Vibration Isolation and Seismic Control
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Factors That Drive Seismic and Wind Design Loads in the IBC

Seismic and wind design loads in the International Building Code and ASCE-7 are driven by project-specific parameters. Depending on a building's use and location, these parameters can differ significantly from those of neighboring structures. Most of these parameters can be found in the basis of design in the structural drawing package, generally on the first page of the structural drawing package. Parameters that affect HVAC equipment and systems are listed below.

FROM THE STRUCTURAL DRAWINGS

International Building Code Year of Issue: Different issues have different requirements and exemptions. Without knowing the version in force on the project, you may be restraining things that don't need restraint, missing things that do, or under restraining critical components.

Seismic Design Category: A building's SDC is based on occupancy, use and the level of expected ground motion. The Seismic Design Category—assigned letters A through F—determines which equipment and systems require seismic restraint. Generally, the higher the letter, the more vulnerable the building, the more items require restraint or the more restraint is required per item.

Site Class: Classifications of soil at the building location are expressed as letters and generally range from hard rock (A) to soft soil (E). Generally speaking, the softer the ground, the more impact of a seismic event on the structure and its contents.

Short Period Spectral Response: The Ss number is the maximum considered earthquake spectral ground acceleration at a period of 0.2 seconds. This figure, derived from USGS maps, is used to compute the seismic forces at a given location. The greater the Ss, the more violent the ground acceleration is expected to be.

Wind Exposure Category: The role neighboring structures and natural features play in wind forces on the building are designated with letters B, C, and D, with the latter indicating the greatest exposure to the wind and least protection.

Wind Speed: The speed, in miles per hour, assumed in a 3-second "peak gust."

FROM OTHER SOURCES

Building Height: The taller the building, the greater the wind loads will be that act on rooftop equipment.

Equipment Elevation: The higher the equipment and systems are installed in the building, the more the swaying motion of the building will affect them and their anchorage during an earthquake.

Component Importance Factor (Ip): A designator assigned to all mechanical, electrical and plumbing equipment and systems in a building denotes the criticality of the item in question. This may have to come from the engineer of record for the equipment or system. The Component Importance Factors are either 1.0 or 1.5. Equipment that is part of a life-safety system (including a smoke evacuation system) or systems that contains natural gas or other hazardous material, are designated as 1.5 no matter what the function of the structure. For critical structures such as hospitals or fire stations, where the building must continue to function, the Ip for all systems is designated as 1.5. This greatly increases the seismic forces that must be overcome when performing an analysis to select restraints for that item. All other equipment and systems are designated as 1.0. Because the Ip factor is linked directly to the system rather than the structure, different factors can be found in the same building.

When working with the IBC code (ASCE 7), there are no Importance Factors that relate to wind. Instead, if working with a critical structure, an entirely different wind map with higher wind speeds is used as a basis for design.

It should be noted that several Importance Factors are used in building projects (structural, building, component, etc.) which often have confusing names; for example, the structural drawings may have an item called Seismic Importance Factor, or something similar. This usually is not the Component Importance Factor as the structural engineer plays no part in assigning the Component Importance Factors to the equipment. As a result, the Component Importance Factor is typically not found on structural drawings.

Two other factors that drive the Seismic loads are the Component Attachment Factor (Ap) and the System Durability Factor (Rp). These parameters are a function of the component type and its mounting condition. A general description of the component type will define them in most cases with piping being a significant exception. The terms for piping will change depending the piping fragility level. Sometimes knowing the function of the piping system is enough to define a typical level of fragility. In other cases, in particular those that deal with high pressures, extremely hazardous, medical gas or some type of unusual processes, some definition of the piping materials and connection types are needed to ensure that the appropriate factors are being considered.

Equipment Physical Characteristics. Equipment size, shape, weight and weight distribution play significant roles in determining seismic and wind restraint requirements. Heavy equipment usually is more challenging to restrain seismically, especially if it has a high center of gravity which makes the equipment more prone to tipping. Large but not necessarily heavy equipment is more difficult to restrain against wind: Its large surface area is susceptible to gusts, and it lacks heft to help anchor it to the building. Some rooftop equipment may have decorative screening walls attached which dramatically increase the area affected by the wind. Often it is not recognized that these screening walls play a role and as a result, information on them sometimes aren't included with equipment submittals.

Often the requirement for restraint will drive the installed equipment footprint to be considerably larger than the basic outline of the equipment. Small, heavy equipment may be challenging to anchor as it may be difficult to fit enough restraints in the available space. The imbalance generated by equipment that has an unsupported section cantilevered to one side or end may generate higher-than-expected seismic forces and also drive the need toward larger restraints. Mounting holes shown on equipment submittal drawings may not be sufficient in size or quantity to allow enough fasteners of adequate size to restrain equipment per code requirements; additional mounting holes or enlarging existing holes may be required.

Equipment Supporting Structure: The type of material (steel, concrete, wood, etc.) to which equipment and systems are attached will determine what kind of attachment hardware is required. Using certain types of hardware introduces additional factors that need to be considered, particularly when using concrete anchors. When working with concrete anchors, because of the nature of the failure, the code requires that they be designed to take as much as 2.5 times the load of a similar through-bolted connection. When designing the connection, the type and thickness of the concrete has to be known. Frequently an oversize base plate that will increase the size, quantity, and spacing of the anchors is required. Concrete slabs less than 4 inches thick and those made of lightweight concrete may be insufficient for wedge-type, concrete screw or adhesive anchors even if fitted with an oversize base plate; the only way to attach to these to the structures may be through-bolting.

Some wall-mounted equipment may require additional strengthening of supporting walls if they are not structurally sufficient (such as drywall on studs). Seismically generated floor loads must also be considered when locating equipment in the building. Lighter weight roof structures may not be sufficient to resist high seismic and wind forces imparted on them by large rooftop equipment during strong winds or earthquakes.

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All of these factors will influence the final wind and seismic restraint design. Failure to take into account one or more during the initial design phase can result in costly and labor-intensive modifications at a later date when access to some areas of the building or equipment may be extremely difficult.

VISCMA is a non-profit association representing the manufacturers of seismic restraint, vibration isolation and noise control equipment. The primary objectives of the organization are to educate the construction industry on the proper use and application of vibration isolation and seismic restraint and to develop standards to continually improve the industry.

In partnership with FEMA and ASCE, VISCMA also publishes three Seismic Installation and Inspection Manuals designed to assist field personnel.

The association office is located at 994 Old Eagle School Road, Suite 1019, Wayne, PA 19087-1866 and can be reached at 610-971-4850 or info@viscma.com.

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