Loading

SPECIFICATIONS

Cities in the U.S. generally base their building code on one of the three model codes:

– Uniform Building Code

– Basic Building Code (BOCA)

– Standard Building Code

Loading

These codes have been consolidated in the 2000 International Building Code.

Loadings in these codes are mainly based on ASCE Minimum Design Loads for Buildings and Other Structures (ASCE 7-95) – has been updated to ASCE 7-98.

Dead Loading

- Weight of all permanent construction
- Constant magnitude and fixed location

Examples: **Dead Load**

- Weight of the Structure
  (Walls, Floors, Roofs, Ceilings, Stairways)
- Fixed Service Equipment
  (HVAC, Piping Weights, Cable Tray, Etc.)

Can Be Uncertain…

- pavement thickness
- earth fill over underground structure

Live Load

- Loads produced by use and occupancy of the structure.
- Maximum loads likely to be produced by the intended use.
- Not less than the minimum uniformly distributed load given by Code.

Live Load

See Table 2-1 from ASCE 7-95

Stairs and exitways:	100 psf
Storage warehouses:	125 psf (light)
	250 psf (heavy)

Minimum concentrated loads are also given in the codes.

Live Loads

TABLE 2–1 Typical Live Loads Specified in ASCE 7–95

Apartment buildings	
Residential areas and corridors serving them	40 psf
Public rooms and corridors serving them	100 psf
Office buildings	
Lobbies and first-floor corridors	100 psf
Offices	50 psf
Corridors above first floor	80 psf
File and computer rooms shall be designed for heavier loads based on anticipated occupancy	
Schools	
Classrooms	40 psf
Corridors above first floor	80 psf
First-floor corridors	100 psf
Stairs and exitways	100 psf
Storage warehouses	
Light	125 psf
Heavy	250 psf
Stores	
Retail	
Ground floor	100 psf
Upper floors	75 psf
Wholesale, all floors	125 psf

Source: Based on *Minimum Design Loads for Buildings and Other Structures*, ASCE Standard ASCE 7–95, with the permission of the publisher, the American Society of Civil Engineers.

Live Load

ASCE 7-95 allows reduced live loads for members with influence area (A_I) of 400 sq. ft. or more:

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

where L_o $\geq 0.50\ L_o$ for members supporting one floor

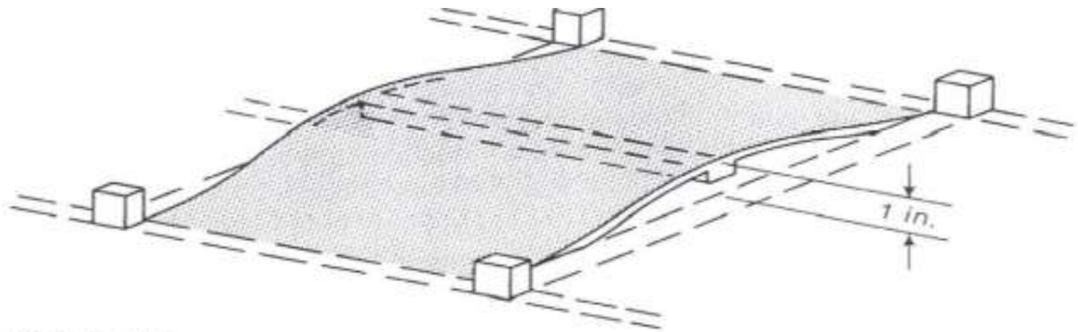
$\geq 0.40\ L_o$ otherwise

Live Loads

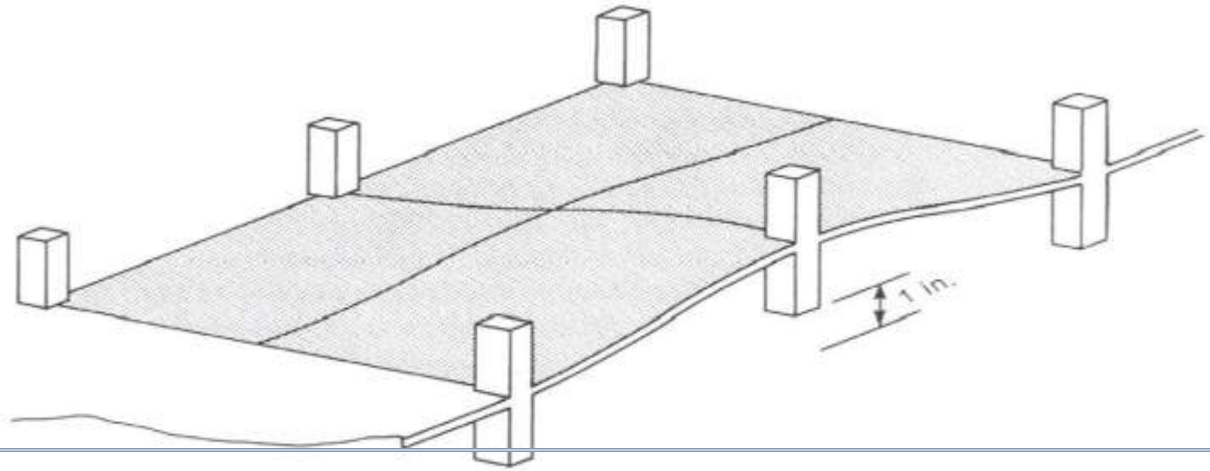
A_I determined by raising member to be designed by a unit amount. Portion of loaded area that is raised = A_I

Beam:	$A_I = 2$ * tributary area
Column:	$A_I = 4$ * tributary area
Two-Way Slab:	A_I = panel area (see Fig. 2-10, text)

Load Reduction



(a) Interior floor beam.



(b) Edge column.

Environmental Load

- Snow Loads
- Earthquake
- Wind
- Soil Pressure
- Ponding of Rainwater
- Temperature Differentials

Classification of Buildings for Wind, Snow and Earthquake Loads

Based on Use Categories (I through IV)

I Buildings and other structures that represent a low hazard to human life in the event of a failure (such as agricultural facilities)

II Buildings/structures not in categories I, III, and IV

Classification of Buildings for Wind, Snow and Earthquake Loads

Based on Use Categories (I through IV)

III Buildings/structures that represent a substantial hazard to human life in the event of a failure (assembly halls, schools, colleges, jails, buildings containing toxic/explosive substances)

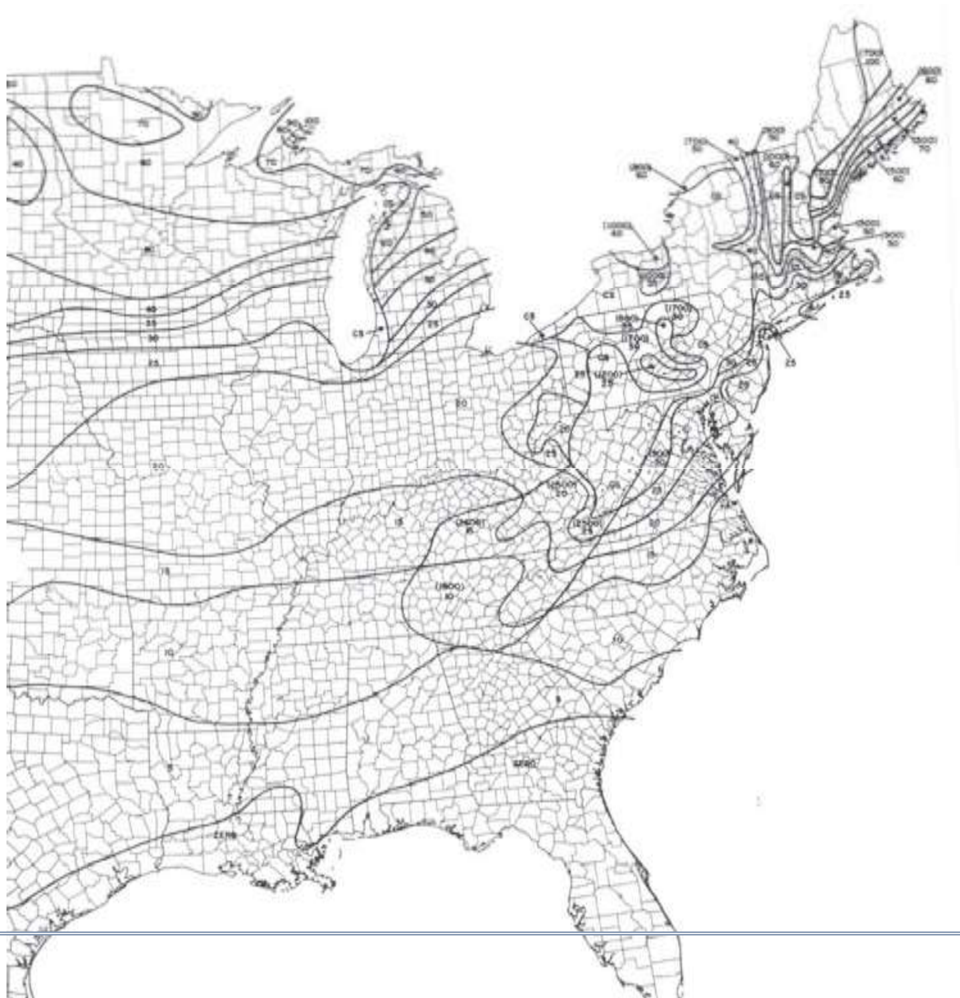
Classification of Buildings for Wind, Snow and Earthquake Loads

Based on Use Categories (I through IV)

IV Buildings/structures designated essential facilities (hospitals, fire and police stations, communication centers, power-generating stations)

Snow Load

The coefficients of snow loads are defined in weight.



Snow Load

Ground Snow Loads (Map in Fig. 6, ASCE 7):

- Based on historical data (not always the maximum values)
- Basic equation in codes is for flat roof snow loads
- Additional equations for drifting effects, sloped roofs, etc.
- Use ACI live load factor
- No LL reduction factor allowed

Wind Load

- Wind pressure is proportional to velocity squared (v^2)

- Wind velocity pressure = q_z

$$q_z = 0.00256\, K_z\, k_{zt}\, V^2\, I$$

Wind Load

$$q_z = 0.00256\, K_z\ k_{zt}\ V^2\ I$$

where

0.00256 reflects mass density of air and unit conversions.

V = Basic 3-second gust wind speed (mph) at a height of 33 ft. above the ground in open terrain. (1:50 chance of exceedance in 1 year)

K_z = Exposure coefficient (bldg. ht., roughness of terrain)

k_{zt} = Coefficient accounting for wind speed up over hills

I = Importance factor

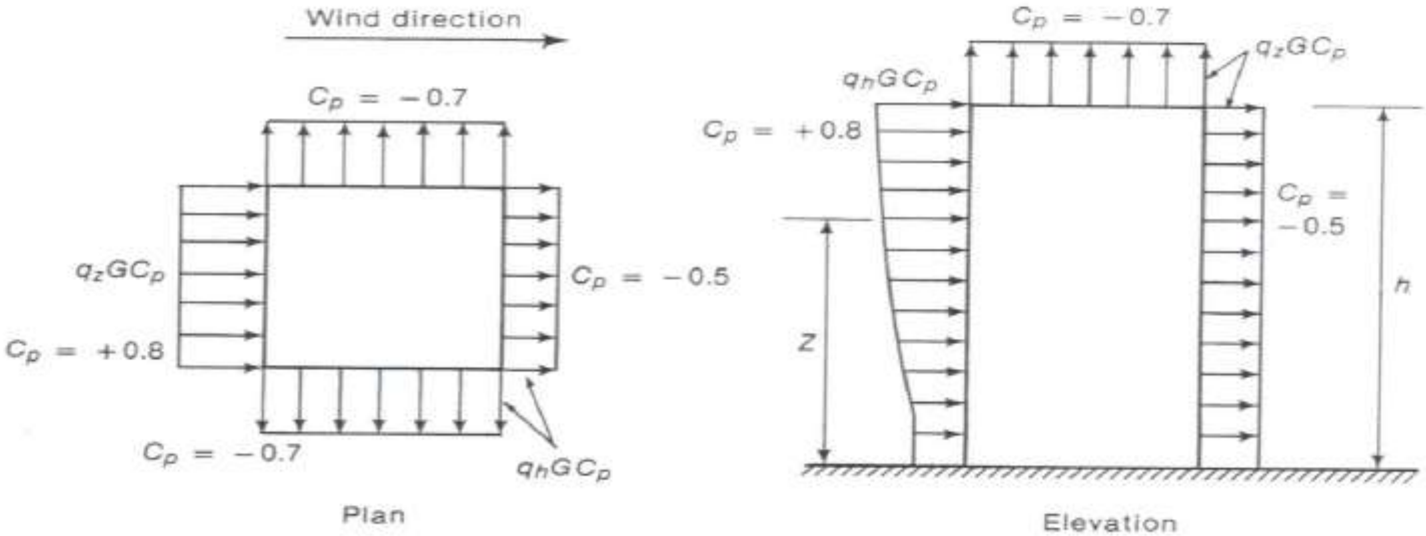
Wind Load

Design wind pressure,

$$p = q_z * G * C_p$$

G = Gust Response Factor

C_p = External pressure coefficients (accounts for pressure directions on building)


Wind direction
Cp = −0.7
qzGCp
Cp = +0.8
Cp = −0.5
Cp = −0.7
qhGCp
Plan
Cp = −0.7
qzGCp
qhGCp
Cp = +0.8
Cp =
−0.5
z
h
Elevation

Earthquake Load

Inertia forces caused by earthquake motion

$$F = m * a$$

- Distribution of forces can be found using equivalent static force procedure (code, not allowed for every building) or using dynamic analysis procedures

Earthquake Load

Inertia forces caused by earthquake motion. Equivalent Static Force Procedure for example, in ASCE 7-95:

$$V = C_s * W$$

where

$V =$ Total lateral base shear

$C_s =$ Seismic response coefficient

$W =$ Total dead load

Earthquake Load

Total Dead Load, W:

1.0 * Dead Load

+ 0.25 * Storage Loads

+ larger of partition loads or 10 psf

+ Weight of permanent equipment

+ contents of vessels

+ 20% or more of snow load

Earthquake Loads

$$C_s = smaller\ of \left\{ \frac{1.2\, C_v}{R\, T^{2/3}} \right. \ and\ \frac{2.5\, C_a}{R}$$

where

C_v = Seismic coefficient based on soil profile and A_v

C_a = Seismic coefficient based on soil profiled and A_a

R = Response modification factor (ability to deform in inelastic range)

T = Fundamental period of the structure

Earthquake Loads

$$C_s = \text{smaller of } \left\{ \frac{1.2\,C_v}{R\,T^{2/3}} \text{ and } \frac{2.5\,C_a}{R} \right.$$

where

T = Fundamental period of the structure

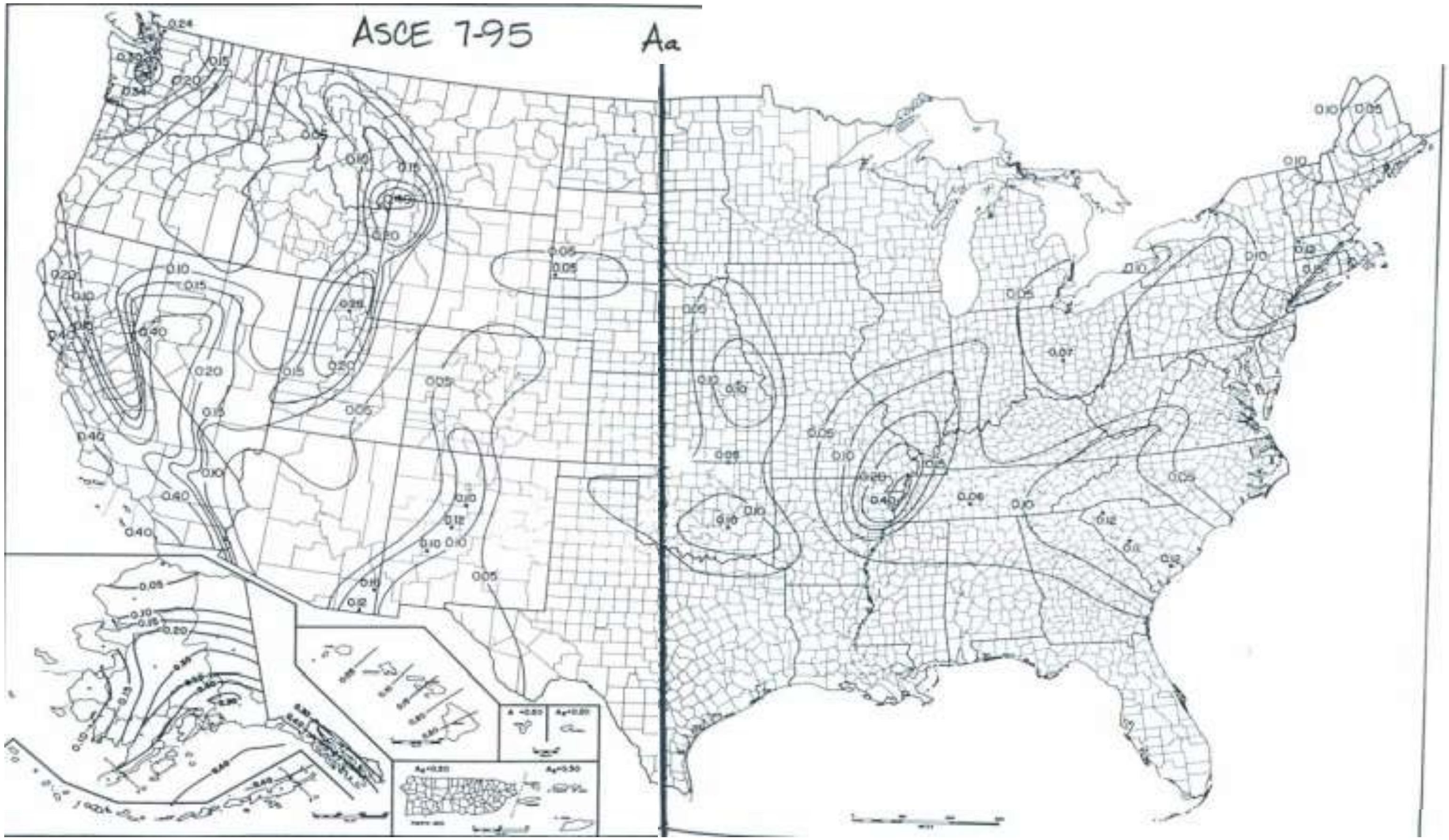
$$T = C_T\, h_n^{\ 3/4}$$

where C_T = 0.030 for MRF of concrete

0.020 for other concrete buildings.

h_n = Building height

Earthquake Map



Roof Load

- Ponding of rainwater
  - Roof must be able to support all rainwater that could accumulate in an area if primary drains were blocked.
  - Ponding Failure:
    - → Rain water ponds in area of maximum deflection
    - → increases deflection
    - → allows more accumulation of water → cycle continues…→ potential failure

Roof Load

- Roof loads are in addition to snow loads
- Minimum loads for workers and construction materials during erection and repair

Construction Loads

- Construction materials
- Weight of formwork supporting weight of fresh concrete