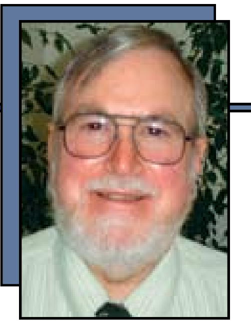

Lateral Bracing For Equipment and Fixtures

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In a Structural Forum article in the May 2007 issue of STRUCTURE® magazine, I shared a number of examples to show how critical sound engineering is for the support and bracing of equipment and fixtures during seismic events. Other examples abound for the effects of wind, flood and various man-created events.

The difficulty in dealing with the support/bracing of equipment and fixtures is not the complexity of analysis and design. It is the ease with which the general public can ignore its need because, unlike the need for support of gravity loads, it only comes into play when an exceptional event such as an earthquake occurs, which may not happen during the lifetime of the building housing it.

It would be different if we all lived and worked on small vessels at sea, where the rocking and rolling caused by waves is constantly inducing lateral forces and everything has to be braced and secured. I remember that, when I lived aboard ship for two years in the Coast and Geodetic Survey, even our office chairs had to be hooked onto a floor-anchored desk to avoid sliding across the deck.

I believe that this lack of perceived need makes lateral bracing of equipment harder to understand and enforce. A contractor can walk away from a project with vertical support in place, but without adequate lateral supports. It may be years before a problem becomes evident – and then with dire effect. This is why good engineering is required and why good construction quality control must be exercised so that bracing is properly designed, and one subcontractor's braces are not altered to make room for the next subcontractor's installation.

Much of the initial definition of a design basis for bracing of architectural and mechanical-electrical-plumbing (M.E.P.) elements came from FEMA documents, which addressed existing building rehabilitation. Damage caused by natural disasters to, and from, architectural and M.E.P. elements was the impetus for developing checklists to identify potentially hazardous conditions based on past experience. Once identified and the cause (i.e., acceleration or displacement) determined, the design of bracing could be made.

Starting in the 1970s, FEMA-sponsored building retrofit and rehabilitation projects included remedial bracing or attachment solutions for architectural elements such as hung ceilings, fascia, partitions and suspended fixtures. The same process followed for M.E.P. elements. Observation of how these elements had failed led to an examination of how to provide a load path to prevent loss of support, or how to provide bracing to prevent displacements that would lead to building or fixture damage.

Because of the enormous costs associated with damage to and from non-structural elements during recent earthquakes, there are now a number of FEMA documents regarding the seismic design of new and rehabilitation of existing buildings, which contain chapters on these elements. In the last few years, this has coalesced into three standards: ASCE 7-05, ASCE 31-03 and ASCE 41-06. ASCE 7 is referenced in the International Building Code for the design of new buildings; the other two standards concern the evaluation and rehabilitation of existing buildings.

Chapter 13 of ASCE 7-05 provides the basis for computing design forces on non-structural elements. It also provides a definition of the Component Importance Factor (Iρ) and a list of exemptions from its requirements. Other than bracing for mechanical and electrical components in Seismic Design Category B, these exemptions all depend on the components having an Iρ=1.0, which means that they are either non-hazardous or not in Occupancy Category IV nor required for life safety.

Life safety determination is relatively straightforward for the building structure; however, for bracing non-structural elements, it may be a more subjective decision based on occupancy patterns. Therein lies the uncertainty as to what requires a specific engineering analysis and design. ASCE 41-06, *Seismic Rehabilitation of Existing Buildings*, states that the determination of which non-structural components need to be rehabilitated is not a part of that standard. Therefore, based on the interpretation of what is, or is not, a life safety issue at any given time, a brand new building may contain elements that need to be rehabilitated immediately after construction according to a different assessment of potential life safety concerns.

For those who think that the determination of the life safety issue is simple, I attach this quotation contained in ASCE 41-06:

"If, during an earthquake, [building occupants] must exit through a shower of falling light fixtures and ceilings, maneuver through shifting and toppling furniture and equipment, stumble down dark corridors and debris-laden stairs, and then be met at the street by falling glass, veneers, or façade components, then the building cannot be described as a safe structure." (Ayres, J.M., and Sun, T.Y. 1973, *Nonstructural damage to buildings, the great Alaska earthquake of 1964,* Engineering, National Academy of Sciences, Washington, D.C.)▪

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