CEE380
Engineering Structures II
Vertical Loads

Subdivide for a structural system

Beam design

Tributary area for beams

Tributary area: Columns
Progressive Collapse

- Figure 2-8: Progressive Collapse

Use of Different Materials

Post and beam structural evolution

\[\text{Corkill, Puderbaugh and Sawyers, (1965)}\]
Greek temple: classic expression of post & beam

Post and beam in traditional Japanese architecture

Contemporary post & beam construction: flexible layout

Glass facade with minimal column support

Early development of post & beam skyscraper

Skeleton frame
Evolution of skeleton frame

And evolving…

Fordham Spire

Dead Loads

- Given: Dimensions and materials
- Find: Dead Load on Beam
- Solution:
  - Look up materials
  - Multiply by the tributary areas
  - Sum

• Given: Dimensions and materials
• Find: Dead Load on Beam
• Solution:
  - Look up materials
  - Multiply by the tributary areas
  - Sum
Dead Loads

- Example [Coleman]: A floor spandrel (perimeter) beam supports a 4-ft width of 6-in thick concrete slab, the same tributary width of acoustical fiber board ceiling system and a 6 ft height of exterior masonry wall composed of 4-in thick and 8 in concrete block (heavy weight) of 55 psf. Calculate the dead load on the beam.

Solution

- Concrete Slab = 6 in x 12 psf/in x 4 ft = 288 lb/ft
- Ceiling = 1 psf x 4 ft = 4 lb/ft
- Brick wall = 39 psf x 6 ft = 234 lb/ft
- Block wall = 55 psf x 6 ft = 330 lb/ft
- Total Load = 872 lb/ft

Dead Load Example

- Determine the total dead load for an interior column of a three story concrete building with bays of 30 ft by 30 ft. Dead loads are 50 psf for the roof and floors.

Solution

- Tributary area at each level for the interior column is 30 ft by 30 ft = 900 ft²
- The roof load = area x dead load = 900 ft² x 50 psf = 45,000 lbs
- The floor load = area x dead load = 2 floors x 900 ft² x 50 psf = 90,000 lbs
- Total column load = 135,000 lbs

Live Loads

- Definition: Loads "produced by the use and occupancy of the building"
- May be uniform or concentrated
- Non-permanent loads, such as
  - People
  - Furniture
  - Vehicles
  - Minor equipment
Live Load Example

- A hotel is to contain a restaurant on the top floor and a ballroom on the second floor, and all other floors will contain guest rooms and corridors. Determine the live load to be used.

LL Reduction ASCE7-10, p. 15 Chapter 4; Table 4.1 pp. 17-19.

\[ L = L_u \left( 0.25 + \frac{15}{\sqrt{A_{I_1}}} \right) \]

for \( K_{L_1} \cdot A_{I_1} \leq 400 \text{ft}^2 \)

- \( L_u \) = reduced design live load per sq. ft. of area supported by member
- \( K_{L_1} \) = live load element factor (Table 4-2)
- \( A_I = \) tributary area

Solution

- Restaurant = 100 psf
- Ballroom = 100 psf
- Corridors = 100 psf
- Guest rooms = 40 psf
- Guest corridors = 40 psf

Roof Live Loads \( L_r \), Chapter 4, p. 15-16

\[ L_r = 20R_1R_2 \]

where \( R_1 = \begin{cases} 1 & \text{for } A_I \leq 200 \text{ ft}^2 \\ 1.2 - 0.001A_I & \text{for } 200 \text{ ft}^2 < A_I < 600 \text{ ft}^2 \\ 0.6 & \text{for } A_I \geq 600 \text{ ft}^2 \end{cases} \]

\[ R_2 = \begin{cases} 1 & \text{for } F \leq 4 \\ 1.2 - 0.05F & \text{for } 4 < F < 12 \\ 0.6 & \text{for } F \geq 12 \end{cases} \]

\( F = \) number of inches of rise per foot for a sloped roof

Area discussion

- ASCE7 used to distinguish between an influence area \( A_I \) and a tributary area \( A_T \) for live loads -- see the commentary. However, the latest ASCE7 modified the LL equation to include the tributary area only.
- Since some building codes still use the notion of influence area, we will discuss it.
Moving live loads

- How do we estimate the largest stress induced in a bridge or parking garage by moving loads?
- Influence lines
  - Notes will be provided
  - Mostly transportation applications
  - Will delay this discussion

(7.0) Snow Loads p. 29

- Also vertical loadings
- Map of ground snow loads provided pp. 34-35: modified for roof loading
- Slope of roof important
- Drift important

Snow Load Calculations

Flat roof Snow Loads $p_f$

$$p_f \text{[psf]} = 0.7 C_C I_p p_g$$

$C_C$ = Exposure Factor, Table 7 - 2, p. 30;
Exposure Section 26.7, p. 246

$I_p$ = Importance Factor, Table 1.5 - 2, p. 5
### Exposure Factor

<table>
<thead>
<tr>
<th>Exposure Factor</th>
<th>For</th>
<th>Partially Exposed</th>
<th>Sheltered</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eave Factor: E</td>
<td>0.6</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>Roof Factor: R</td>
<td>0.9</td>
<td>1.0</td>
<td>1.1</td>
</tr>
</tbody>
</table>

Table 5.1 Exposure Factor, C

### Thermal Factor

<table>
<thead>
<tr>
<th>Thermal Condition</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sun</td>
<td>1.0</td>
</tr>
<tr>
<td>Sunshine</td>
<td>1.0</td>
</tr>
<tr>
<td>Sheltered</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Table 5.2 Thermal Factor, C

### General

<table>
<thead>
<tr>
<th>General</th>
<th>46</th>
</tr>
</thead>
</table>

### Snow Loads Figure [partial]

![Snow Loads Figure](image)

### Snow Loads Continued

Minimum Snow Load for Low-Slope Roofs, $p_{s}$ (p. 29)

- Monoslope, hip & gable roofs with slopes less than 15 degrees:
  - Where $p_{s} < 20$ psf, $p_{s} = \min\{F, p_{s}\}$
  - Where $p_{s} > 20$ psf, $p_{s} = 20$ psf

Sloped Roof Snow Loads (p. 31)

- $p_{s} = C_{f} p_{f}$

Where $C_{f}$ = Roof Slope Factor Figure 7-2 p. 36

Unbalanced Roof Loads (p. 32)

Rain-on-Snow Surcharge Load: p. 33

This may apply to Puget Sound area.
References

- ASCE7
- *Structural Systems Design*, Coleman [out of print]
- *Army Manual TM 5-809-10*

Summary

- Introduction to ASCE7-10
- Dead and Live Loads
  - Tributary areas--load path
  - Tables for use
  - Effect of moving live loads (cars) determined by influence line procedures
- Snow Loads
- Effect of lateral loads differs from vertical ones.