Seismic Anchorage and Bracing Requirements for Equipment and Utilities in Buildings

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Building codes have evolved over the decades to incorporate new understandings of building responses during earthquakes. In general, the result has been more rigorous building code design requirements for a structure's frames, walls, critical connections and foundations that resist these primarily horizontal forces and serve to keep a building standing after an earthquake. These primary structural components are referred to as the lateral force-resisting systems (LFRS).

What has also been learned from post-earthquake investigations is that a substantial amount of damage sustained by buildings results from unrestrained equipment and utility systems that have been free to move "out of phase" inside the building. This "differential" movement causes piping and ducting systems to rupture and equipment to slide across the floor and/or tip over. Such occurrences can threaten the safety of occupants, block exits, render fire-suppression systems ineffective and contaminate buildings. Consequently, the building code revisions in the 1990s and 2000s have incrementally expanded the requirements for the seismic design of equipment anchorage and utility bracing in buildings.

Design Parameters:

Each building site and building use has its own seismic force profile. Seismic "zones" no longer exist under the International Building Code (IBC). The US Geological Survey has mapped the anticipated ground acceleration for the contiguous United States. These design ground accelerations are mapped using the latitude and longitude of a building site. Overall, design forces for equipment anchorage and utility bracing take into consideration the following parameters:

- Occupancy category (more important structure = higher design forces)
- Seismicity at the building site (higher seismicity = higher design forces)
- Soil types at building site (softer soils = higher design forces)
- Elevation of equipment or utility within building (higher elevation = higher design forces)
- Ductility of equipment or utility (more brittle material = higher design forces)
- Flexibility of the equipment anchorage or utility bracing (more flexible = higher design forces)

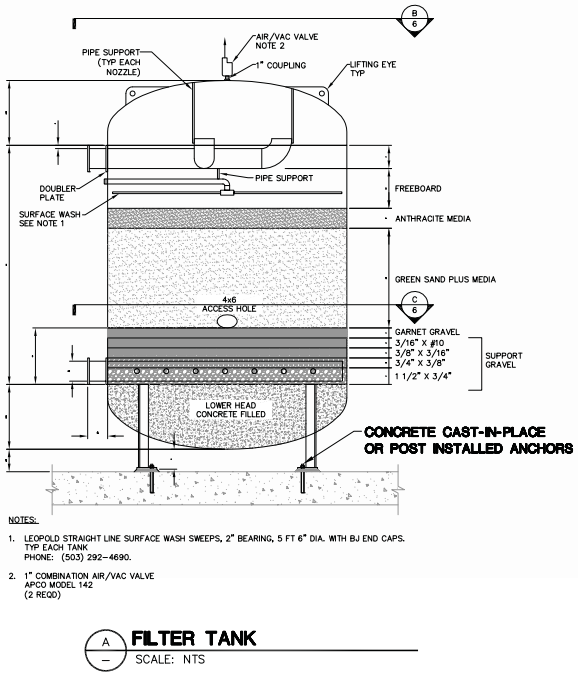
Basic Design Thresholds:

The building code and related design standards specify the thresholds for seismic anchorage and bracing design for the building components listed below. Design requirements in several cases are related to the building or system Importance Factor, I. Examples of buildings or systems with an Importance Factor, I = 1.5 include:

- Life safety components required to be operational after an earthquake, including sprinkler systems
- Components containing hazardous materials
- Components in Occupancy Category IV structures, including but not limited to hospitals, emergency response facilities, and water storage and pumping facilities required to maintain supply and pressure for fire suppression

Equipment Anchorage:

- Required for equipment > 400 pounds
- Required for equipment > 20 pounds installed 4' above a floor



Piping System Bracing:

- Required for pipe > 1" diameter when I = 1.5
- Required for pipe > 3" diameter when I = 1.0
- Not required when pipe is supported within 12" of structure or pipe is highly deformable

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Electrical System Bracing:

- Required for conduit or trays > 10 pounds per foot when I = 1.5
- Anchorage required for equipment > 100 pounds when I = 1.5

Fire Sprinkler System Bracing:

- Required to be designed in accordance with NFPA 13
- Required to be designed by a registered design professional in some jurisdictions (Oregon)

Ducting System Bracing:

- Required for ducts > 6 square feet in cross-sectional area
- Required for in-line components > 75 pounds
- Not required where ducting is supported within 12" of structure

Piping system vulnerable to "out-of-phase" movement

Utility Services and Building Isolation Joints:

- Underground utilities should be installed with flexible couplings where differential movement is anticipated between the ground and the structure. (The photo below illustrates an installation in which a force main is braced beneath a structure to prevent differential movement between the underground alignment and the structure.)
- Above ground utility systems spanning between building isolation joints shall provide for anticipated differential movement.

Force main braced to prevent differential movement

Summary:

In order to minimize the probability of failure of essential or hazardous systems after an earthquake, new facilities must, and existing facilities should, satisfy the above equipment anchorage and utility bracing requirements. A first step for existing facility operators is to complete an inventory of existing conditions to determine if improvements are warranted. Thereafter, an action plan can be established and implemented over time as part of an ongoing maintenance program. A proactive path to compliance is the best strategy!

If you have any questions or would like more information, please contact Patrick Murphy at 503.655.1342.

Reference documents:

1. *2006 International Building Code (with local amendments)*
2. *ASCE 7-05, "Minimum Design Loads for Buildings and Other Structures"*
3. *NFPA 13, "Installation of Sprinkler Systems", latest edition*
4. *"Seismic Restraint Manual – Guidelines for Mechanical Systems"; Sheet Metal and Air Conditioning Contractors' National Association (SMACNA), latest edition*