

The 2003 IBC section 1617.6.1.2 corrected the ASCE 7-02 omission by duplicating the same basic language that appears in the 1997 UBC. ASCE 7-05 section 12.2.3.1 has now corrected the omission and added the two-stage procedure.

Effect of redundancy coefficient. The UBC and ASCE 7-05 two-stage procedure for rigid podium structures properly accounts for the influence of redundancy coefficients on effective R values. These effects must also be accounted for in other vertical combinations.

Horizontal Combinations

Systems used in horizontal combinations are of potential concern if the individual systems deform in significantly different elastic or inelastic patterns. Differential inelastic deformations lead to substantial redistribution of forces between the combined systems, resulting in high collector forces between the systems or high torsion when the systems are offset from each other. ASCE 7-02 section 9.5.2.2.2.1 and 1997 UBC section 1630.4.4 limited the combined system R value on a given axis to the lowest value of the individual systems used on that axis. The intent was to delay yielding in any one system until all the systems could yield together.

When a different system is used for each principal direction, the concern was that a flexible, high- R system in one direction would cause large transverse displacements to a brittle, low- R bearing wall system framing in the other direction. Excessive out-of-plane distortions of the low- R system can lead to either failure of the bearing wall or separation of the wall from the roof or floor framing it supports. For these conditions, both ASCE 7-02 section 9.5.2.2.2.1 and 1997 UBC section 1630.4.3 identified conditions in which the lowest value of any system was to be used for *all* systems in *any* direction. ASCE 7-02 triggered this requirement for all Seismic Design Categories if any system had an R value less than 5. In comparison, the UBC was triggered only when any system was a bearing wall system, and then only in Seismic Zones 3 and 4.

The ASCE 7-02 provision in some situations was overly restrictive. The threshold R value of 5 properly considered plain concrete and masonry shear walls, which are vulnerable, and properly exempts light-framed walls with wood structural panels, which are not. But it also included less vulnerable systems such as steel ordinary concentrically braced frames in bearing wall systems ($R = 4$) and even steel intermediate moment-resisting frames ($R = 4.5$).

In response to these issues, ASCE 7-05 section 12.2.2 has taken an alternate route, by completely removing any orthogonal systems requirement. The justification made for the removal was that other code provisions for displacement compatibility that have been added since the original provisions were adopted have essentially replaced the need for the former provision. By implication, then, the replacement section in ASCE 7-05 is section 12.12.4 (for Seismic Design Category D, E, or F).

Exception for separate lines of resistance. ASCE 7-05 section 12.2.3.2 includes a separate procedure for structures having different structural systems on independent lines of resistance, where the following three conditions are all met: (1) Occupancy type I or II building, (2) two stories or less in height, and (3) use of light-frame or flexible diaphragms. This procedure permits each line of resistance to be designed using the value of R that is greatest for any systems found along that line of resistance, and independent of the R value required for any other line of resistance in the building. The value of Ω_0 and C_d used for each line of resistance at any story is the largest value of this factor for the R value used in the same direction being considered. The R value used for design of diaphragms is the lesser of R for any systems utilized within all lines of resistance in that direction of application of seismic forces.

The Seismology Committee interprets this exception to apply to a range of situations in which light framing is combined with cantilever columns, moment frames around large wall openings, and diagonally braced wall framing. In particular, the exception is taken to apply to elements placed on either side of garage openings in typical houses. Likewise, it also may apply to interior lines of resistance such as braced frames that are located within concrete or masonry wall buildings, provided that the diaphragm type is flexible.