The Performance Basis for ASCE 7-10

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New provisions set the guidelines for using a performance-based design procedure.

FOR MANY YEARS, U.S. building codes have included an "alternative means and methods" clause that permits the use of design procedures and construction methods that are different from those specified under the prescriptive provisions of the code. This clause has permitted the pioneering use of many important innovations that were later adopted under the prescriptive provisions including: high-strength low alloy steels, welded construction, high-strength bolted construction, seismic isolation, buckling-restrained braced frames, and many others. In recent years, this same clause has served as the basis for performance-based seismic design, a technique that has become increasingly popular for the design of tall buildings and other major structures.

Under the alternative means clause, the authority having jurisdiction is permitted to approve any design or construction technique that can be demonstrated capable of providing equivalent protection of the public as construction that fully conforms to the prescriptive provisions. Unfortunately, the building codes have never defined what constitutes equivalent performance. Therefore design professionals invoking this clause often have had to make arbitrary decisions in this regard, sometimes resulting in a protracted approval process and often leaving the design professional at considerable risk of liability. The 2010 edition of ASCE 7, *Minimum Design Loads for Building and Other Structures*, has taken a major step toward remedy of this problem by adopting quantitative performance-based design criteria into Chapter 1 of the standard.

Traditionally, ASCE 7, like the AISC *Specification* and other industry specifications, has recognized two basic methods for design: Allowable Stress Design and Strength Design. ASCE 7-10 introduces a third, performance-based procedure that may be used for the design of any structure and for any load condition, subject to the approval of the authority having jurisdiction. Under the new procedure, the engineer must demonstrate, through analysis, testing, or a combination of these, that the structure is capable of providing reliability not less than that obtainable using Strength Design procedures. Analysis must be based on rational principals of engineering mechanics. Testing must be sufficient to demonstrate the variability in structural behavior and performance.

Importantly, two tables in the Commentary define the minimum acceptable reliability levels. Table C1.3.2a (reproduced as Table 1 here) defines the limiting acceptable failure rate for a member or connection under combinations of dead, live, wind, snow, and other loads, excluding seismic. Although never before formally published, these failure probabilities for many years have served as the notional basis for the strength load combinations contained in ASCE 7 and the companion resistance factors contained in the materials standards. In addition to the failure probabilities, the table also indicates the reliability factors (β) used in the formulation of resistance factors. Companion commentary to Chapter 2 of the standard describes how load and resistance factors can be formulated for new load cases and structural elements consistent with the standard. Table C.1.3.2b (reproduced as Table 2 here) defines the reliability for load combinations including seismic considerations.

Another significant change evident in the tables is that ASCE 7 has changed the term "Occupancy Category," used by the building code for many years as a means of determining required design conservatism, to "Risk Category." This change acknowledges that the purpose of these categories is to regulate the acceptable risk of failure for buildings, and that this depends on other factors than just the structure's occupancy, including the number of persons endangered by a structural failure. Under this concept, a utility structure, such as a water treatment plant, that serves thousands of individuals, and which has no redundant backup, would be assigned to a higher risk category than one that serves a limited number of people or is part of a system containing many treatment plants that offer system redundancy. Corresponding with this change, the laundry list of building types that were assigned to the different Occupancy Categories have been removed from the standard. Commentary to the standard provides additional discussion on assignment of risk category. However, engineers should be aware that the building code still assigns Occupancy Category and the code's requirements take precedence to the standard in this regard. The standard notes

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Basis	Risk Category			
	I	II	III	IV
Failure that is not sudden and does not lead to wide-spread progression of damage	$P_f = 1.25\times10^{-4}$ β = 2.5	$P_f = 3\times10^{-5}$ β = 3.0	$P_f = 1.25\times10^{-5}$ β = 3.25	$P_f = 5\times10^{-5}$ β = 3.5
Failure that is sudden or leads to wide-spread progression of damage	$P_f = 3\times10^{-5}$ β = 3.0	$P_f = 5\times10^{-5}$ β = 3.5	$P_f = 2\times10^{-6}$ β = 3.75	$P_f = 7\times10^{-7}$ β = 4.0
Failure that is sudden and leads to wide-spread progression of damage	$P_f = 5\times10^{-6}$ β = 3.5	$P_f = 7\times10^{-7}$ β = 4.0	$P_f = 2.5\times10^{-7}$ β = 4.25	$P_f = 1\times10^{-7}$ β = 4.5

Table 1: Acceptable Reliability (maximum annual probability of failure) and associated reliability indices (β) for load conditions that do not include seismic.

Risk Category I and II	
Total or partial collapse	10% given Maximum Considered effects
Failure that results in individual life endangerment	25% given Maximum Considered effects
Risk Category III	
Total or partial collapse	6% given Maximum Considered effects
Failure that results in individual life endangerment	15% given Maximum Considered effects
Risk Category IV	
Total or partial collapse	3% given Maximum Considered effects
Failure that results in individual life endangerment	10% given Maximum Considered effects

Table 2: Acceptable Reliability (maximum probability of failure) for load conditions that include seismic.

that where a building code is in effect, the Risk Category assigned to a structure cannot be less than the Occupancy Category prescribed by the building code.

The inclusion of performance-based design as a legitimate alternative to the traditional ASD and Strength Design procedures is an important step forward. It is possible that in the next edition of ASCE 7 the performance-based approach will appear as the primary design method, with the ASD and Strength procedures noted as acceptable alternative "deemed to comply" methods. In the future, the performance criteria presented in the standard likely will be expanded to cover additional performance issues, including failure of cladding and loss of function of electrical and mechanical equipment. Consideration of these performance issues already is covered in the standard's wind and seismic requirements; however, definition of the anticipated performance is lacking. The Building Seismic Safety Council's Provisions Update Committee already has initiated work to begin quantifying these additional performance goals. MSC