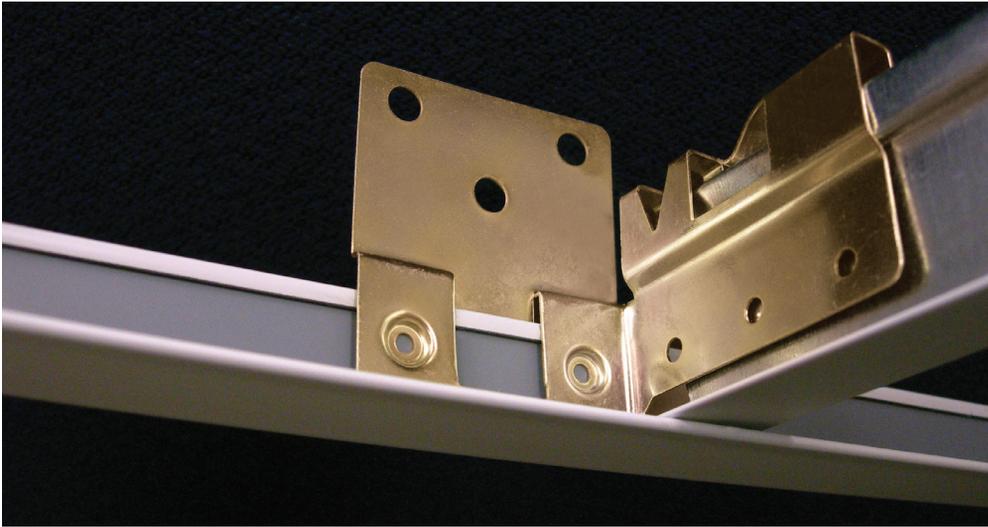


SEISMIC CONSIDERATIONS FOR INTERIOR, SUSPENDED CEILING SYSTEMS

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This seismic perimeter clip may be provided by the ceiling manufacturer with pre-drilled screw holes, ensuring timesaving, error-free installation. Photo courtesy of ROCKFON.

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The Pacific Coast is the most earthquake-prone region of Canada. Each year, more than 1,000 earthquakes are reported in western Canada, including some of the world's largest at magnitudes of eight and nine. Earlier this year, in February 2017, two 4.7 magnitude earthquakes were recorded offshore of British Columbia, and research shows that there is a one in four chance that a major earthquake will occur in the area in the next 50 years.

According to the City of Vancouver, "A recent study from the Insurance Bureau of Canada estimates that the cost of a megathrust earthquake off the coast of BC would be as high as \$75 billion. A smaller earthquake closer to Vancouver could cause even greater damage."

Canada's model building code, the *National Building Code of Canada* (NBCC), sets detailed seismic mitigation requirements to protect people and property during seismic events. Since the regulation of building construction is a provincial responsibility in Canada, it is up to each province and/or territory to either adopt the NBCC in its entirety or use it as a basis to develop its own local code.

While seismic design of structural components, despite its complexity, is covered in detail in those building codes and is well understood by designers, the requirements for seismic restraint for non-structural components (also known as operational and functional components) has historically been a more obscure and less well-defined issue.

To support these goals and to shed some light on the issue, the Canadian Standards Association's CSA S832 "Seismic risk reduction of operational and functional components (OFCs) of buildings" was first published in 2006 and is now referenced in the NBCC. According to CSA S832, OFCs are "those components within a building which are directly associated with the function and operation of the facility. OFCs consist of architectural components, building services components, and building contents." In most commercial buildings, the structural system typically represents only 25 per cent of the building's components, while OFCs account for the remaining 75 per cent.

CSA S832 further states, "The main cause of casualties and property damage in the event of an earthquake is

often the failure of these OFCs. In many cases, losses associated with damage to these components are considerably greater than damage to the structural systems."

The equivalent static force procedure in accordance with the NBCC 2015 allows users to determine whether OFCs require seismic restraints using calculations based on three important factors:

1. Building importance factor, i.e. Low, Normal, High or Post-Disaster;
2. Soil type/site class, based on geotechnical survey of the soil profile; and
3. Anticipated ground motion for the location (short-period spectral acceleration).

The seismic hazard index calculation, specified requirements and determination of construction solutions should be set by a professional engineer and documented in stamped shop drawings. Moreover, certain local codes, such as the British Columbia Building Code, also may require the engineer to inspect the project site to confirm in writing that the materials and systems were installed as specified. It is important to note that the 2015 edition of the NBCC now requires all buildings to account for seismic effects in their design. This is in stark contrast with the 2010 edition in which certain cases with a low seismic hazard index were exempt.

Designers have a crucial duty to ensure that these OFCs, including suspended ceiling systems, have been properly designed to withstand seismic forces to increase life safety, ensure immediate and continued occupancy of structures, and potentially decreasing economic loss and possible long-term liability costs during seismic events.

Even in well-designed buildings, ceilings are important OFCs and are vulnerable to earthquake damage.

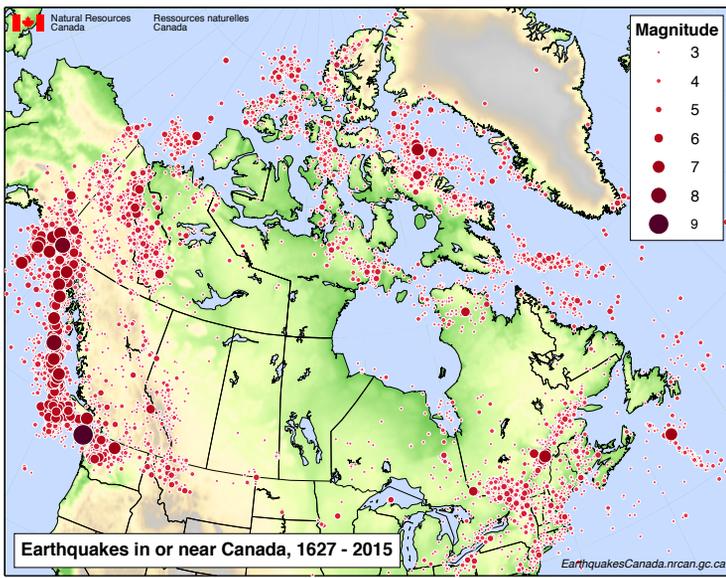


Image courtesy of Natural Resources Canada.

Suspended acoustic panel ceilings have been the preferred design choice in commercial buildings since the 1950s. These interconnected ceiling systems consist of a metal grid comprised of cross-tees and main runners. The main runners of a ceiling system's grid are suspended by hanger wires from the structure above. Wall channels or wall angles provide a clean look around the perimeter.

Lay-in and snap-up ceiling panels, such as acoustic stone wool ceiling tiles or metal panels, are used to conceal the visible structure, pipes, wires and HVAC equipment, as well as the suspension system. Ceiling suspension systems with snap-up torsion spring panels allow maintenance staff access to the plenum area without completely removing the panel or an entire row of panels. The torsion spring panels' connection to the suspension system is strong enough to be effective in areas concerned with seismic activity.

During a seismic event, damage can occur at the perimeter when the vibration period of ceiling systems significantly differs from the surrounding building structure or other OFCs, such as a non-load-bearing partition wall. This can compromise structural integrity at the perimeter, increasing ceiling motion and also potentially leading to total failure of the ceiling system. Ceilings with heavy light fixtures may be susceptible to damage around the fixtures, causing light fixtures to fall into the occupied spaces. The consequences may include damaged property, blocked egress or life-safety hazards.

However, properly specified and installed, suspended ceiling systems with acoustic panels can meet current codes and seismic performance requirements for commercial buildings in western Canada.

To help minimize risk and damage, installation standards for ceiling suspension systems, such as *ASTM E580* "Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions," should be referenced by the designer to ensure:

- Ceiling suspension systems are strong enough to resist lateral force imposed upon them without failing; and
- Border panels are prevented from falling from the ceiling plane.

ASTM E580 outlines prescriptive installation methods to reduce the risk of suspended acoustic ceiling failure during a seismic event. However, users in Canada should exercise caution when specifying this standard, as it is based on Seismic Design Categories (SDCs) as defined by the *U.S. International Building Code* and the American Society of Civil Engineers' *ASCE 7* "Minimum Design Loads for Buildings and Other Structures."

Similar to the NBCC 2015 Seismic Hazard Index, but very different in their calculation methodology, SDCs should be established for each construction project based on three factors:

1. Occupancy category with respect to a building's function;
2. Soil type in a specific geographic area; and
3. Anticipated ground motion.

These SDCs guide the specific product performance installation methods to withstand certain seismic activity levels.

- SDC A – Very small seismic vulnerability.
- SDC B – Low to moderate seismic vulnerability.
- SDC C – Moderate seismic vulnerability.
- SDC D – High seismic vulnerability.
- SDC E, F – Very high seismic vulnerability and near a major fault.

The engineer of record is required to determine the SDC and the best application to meet the project specifications, often using detailed information from ceiling manufacturers and industry associations. The Ceilings & Interior Systems Construction Association "*CISCA Seismic Construction Handbook*" summarizes industry standard construction for acoustical ceiling suspension systems. The handbook shows substantial differences for ceilings in SDC C and SDCs D, E and F, given the significant differences of a particular project's seismic vulnerability.

As noted in the *CISCA* handbook, SDC C requires an intermediate or heavy-duty suspension system as defined by *ASTM C 635* "Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings." However, only heavy-duty load rating suspension systems are recommended for SDCs D, E and F.

The suspended ceiling system's exposed tee construction permits direct upward access to mechanical systems and is a cost-effective solution to seismic requirements. Stab-in cross-tees cantilever during installation and will not fall out, making not only for an easier installation, but also for greater protection against lateral pullout.

Historically, engineers have specified a two-inch-wide perimeter wall molding plus stabilizer bars to provide

support and prevent the ceiling grid from spreading apart along the molding. Recently, some engineers are now selecting a new method of stabilizing tees using a seismic perimeter clip. This innovative method allows installing contractors to use a 15/16-inch angle in lieu of the two-inch angle and eliminates costly stabilizer bars.

Supporting timesaving, error-free installation, the seismic perimeter clip may be provided by the ceiling manufacturer with pre-drilled screw holes. One manufacturer also finishes the clip in a bright gold color to make it easily identifiable on job-site inspections.

Engineers considering this new method may choose to perform their own analysis or can rely on qualified, independent sources, such as the International Code Council-Evaluation Services (ICC-ES), to do the analysis and provide their findings. The ICC-ES reports provide specific, technical evidence relied on by engineers throughout North America and beyond. In addition, full-scale seismic testing of ceiling systems and perimeter clip components have been conducted at the Structural Engineering Earthquake Simulation Laboratory at the State University of New York at Buffalo.

Properly specified and installed, ceiling suspension systems with acoustic panels can help meet national and local codes, and project-specific seismic performance requirements in all SDCs. When engineered to reduce installation and inspection time, suspended ceiling systems not only support life safety and property preservation during an earthquake, but also can save associated material and labor costs. ●

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