| | |
|---|---|
| Combination 6a: | $D + 0.75L + 0.75(0.6W) + 0.75(L_r \text{ or } S \text{ or } R)$. Because $W$ and $E$ are zero, this expression reduces to combination 4. |
| Combination 6b: | $D + 0.75L \pm 0.75(0.7E) + 0.75S$. This combination also gives the same result as combination 4. |
| 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. |

**ANSWER** Combination 4 controls, and the required service load strength is 158.5 kips.

d. From the ASD relationship, Equation 2.7,

$$R_a \leq \frac{R_n}{\Omega}$$

$$158.5 \leq \frac{R_n}{1.67}$$

$$R_n \quad 265 \text{ kips}$$

**ANSWER** The required nominal strength is 265 kips.

Example 2.1 illustrates that the controlling load combination for LRFD may not control for ASD.

When LRFD was introduced into the AISC Specification in 1986, the load factors were determined in such a way as to give the same results for LRFD and ASD when the loads consisted of dead load and a live load equal to three times the dead load. The resulting relationship between the resistance factor $\phi$ and the safety factor $\Omega$, as expressed in Equation 2.8, can be derived as follows. Let $R_n$ from Equations 2.6 and 2.7 be the same when $L = 3D$. That is,

$$\frac{R_u}{\phi} = R_a\Omega$$

$$\frac{1.2D + 1.6L}{\phi} = (D + L)\Omega$$

or

$$\frac{1.2D + 1.6(3D)}{\phi} = (D + 3D)\Omega$$

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

## 2.5 PROBABILISTIC BASIS OF LOAD AND RESISTANCE FACTORS

Both the load and the resistance factors specified by AISC are based on probabilistic concepts. The resistance factors account for uncertainties in material properties, design theory, and fabrication and construction practices. Although a complete treatment of probability theory is beyond the scope of this book, we present a brief summary of the basic concepts here.

Experimental data can be represented in the form of a histogram, or bar graph, as shown in Figure 2.1, with the abscissa representing sample values, or events, and the ordinate representing either the number of samples having a certain value or the frequency of occurrence of a certain value. Each bar can represent a single sample value or a range of values. If the ordinate is the percentage of values rather than the actual number of values, the graph is referred to as a *relative* frequency distribution. In such a case the sum of the ordinates will be 100%. If the abscissa values are random events, and enough samples are used, each ordinate can be interpreted as the probability, expressed as a percentage, of that sample value or event occurring. The relative frequency can also be expressed in decimal form, with values between 0 and 1.0. Thus the sum of the ordinates will be unity, and if each bar has a unit width, the total area of the diagram will also be unity. This result implies a probability of 1.0 that an event will fall within the boundaries of the diagram. Furthermore, the probability that a certain value or something smaller will occur is equal to the area of the diagram to the left of that value. The probability of an event having a value falling between $a$ and $b$ in Figure 2.1 equals the area of the diagram between $a$ and $b$.

Before proceeding, some definitions are in order. The *mean*, $\bar{x}$, of a set of sample values, or *population,* is the arithmetic average, or

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

where $x_i$ is a sample value and $n$ is the number of values. The *median* is the middle value of $x$, and the *mode* is the most frequently occurring value.

**FIGURE 2.1**