Briefing Paper 5

Seismic Response of Nonstructural Components

Part B: Proper Anchorage of Ceilings, Interior Walls, Glazing, and Parapets

Introduction

This Briefing Paper 5, *Seismic Response of Nonstructural Components*, consists of three parts that discuss how earthquakes affect a variety of nonstructural building components, and how they should be anchored or braced to resist seismic forces. Part A defines the types of systems and equipment that can be affected, describes the way they respond to earthquake motions, and discusses various anchorage systems and their limitations. This Part B describes the vulnerability and proper retrofit anchorage methods for suspended ceilings, interior gypsum walls, partitions, glazing, window walls, parapets and nonstructural masonry walls. Part C describes the vulnerability and proper retrofit anchorage for other nonstructural components types: cladding and veneers, floor- or roof-mounted equipment, and suspended equipment, ducts, pipes and light fixtures.

Suspended Ceilings

Typical ceilings in modern buildings are comprised of a metal grid suspended from the structure above with lay-in acoustical panels. In an earthquake, the metal grid easily moves horizontally if it is not adequately braced. This lateral movement causes the ceiling to buckle where the movement is suddenly restrained by adjoining walls or columns. Where buckling occurs, metal-grid-mounted objects such as light fixtures, HVAC diffusers, exit signs, and ceiling panels may fall on occupants and furnishings below (Figure 1). Some buildings will contain suspended ceilings of gypsum board or gypsum lath and plaster. Bracing in such ceilings is

Figure 1. Earthquake-damaged suspended ceiling. EERI photo..

usually provided by light-gauge metal bracing of the main runners that carry the ceiling finish. Older installations may not have any bracing because the typical T-bar ceiling bracing is not present. Ceilings in much older buildings tend to be plaster on a wood lath backing and are very rigid and much heavier than modern lay-in tile ceilings. Bracing these ceilings requires a careful evaluation of their current restraint conditions and vertical support. An important retrofit consideration with rigid ceilings is to provide sufficient clearance from the bounding wall lines to prevent pounding damage between the ceiling and the walls.

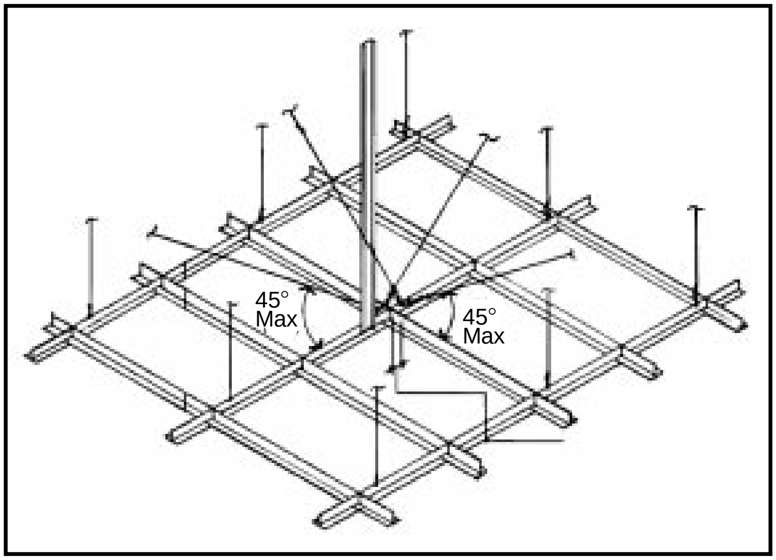

Figure 2. Elements of properly braced ceilings.

Typical methods to prevent suspended ceiling damage are:

- Install bracing wires inclined at 45 degrees to brace the ceiling grid horizontally as in Figure 2.
- Install vertical compression posts to brace the ceiling grid vertically as in Figure 2.
- Provide separate vertical suspension wires for heavy ceiling-mounted objects.
- Provide separation space between the ceiling and other less flexible elements that either penetrate the ceiling or form a stiff boundary along ceiling edges.
- Provide separation joints between portions of the building that may move differentially

Interior Gypsum-Board Walls and Partitions

All interior walls and partitions must be anchored at their top and bottom to resist earthquake forces that will tend to push them over. Power-driven fasteners are typically used to connect a light-gauge metal bottom track to a concrete floor and can also be used at the top track when the next structural framing level above consists of metal deck with concrete fill, or a concrete slab. Sheet metal screws are typically used to connect metal top and bottom tracks to wood-framed floors or wood-framed roof construction. Wood-framed partitions need similar attachments using nails.

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Ceiling-height partitions are especially vulnerable when they are used to support heavy objects such as book cases mounted to the wall and when the partitions are not connected to other walls in the perpendicular direction. Ceiling-height walls should not be assumed to be properly braced if their top track is connected directly to a T-bar suspended ceiling runner, because most suspended ceiling systems are not designed for this additional lateral load. Relying on perpendicular walls to provide sufficient bracing requires that the walls providing bracing be spaced at sufficiently close intervals to prevent excessive deflection of the wall being braced.

Typical methods to prevent partition damage are:

- Extend the wall studs from the floor to the structure (floor or roof) above and connect both the top and bottom tracks (or sill plate and top plate) to the floor and the structure above.

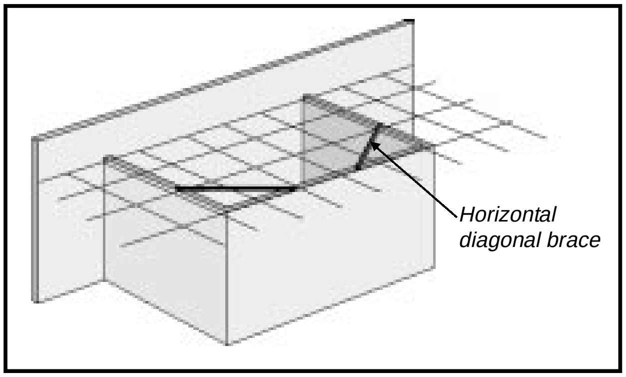

Figure 3. Partition braced by cross walls.

- Brace the top of ceiling-height partition walls to the structure above with kicker studs installed at 45 degrees in alternating directions at four-foot intervals. Connect bottom track or sill to floor, the kicker to the top track or plate, and the kicker stud to the structure above.
- Brace partition walls to perpendicular walls with braces located in the plane of the top track or plate of the wall (see Figure 3). The braces should form 45-degree angles with the walls. Connect the bottom track or sill to the floor, connect the brace to top track or plate of each wall, and connect a stud of the perpendicular wall to a stud in the partition being braced.

Glazing and Window Walls

Exterior window walls can be very large in modern buildings, and floor-to-ceiling glazing is also fairly common inside office areas. Cuts from broken glass are the most common type of earthquake injury. Glass breakage is typically caused by the deflection of the structure beyond the capacity of the window wall system or frame. Severe injuries can result outside of buildings particularly where window walls are located high above pedestrian areas and building exits.

Typical methods to prevent glass breakage or reduce risk are:

- Use laminated or tempered glass to reduce the size of the broken glass pieces.
- Use a glazing or frame system that allows for greater deflection.

Parapets and Nonstructural Masonry Walls

Unbraced parapets, particularly those constructed of unreinforced masonry are very susceptible to collapse in even small earthquakes. An example is shown in Figure 4. Wood-framed parapets, especially those that are very tall or that have heavy ornamentation or projecting cornices, can also fall due to the large drifts and accelerations that occur at roof level.

Glass masonry walls and hollow clay tile walls are sometimes used as interior nonstructural walls. These materials provide desirable appearance and fire-resistant characteristics. However, because of their mass, they are vulnerable in

Figure 4. Failed parapet. EERI photo..

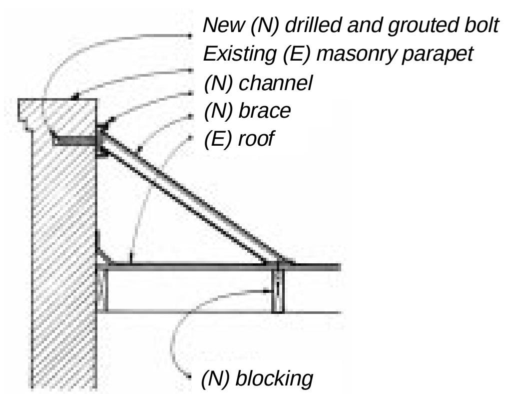

Figure 5. Strengthening of parapet with steel braces.

earthquakes if not properly reinforced or braced. In older buildings, nonstructural masonry elements are especially vulnerable to failure in the out-of-plane direction. The falling hazard these elements pose can lead to serious injury or loss of life.

Nonstructural masonry walls are also commonly used in older concrete frame buildings as infill between the perimeter-frame beams and columns. These infill walls are susceptible to out-of-plane failure. Under lateral loads they can crack and dislodge individual pieces of masonry. When these infill walls contain openings or extend only a portion of the story height, they can cause serious damage to adjacent columns. The infill causes this damage by bracing the columns at locations where the building's original design did not anticipate such stresses. In these cases, it is prudent to provide a separation between the infill masonry and the adjacent column, although this does complicate the task of providing adequate out-of-plane bracing of the masonry infill.

Typical methods to prevent parapet and nonstructural masonry wall damage are:

- Brace slender parapets to the roof structure (Figure 5).
- Add reinforcement or overlays to improve the resistance to in-plane forces.
- Brace for out-of-plane forces on nonstructural interior masonry and hollow tile partitions.
- Provide out-of-plane bracing of exterior masonry infill walls and provide a separation between the masonry and adjacent concrete columns.

About this Briefing Paper Series

Briefing papers in this series are concise, easy-to-read summary overviews of important issues and topics that facilitate the improvement of earthquake-resistant building design and construction quality.

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