"Architecture is inhabited sculpture."

- Constantin Brancusi
Loads and Load Paths

• Structural Design
• Design Loads
  – Dead Load
  – Live Load
  – Snow Load
  – Lateral Loads
• Load Types
• Load Combinations
• Load Path
• Calculating Beam Loads
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<th>Steps in Structural Design</th>
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Design Loads

• The load that is assumed for the design of a structure
• May include one or more of the following:
  – Dead Load
  – Live Load
  – Snow and Ice Load
  – Rain Load
  – Flood Load
  – Wind Load
  – Earthquake Load
  – Earth Pressure Load
Design Loads

Dead Loads (DL) – fixed loads

_The weight of the building components
_The weight of fixed service equipment

Photos courtesy www.constructionphotographs.com
Design Loads

Live Loads (LL) – transient and moving loads

_Loads produced by the use and occupancy of a building_

_Live load may be variable during a structure’s lifetime_

_Specified in building codes_
Design Loads

Snow Load

– Force of accumulated snow on a roof
– Specified in building codes (or local building department)

– Depends on
  • Location
  • Exposure to wind
  • Importance of building
  • Roof slope
Design Loads

Design Snow Load Calculation

\[ p_s = 0.7 C_s C_e C_t I_s p_g \]

- \( p_s \) = Design snow load
- \( C_s \) = Roof slope factor
- \( C_e \) = Exposure factor
- \( C_t \) = Thermal factor
- \( I_s \) = Importance factor
- \( p_g \) = Ground snow load
Design Snow Load

• Find the ground snow load
• For Springfield, CO (red dot) the snow load is 15 psf

Minimum Snow Load

• If $p_g \leq 20\text{ psf}$, then $p_s \geq I_s p_g$
• If $p_g > 20\text{ psf}$, then $p_s \geq I_s \cdot 20\text{ psf}$
Design Loads

Lateral Loads
  – Wind Loads
  – Earthquake Loads
  – Flood Loads
  – Earth Pressure Loads
Wind Load (WL)

- Resulting loads yield:
  - Lateral load on walls
  - Downward and upward pressure on roofs
  - Overturning of the structure

- Specified in building codes
Earthquake Loads (EQ)

- Vertical and lateral forces (dynamic)
- Building codes can simplify loading
Design Loads

Flood Loads

– Lateral forces resulting from static and dynamic water pressure
– Building codes specify that buildings be constructed above the flood elevation or flood-proofed
  • Design requirements dependent on flood zone

BFE (Base Flood Elevation) – The water surface elevation resulting from a flood with a 1% chance of equaling or exceeding that level in any given year

Dry flood-proofing: Building must be designed and constructed to be watertight to floodwaters
Design Loads

Soil Pressure Loads

– Soil adjacent to a structure will apply a lateral force
– Magnitude increases with depth
Load Types

Uniformly Distributed Load

Concentrated Load
Load Combinations

• A building will be subjected to many loads simultaneously
• Codes specify combinations of loads that must be considered in the design
• Examples
  • D + L + (L_r or S or R)
  • D + L + W
  • D + L + S + E/1.4

Where D = Dead load
  L = Live load
  L_r = Roof live load
  W = Wind load
  S = Snow load
  E = Earthquake load
  R = Rain load
Design Loads

• The building dead load is the only known load.
• All other forces will vary in magnitude, duration, and location.
• The building is designed for design load possibilities that may never occur.
Load Path

- The path that a load travels through the structural system
- "Tracing" or "chasing" the loads
- Each structural element must be designed for all loads that pass through it
Load Path

Every load applied to the building will travel through the structural system until it is transferred to the supporting soil.
Structural Elements

• Within the structural systems, individual **structural elements** must work together to carry and transfer the applied loads to the ground.

• Examples of structural elements include:
  - Roof Decking
  - Elevated Slabs
  - Load Bearing Walls
  - Connections
  - Beams
  - Girders
  - Columns
  - Footing
“Load Chasing” for Structural Design

The structural design is performed by “chasing the loads” of the dead and live load from slabs to beams to girders, then on to the columns or walls. The loads are then carried down to the footing or foundation walls and finally to the earth below.
Partial View of 2nd Floor Framing

For clarity the ground floor slab, 2nd floor slab, roof framing, and roof deck are not shown.
Partial 2\textsuperscript{nd} FLOOR FRAMING PLAN

- **Beam**
- **Girder**

**Design Area**
Tributary Area = Beam Span (length) x Tributary Width
Beam Uniform Load = Floor Loading (psf) x Tributary Width (ft)
Tributary Area = Beam Span (length) x Tributary Width

Tributary Area = (18 ft) \times (6.67 \text{ ft}) = 120 \text{ ft}^2
Calculating Beam Loading

Assume that the floor system must support its own weight of 40 psf (dead load) and a live load of 100 psf. What is the uniform load applied to the beam?

Total Floor Load = 40 + 100 = 140 psf

Uniform Load = \( \frac{\text{Total Floor Load}}{\text{Tributary Width}} \)

= \( \frac{140 \text{ psf}}{\text{ft}} \times \text{ft} \)

= 140 \text{ psf/ft}

= 140 \text{ psf/934 plf}
Calculating Girder Loading

Partial 2nd FLOOR FRAMING PLAN

DESIGN AREA

Interior Girder

Beam

Exterior Girder
Calculating Column Loads

Beam

Girder
Calculating Column Loads

Tributary Area = (18 ft)(20 ft) = 360 ft²
Calculating Column Loads

Assume that the floor system must support its own weight of 40 psf (dead load) and a live load of 100 psf. What is the column load for column B3?

Total Floor Load = 40 + 100 = 140 psf

Column Load = Tributary Area \_ Total Floor Load

\[
\text{Column Load} = \frac{(360 \text{ ft})^2(140)}{50,400} \approx 50,400 \text{ lb}
\]
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Partial Roof FLOOR FRAMING PLAN