Chapter C15
SEISMIC DESIGN REQUIREMENTS FOR NONBUILDING STRUCTURES

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The National Earthquake Hazards Reduction Program (NEHRP) Provisions contain additional design requirements for nonbuilding structures in an Appendix to Chapter 14 of the NEHRP Provisions. The NEHRP Commentary contains, in addition to Chapter 14, additional guidance in an Appendix to Chapter 14. These additional resources should be referred to in designing nonbuilding structures for seismic loads.

C15.1.3 Structural Analysis Procedure Selection

In Section 12.6 of this standard, specific seismic analysis procedure requirements for building structures are defined on the bases of the seismic design category, fundamental period, T, and the presence of certain plan and vertical irregularities in the structural system. Review of Table 12.6-1 shows that the use of the equivalent lateral force procedure is not permitted for structures with fundamental period greater than $3.5T_s$ (where $T_s = S_{D1}/S_{DS}$). This requirement is based on the fact that, unlike the dominance of the first mode response in case of buildings with lower first mode period, higher vibration modes do contribute more significantly in situations when the first mode period is larger than $3.5T_s$. The provision reflects that the second mode frequency is at least 3.50 times the first mode frequency (corresponding to the assumption of a classic shear building model) so that the spectral acceleration corresponding to the second and/or higher modes will fall on the peak of the design response spectrum, resulting in a larger contribution of higher modes to the total response.

Based on the above discussion, it follows that dynamic analysis (modal response analysis, linear time-history analysis, and nonlinear time-history analysis) is required for building-like nonbuilding structures if the first mode period is larger than $3.5T_s$ (nonbuilding structures such as single pedestal elevated water tanks that are single degree of freedom systems for all practical purposes are not subject to this requirement).

Some additional guidelines and recommendations for nonbuilding structures are provided below for building-like nonbuilding structures as well as nonbuilding structures not similar to buildings.

Building-Like Nonbuilding Structures. Provisions of Table 12.6-1 serve as a guideline for selection of analysis method for building-like nonbuilding structures. However, as illustrated in the following text, these provisions need to be carefully scrutinized for their relevance to building-like nonbuilding structures:

1. Consideration of irregularities: The criteria for analysis method selection, as delineated in Table 12.6-1 of this standard, refer to various kinds of plan and vertical irregularities that can trigger a dynamic analysis requirement. In particular, plan irregularities of Types 1a and 1b as well as vertical irregularities of Types 1, 2, and 3 require dynamic analysis for Seismic Design Categories D, E, and F (the various types of plan and vertical irregularities are summarized in Tables 12.3-1 and 12.3-2 of this standard, respectively). The vertical irregularities concerning a weak or soft story are equally relevant to building-like nonbuilding structures. The following discussion provides some guidance on the relevance of the plan irregularities and Types 2 and 3 vertical irregularities.
   (a) Plan irregularities: It is worth noting that the premise behind the plan irregularities is the assumption that the structure in question has rigid horizontal diaphragms. As such, a building-like nonbuilding structure should be examined for the relevance of this assumption because building-like nonbuilding structures can have no diaphragms at all, nonrigid diaphragms, or both.
   (b) Vertical irregularities: The Type 2 vertical irregularity concerns weight/mass distribution. This provision is relevant when the various story levels do actually support significant loads. As such, this provision is not applicable when a building-like nonbuilding structure supports significant masses only at certain elevations while other levels support small masses associated with stair landings, access platforms, and so forth.