approximation is valid for a broad range of common probability distributions used to model structural loads. The load factor is an increasing function of the bias in the estimation of the nominal load, the variability in the load, and the target reliability index, as common sense would dictate.

As an example, the load factors in combination (2) of Section 2.3.2 are based on achieving a β of approximately 3.0 for a ductile limit state with moderate consequences (e.g., formation of first plastic hinge in a steel beam). For live load acting as a principal action, $\mu_Q/Q_n = 1.0$ and $V_Q = 0.25$; for live load acting as a companion action, $\mu_Q/Q_n \approx 0.3$ and $V_Q \approx 0.6$. Substituting these statistics into Eq. C2.3-1, $\gamma_Q = 1.0[1 + 0.8(3)(0.25)] = 1.6$ (principal action) and $\gamma_Q = 0.3[1 + 0.4(3)(0.60)] = 0.52$ (companion action). ASCE Standard 7-05 stipulates 1.60 and 0.50 for these live load factors in combinations (2) and (3). If an engineer wished to design for a limit state probability that is less than the standard case by a factor of approximately 10, β would increase to approximately 3.7 and the principal live load factor would increase to approximately 1.74.

Similarly, resistance factors that are consistent with the above load factors are well approximated for most materials by

$$\phi = (\mu_R/R_n)\exp[-\alpha_R\beta V_R] \qquad \text{(C2.3-2)}$$

in which μ_R = mean strength, R_n = code-specified strength, V_R = coefficient of variation in strength, and α_R = sensitivity coefficient equal approximately to 0.7. For the limit state of yielding in an ASTM A992 steel tension member with specified yield strength of 50 ksi (345 MPa), $\mu_R/R_n = 1.06$ (under a static rate of load) and $V_R = 0.09$. Eq. C2.3-2 then yields $\phi = 1.06 \exp[-(0.7)(3.0)(0.09)] = 0.88$. The resistance factor for yielding in tension in Section D of the *AISC Specification* (2010) is 0.9. If a different performance objective were to require that the target limit state probability be decreased by a factor of 10, then ϕ would decrease to 0.84, a reduction of about 7%. Engineers wishing to compute alternative resistance factors for engineered wood products and other structural components where duration-of-load effects might be significant are advised to review the reference materials provided by their professional associations before using Eq. C2.3-2.

There are two key issues that must be addressed to utilize Eqs. C2.3-1 and C2.3-2: selection of reliability index, β, and determination of the load and resistance statistics.

The reliability index controls the safety level, and its selection should depend on the mode and consequences of failure. The loads and load factors in ASCE 7 do not explicitly account for higher reliability indices normally desired for brittle failure mechanisms or more serious consequences of failure. Common standards for design of structural materials often do account for such differences in their resistance factors (for example, the design of connections under AISC or the design of columns under ACI). Tables C1.3.1(a) and C1.3.1(b) provide general guidelines for selecting target reliabilities consistent with the extensive calibration studies performed earlier to develop the load requirements in Section 2.3.2 and the resistance factors in the design standards for structural materials. The reliability indices in those earlier studies were determined for structural members based on a service period of 50 years. System reliabilities are higher to a degree that depends on structural redundancy and ductility. The probabilities represent, *in order of magnitude*, the associated annual member failure rates for those who would find this information useful in selecting a reliability target.

The load requirements in sections 2.3.2–2.3.4 are supported by extensive peer-reviewed statistical databases, and the values of mean and coefficient of variation, μ_Q/Q_n and V_Q, are well established. This support may not exist for other loads that traditionally have not been covered by this Standard. Similarly, the statistics used to determine μ_R/R_n and V_R should be consistent with the underlying material specification. When statistics are based on small-batch test programs, all reasonable sources of end-use variability should be incorporated in the sampling plan. The engineer should document the basis for all statistics selected in the analysis and submit the documentation for review by the authority having jurisdiction. Such documents should be made part of the permanent design record.

The engineer is cautioned that load and resistance criteria necessary to achieve a reliability-based performance objective are coupled through the common term, β in Eqs. C2.3-1 and C2.3-2. Adjustments to the load factors without corresponding adjustments to the resistance factors will lead to an unpredictable change in structural performance and reliability.

C2.4 COMBINING NOMINAL LOADS USING ALLOWABLE STRESS DESIGN

C2.4.1 Basic Combinations

The load combinations listed cover those loads for which specific values are given in other parts of