Construction
CANADA

Considerations for Suspended Ceiling Systems

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By Isabelle Champagne, CTR

From the time ceiling suspension systems were created, selection criteria have always been based on strength of components, ease of installation, and esthetics. Today, most projects also include safety and sustainability as product characteristics of the ceiling suspension.

A 700-year history

Ceiling suspension systems, also known as T-bar or grid, are a component of modern dropped ceilings. These have been around much longer than most people would suspect. Some of the earliest recorded suspended ceilings are from 14th century Japan. Their use was purely for esthetics and to conceal the unfinished surface above them. They consisted of wood or metal bars arranged in geometric patterns, hung from above, in open interior spaces.

Fast-forwarding to the 1950s, U.S. patent-holder Donald A. Brown is largely credited as the inventor of modern, acoustic, dropped ceilings. This is the era of open-plan office floors with uninterrupted rows of desk workers beneath long spans of ceiling grid. In addition to being quick to install, the success of this system is due in part to maintenance staff's appreciation for the easy access to the space above it by removing ceiling tiles.

The wide-reaching and successful adoption of ceiling suspension systems is due in part to their quick installation and easy access to the plenum space above.

Some of the early suspended ceiling designs were less accessible than others. When a light or air vent was to be removed from the middle of the ceiling, it could require displacing an entire row of tiles to get to replace or repair the fixture. An accessible ceiling is now the norm in the global construction industry.

Standard suspended ceiling components

A dropped ceiling consists of metal channels in the shape of an upside-down "T," suspended on wires from the overhead structure, and connected to one another in a regularly spaced pattern of cells. These cells are filled with lightweight ceiling tiles made of a variety of materials, from cellulose and stone wool to fibreglass, aluminum, and steel.

Based on ASTM C635, *Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings*, the common direct-hung suspension system is made of:

- main runners (main tees) directly suspended with hanger wires to the above substrate;
- cross runners (cross tees) connected to the main tees via their respective end details, which click or hook into themselves in the evenly spaced, punched holes in the main runners;
- wall angles used to support the ceiling tiles and suspension components at terminations, such as soffit bulkheads or walls; and
- perimeter trim located at the periphery of wall-to-wall ceilings, and can be used as wall moulding or as trim encasing the dropped ceiling in a cloud design.

The suspension components are manufactured from a variety of materials depending on the application. Most commonly, these materials are commercial quality painted steel, hot-dip galvanized steel, aluminum, or stainless steel. Wall mouldings are made of aluminum or steel to match the suspension choice, and aluminum is used for perimeter trims.

The ceiling system can be based on either an exposed or a concealed grid. Esthetics or a need to frequently access the plenum will dictate that choice. An exposed grid is used for holding acoustical ceiling tiles or metal panels, which are either flush or tegular. The suspension is visible and several types are available to meet these requirements. Concealed grid is used for suspending gypsum boards at the ceiling in lieu of studs, acoustical ceiling tiles with special concealing edges, and specialty metal ceiling systems.

Applications and installations

Suspended ceiling systems affect nearly every commercial interior space and several exterior applications.

Installation methods of ceiling suspension systems on commercial buildings are enforced by ASTM C636, *Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels*. This standard calls for proper installation of ceiling components, such as:

- spacing of main runners at 1.2 m (4 ft) on centre (o.c.);
- minimum 12-gauge hanger wires;
- hanger wire wrapped with three tight turns over 76.2 mm (3 in.) length;
- hanger wire within 76.2 mm of expansion reliefs unless otherwise tested; and
- counter-sloping allowed under specific circumstances.

Suspension systems are non-structural components of a building and play an important role in safety. They can add valuable extra time for safe egress in the unlikely event of a fire or an earthquake. Securely holding the ceiling components in place, they also help reduce property damage to movable partitions, furniture, and equipment. Finally, they provide a safety net against functional loss within critical facilities, such as data centres, fire stations, hospitals, and other post-disaster facilities, where failure of essential systems would make it difficult or impossible to carry out the facility's functions.

Seismic safety

The *National Building Code of Canada* (*NBC*) sets detailed mitigation requirements to protect people and property during seismic events. It is important to note the 2015 edition of *NBC* now requires design of all buildings to account for seismic effects. This is in contrast with the 2010 edition in which certain cases with a low seismic hazard index were exempt.

Referenced in *NBC*, the Canadian Standards Association's (CSA's) S832, *Seismic risk reduction of operational and functional components (OFCs) of buildings*, 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 *NBC* 2015 allows users to determine whether OFCs require seismic restraints using calculations based on three important factors:

- building importance factor (*i.e.* low, normal, high, or post-disaster);
- soil type/site class, based on geotechnical survey of the soil profile; and
- anticipated ground motion for the location (short-period spectral acceleration).

The requirement for the importance factor, also called the importance category, resides in the structural design part of the code. Its determination, however, is under the purview of the architect and owner, not the structural engineer. Using the

Combining Sound Privacy and Modern Esthetics

Photo © Studio Shai Gil. Photo courtesy Rockfon

Custom pattern suspension systems, stone wool ceiling panels, and metal perimeter trim helped Aercoustics Engineering in Mississauga, Ont., create an acoustically comfortable office in a former warehouse space.

Aercoustics Engineering wanted to create a modern, acoustically comfortable, and pleasing office environment. Its new 836-m^2 (9000-sf) office in Mississauga, Ont., transformed a former warehouse space attached to a larger multitenant office building. The design and construction team included iN Studio, general contractor (GC) mform Construction Group, and installing contractor Maxxan.

The challenge was to leverage the dynamics of collaborative office space—with glass walls and doors to maintain visual connection to the daylit open areas—yet create sound privacy and acoustic comfort in enclosed meeting rooms and other areas. Stone wool ceiling panels, metal perimeter trim, and suspension systems were a key part of the solution in meeting Aercoustics' project goals.

Different acoustic ceiling tiles, all from the same manufacturer, were specified to achieve the unique goals of each room's function. For example, in the smaller, private telephone rooms, stone wool ceiling panels with high sound absorption were installed into a 14-mm (9/16-in.) exposed suspension system. In addition to the acoustic ceiling panels, large sliding wood doors with acoustic seals enable staff to take a call or attend a video conference with full access to their server-based network, confident their conversations are not overheard or disturbing others outside the room.

Aercoustics required a noise reduction coefficient (NRC) of 0.80 or greater in most of its meeting rooms. The larger meeting rooms were constructed with architectural glass walls and custom doors to help with sound isolation and privacy, while maintaining a modern esthetic.

The ceiling manufacturer customized the panels in the enclosed meeting and collaboration spaces to enhance the visual interest, as well as to accommodate each room's lighting and HVAC equipment. Adding to these attractive ceilings, metal perimeter trim integrates with the 14-mm suspension systems to provide a neat, clean edge.

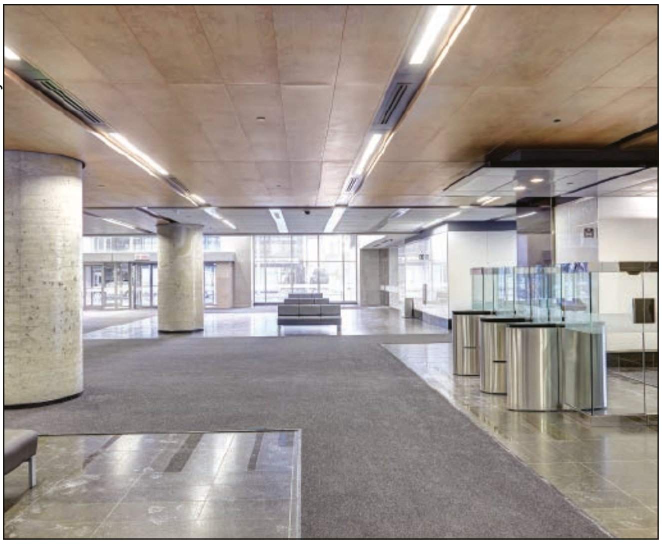
The mildly textured, reflective white surface of the stone wool panels reflects up to 85 per cent of available light. This better distribution of natural light combined with the office's efficient lighting fixtures helps to lower the use of electricity and cooling, saving both energy and associated costs. Further helping the people in the meeting rooms be comfortable, each features its own HVAC controls.

While bright, white, light-reflective ceilings were specified for the meeting rooms, a different esthetic was required for the acoustic demonstration studio. Here, black panels were used to create a dramatic effect. These low-reflection, black surfaces and high-performing sound-absorptive ceiling panels cost-effectively improve both the studio's visual and acoustic experience.

The office staff also can feel more confident in the safety of their workspace. The metal ceiling suspension system is International Code Council-Evaluation Service (ICC-ES) listed for seismic applications and flame spread Class A rated. Stone wool also is non-combustible and does not contribute to the development or spread of fire.

Metal and stone wool have no nutritional value for harmful organisms such as mould or bacteria, helping maintain cleaner, healthier indoor air quality (IAQ). Additionally, the stone wool acoustic ceiling solutions installed in Aercoustics' offices have earned the Underwriters Laboratories' (UL's) GreenGuard Gold certification for low-emitting products and can withstand high levels of humidity.

Along with contributing to comfortable acoustics and lighting, the ceiling panels are made from basalt rock and contain up to 42 per cent recycled material. The metal perimeter trim and suspension systems also contain a high percentage of recycled content and, at the end of their use as part of a ceiling system, can be locally recycled.



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Suspension systems are non-structural components of a building and play an important role in safety, potentially adding valuable time for safe egress in the event of a fire or an earthquake.

Photo © Studio Shai Gil. Photo courtesy Rockfon

Finishing options for metal suspension systems include nearly any colour of paint, metallic coatings, and anodizing options to contrast or complement the panels. In this example, a black painted suspension system complements black ceiling panels.

project's importance factor and site class, a seismic hazard index can be calculated. This calculation, specified requirements, and determination of construction solutions should be set by a professional engineer and documented in stamped plans.

Since the regulation of building construction is a provincial responsibility, it is up to each province and/or territory to either adopt *NBC* in its entirety or use it as a basis to develop its own local code. Certain local codes, such as the *Ontario Building Code* (*OBC*), note that if the value of the seismic hazard index is equal to or greater than 0.35, restraint will be needed for architectural elements including mechanical and electrical equipment, parapets, light fixtures, and suspended ceilings. Local codes also may require the engineer to inspect the project site to confirm in writing the materials and systems were installed as specified.

If the importance factor is not considered during the building's early design and specification stage, and if provisions for seismic design, restraint, and inspection are not incorporated in the drawings and specifications for permit and construction, revisions to comply with the code requirements may later result in a difficult and costly surprise.

Specifiers and designers also should exercise caution when referencing ASTM E580, *Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions,* as this is based on seismic design categories (SDCs) as defined by the *International Building Code* (*IBC*), and its practices generally are accepted in Canada.

Similar to *NBC* 2015 seismic hazard index, but very different in its calculation methodology, SDCs guide the specific product performance installation methods to withstand certain seismic activity levels. These five levels range from SDC A, very small seismic vulnerability, to SDCs E and F, very high seismic vulnerability and near a major fault. In accordance with ASTM E580, seismic clips, stabilizer bars, and seismic separation joints may be required depending on the types of occupancy and soil, geography, and sizes of the ceiling. The building permits will need to refer to SDCs A to F for construction of suspended ceilings weighing less than 9.53 kg/m^2 (4 psf).

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 pull-out.

A third-party certification on product performance is often referenced as accepted documentation for demonstrating code compliance to the authority having jurisdiction (AHJ). Most ceiling manufacturers in North America list their suspension systems with the International Code Council-Evaluation Service (ICC-ES). Within an ICC-ES report, detailed information on components' dimensions and accessories, such as seismic clips, are described. This description includes duty classification, thickness, flange, bulb, and allowable load and span.

Specialty and drywall suspension systems

In addition to seismic performance, other considerations for special ceiling specifications are:

- non-ferrous suspension systems for magnetic resonance imaging (MRI) rooms;
- heavy duty main runners for supporting wire baskets in data centres; and
- drywall suspension systems for both non-fire rated assemblies and hourly fire-rated floor-ceiling and ceiling-roof assemblies, in condominiums, office buildings, and retail spaces.

Drywall suspensions provide a lightweight alternative structure to traditional cloud construction, where they can replace the steel or wood supports as a cost-effective option for commercial ceiling installation. These systems include furring main runners, which are installed with either a cross tee or cross channel, a hat-shaped piece offering a large knurled surface for drywall screws.

James Michael Flaherty Building, Ottawa

The ceiling systems employed at Ottawa's 90 Elgin Street federal office complex support the project's requirements for comfort, safety, durability, and sustainability as well as meeting the criteria for Leadership in Energy and Environmental Design (LEED) Gold.

A 60,387-m^2 (650,000-sf), 17-storey federal office complex makes its home at 90 Elgin Street on Crown-owned property among Ottawa's national monuments and institutions. The $250-million building features metal suspended ceiling systems throughout its lobby and offices. In addition to helping create an attractive workplace, these ceiling systems also support requirements for comfort, including acoustics; safety, including seismic conditions; and sustainability, including Leadership in Energy and Environmental Design (LEED) Gold criteria.

As the 90 Elgin Street's development manager, GWL Realty Advisors ensured the building would be worthy of its prominent placement and national significance for the federal government as the landowner and The Great-West Life Assurance Company as the building owner. Designed by the joint venture of DIALOG and David S McRobie Architects (DSMA), the building's stature and style are consistent with other significant federal buildings surrounding Confederation Square.

Bringing this vision to reality, Ron Engineering and Construction (Eastern) served as the design-builder. The project team needed to balance cost effectiveness with a high-quality standard. The request for proposal (RFP) called for high-quality materials in the lobby such as granite, glass, metals, and a wood ceiling. Not only were these high-end finishes expensive, but also very hard surfaces.

There was concern excessive reverberation caused by the use of hard surfaces would make it difficult to hear any announcements over the public address. The ceiling was the primary opportunity to improve the acoustic performance. Challenges the ceiling team needed to address included designing for sustainability and potential earthquakes.

Once the whole team understood the project's design criteria and parameters, alternatives fitting the budget and meeting design expectations could be explored. A solution was found in specialty metal ceiling panels and matching custom metal trim, painted to look like real wood, paired with standard suspension systems. Installing contractor Advance Drywall worked with the manufacturer to co-ordinate a full-scale mockup and work through the details before scaling up to the actual installation.

Suspended at various planes, the rectangular ceiling pods add visual interest to the main lobby. Achieving the intended look and performance involved more than 492 m^2 (5300 sf) of metal lay-in, reveal edge, solid aluminum panels. Black, lay-in metal panels knit together the ceiling's rectangular pods and panels.

In contrast to the warm wood-look finish, a sleek metallic silver anodized finish was selected for the linear metal ceiling in the lobby entrance on Elgin Street facing the National Arts Centre. To create this eight-storey-tall grand welcome, Advance Drywall installed 200-mm (8-in.) wide, square edge, open reveal, metal panels. A similar ceiling system was used for the secondary lobby entrance.

Silver anodizing also was the finish of choice on the ceiling pods positioned at the elevator bays. These pods are composed of standard suspension systems, metal perimeter trim, and lay-in metal panels. An acoustical backer and perforation on the panels offer high sound absorption, achieving an NRC of 0.90. Elsewhere in the lobby, 0.70 NRC was acceptable.

Final details were presented to confirm how the various ceiling systems integrated with the lighting, air diffusers, sprinklers, security systems, and columns. The lighting fixtures already had been ordered, so extra care was needed to make sure the ceiling panels were properly sized for a smooth installation. Not only did the ceiling system need to accommodate these elements, but also needed to provide easy access to the plenum for potential repairs and updates to wires, pipes, ducts, and other components. The hook-on metal panels allow maintenance staff downward accessibility to the plenum, without the need for special tools. The ceiling manufacturer pre-cuts everything in the factory and engineered a new attachment for the hook-on system, along with special wall channels, column rings, and connectors.

Standard ceiling suspension systems were installed in the majority of the offices. Promoting team building and enhancing workplace well-being, the offices' interior design subscribes to the new "Government of Canada's Workplace 2.0 Fit-up Standards." This initiative champions the design of modern workplace to attract, retain, and encourage public servants to work smarter, greener, and healthier. These also mesh with the Canadian Green Building Council's (CaGBC's) LEED guidelines.

The project earned LEED Gold certification for Core and Shell.

Photo © Bochsler Creative Services. Photo courtesy Rockfon

Suspended ceiling systems not only accommodate panels of various sizes, but also lighting, air diffusers, sprinklers, security systems, and columns. For a federal office complex in Ottawa, the metal ceiling system manufacturer pre-cut everything in the factory and engineered a new attachment for the hook-on system, along with special wall channels, column rings, and connectors.

Panel and esthetic options

All suspension systems perform the same function of holding panels in a single plane from the overhead building structure. They will differ in their compatibility with certain styles of panels. They will simplify or embellish the appearance of the finished ceiling.

Suspension systems come in a wide variety of looks and in a range of prices. The industry standard is a 24-mm (15/16-in.) grid face; it is the workhorse in the industry for supporting standard acoustic ceiling panels. The 24-mm suspension is built with a face large enough to suspend semi-concealed and fully concealed acoustical ceiling tiles. These edges types partially or completely conceal the suspension. The 24 mm suspension is used with most specialty lay-in ceiling panels for ease of installation and removal, and is also used with specialty applications, such as clean rooms and data centres. For these high-performance installations, a gasket is applied to the inner face of the suspension to provide positive air pressure isolation between the ceiling plenum and the room below it.

The 14-mm (9/16-in.) suspension system provides an architecturally desirable, narrow face. Bolt-slot options with a 3-mm (1/8-in.) or 6-mm (1/4-in.) reveal can add depth with a shadow line in the centre of the suspension, or centre bulb creating a premium double reveal. The grid fits flush with the face of reveal-edge panels, and mitred intersections provide a clean, tailored appearance. To create these esthetic variations, a tegular edge infill panel is installed with narrow wall angles or with shadow mouldings, often called step moulding because of their resemblance to a small staircase.

Suspensions systems and their accessories, such as wall mouldings, C channels, and perimeter trims can be finished to match or contrast with the ceiling tiles' colour. Finishing options for metal suspension systems include nearly any colour of paint, metallic coatings, and anodizing options, or finishes complementing the look of wood of the panels. White, black, and silver colours remain the most popular choices.

Ceiling suspension systems have been an integral part of office and institutional spaces for decades. They provide an exposed or concealed support system to the ceiling tiles, accommodate light fixtures and other components, and help separate the plenum space from the working area. As a sixth plane complementing walls and floors, ceilings have become the focus for elegant, functional, acoustical, and sustainable characteristics. Ceilings cannot meet expectations without their backbone—their suspension systems.

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