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Seismic Safety for Acoustic Ceilings

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Specifying Seismic Ceiling Safety

by Mark Taylor

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THE *INTERNATIONAL BUILDING CODE* (*IBC*) SETS MINIMUM REQUIREMENTS FOR LIFE SAFETY AND PRESERVATION OF PROPERTY. ALL 50 STATES AND THE U.S. VIRGIN ISLANDS USE THE CODE AT LOCAL OR STATEWIDE LEVELS. FOLLOWING ITS REQUIREMENTS HELPS INCREASE SAFETY AND MAY DECREASE POSSIBLE LONG-TERM LIABILITY COSTS. PROPERLY SPECIFIED AND INSTALLED IN COMMERCIAL BUILDINGS, CEILING SUSPENSION SYSTEMS WITH ACOUSTIC PANELS CAN MEET CURRENT CODES AND SEISMIC PERFORMANCE REQUIREMENTS ACROSS THE UNITED STATES.

According to the 2012 *IBC*, a Seismic Design Category (SDC) must be established for each construction project based on anticipated ground motion, the type of soil in a specific geographic area, and the occupancy category. These SDCs determine specific product performance and installation methods required by code to withstand certain seismic activity levels.

A professional engineer or a registered architect must specify the SDC on the project drawings. Structural engineers ultimately have responsibility for building elements and systems that carry the structure's loads. However, these components only represent 25 percent of a typical commercial building's inventory. The remaining 75 percent are non-structural components—such as is the

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case for suspended ceiling systems—where responsibilities are assigned to multiple team members.

Industry standard construction

Ceilings are important non-structural components vulnerable to earthquake damage, even in well-designed buildings. Suspended, acoustic panel ceilings have been the preferred design choice in commercial buildings since the 1950s. The interconnected ceiling systems typically consist of a metal grid comprising cross-tees and main runners.

The main runners are suspended by hanger wires from the structure above, and wall channels or angles provide a clean look around the perimeter. Lay-in and snap-up ceiling panels, such as stone wool acoustic ceiling tiles, are used to conceal the visible structure, pipes, wires, HVAC equipment, and suspension system.

For frequently accessed plenum areas, ceiling suspension systems with snap-up torsion spring panels allow maintenance staff access without completely removing the panel. The connection's strength to the suspension system enables torsion spring panels 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 and other nonstructural components, such as non-load-bearing partition walls. 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 lighting 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, and life-safety hazards.

AMR Architects designed Arkansas State University's Humanities and Social Sciences building's exterior to complement the campus' historic architecture and its modern interior to meet seismic and acoustic performance requirements.

Figure 1

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

The Seismic Design Categories (SDCs) set out in the 2012 edition of the *International Building Code* (*IBC*).

Intended to minimize risk and damage, installation standards for ceiling suspension systems in SDCs are specified 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/E580M, *Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions*, covers acoustical ceiling suspension systems and their additional requirements for SDC C, D, E, and F as outlined in *IBC* 2012 (Figure 1). Local authorities having jurisdiction (AHJs) determine the application of these practices often using project specifications and detailed information from ceiling manufacturers and industry associations.

The 2014 Ceilings & Interior Systems Construction Association (CISCA) *Seismic Construction Handbook* summarizes industry standard construction per the 2012 *IBC* for acoustical ceiling suspension systems.[1] The chart in "*IBC* 2012 Industry Standard Construction" (beginning on page 12) references the CISCA handbook and shows the substantial differences for SDC C and SDCs D, E, and F with respect to the significance of a particular project's seismic vulnerability.

Budget constraints required value-engineered options for the Humanities and Social Sciences Building's ceiling systems selections, which included stone wool acoustic ceiling panels and seismic ceiling suspension systems.

Installation and inspection

As noted in the chart, most ceiling systems are offered in 'intermediate-duty' and 'heavy-duty' performance per ASTM C635, *Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings*, to satisfy the requirements of all seismic code constructions. The 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 protecting against lateral pull-out.

IBC 2012 INDUSTRY STANDARD CONSTRUCTION

	SDC C	SDCs D, E, and F
Code Sections	American Society of Civil Engineers (ASCE) 7-10, *Minimum Design Loads for Buildings and Other Structures*. Section 13.5.6.2.1	ASCE 7-10. Sections 13.5.6, 13.5.6.2 and 13.5.6.2.2
ASTM C635 Duty Rating	• Intermediate or heavy-duty load rating suspension systems as defined by ASTM C635, *Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings*	• Heavy-duty load rating suspension systems as defined in ASTM C635 is required
Suspension System Connections	• Minimum main-runner splices and cross-runner intersections strength of 27.2 kg (60 lb)	• Minimum main-runner splices and cross-runner intersections strength of 81.6 kg (180 lb)
Vertical Suspension Wires	• Vertical hanger wires must be a minimum No. 12 gage • Vertical hanger wires maximum 1200 mm (4 ft) on center (oc) unless justified by calculations or test results • For field-tied connections, vertical hanger wires must be sharply bent and wrapped with three turns in 75 mm (3 in.) or less • All vertical hanger wires may not be more than 1/6 out of plumb without having additional wires counter splayed • Wires may not attach to or bend around interfering equipment. Use trapezes to avoid such obstacles	• Vertical hanger wire must be a minimum No. 12 gage • Vertical hanger wires maximum 1200 mm oc unless other design approvals are listed by the manufacturer • Vertical hanger wires must be straight and shall not use bends or localized kinks for leveling the system • For field-tied connections, vertical hanger wires must be sharply bent and wrapped with three turns in 75 mm or less • All vertical hanger wires may not be more than ⅙ out of plumb without having additional wires counter-splayed • A device used to secure the hanger wire to the structure above must sustain a minimum load of 40 kg (90 lb) • Power-actuated fasteners are now permitted for loads that do not exceed 40 kg (90 lb) in concrete and do not exceed 110 kg (250 lb) in steel • Wires may not attach to or bend around interfering equipment; use trapezes to avoid such obstacles
Lateral Force Bracing	• Lateral force bracing is not permitted	• Ceilings less than or equal to 13.4 m^2 (144 sf) and surrounded by walls connected to the structure above are exempt from these requirements of this practice • Lateral force bracing is required for all ceilings more than 90 m^2 (1000 sf) • Where required, lateral force bracing (splay wires or rigid bracing and a compression post) must be located within 50 mm (2 in.) of main-/cross-runner intersection and splayed approximately 90 degrees apart in the plan view, at a maximum 45-degree angle from the horizontal and located 3600 mm (12 ft) on center in both directions, starting 1800 mm (6 ft) from two adjacent walls • Lateral force bracing must be spaced a minimum of 150 mm (6 in.) from unbraced horizontal piping or ductwork • Lateral force bracing connection strength must be a minimum of 110 kg (250 lb) • Rigid bracing must be designed to limit deflection to less than 6.5 mm (¼ in.) • Unless rigid bracing is used or calculations have shown lateral deflection is less than 6.5 mm (¼ in.), sprinkler heads and other penetrations shall have a minimum of 25 mm (1 in.) clear space in all directions

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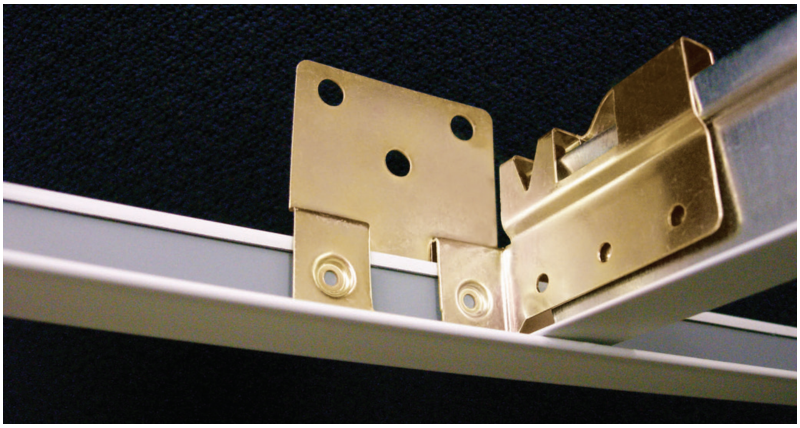

This clip meets seismic criteria set forth by *IBC* to stabilize main and cross-tees at the ceiling's perimeter. It ties together perimeter components and has been tested and recognized as an alternate method of stabilizing tees at the perimeter. Its robust construction allows contractors to use a sleek 24-mm (15⁄16-in.) angle in lieu of the less-desirable 50-mm (2-in.) angle and eliminates costly stabilizer bars.

Current code requirements include a 50-mm (2-in.) wide perimeter wall molding, and stabilizer bars to provide support, and prevent the ceiling grid from spreading apart along the molding. Some ceiling manufacturers offer a seismic perimeter clip as an alternate method of stabilizing tees at the perimeter. This allows installing contractors to use a 24-mm (15⁄16-in.) angle in lieu of the 50-mm (2-in.) angle and eliminates costly stabilizer bars. Supporting timesaving, error-free installation, at least one manufacturer provides the seismic perimeter clip with pre-drilled screw holes and in a bright gold to make it easily identifiable on jobsite inspections.

While *IBC* establishes the requirements, it is the code official that has the power to enforce its provisions. Code officials also have the latitude to allow materials and methods of construction not addressed in the code. In this case, they can perform their own analysis of the evidence presented or they can rely on independent, qualified sources such as International Code Council-Evaluation Services (ICC-ES) to do the analysis and provide their findings. The ICC-ES resulting report is specific, technical evidence on which the code official can base approval of a particular design without delaying construction.

IBC 2012 INDUSTRY STANDARD CONSTRUCTION *continued*

Perimeter	• Perimeter closure (molding) width must be a minimum of 22 mm (7⁄8 in.) • A minimum clearance of 9.5 mm (3⁄8 in.) must be maintained on all four sides • The suspension system's ends on all four walls must be free to move • When a closure angle with a supporting shelf less than 22 mm (7⁄8 in.) is used, perimeter runners must be supported by vertical hanger wires not more than 200 mm (8 in.) from the wall • Proprietary solutions may utilize approved attachment devices on some walls and varying closure widths • Perimeter runner ends must be tied together to prevent spreading	• Perimeter closure (molding) width must be a minimum of 50 mm (2 in.) • Proprietary solutions using approved perimeter clips may utilize perimeter closures less than 50 mm (2 in.) • The suspension system must be connected to the perimeter on two adjacent sides • A minimum clearance of 20 mm (3⁄4 in.) must be maintained on two, unattached adjacent sides • Perimeter runners must be supported by vertical hanger wires not more than 200 mm (8 in.) from the wall • Unattached perimeter runner ends must be tied together to prevent spreading
Light Fixtures	• Lighting fixtures must be positively attached to the suspension system by at least two connections each capable of supporting the weight of the lighting fixture (National Electrical Code) • Surface-mounted lighting fixtures shall be positively clamped to the suspension system • Clamping devices for surface-mounted lighting fixtures shall have safety wires to the suspension system or the structure above • Lighting fixtures and attachments weighing 4.5 kg (10 lb) or less (*e.g.* canister light fixtures) require one No. 12 gage (minimum) hanger wire connected from the housing to the structure above; this wire may be slack • Lighting fixtures weighing more than 4.5 kg, but less than 25 kg (56 lb), require two No. 12 gage (minimum) hanger wires connected from the fixture housing to the structure above; these wires may be slack • Lighting fixtures weighing 25 kg or more require independent support from the structure above by approved hangers. • Pendent-hung light fixtures shall be supported by a minimum one No. 9 gage wire or other approved alternate support • Rigid conduit is not permitted for the attachment of fixtures	• Lighting fixtures must be positively attached to the suspension system by at least two connections each capable of supporting the weight of the lighting fixture • Surface-mounted lighting fixtures shall be positively clamped to the suspension system • Clamping devices for surface-mounted lighting fixtures shall have safety wires to the suspension system or the structure above • When cross-runners with a load carrying capacity of less than 24 kg/m (16 lb/ft) are used, supplementary hanger wires are required • Lighting fixtures and attachments weighing 4.5 kg (or less require one No. 12 gage minimum hanger wire connected to the housing (*e.g.* canister light fixture) and connected to the structure above; this wire may be slack • Lighting fixtures weighing more than 4.5 kg, but less than 25 kg require two No. 12 gage minimum hanger wires connected to the fixture housing on opposite diagonal corners and connected to the structure above; these wires may be slack • Lighting fixtures weighing 25 kg or more require independent support from the structure by approved hangers • Pendent-hung light fixtures shall be supported by a No. 9 gage minimum hanger wire or other approved alternate • Rigid conduit is not permitted for the attachment of fixtures

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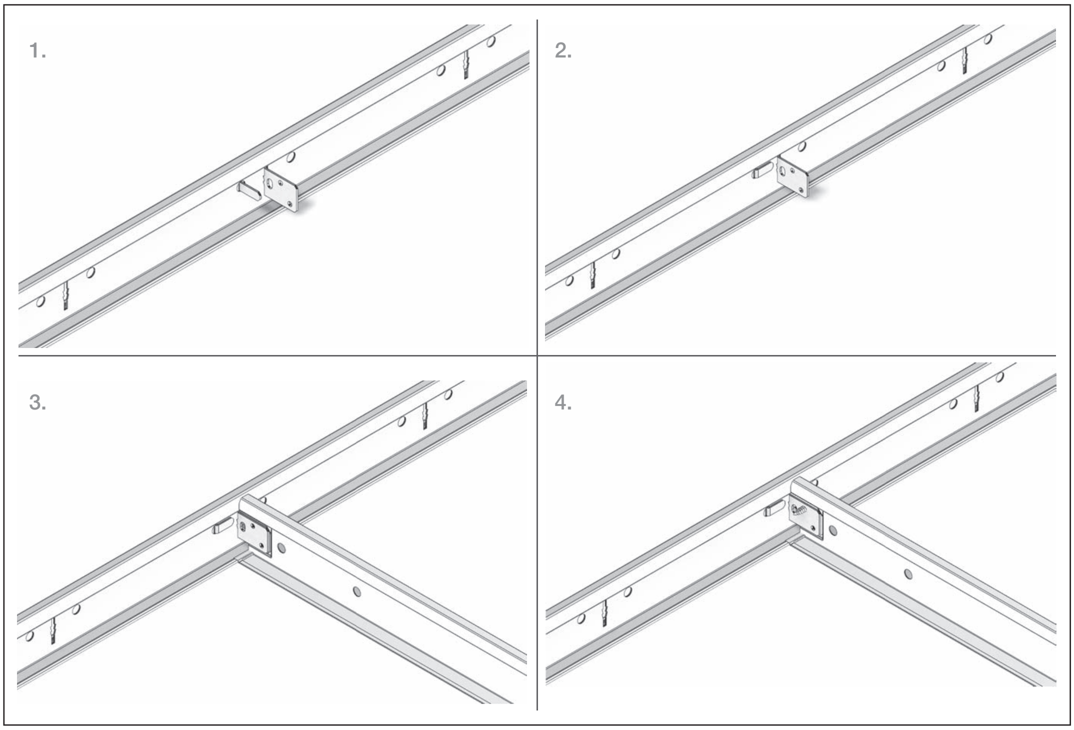
Along with meeting the building's safety and acoustic performance needs, the seismic ceiling suspension system further contributes to the ceiling's anti-microbial performance and sustainable goals.

As ceiling panel performance and non-tee bar suspension systems are not well-defined in the *IBC* requirements, ceiling system manufacturers and structural engineering firms have worked together to test both standard and non-standard ceiling systems for seismic performance at the Structural Engineering Earthquake Simulation Laboratory (SEESL) at the State University of New York (SUNY) at Buffalo. The results of these full-scale seismic tests offer proven safety and performance support for standard and non-standard ceilings, flexible design options, and more efficient installation designs.

Properly specified and installed, ceiling suspension systems with acoustic panels can meet current codes and seismic performance requirements in all SDCs and all U.S. jurisdictions. When engineered to reduce

IBC 2012 INDUSTRY STANDARD CONSTRUCTION *continued*

Mechanical Services	• Flexibly mounted mechanical services weighing less than or equal to 9 kg (20 lb) must be positively attached to main runners or cross-runners with the same load-carrying capacity as the main runners • Flexibly mounted mechanical services weighing more than 9 kg (20 lb), but less than 25 kg (56 lb), or less require two No. 12 gage (minimum) hanger wires; these wires may be slack • Flexibly mounted mechanical services 25 kg or more require direct support from the structure	• Flexible mechanical services weighing less than 9 kg (20 lb) must be positively attached to main runners or to cross-runners that have the same load carrying capacity as the main runners • In addition to the previous requirement for positive attachment, flexible mechanical services weighing more than 9 kg, but less than 25 kg, require two No. 12 gage minimum hanger wires connected to the fixture housing on opposite diagonal corners and connected to the structure above; these wires may be slack • Flexible mechanical services more than 25 kg require direct support from the structure
Special Consideration	• All ceiling penetrations must have a minimum of 9.5 mm (⅜ in.) clearance on all sides	• Direct concealed systems must have stabilizer bars a maximum of 1500 mm (60 in.) oc with stabilizer bars within 600 mm (24 in.) of the perimeter • Bracing is required for ceiling plane elevation changes • Cable trays and electrical conduits shall be supported and braced independently of the ceiling • As an alternate to providing large clearances around sprinkler system penetrations through ceilings, the sprinkler system and ceiling suspension system are permitted to be designed by a design professional and tied together as an integral unit; such a design shall consider the mass and flexibility of all elements involved, including the ceiling, sprinkler system, light fixtures, and mechanical (HVAC) • Seismic separation joints, bulkheads braced to the structure, or full-height partitions are required that divide the ceiling into areas less than or equal to 230 m^2 (2500 sf) • Areas divided into 230-m^2 sections as above, must have a ratio of the long side to the short side of less than or equal to 4:1 • All ceiling penetrations and independently supported fixtures or services must have closures, which allow for a 25-mm (1-in.) movement • A licensed design professional must review the interaction effects of non-essential ceiling components on essential ceiling components to prevent their failure
Partitions	• The ceiling may not provide lateral support to partitions • Partitions attached to the ceiling must use flexible connections to avoid transferring force to the ceiling	• Partition bracing must be independent of ceiling
Exceptions	• The ceiling weight must be 2.5 psf or less; for ceilings more than 2.5 psf, the prescribed construction for SDCs D, E, and F must be used	
Exemption	• Ceilings less than or equal to 13.3 m^2 (144 sf) and surrounded by walls connected to the structure above are exempt from the requirements of this practice	• Ceilings less than or equal to 13.3 m^2 and surrounded by walls connected to the structure above are exempt from the requirements of this practice



According to *IBC*, all system connections in SDCs D, E, and F are required to be stronger than 82 kg (180 lb) of pull out force. This unopposed tee clip is utilized when a cross-tee does not have another cross-tee to engage the ends and meets the above requirement when used with selected ceiling suspension systems.
Step 1: Insert clip into slot.
Step 2: Bend short leg.
Step 3: Insert cross-tee.
Step 4: Insert screw.

Images courtesy Rockfon

installation time, ceiling suspension systems not only support life safety and the property preservation during an earthquake, but they also can save associated material and labor costs. Combined with the inherent properties of stone wool acoustic ceiling panels,[2] these systems also protect people from noise and the spread of fire, while making a constructive contribution toward a sustainable future. **CS**

Notes

[1] Visit www.cisca.org/i4a/ams/amsstore/itemview.cfm?ID=274.

[2] For more information on stone wool ceiling assemblies, see Cory Nevins' article, "Designing Stone Wool Ceiling Assemblies," in the August 2014 issue of *The Construction Specifier*. Visit www.constructionspecifier.com/designing-stone-wool-ceiling-assemblies.

ADDITIONAL **INFORMATION**

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Mark Taylor is the marketing manager for Rockfon's ceiling systems for North America. He began his career in the commercial building industry as a carpenter; in addition to field experience, he earned a bachelor's degree in industrial technology from Eastern Illinois University. Continuing to grow and share his industry knowledge, Taylor is a member of the Ceilings & Interior Systems Construction Association (CISCA) and recently published Rockfon's new brochure titled, "Seismic Relief." He can be reached at mtaylor@rockfon.com.

Abstract
Properly specified and installed, ceiling suspension systems with acoustic panels can meet current codes and seismic performance requirements in all U.S. jurisdictions. When engineered to reduce installation time, ceiling suspension systems not only support life safety and the property preservation during an earthquake, but they also can save associated material and labor costs. Combined with the inherent properties of stone wool acoustic ceiling panels, these systems also protect people from noise and the spread of fire, while making a constructive contribution toward a sustainable future.

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