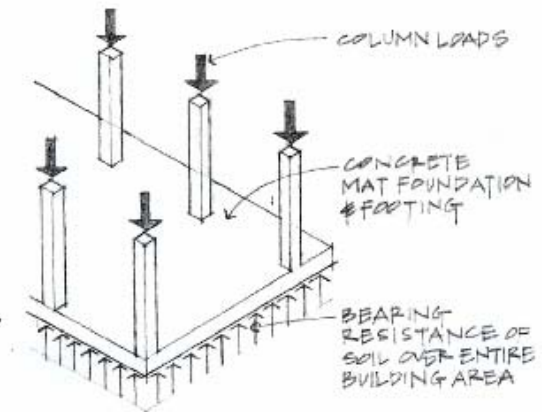Figure 4.25 Wall footing.

Figure 4.26 Mat or raft foundation.

Load Paths

- ## deep foundations
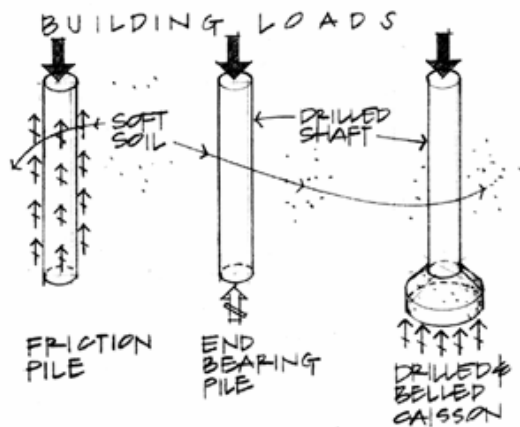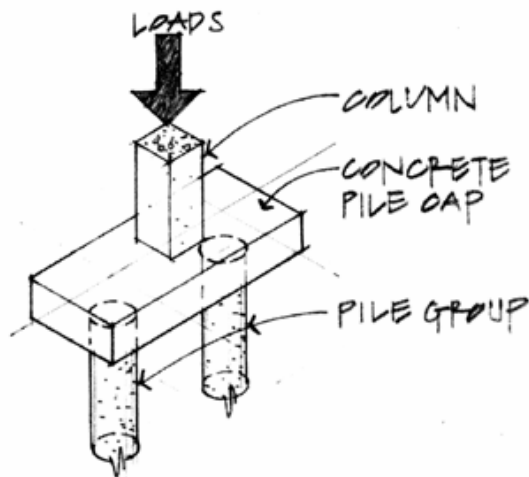

Figure 4.27   Pile foundations.

Figure 4.28   Pile cap on one pile group.
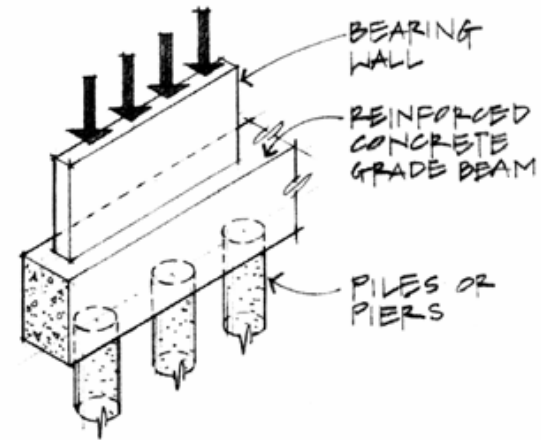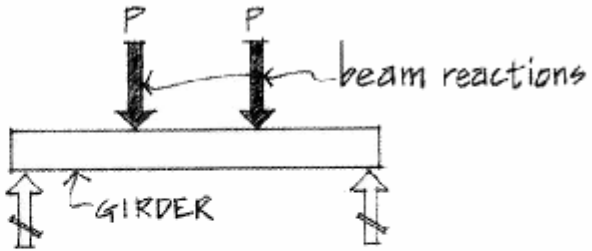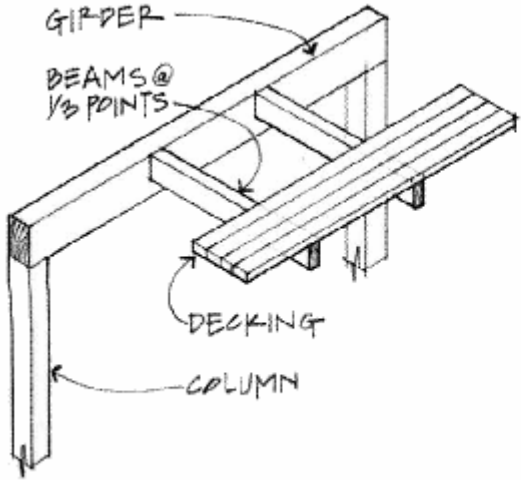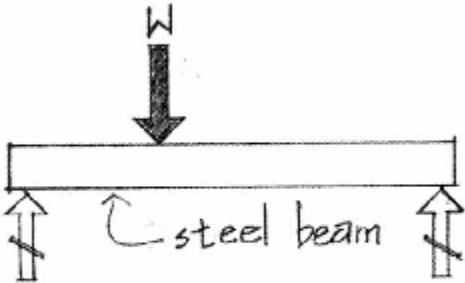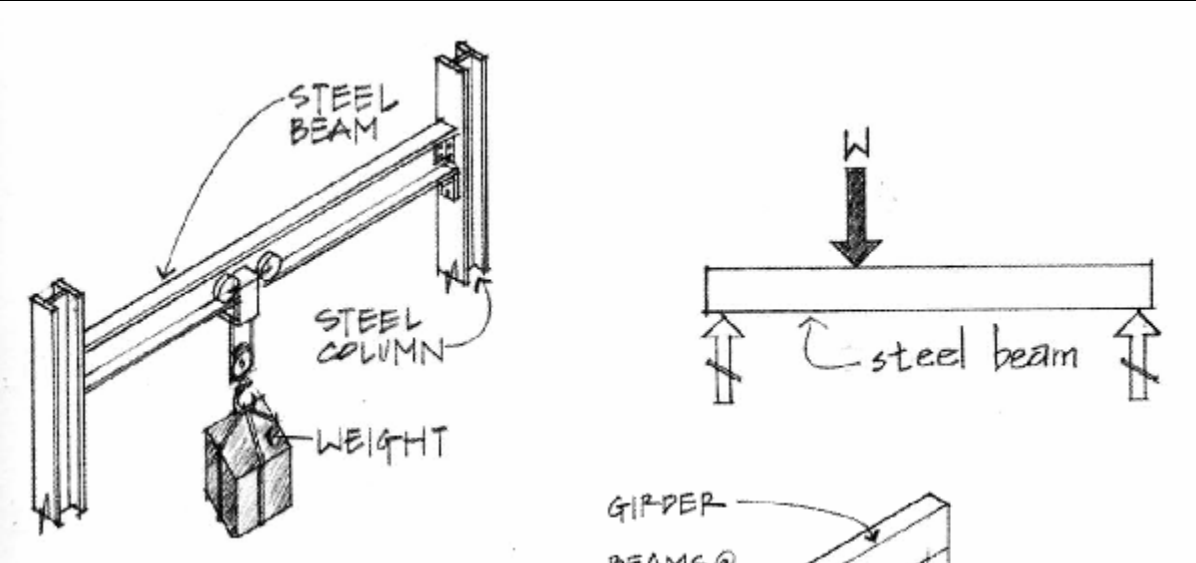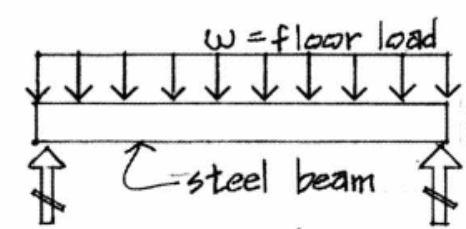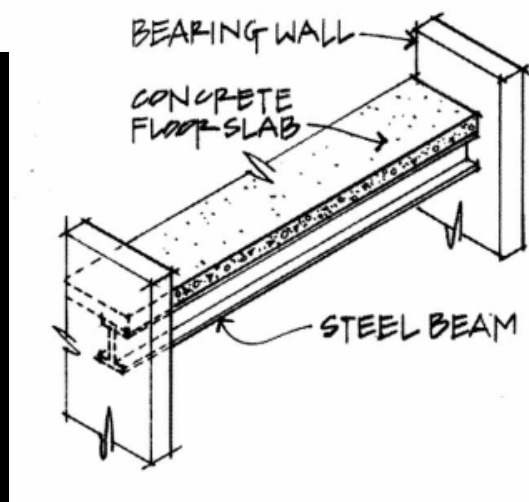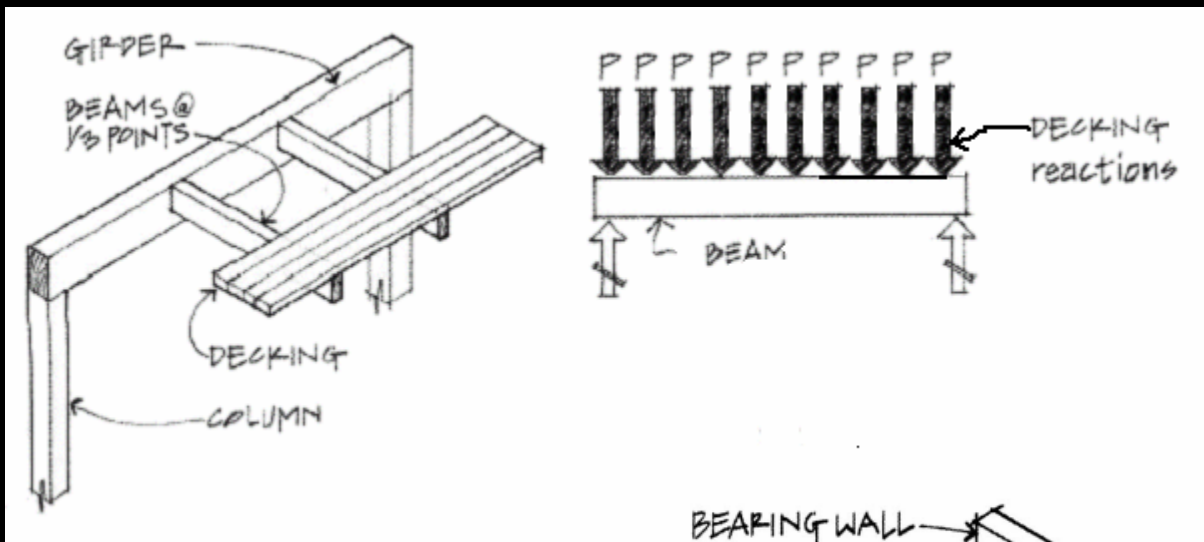
Figure 4.29   Grade beam supporting a bearing wall.

Concentrated Loads

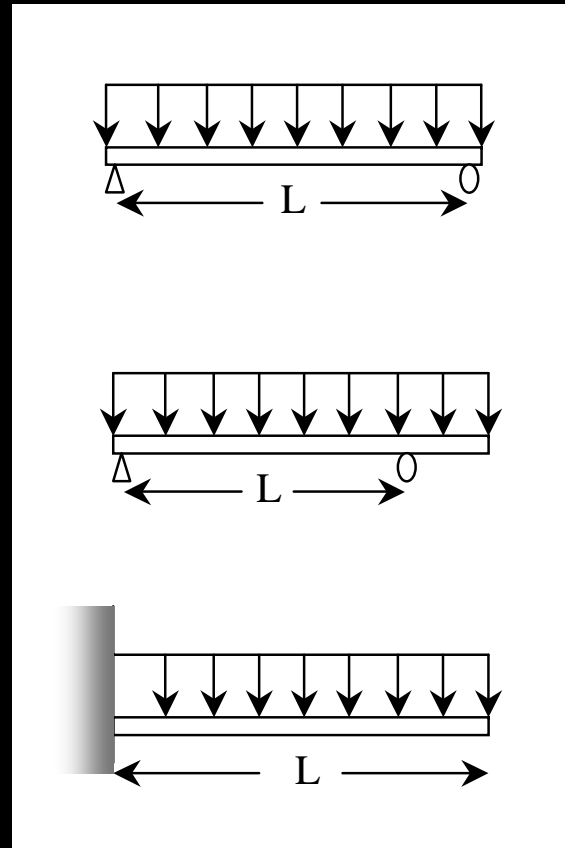# *Distributed Loads*

Distributed Loads

- *statically determinate beam supports*
  - *simple*

  - *overhang*

  - *cantilever*

Distributed Loads

- ## *continuous beams*
  - *– statically indeterminate*
  - *– floors*

effective span

inflection point
(where beam curvature
changes direction)

(a) CONTINUOUS BEAM

effective span

(b) SIMPLE BEAM

actual span

effective span

inflection point
(no moment, no bending)

CONTINUOUS BEAMS (deflection diagram)

actual span

effective span

pinned joints at
inflection points

GERBER BEAMS
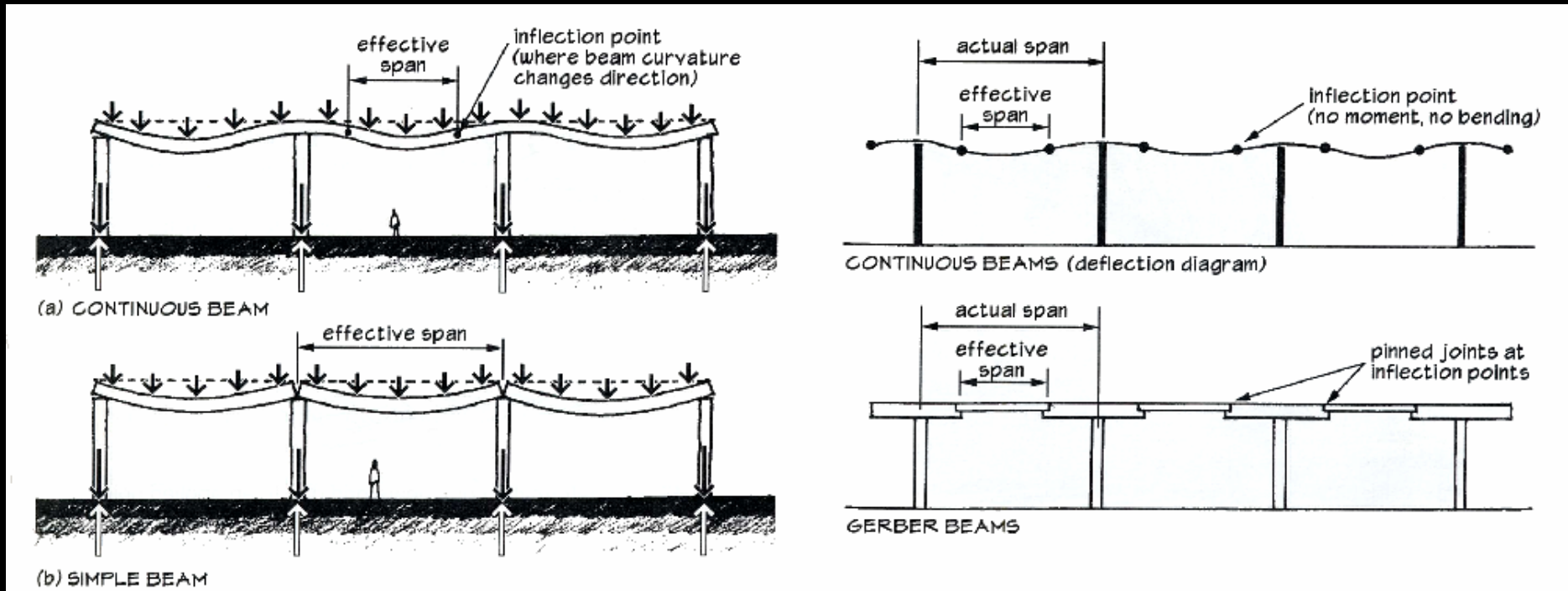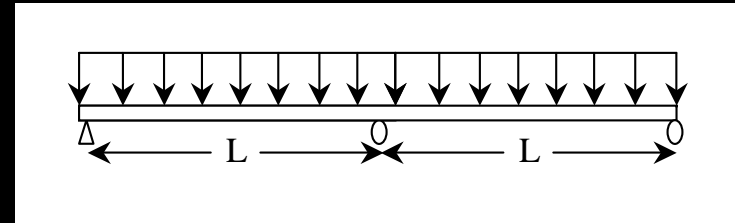
Equivalent Force Systems

- *replace forces by resultant*

- *place resultant where M = 0*

- *using <u>calculus</u> and area centroids*

$$W = \int_0^L wdx = \int dA_{\text{loading}} = A_{\text{loading}}$$
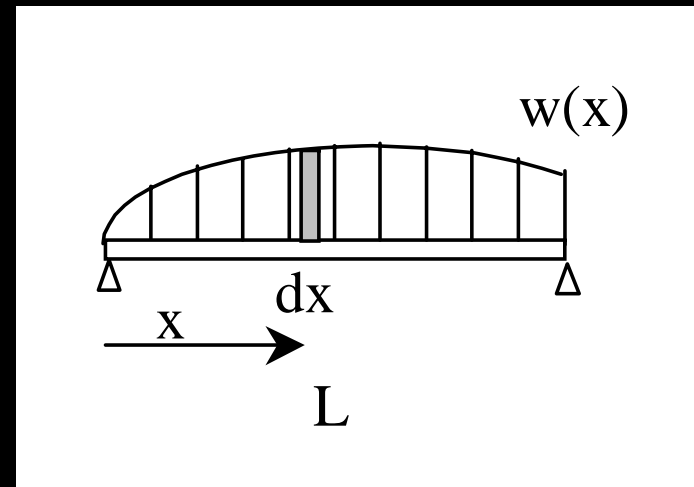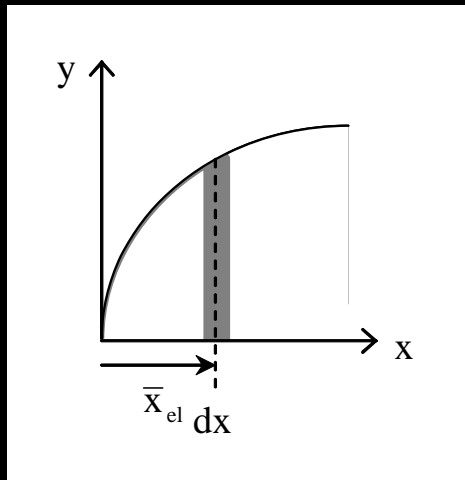
Area Centroids

- ## *Table 7.1 – pg. 242*

Centroids of Common Shapes of Areas and Lines

Shape		$\bar{x}$	$\bar{y}$
Triangular area		$\dfrac{b}{3}$ *right triangle only*	$\dfrac{h}{3}$
Quarter-circular area		$\dfrac{4r}{3\pi}$	$\dfrac{4r}{3\pi}$
Semicircular area		0	$\dfrac{4r}{3\pi}$
Semiparabolic area		$\dfrac{3a}{8}$	$\dfrac{3h}{5}$
Parabolic area		0	$\dfrac{3h}{5}$

Load Areas

- *area is width x "height" of load*
- *w is load per unit length*
- *W is total load*