LESSON 4: GRAVITY LOADS

READ: TEXT, CHAPTER 2

A. TYPES OF LOADS:
- GRAVITY LOADS: (THIS CLASS)
  - DEAD LOADS
    - STRUCTURE AND PERMANENT ATTACHMENTS
    - WELL KNOWN
    - ALWAYS PRESENT
  - LIVE LOADS
    - REMOVABLE LOADS:
      - OCCUPANTS, EQUIPMENT, AND FURNISHINGS
    - VARIABLE
    - ESTIMATED FROM EXPERIENCE, WORST CASE
  - SNOW LOADS
    - SPECIAL ROOF LIVE LOAD
    - VARIES BY REGION
    - ESTIMATED FROM STATISTICS, WORST CASE

(WITHIN REASON)

- LATERAL LOADS: (NEXT CLASS)
  - WIND LOAD
    - VARIES BY REGION
    - ESTIMATED FROM STATISTICS
    - AFFECTS TALL & WIDE STRUCTURES MOST STRONGLY
  - SEISMIC LOADS:
    - VARIES BY REGION
    - ESTIMATED FROM STATISTICS
    - AFFECTS MASSIVE STRUCTURES MOST STRONGLY

* BUILDING CODES TREAT DIFFERENT TYPES OF LOADS DIFFERENTLY

(BUILDING CODES? WHAT ARE THOSE?)

B. USE OF CODES IN STRUCTURAL ENGINEERING:

1. BUILDING CODE
   - WIDELY AGREED UPON STANDARDS FOR CONSTRUCTION OF BUILDINGS ← (ALSO BRIDGE CODES)
   - BASED ON EXPERIENCE, LOGIC, RESEARCH
     → CONSENSUS VIEW OF PRACTITIONERS
   - "CODE" BECAUSE THEY CARRY THE WEIGHT OF LAW

   a.) INTERNATIONAL BUILDING CODE (IBC)
   b.) ASCE 7 - AMERICAN SOCIETY OF CIVIL ENGINEERS, COMMITTEE 7
   - DEFINE, AMONG OTHER THINGS, DESIGN LOADS

2. STRUCTURAL CODES: MATERIAL & STRUCTURE SPECIFIC DESIGN RULES

(DESIGN COURSES)

C. DEAD LOAD:

1. DEFINITION
   - WEIGHT OF STRUCTURE AND PERMANENTLY ATTACHED COMPONENTS
   - EXAMPLES:
     - BEAMS
     - COLUMNS
     - FIREPROOFING
     - SLABS
     - CEILINGS
     - PARTITIONS
     - A/E { LIGHTING; DUCTS; AIR HANDLING EQMT. } HVAC
     - SPRINKLER SYSTEMS
   - STRUCTURE SPECIFIC
     - DEFINED BY BUILDING SYSTEMS SPECIFIED BY
       - ARCHITECT
       - STRUCTURAL ENGINEER
       - ELECTRICAL ENGINEER
       - MECHANICAL ENGINEER
     - SOURCES:
       - MATERIAL PROPERTIES
       - MANUFACTURER DATA
       - BUILDING CODE MINIMUM (ASCE7) (See handout)

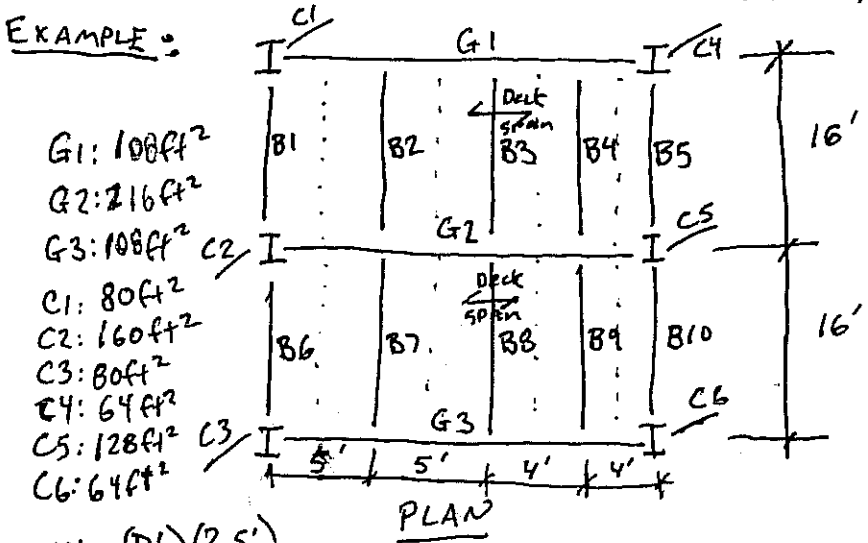
* BUILDING CODE IS A MINIMUM, NEVER A SURROGATE FOR ENGINEERING JUDGEMENT!!!

2. APPLICATION OF DEAD LOAD
   - VERTICALLY ORIENTED AREA LOADS:

$$DL = \frac{\text{FORCE}}{\text{APPLICATION AREA}} \rightarrow \left(\frac{lb}{ft^2}\right) \rightarrow (psf)$$

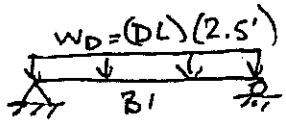
   - TRIBUTARY AREA OF A MEMBER:
     PORTION OF STRUCTURE SUPPORTED BY A MEMBER.

EXAMPLE:



B1: 40 ft²
B2: 80 ft²
B3: 72 ft²
B4: 64 ft²
B5: 32 ft²
B6: 40 ft²
B7: 80 ft²
B8: 72 ft²
B9: 64 ft²
B10: 32 ft²

G1: 108 ft²
G2: 216 ft²
G3: 108 ft²
C1: 80 ft²
C2: 160 ft²
C3: 80 ft²
C4: 64 ft²
C5: 128 ft²
C6: 64 ft²



D, LIVE LOAD:

1. DEFINITION

- WEIGHT OF NON-PERMANENTLY ATTACHED STUFF
- EXAMPLES: PEOPLE
  FURNITURE
  EQUIPMENT
  DOCUMENTS – FILES
  – BOOKSHELVES
  STORAGE

  BRIDGES: PEDESTRIANS, VEHICLES, TRAINS
- DEFINED BY STRUCTURAL USAGE
  - SOURCES:
    - BUILDING CODE MINIMUM (ASCE 7)

      SEE Handout
    - STRUCTURE SPECIFIC, SPECIAL LOAD

2. APPLICATION OF LIVE LOAD:

- VERTICAL AREA LOAD (DOWN)
- TRIBUTARY LOAD
  - LIVE LOAD REDUCTION FACTOR (LLRF)

    See Handout

ALSO SOME CONC. LOAD REQUIREMENTS

FOR MEMBERS CARRYING UNIFORM LIVE LOAD:
SPECIAL PROVISIONS FOR MEMBERS WITH LARGE TRIBUTARY AREA
- GIRDERS,
- COLUMNS (MULTIPLE FLOORS)

* IDEA: UNLIKELY THAT ENTIRE TRIBUTARY AREA WILL BE LOADED WITH MAX. LIVE LOAD AT THE SAME TIME.

ASCE 7, 4.8 : if $K_{LL} A_T \geq 400 ft^2$

$$L = L_o \left(0.25 + \frac{15}{\sqrt{K_{LL} A_T}}\right)$$

"Influence Area"

L = Reduced design live load
L_o = Original, unreduced live load
K_{LL} = Live load element factor
ex. INTERIOR COLUMNS : 4
INTERIOR BEAMS : 2
SLABS : 1

A_T = TRIBUTARY AREA

Restrictions:
$L \geq 0.5 L_o$ (single-floor members)
$L \geq 0.4 L_o$ (multi-floor members)
if $L_o > 100 psf \longrightarrow L = L_o$ (single-floor members)
$L \geq 0.8 L_o$ (multi-floor members)
if $L_o \leq 100 psf$, No reduction in public assembly areas.

E: SNOW LOADS

- ACCUMULATION OF SNOW ON EXPOSED PORTIONS OF THE STRUCTURE (ROOF)

ASCE 7: Sec. 7 $P_s = 0.7 C_s C_e C_t I P_g$

P_g: ground snow load
- Houghton: 80 psf ← !!!
- Detroit: 20 psf

SNOW LOAD MAP IN IBC or ASCE 7

I: Importance factor

Increases factor of safety for heavily occupied or critical structures (15%)

- Typical building (II): $I = 1.0$
- Gathering place (III): $I = 1.1$
- Emergency Center (III): $I = 1.2$
- Storage Facility (I): $I = 0.8$

(#) = occupancy category.

C_t: Thermal factor

Accounts for snow melt due to structure heat

Heated buildings: $C_t = 1.0$
Unheated structures: $C_t = 1.2$

When in doubt, be conservative

C_e: EXPOSURE FACTOR:

Accounts for wind blowing off structure

Windy site: $C_e = 0.7$
Non-windy site: $C_e = 1.0$
Sheltered site: $C_e = 1.3$

C_s: Slope factor

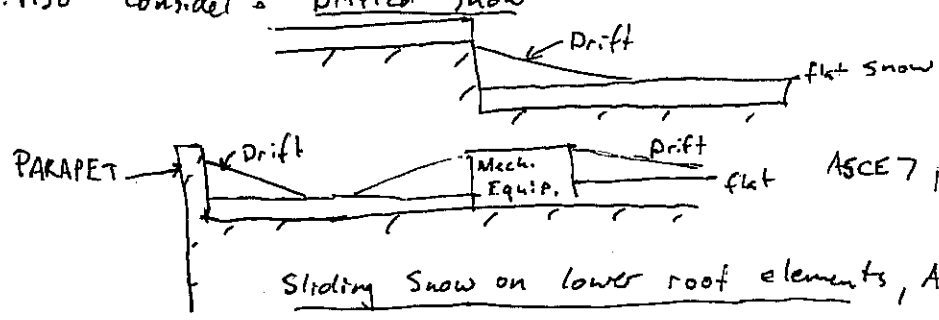
Accounts for snow sliding off pitched roofs

Flat roof: 1.0
Heavily sloped roof: 0

Will not put on H.W. or Exam

also includes some surface roughness accomodations

Also consider: Drifted Snow



ASCE 7, Sec. 7.7 & 7.8

Sliding Snow on lower roof elements, ASCE 7, SEC. 7.9

F. Load Combinations

STATISTICALLY LIKELY, WORST REASONABLE CASE LOADINGS DEFINED BY CODE (ASCE 7)

Common cases*:

1.4 D
1.2 D + 1.6 L + 0.5 S
1.2 D + 1.6 S + L
1.2 D + 1.6 S + 0.8 W
1.2 D + 1.6 W + L + 0.5 S
1.2 D + E + L + 0.2 S
0.9 D + 1.6 W
0.9 D + E

D = Dead Load
L = Live Load
S = Snow Load
W = Wind Load
E = Seismic Load

* Includes safety factors.
* More on this in design course