Soft/Weak Story Problems and Solutions for Residential Structures

Authors:

Gary R. Searer, Wiss, Janney, Elstner Associates, Inc., gsearer@wje.com
Joseph Valancius, Wiss, Janney, Elstner Associates, Inc., jvalancius@wje.com

ABSTRACT

Residential structures with soft, weak, or open-front walls are common in high seismic areas like the west coast of the United States. Tuck-under parking is particularly problematic in many buildings built in the 1960s through the 1980s, when stucco and gypsum board were widely used to resist lateral loads in two-, three-, and even four-story structures. The 1994 Northridge earthquake demonstrated the problematic nature of these types of structures.

In order to address these well-known deficiencies in a reasonably economical fashion, Chapter 4 of the Guidelines for the Seismic Rehabilitation of Existing Buildings (GSREB) was developed and then subsequently adopted into the International Existing Building Code (IEBC) as Appendix Chapter 4. Although Appendix Chapter 4 of the IEBC has a noble goal (reducing the seismic risk associated at a reasonable cost), there are a number of provisions within the chapter that tend to preclude economic solutions. This paper addresses those problems, including what the authors believe are excessive engineering analysis requirements as well as excessive design force levels in the current code. The excessive design forces result from the requirement that the R-value for the design of the rehabilitation measures can be no larger than that for the stories above. Since the stories above are almost exclusively stucco and gypsum board -- for which an extremely low R-value of 2 is now mandated -- the design forces for the rehabilitation measures become excessive. High base shear coefficients can result in much tighter nail spacing (which can result in less-ductile behavior); drive the design towards double-sided shear walls; dramatically increase the number of sheet metal clips and anchor bolts; dramatically increase the size of the holddowns and required overturning resistance needed to anchor the holddowns; and trigger requirements for 3x or 4x wood sills and studs upon which plywood is spliced. None of these trends is conducive to economical designs.

Several case studies are presented to demonstrate problems with the current provisions in the IEBC and to demonstrate how, if engineering judgment is used, reasonable solutions can be implemented in actual buildings in what the authors believe to be an effective and economical manner (i.e. significant reduction of risk for a reasonable amount of money and a reasonable amount of engineering effort).

Information regarding each building is presented, constraints posed by architectural, mechanical, and electrical systems are described, details regarding the strengthening measures are shown, and the costs associated with the work are provided. Issues regarding owner reticence to invest in structural strengthening are also discussed, and possible modifications to the IEBC are suggested.