ASCE-7-10

2.3 COMBINING FACTORED LOADS USING STRENGTH DESIGN

2.3.1 Applicability

The load combinations and load factors given in Section 2.3.2 shall be used only in those cases in which they are specifically authorized by the applicable material design standard.

2.3.2 Basic Combinations

Structures, components, and foundations shall be designed so that their design strength equals or exceeds the effects of the factored loads in the following combinations:

1. $1.4D$
2. $1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$
3. $1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (L \text{ or } 0.5W)$
4. $1.2D + 1.0W + L + 0.5(L_r \text{ or } S \text{ or } R)$

R: rain Loads
S: snow Loads

D: Dead Loads, Moments or Reactions

L: Live Loads, Moments or Reactions

Lr: roof Load

W: Wind Load

Load at Its Lifetime Maximum
D (during construction; other loads not present)
L
L_r or S or R (a roof load)
W (acting in the direction of D)

5. $1.2D + 1.0E + L + 0.2S$
6. $0.9D + 1.0W$
7. $0.9D + 1.0E$

E acting in the direction of D
W → acting
E → acting ✓ in the direction of D

Note that *D*, *L*, *W*, *S*, etc. are loads in a general sense, which includes bending moment, shear, axial force, and torsional moment. Sometimes these internal forces are called *load effects*. Thus, the symbol *D* means dead load, dead load moment, dead load shear, dead load axial force, etc. An explanation of the statistics relating to snow and wind load factors is given by Ravindra, Cornell, and Galambos [1.32]. The factors for earthquake *E* are reduced from 1.5 in the 1986 LRFD Specification to 1.0 in the 1993 Specification. This

Section B2 of the AISC Specification says to use the load factors and load combinations prescribed by the governing building code. If the building code does not give them, then ASCE 7 (ASCE, 2010) should be used. The load factors and load combinations in this standard are based on extensive statistical studies and are prescribed by most building codes.

AISC Page -2-10

ASCE - 2010

2.3.2 Basic Combinations

Structures, components, and foundations shall be designed so that their design strength equals or exceeds the effects of the factored loads in the following combinations:

1. $1.4D$
2. $1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$
3. $1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (L \text{ or } 0.5W)$
4. $1.2D + 1.0W + L + 0.5(L_r \text{ or } S \text{ or } R)$

Load and Resistance Factor Design

For LRFD, the required strength is determined from the following factored combinations,[1] which are based on ASCE/SEI 7 Section 2.3:

1. $1.4D$ (2-3a)
2. $1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$ (2-3b)
3. $1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (0.5L \text{ or } 0.5W)$ (2-3c)
4. $1.2D + 1.0W + 0.5L + 0.5(L_r \text{ or } S \text{ or } R)$ (2-3d)

ASCE - 2010

Combination 5: $1.2D + 1.0E + L + 0.2S$
Combination 6: $0.9D + 1.0W$
Combination 7: $0.9D + 1.0E$

where

D = dead load
L = live load due to occupancy
L_r = roof live load
S = snow load
R = rain or ice load*
W = wind load
E = earthquake (seismic load)

AISC Page 2-11

5. $1.2D + 1.0E + 0.5L + 0.2S$
6. $0.9D + 1.0W$
7. $0.9D + 1.0E$

Manual - 14

if $L \not> 100$ psf

In combinations 3, 4, and 5, the load factor on L can be reduced to 0.5 if L is no greater than 100 pounds per square foot, except for garages or places of public assembly. In combinations with wind or earthquake loads, you should use a direction that produces the worst effects.

ASCE - 2010

EXCEPTIONS:

1. The load factor on L in combinations 3, 4, and 5 is permitted to equal 0.5 for all occupancies in which L_o in Table 4-1 is less than or equal to 100 psf, with the exception of garages or areas occupied as places of public assembly.
2. In combinations 2, 4, and 5, the companion load S shall be taken as either the flat roof snow load (p_f) or the sloped roof snow load (p_s).

Where fluid loads F are present, they shall be included with the same load factor as dead load D in combinations 1 through 5 and 7.

Where load H are present, they shall be included as follows:

1. where the effect of H adds to the primary variable load effect, include H with a load factor of 1.6;
2. where the effect of H resists the primary variable load effect, include H with a load factor of 0.9 where the load is permanent or a load factor of 0 for all other conditions.

L : Live Load

S : Snow Load

F : Fluid Load

H : Earth Load

ASCE - 2010

2.4 COMBINING NOMINAL LOADS USING ALLOWABLE STRESS DESIGN

2.4.1 Basic Combinations

Loads listed herein shall be considered to act in the following combinations; whichever produces the most unfavorable effect in the building, foundation, or structural member being considered. Effects of one or more loads not acting shall be considered.

1. D
2. $D + L$
3. $D + (L_r \text{ or } S \text{ or } R)$
4. $D + 0.75L + 0.75(L_r \text{ or } S \text{ or } R)$
5. $D + (0.6W \text{ or } 0.7E)$

6a. $D + 0.75L + 0.75(0.6W) + 0.75(L_r \text{ or } S \text{ or } R)$

6b. $D + 0.75L + 0.75(0.7E) + 0.75S$

7. $0.6D + 0.6W$
8. $0.6D + 0.7E$

AISC Chapter 2 - 11

ASD

Allowable Strength Design

For ASD, the required strength is determined from the following combinations, which are also based on ASCE/SEI 7 Section 2.4:

1.	D	(2-4a)
2.	$D + L$	(2-4b)
3.	$D + (L_r \text{ or } S \text{ or } R)$	(2-4c)
4.	$D + 0.75L + 0.75(L_r \text{ or } S \text{ or } R)$	(2-4d)
5.	$D + (0.6W \text{ or } 0.7E)$	(2-4e)
6a.	$D + 0.75L + 0.75(0.6W) + 0.75(L_r \text{ or } S \text{ or } R)$	(2-4f)
6b.	$D + 0.75L + 0.75(0.7E) + 0.75S$	(2-4g)
7.	$0.6D + 0.6W$	(2-4h)
8.	$0.6D + 0.7E$	(2-4i)

ASCE - 10

Load Combinations For allowable stress method

EXCEPTIONS:

1. In combinations 4 and 6, the companion load S shall be taken as either the flat roof snow load (p_f) or the sloped roof snow load (p_s).
2. For nonbuilding structures, in which the wind load is determined from force coefficients, C_f, identified in Figures 29.5-1, 29.5-2 and 29.5-3 and the projected area contributing wind force to a foundation element exceeds 1,000 square feet on either a vertical or a horizontal plane, it shall be permitted to replace W with $0.9W$ in combination 7 for design of the foundation, excluding anchorage of the structure to the foundation.
3. It shall be permitted to replace $0.6D$ with $0.9D$ in combination 8 for the design of Special Reinforced Masonry Shear Walls, where the walls satisfy the requirement of Section 14.4.2.

Steel Design

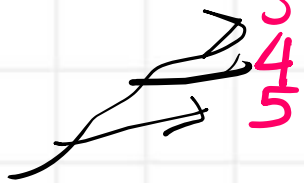
A column (compression member) in the upper story of a building is subject to the following loads:

Dead load:	109 kips compression
Floor live load:	46 kips compression
Roof live load:	19 kips compression
Snow:	20 kips compression

a. Determine the controlling load combination for LRFD and the corresponding factored load.

SEGUI 5ths

Cases 3, 4, 5



Use (0.5L) → L.L

Based on AISC

Load and Resistance Factor Design

For LRFD, the required strength is determined from the following factored combinations,[1] which are based on ASCE/SEI 7 Section 2.3:

1. $1.4D$ (2-3a)
2. $1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$ (2-3b)
3. $1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (0.5L \text{ or } 0.5W)$ (2-3c)
4. $1.2D + 1.0W + 0.5L + 0.5(L_r \text{ or } S \text{ or } R)$ (2-3d)

D = 109 kips

L = 46 kips

Lr = 19 kips

S = 20 kips

⇒ 1.4 (109) = 152.60 kips

→ 1.2(109) + 1.6(46) + 0.5(19 or 20)

= 214.40 kips

↳ = 1.2(109) + 1.6(20) + (0.5)(46) =

= 194.80 kips

↳ 1.2(109) + 0 + 0.5(46) + 0.5(20) = 163.80 kips

A column (compression member) in the upper story of a building is subject to the following loads:

Dead load:	109 kips compression
Floor live load:	46 kips compression
Roof live load:	19 kips compression
Snow:	20 kips compression

a. Determine the controlling load combination for LRFD and the corresponding factored load.

LRFD

Cases 5 & 6 & 7

Based on AISC

D = 109 kips

L = 46 kips

Lr = 19 kips

S = 20 kips

5. $1.2D + 1.0E + 0.5L + 0.2S$
6. $0.9D + 1.0W$
7. $0.9D + 1.0E$

5. $1.2(109) + 0 + 0.5(46) + 0.2(20) = 157.80$ kips

6 & 7 NO W NO E

combination 6&7 donot apply

nd 7: smaller result than combination 4.
$0.9D \pm (1.0W \text{ or } 1.0E)$. These combinations do not apply in this example, because there are no wind or earthquake loads to counteract the dead load.

Part c)

Combination 2 given the highest value

Which is = 214.40 kips

(b) Required nominal strength For $\phi = 0.90$

Use $\sum \gamma_i Q \leq \phi R_n$ or $R_{ult} \leq \phi R_n$

$214.4 \leq 0.90\ R_n$

$R_n = 214.40 / 0.90 = 238.22$ kips

$R_n \geq 238.22$ kips

a. Determine the controlling load combination for LRFD and the corresponding factored load.

b. If the resistance factor ϕ is 0.90, what is the required *nominal* strength?

c. Determine the controlling load combination for ASD and the corresponding required service load strength.

d. If the safety factor Ω is 1.67, what is the required nominal strength based on the required service load strength?

given D = 109 kips
L = 46 kips
Lr = 19 kips
S = 20 kips

AISC

Allowable Strength Design

For ASD, the required strength is determined from the following combinations, which are also based on ASCE/SEI 7 Section 2.4:

C. The controlling Load Combinate
Load Case – 4

1.	D	(2-4a)
2.	$D + L$	(2-4b)
3.	$D + (L_r \text{ or } S \text{ or } R)$	(2-4c)
4.	$D + 0.75L + 0.75(L_r \text{ or } S \text{ or } R)$	(2-4d)
5.	$D + (0.6W \text{ or } 0.7E)$	(2-4e)
6a.	$D + 0.75L + 0.75(0.6W) + 0.75(L_r \text{ or } S \text{ or } R)$	(2-4f)
6b.	$D + 0.75L + 0.75(0.7E) + 0.75S$	(2-4g)
7.	$0.6D + 0.6W$	(2-4h)
8.	$0.6D + 0.7E$	(2-4i)

No W, No E

D = 109 kips
D + L = 109 + 46 = 155 kips
D + (Lr or S or R) = 109 + 20 = 129 kips
109 + 0.75(46) + 0.75(20) = 158.5 kips
109 + 0 = 109 kips
109 + 0.75(46) + 0 + 0.75(20) = 158.5
→ 109 + 0.75(46) + 0 + 15 = 158.5 kip

Maximum Load Combinatio

Combinations 7 and 8: $0.6D \pm (0.6W \text{ or } 0.7E)$. These combinations do not apply in this example, because there are no wind or earthquake loads to counteract the dead load.

(d) $\Omega = 1.67$ what is P_N

$\frac{P_N}{\Omega} \geq P_T$ $\quad P_{T\,(asd)} = 158.50$ kips

$P_N = 158.5(1.67) = 264.70$ kips $\simeq 265$ kips

$P_n \geq 265$ kips.

Part c) Load combination 4 Controlling Load Combination for ASD

ACI-318-14

Table 5.3.1—Load combinations

Load combination	Equation	Primary load
$U = 1.4D$	(5.3.1a)	D
$U = 1.2D + 1.6L + 0.5(L_r \text{ or } S \text{ or } R)$	(5.3.1b)	L
$U = 1.2D + 1.6(L_r \text{ or } S \text{ or } R) + (1.0L \text{ or } 0.5W)$	(5.3.1c)	L_r or S or R
$U = 1.2D + 1.0W + 1.0L + 0.5(L_r \text{ or } S \text{ or } R)$	(5.3.1d)	W
$U = 1.2D + 1.0E + 1.0L + 0.2S$	(5.3.1e)	E
$U = 0.9D + 1.0W$	(5.3.1f)	W
$U = 0.9D + 1.0E$	(5.3.1g)	E

5.3.2

The effect of one or more loads not acting simultaneously shall be investigated.

5.3.3

The load factor on live load **L** in Eq. (5.3.1c), (5.3.1d), and (5.3.1e) shall be permitted to be reduced to 0.5 except for (a), (b), or (c):

(a) Garages

(b) Areas occupied as places of public assembly

(c) Areas where **L** is greater than 100 lb/ft^2

ASCE-7-10	AISC-10	IBC-12	Chapter 35
ASCE-7-16	AISC-16	IBC-18	

ACI-318-11	IBC-12
ACI-318-14	IBC-18