A. DESIGN REFERENCES:


ASCE 7-10 - Minimum Design Loads for Buildings and Other Structures


Building Code Requirements for Reinforced Concrete (ACI 318-08), American Concrete Institute.

Building Code Requirements for Masonry Structures (ACI 530-08) and Specifications for Masonry Structures (ACI 530.1-08), American Concrete Institute

ASTM Standards, American Society for Testing and Materials


SDI Specifications and Commentaries for Non-Composite Steel Form Deck and Steel Roof Deck, Steel Deck Institute

B. DESIGN LOADS:

All portions of the structure shall be designed in accordance with the following:

VERTICAL LOADS

**ROOF**

*Dead Loads: (estimated before design, verified after)*
*(Self-weight and weights of supported equip & building materials)*

Typical roof: Single ply membrane attached with
allowance for built-up roof = 5 psf
Insulation = 5 psf
Deck = 2 psf
Framing (estimate) = 6 psf
Mech. & Elect. (HVAC & lights) = 5 psf
Misc. Hanging (ceiling & sprk) = 5 psf

Total DL = 28 psf

*Live Loads: (variable – location and magnitude)*

Live Load (non-reduced) LL = 20 psf
## ELEVATED FLOOR SLABS

**Dead Loads:** *(estimated before design, verified after)*  
*(Self-weight and weights of supported equip & building materials)*  
- 3" NWT Concrete on Form Deck = 36 psf  
- Framing (estimate) = 10 psf  
- Mech. & Elect. (HVAC & lights) = 5 psf  
- Misc. Hanging (Sprinklers, Ceiling etc.) = 5 psf  
- **Floor DL** = 56 psf

**Live Loads:**  
*(Floor LL based on Occupancy)*  
- Office Areas = 50 psf  
- Public Rooms and Lobbies = 100 psf  
- Equipment and Mechanical Areas = 150 psf

## SLAB-ON-GRADE

**Live Loads:** *(Industrial Floor)*  
- Uniform Live Load = 500 psf  
- Actual Wheel Loads for a Forklift capable of carrying 2 (two) 2,000 pound pallets  
- Concentrated Rack Storage post loads  
  (see Rack Layout)

## ENVIRONMENTAL LOADS *(based on location) (usually lateral)*

**Snow Loads:**  
- Ground Snow Load = 10 psf  
- Ce = 1.0 Exposure Factor (Exposure C, Partially Exposed)  
- Ct = 1.0 Thermal Factor  
- I = 1.2 Importance Factor

**Wind:**  
Per International Building Code  
- Basic Wind Speed, V = 90 mph  
- Use Factor, I (Essential Facility) = 1.15

**Seismic:**  
- $S_s = 0.409$  
- $S_1 = 0.139$  
- Site Class = D  
- Seismic Use Group = I  
- Seismic Design Category = D  
- Response Modification Coefficient, R = 5 (both directions)

*(Other Loads :)*  
*(Traffic, Impact, Longitudinal, Soil, Thermal, Fluid, Blast……...)*
Design Philosophies

“Limit States” Design Philosophy

**Strength**  \( \rightarrow \)  **Serviceability**

**Strength** – Safety Related – (Flexural, Axial strength, Buckling, Fatigue, Fracture, Yielding) Focus of AISC specification

**Serviceability** – Performance – (Concerns use & occupancy, deflection, vibration, cracking, deterioration)

**Allowable Strength Design (ASD)**

Members are sized to support Service (Unfactored) loads based on Allowable strength

Typical:

\[
R_a \leq \frac{R_n}{\Omega}
\]

Where:

- \( R_a \) = Allowable Strength
- \( R_n \) = Nominal Strength according to Specification provision
- \( \Omega \) = Factor of Safety given by Specification,
  Typical range – 1.50 to 2.00

**Examples:**

Nominal moment strength

\[
M_a \leq \frac{M_n}{\Omega}
\]

F.O.S. = 1.67 (bending)

Actual Moment (Unfactored)

Nominal axial compressive strength

\[
P_a \leq \frac{P_n}{\Omega}
\]

F.O.S. = 1.67 (compression)

Actual Axial Force (Unfactored)
Allowable Strength

\[ \sum R_i = R_a \leq \frac{R_n}{\Omega} \]

Required Strength determined from ASD Load Combinations

**Load Combination Equations**

\( D = \) dead load  
\( L = \) live load due to occupancy  
\( L_r = \) roof live load  
\( S = \) snow load  
\( R = \) rain load exclusive of the ponding contribution  
\( W = \) wind load  
\( E = \) earthquake load

**ASD Equations**

1. \( D \)
2. \( D + L \) (floor)
3. \( D + (L_r \ or \ S \ or \ R) \) (roof)
4. \( D + 0.75L + 0.75(L_r \ or \ S \ or \ R) \) (column)
5. \( D + (0.6W \ or \ 0.7E) \)
6a. \( D + 0.75L + 0.75(0.6W) + 0.75(L_r \ or \ S \ or \ R) \)
6b. \( D + 0.75L + 0.75(0.7E) + 0.75(S) \)
7. \( 0.6D + 0.6W \)
8. \( 0.6D + 0.7E \)

**Note 1.** 0.6\( W \) and 0.7\( E \) reduction of wind and earthquake force which is already factored or ultimate

**Note 2.** 0.75 in equations 4. and 6. – Combination of time-variable loads (0.75 not taken on dead load)

Ref:  
ASCE 7-10 – p. 8  
Steel Manual-14th ed – p. 2-11  
Text – p. 57
Load & Resistance Factor Design (LRFD)
Members are sized to support Factored loads based on Reduced Material strength

Typical: \[ \frac{R}{u} \leq \phi \frac{R}{n} \]
Nominal strength

\[ \sum \lambda_i Q_i \leq \phi \frac{R}{n} \]
“Load” factor, typ. > 1.0  “Resistance” factor, typ. < 1.0
Working (service) load

\( \phi \): Accounts for uncertainties in material strength, dimensions, workmanship (fabrication/erection stresses), residual stresses (uneven cooling), also, the consequence of failure.

\( \lambda_i \): Accounts for uncertainties in estimating magnitude \((D = 1.2, L = 1.6)\) Dead estimate more accurate the live load estimate.

Environmental loads – Act of God/Nature, difficult to predict Earthquake and Wind (already ultimate/factored load), \(W = E = 1.0\) (formerly 1.6)

**LRFD Equations**

1. \(1.4D\) (only dead load)
2. \(1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)\) (floor/column)
3. \(1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (L^* \text{ or } 0.5W)\) (roof/column)
4. \(1.2D + 1.0W + L^* + 0.5(L_r \text{ or } S \text{ or } R)\) (column/roof)
5. \(1.2D + 1.0E + L^* + 0.2S\)
6. \(0.9D + 1.0W\)
7. \(0.9D + 1.0E\)

Ref: ASCE 7-10 – p. 7
Steel Manual-14th ed – p. 2-10
Text – p. 53

* The load factor on \(L\) in combinations (3.), (4.), and (5.) is taken as 1.0 for floors in places of public assembly, for live loads in excess of 100 psf and for parking garage live load. The live factor is permitted to equal 0.5 for other live loads.

Downward load (gravity) ↓ is positive (+). Load combinations 1. through 5. account for the maximum gravity load.

Upward load (uplift) ↑ is negative (-). Load combinations 6. and 7. are used to account for the possibilities of uplift.
Example #1 (Example 2-1, p. 55, text)

W24x55 @ 8’-0”

\[ D = 50 \text{ psf (not including self-weight)} \]

\[ L = 80 \text{ psf} \]

Find Governing Load, lbs / ft or plf

\[ D = 55 \text{ plf} + (50 \text{ psf}) 8 \text{ ft} = 455 \text{ plf} \]

\[ L = (80 \text{ psf}) 8 \text{ ft} = 640 \text{ plf} \]

1. \[ U = 1.4 \left( \frac{D}{D} \right) = 1.4 \left( \frac{455}{D} \right) = \frac{637}{D} \text{ plf} \]

2. \[ U = 1.2 \left( D \right) + 1.6 \left( L \right) + 0.5 \left( L_r \text{ or } S \text{ or } R \right) = \]

\[ 1.2 \left( 455 \right) + 1.6 \left( 640 \right) + 0.5 \left( 0 \right) = \frac{1570}{D} \text{ plf} \]

– controls

Example #2

\[ D = 20 \text{ psf} \]

\[ S = 30 \text{ psf} \]

\[ W = 32 \text{ psf (assume suction – upward only)} \]

Determine U:

1. \[ U = 1.4 \left( D \right) = 1.4 \left( 20 \right) = \frac{28}{D} \text{ psf} \]

2. \[ U = 1.2 \left( D \right) + 1.6 \left( L \right) + 0.5 \left( L_r \text{ or } S \text{ or } R \right) = \]

\[ 1.2 \left( 20 \right) + 1.6 \left( 0 \right) + 0.5 \left( 30 \right) = \frac{39}{D} \text{ psf} \]

3. \[ U = 1.2 \left( D \right) + 1.6 \left( L_r \text{ or } S \text{ or } R \right) + (0.5 L \text{ or } 0.5 W) = \]

\[ 1.2 \left( 20 \right) + 1.6 \left( 30 \right) + 0.5 \left( -32 \right) = \frac{56}{D} \text{ psf} \]

or \[ 1.2 \left( 20 \right) + 1.6 \left( 30 \right) = \frac{72}{D} \text{ psf} \]

4. \[ U = 1.2 \left( D \right) + 1.0 \left( W \right) + 0.5 \left( L \text{ or } 0.5 \left( L_r \text{ or } S \text{ or } R \right) = \right) \]

\[ 1.2 \left( 20 \right) + 1.0 \left( -32 \right) + 0.5 \left( 0 \right) + 0.5 \left( 30 \right) = \frac{7}{D} \text{ psf} \]

or \[ 1.2 \left( 20 \right) + 0.5 \left( 30 \right) = \frac{39}{D} \text{ psf} \]

5. \[ U = 1.2 \left( D \right) + 1.0 \left( E \right) + 0.5 \left( L \right) + 0.2 \left( S \right) = \]

\[ 1.2 \left( 20 \right) + 1.0 \left( 0 \right) + 0.5 \left( 0 \right) + 0.2 \left( 30 \right) = \frac{30}{D} \text{ psf} \]

6. \[ U = 0.9 \left( D \right) + 1.0 \left( W \right) = \]

\[ 0.9 \left( 20 \right) + 1.0 \left( -32 \right) = \frac{-14}{D} \text{ psf} \]

7. \[ U = 0.9 \left( D \right) + 1.0 \left( E \right) = \]

\[ 0.9 \left( 20 \right) + 1.0 \left( 0 \right) = \frac{18}{D} \text{ psf} \]

The roof should be designed for:

\[ 72 \text{ psf (downward)} \]

\[ 3. \left( 1.2D + 1.6S \right) \]

\[ -14 \text{ psf (upward)} \]

\[ 6. \left( 0.9D + 1.0W \right) \]