or compression buckling, $\Omega = 1.67$.* For limit states involving rupture, $\Omega = 2.00$. The relationship between resistance factors and safety factors is given by

$$\Omega = \frac{1.5}{\phi} \tag{2.8}$$

For reasons that will be discussed later, this relationship will produce similar designs for LRFD and ASD, under certain loading conditions.

If both sides of Equation 2.7 are divided by area (in the case of axial load) or section modulus (in the case of bending moment), then the relationship becomes

$$f \leq F$$

where

f = applied stress
F = allowable stress

This formulation is called *allowable stress design.*

EXAMPLE 2.1

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.
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?

SOLUTION Even though a load may not be acting directly on a member, it can still cause a load effect in the member. This is true of both snow and roof live load in this example. Although this building is subjected to wind, the resulting forces on the structure are resisted by members other than this particular column.

a. The controlling load combination is the one that produces the largest factored load. We evaluate each expression that involves dead load, D; live load resulting from occupancy, L; roof live load, L_r; and snow, S.

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*The value of Ω is actually $1\frac{2}{3} = 5/3$ but has been rounded to 1.67 in the AISC specification.

Combination 1: $1.4D = 1.4(109) = 152.6$ kips

Combination 2: $1.2D + 1.6L + 0.5(L_r$ or S or $R)$. Because S is larger than L_r and $R = 0$, we need to evaluate this combination only once, using S.

$$1.2D + 1.6L + 0.5S = 1.2(109) + 1.6(46) + 0.5(20) = 214.4 \text{ kips}$$

Combination 3: $1.2D + 1.6(L_r$ or S or $R) + (0.5L$ or $0.5W)$. In this combination, we use S instead of L_r, and both R and W are zero.

$$1.2D + 1.6S + 0.5L = 1.2(109) + 1.6(20) + 0.5(46) = 185.8 \text{ kips}$$

Combination 4: $1.2D + 1.0W + 0.5L + 0.5(L_r$ or S or $R)$. This expression reduces to $1.2D + 0.5L + 0.5S$, and by inspection, we can see that it produces a smaller result than combination 3.

Combination 5: $1.2D \pm 1.0E + 0.5L + 0.2S.$ As $E = 0$, this expression reduces to $1.2D + 0.5L + 0.2S$, which produces a smaller result than combination 4.

Combinations 6 and 7: $0.9D \pm (1.0W$ or $1.0E)$. These combinations do not apply in this example, because there are no wind or earthquake loads to counteract the dead load.

ANSWER Combination 2 controls, and the factored load is 214.4 kips.

b. If the factored load obtained in part (a) is substituted into the fundamental LRFD relationship, Equation 2.6, we obtain

$$R_u \le \phi R_n$$

$$214.4 \le 0.90 R_n$$

$$R_n \quad 238 \text{ kips}$$

ANSWER The required nominal strength is 238 kips.

c. As with the combinations for LRFD, we will evaluate the expressions involving D, L, L_r, and S for ASD.

Combination 1: $D = 109$ kips. (Obviously this case will never control when live load is present.)

Combination 2: $D + L = 109 + 46 = 155$ kips

Combination 3: $D + (L_r$ or S or $R)$. Since S is larger than L_r, and $R = 0$, this combination reduces to $D + S = 109 + 20 = 129$ kips

Combination 4: $D + 0.75L + 0.75(L_r$ or S or $R)$. This expression reduces to $D + 0.75L + 0.75S = 109 + 0.75(46) + 0.75(20) = 158.5$ kips

Combination 5: $D \pm (0.6W$ or $0.7E)$. Because W and E are zero, this expression reduces to combination 1.