Lesson Plan General Loads and Snow Loads

TAKE WITH ME:
1) ASCE-7
2) Southern Building Code
3) International Building Code

Overheads:
1) ground snow maps
2) weight of construction materials
3) minimum live loads
4) concentrated loads
5) snow load tables

Handouts:
1) ASCE-7, Southern Building Codes

Objectives:
Learn about dead and live loads.
Start on snow loads.

I. **Design process for structures**.

Typically, the owner of the structure will work with architects, and then eventually engineers.

Sometimes they work directly with engineers.

Initially, they will develop functional and aesthetic requirements for the structure.

1) What will the structure be used for?
2) How big does it have to be?
3) How do we want it to look?

All structures have to meet some minimum requirements. In the case of buildings, we usually have to satisfy the model building codes that are adopted by local municipalities.

From the perspective of the building codes, we generally will do the following:

1) Determine the occupancy classifaction of the building – or – determine vehicle classification, traffic rates, etc. for a bridge
2) Determine physical properties and layout of the building
3) Determine type of construction allowed by code
4) Check occupancy requirements
5) Check construction requirements
6) Review design from the perspective of applicable standards
7) Check other requirements

Our role as the engineer focuses on items 1 and 6 although all of the items affect us.

We will focus on:

1) develop functional requirements for structure
2) develop initial layout and design of structure
3) calculate loads on the structure
4) analyze forces on structure
5) look up allowable stresses from the design specification
6) adjust allowable stresses for conditions of use
7) calculate the minimum <u>safe size of material to use</u>
8) check <u>serviceability</u>
9) finalize design
10) work with contractor – deal with design modifications, change orders
11) what else?????

II. Introduction to Loads.

The selection of design criteria is an exercise of experience, knowledge, and judgement that is the primary responsibility of the designer.

Building codes, agencies, and clients define criteria - but this doesn't absolve the engineer from this duty.

It's your responsibility to use your own judgement and if necessary use more strict requirements than those recommended by the codes, etc.

The primary concerns in this context are Strength - Safety (load) and Serviceability (deflection) criteria.

III. Load Criteria.

A. Load combinations

We generally don't combine all loads at once - because of low probability that all will occur simultaneously.

We calculate these combinations and then use the one that results in the largest member size: see page 5 in ASCE7 for ASD LCs:

D
D + L + F + H + T + (Lr or S or R)
etc

B. Dead Load -

weight of the structure and all permanently affixed equipment, machines and fixtures, either installed initially or anticipated for future installation

See ASCE-7 or SBC for recommendations and weights of materials. **<u>OH</u>**

C. Live Loads.

Live Load - anything other than dead load; includes occupancy loads, impact loads. Doesnt usually include wind, snow, seismic

1. Uniform Loads

Minimum uniformly distributed live loads are shown in Table 2 ASCE7
Be familiar with building codes!!! They might publish ones that are different.

SBC Table 1604.1 has minimum uniform loads

2. Concentrated Loads

In addition to uniform loads, concentrated loads must be considered. See Table 3 ASCE7 for examples. (SBC Table 1604.3)

3. Others - handrails, impact loads, craneways

4. Reduction in Live Loads.

We can reduce uniform live loads for large influence areas (>400 sq ft) because there is a low probability that the full uniform load will be distributed over the entire area (except for places of public assembly ....)

a. Tributary area. - the total area that is assumed to load a structural member

See Sketch

See ASCE7 Section 4.8 or SBC 1604.2

IV. Roof Live Loads

A. Roof Live Loads.

Building codes generally require some minimum live load for roof design

See SBC 1604.6

Example: for low risk agricultural buildings, SBC uses 10 psf

V. Snow loads.

Ground snow loads are shown on the maps. (50 yr recurrence)

2% probability of annual occurrence

We convert ground loads to roof loads by using an equation as shown in ASCE-7

in text:

$$\text{Snow Load on Flat Roof} = p_f = 0.7\ C_e C_t I p_g$$

$$\text{Snow Load on Sloped Roof} = p_s = C_s p_f$$

where: p_f = snow load for flat roof
p_g = ground snow load from maps
C_e = exposure factor for building (wind effects)
C_t = temperature factor for roof (thermal effects)
I = importance factor
p_s = snow load for sloped roof
C_s = slope factor

Low slope roofs (5-15 deg slope)
Sloping roofs (slope > 15 deg)

C_e, exposure factors from Table 7-2

A is for large city centers, 50% of buildings have heights > 70 ft (terrain prevails for at least **2** mile in all directions)

B is for urban and suburban areas, wooded areas, or terrain with numerous closely spaced obstructions the size of single-family dwellings (at least 1500 ft of 10*h in all directions)

C is for open terrain with scattered obstructions having heights generally less than 30 ft; flat open country or grassland

D is for unobstructed areas exposed to wind flowing over open water for at least 1 mile (within 1500 feet of shoreline)

Note the different categories of roof exposures: Fully exposed, Partially exposed, Sheltered)

C_t is a thermal factor from 7-3

for heated structure	(1.0)
for structure just above freezing	(1.1)
for unheated structure	(1.2)

I is importance factor from Table 7-4

Cat. I	0.8	(low hazard bldg, ag. bldgs.)
Cat II	1.0	(everything except what's listed below)
Cat. III	1.1	(more than 300 people may congregate)
Cat. IV	1.2	(essential facilties - hospitals, fire stations, police stations, power stations, etc.)

C_s is Slope Factor from Figure 7-2

For warm roofs with unobstructed slippery surfaces, Cs from dashed line in Fig. 7-2a

For other warm roofs that aren't slippery, use solid line in Fig. 7-2a

For cold roofs with slippery surface, use dashed line in Fig. 7-2b

For cold roofs not slippery, use solid line in Fig. 7-2b

See notes on curved roofs (over 70 deg., assume no snow load) use angle from eave to peak

Multiple Folded, Sawtooth, Barrel Vault - assumed to be flat (no reduction)

We also account for unbalanced snow loads

We also account for Drifts on lower roofs

We also account for roof projections which can cause drifts.

We also account for sliding snow (falling on lower roofs).

Pay particular attention to rain on snow!!!

Pay attention to ponding loads.

EXAMPLE:

Given:

Fire station near Muscle Shoals, Alabama.

Fire station has flat, standing seam metal roof. Station is located in dense conifer forest in an urban area. Station has a well insulated roof. There are no other obstructions on the roof or higher roofs around the building.

Find: Design snow load if roof is a) almost flat and b) sloped with 4:12 slope

Solution:

a) flat roof

Ground snow load in Muscle Shoals = 10 psf (From ASCE7, Figure 7-1)

Exposure Factor, Ce = 1.2 (Exposure B, sheltered)

Importance Factor, I = 1.2 for essential building, Category IV (from Table 7-4)

Thermal factor, Ct = 1.0 (or you could use 1.2 to be very conservative)

pf = 10 psf * 1.2 * 1.2 * 1.0 = 14.4 psf

b) 4:12 roof slope

Assume roof is cold (well insulated) and slippery.

Cs = 0.95 from Figure 7-2b.

ps = 0.95 * pf = 13.7 psf

So, the balanced snow load on the roof is 13.7 psf.

What about unbalanced snow load?