ARCHITECTURAL STRUCTURES I: 
STATICS AND STRENGTH OF MATERIALS
ENDS 231
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lecture
ten

load tracing
and types
Structural Loads

- gravity acts on mass \((F=m\times g)\)
- 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
Load Tracing

- how loads are transferred
  - usually starts at top
  - distributed by supports as actions
  - distributed by tributary areas

- Snow or roof load for non-snow areas
- Use and occupancy
- Self-weight of structure
- Ground reaction
Load Tracing

Horizontal spanning system

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).

tributary area
Load Tracing

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

\[ w = \left( \frac{\text{load}}{\text{area}} \right) \times \text{(tributary width)} \]
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

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
Concentrated Loads
Distributed Loads
Distributed Loads

- statically determinate beam supports
  - simple
  - overhang
  - cantilever
Distributed Loads

- continuous beams
  - statically indeterminate
  - floors
Equivalent Force Systems

- replace forces by resultant
- place resultant where $M = 0$
- using calculus and area centroids

$$W = \int_0^L w \, dx = \int dA_{\text{loading}} = A_{\text{loading}}$$
# Area Centroids

- **Table 7.1 – pg. 242**

<table>
<thead>
<tr>
<th>Shape</th>
<th>( \bar{x} )</th>
<th>( \bar{y} )</th>
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</thead>
</table>
| Triangular area        | \( \frac{b}{3} \) | \( \frac{h}{3} \)  
|                        | (right triangle only) |
| Quarter-circular area  | \( \frac{4r}{3\pi} \) | \( \frac{4r}{3\pi} \) |
| Semicircular area      | 0             | \( \frac{4r}{3\pi} \) |
| Semiparabolic area     | \( \frac{3a}{8} \) | \( \frac{3h}{5} \) |
| Parabolic area         | 0             | \( \frac{3h}{5} \) |

## Centroids of Common Shapes of Areas and Lines

- **Triangular area**
  - **Shape:** Triangular area
  - **Centroid Coordinates:** \( \bar{x} = \frac{b}{3} \), \( \bar{y} = \frac{h}{3} \)
  - **Note:** Right triangle only

- **Quarter-circular area**
  - **Shape:** Quarter-circular area
  - **Centroid Coordinates:** \( \bar{x} = \frac{4r}{3\pi} \), \( \bar{y} = \frac{4r}{3\pi} \)

- **Semicircular area**
  - **Shape:** Semicircular area
  - **Centroid Coordinates:** \( \bar{x} = 0 \), \( \bar{y} = \frac{4r}{3\pi} \)

- **Semiparabolic area**
  - **Shape:** Semiparabolic area
  - **Centroid Coordinates:** \( \bar{x} = \frac{3a}{8} \), \( \bar{y} = \frac{3h}{5} \)

- **Parabolic area**
  - **Shape:** Parabolic area
  - **Centroid Coordinates:** \( \bar{x} = 0 \), \( \bar{y} = \frac{3h}{5} \)
Load Areas

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

\[ w \cdot x = W \]

\[ \frac{w \cdot x}{2} = \frac{W}{2} \]

\[ \frac{w \cdot x}{6} = \frac{W}{6} \]