ASCE 7-05 Simplified Alternative Seismic Design Procedure

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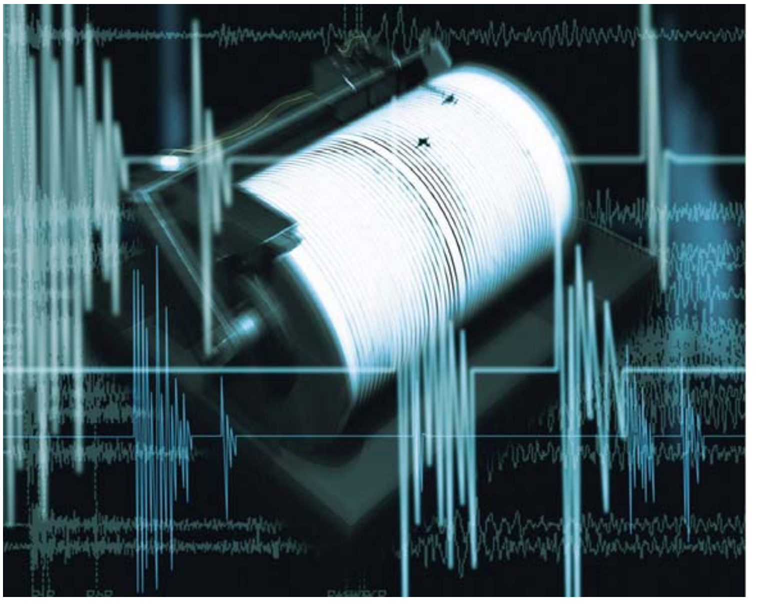

As a result of concerns voiced by engineers and building officials that seismic design provisions were becoming increasingly complex and difficult to implement, especially for relatively small, regular structures, which constitute the greatest percentage of construction in the U.S., a simplified seismic design procedure was developed by the American Society of Civil Engineers (ASCE). This procedure has been included in the *International Building Code* (IBC) since its first edition in 2000 by reference to ASCE 7, *Minimum Design Loads for Buildings and Other Structures,* but code users should be aware that the 2006 IBC references the updated and reformatted 2005 edition of ASCE 7, resulting in a number of changes to the simplified seismic design procedure.

The first change to note is that all of the provisions for the simplified procedure are collected in Section 12.14 of ASCE 7-05. Included in this standalone section are requirements for seismic load effects and combinations, seismic-force-resisting systems, diaphragm flexibility, application of loading, design and detailing, and application of a simplified lateral force analysis.

Section 12.14.1.1 gives twelve limitations that must be satisfied for use of the simplified procedure (see Table 1). Although it may at first glance appear to be a daunting task to satisfy so many limitations, the reality is that the procedure is applicable to a wide range of relatively stiff, low-rise structures that fall under Occupancy Categories I and II and possess seismic-force-resisting systems that are arranged in a torsionally-resistant, regular layout. In essence, these limitations define a set of simple, redundant structures that can be analyzed using a lesser number of prescriptive requirements than the more comprehensive analytical procedures of ASCE 7-05.

The seismic load effect, E, is defined the same in the simplified procedure as in the general requirements of ASCE 7-05 Section 12.4 and consists of the effects of horizontal and vertical earthquake-induced forces E_h and E_v, respectively. However, in Section 12.4 E_h is equal to the redundancy factor, ρ, multiplied by the effect of horizontal seismic forces, Q_E, whereas in the simplified procedure E_h is equal to Q_E ($\rho = 1.0$).

The seismic load combinations of Section 12.14 are also the same as those in Section 12.4. In the simplified procedure, the system overstrength factor, Ω_o, is taken as 2.5, which is consistent with the values of Ω_o given in Table 12.2-1 for bearing wall and building frame systems. Table 12.14-1 reproduces portions of Table 12.2-1 for the systems permitted to be designed using the simplified procedure and provides references to sections of the standard pertaining to detailing requirements; the response modification coefficient, R; and system limitations for Seismic Design Categories B through E. As previously noted, the system overstrength factor, Ω_o, is taken as 2.5 so it is not included in the table. Also, because drift calculations are not required (see Section 12.14.8.5 and the discussion below), the deflection amplification factor, C_d, is not included.

In the ASCE 7-05 simplified seismic design procedure, untopped metal deck, wood structural panels and similar panelized construction are permitted to be considered flexible diaphragms, and lateral load is distributed to the vertical elements of the seismic-force-resisting system using tributary area. For diaphragms that are not flexible, a simple rigidity analysis is required, which includes torsional moments resulting from eccentricity between the locations of center mass and center of rigidity. Analysis of accidental torsion and dynamic amplification of torsion is not required, representing another significant simplification of calculations.

The design seismic forces, which are determined in accordance with Section 12.14.8, are permitted to be applied separately in each orthogonal direction. Simultaneous application of seismic forces need not be considered for structures assigned to Seismic Design Category C and higher because structural irregularities are not permitted.

Table 1.
Limitations to use of the simplified design procedure.

1	Occupancy Category I or II
2	Site Class A through D
3	Structure height less than or equal to 3 stories
4	Seismic-force-resisting system must be bearing wall or building frame
5	Two lines of walls or frames are required in each of two major axis directions
6	At least one line of walls or frames is required on each side of the center of mass in each direction
7	Equation 12.14-1 must be satisfied for structures with flexible diaphragms
8	Equations 12.14-2A and 12.14-2B must be satisfied for structures with diaphragms that are not flexible
9	Lines of walls or frames must be oriented at angles of no more than 15 degrees from the major orthogonal axes of the building
10	The simplified procedure must be used for each major orthogonal horizontal axis of the building
11	In-plane or out-of-plane structural irregularities are not permitted
12	Lateral load resistance of any story must be at least 80 percent of the story above

The design and detailing requirements are given in Section 12.14.7. They are independent of the Seismic Design Category because the simplified procedure can only be used to design regular systems (as noted previously, vertical and horizontal structural irregularities are prohibited). By satisfying the prescriptive requirements for regularity, numerous requirements for irregular systems are eliminated.

The seismic base shear, V, is determined by Equation 12.14-11. This equation represents the horizontal short-period segment of the design response spectrum, which is independent of the period of the structure. The value of the seismic base shear is increased by 10 and 20 percent for two-story and three-story buildings, respectively. These increases primarily account for the method that is used for vertical distribution of the base shear, which is based on tributary weight, and have been shown by parametric studies to be adequate without being overly conservative. A step-by-step procedure for determining V is given in Figure 1.

Note that in lieu of determining the site coefficient, F_a, in accordance with Section 11.4, which requires knowledge of the soil profile to a depth of 100 feet below the surface of the site, the default values of F_a given in Section 12.14.8.1 may be used for rock sites (where there is no more than 10 feet of soil between the rock surface and the bottom of the spread footing or mat foundation) or soil sites. Limiting applicability of the simplified design procedure to these sites results in the need for only a basic geotechnical investigation: 100-foot-deep borings and seismic shear velocity tests are not necessary.

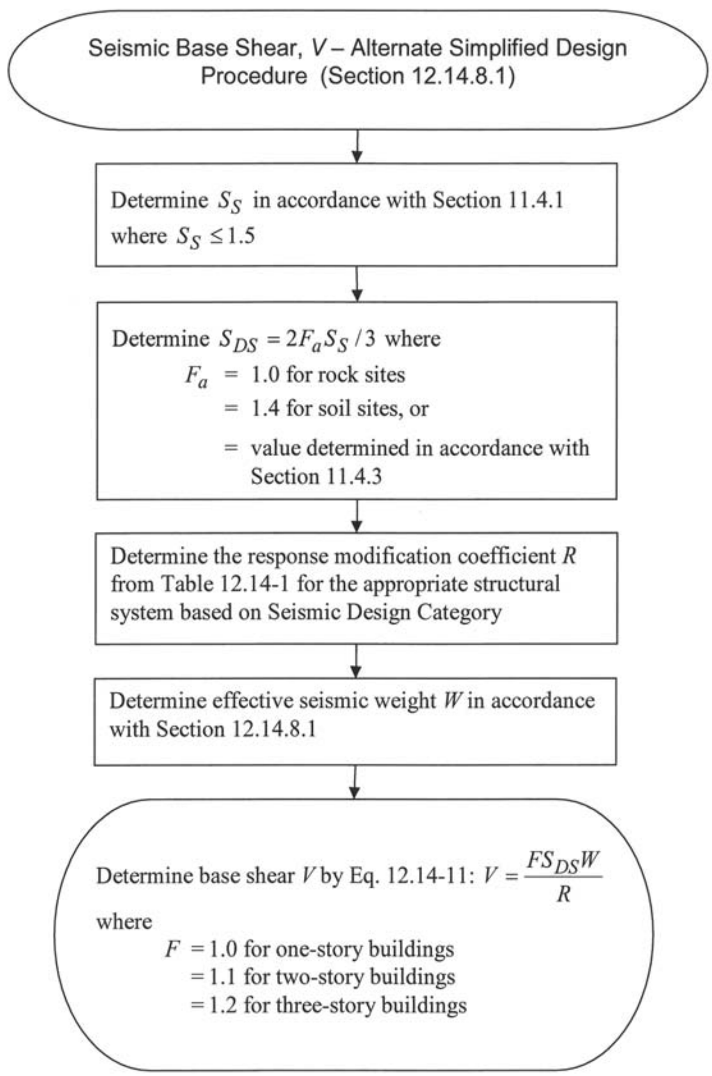

Figure 1. Determination of seismic base shear, *V*.

As was previously indicated, the simplified design procedure does not require a drift check. This is because it is assumed that bearing wall and building frame systems within the prescribed height range will not require it (unlike moment frame systems, where drift is a major concern in design). For requirements such as those for structural separations between buildings or the design of cladding, the allowable drift is to be taken as 1 percent of the building height.

In short, the simplified alternative seismic design procedure given in ASCE 7-05 Section 12.14 significantly decreases the number of requirements that need to be satisfied for a common class of buildings. Not only does this procedure save on overall design time, it lessens the chance that an important requirement is overlooked inadvertently. More information, including flow charts and design examples, can be found in the ICC publication *Structural Load Determination Under 2006 IBC and ASCE/SEI 7-05*. ◆

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