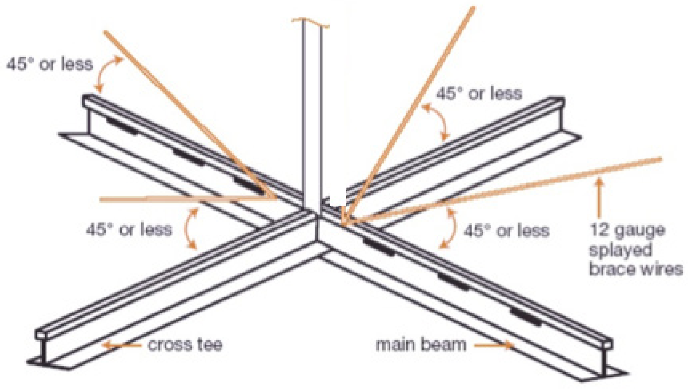
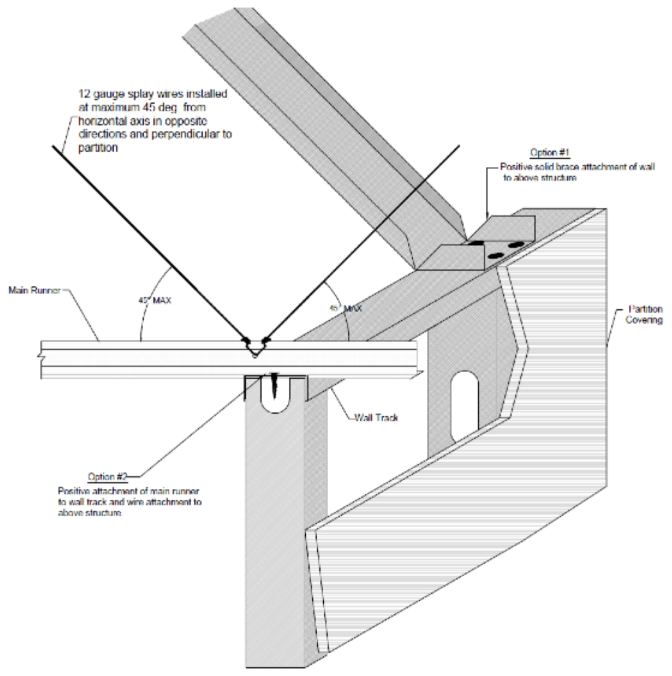
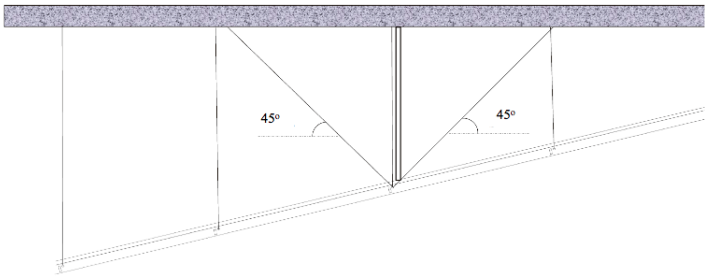






Seismic Construction Handbook

CISCA
Ceilings & Interior Systems Construction Association ®

Seismic Construction Handbook

Introduction

Scope

This document is intended to help the reader understand the seismic construction requirements for lay-in, suspended ceilings. It explains those requirements and demonstrates generally accepted construction methods that comply with these requirements. It also includes a comprehensive list of documents containing these requirements. It will list what suspended ceiling systems are covered by the IBC/ASCE 7 prescriptive requirements and which are not. Finally, it will give tips to reduce construction costs and suggestions to solve commonly encountered problems.

Building Codes

Most people are aware that nearly all construction in the United States is governed by building codes.

Most building code requirements arise from two concerns: Life Safety and Aesthetics. Examples of life safety concerns are fire safety, earthquake, wind and structural requirements. Examples of aesthetic concerns are fencing and usage codes (commercial, industrial, residential), as well as signage requirements. It is important to understand that most codes are written "after the fact." That is, life safety codes are written or updated after a failure. Aesthetic codes are written or updated after residents complain to local government. Although code requirements seem arbitrary, they are almost always rooted in past problems. Anyone from California or Florida is familiar with changes in code requirements after natural disasters like earthquakes or hurricanes.

Code prioritization, that is, which document controls the construction in question, is likewise poorly understood. The IBC and ASCE 7 are described as "model codes." They do not have the force of law unless adopted by governments. In most states this occurs at the state level. The state code is then adopted by local jurisdiction. Some states do not have a state-level building code so all adoption is at the local level. Both the state and local jurisdictions can and do make changes to the codes. Thus, the only way to know the exact requirements is to know what is required by the governmental agency having jurisdiction. Additionally, many states have separate bodies responsible for schools, hospitals, prisons, state-owned construction, etc. It is the responsibility of the design professional of record to determine the actual requirements for each construction project.

Because of several agencies "adopting" other standards as part of their own, the prioritization for seismic construction of suspended ceilings is particularly complex. The hierarchy from lowest to highest is as follows:

- ASTM E580
- ASCE 7 (which adopts ASTM E580 for most of its seismic requirements for suspended ceilings)
- IBC (which adopts ASCE 7 for nearly all seismic requirements)
- State Building Code
- Local Jurisdiction (city, county, township, or state agency such as (OSHPD))

The local jurisdiction has the final say for all code requirements. Thus, the City of Los Angeles has requirements different from the state of California and the state of Oregon has different requirements from the IBC. It is generally only possible to know all the requirements at the local level by doing business in that jurisdiction.

Although this priority may seem backwards, it is actually the most practical way of administering code enforcement. The model codes cannot possibly anticipate the requirements of every jurisdiction. Jurisdictions with unique natural hazards, such as Florida (hurricanes) or Hawaii (active volcanoes), will be much more qualified to make specific code requirements for these conditions. Agencies responsible for specialized use construction, such as OSHPD (hospitals), will have a better understanding of the requirements of these facilities. Furthermore, construction details often make compliance with specific code requirements impractical. Local officials and inspectors need the authority to approve alternate construction details to avoid needlessly costly rework.

The prescriptive requirements in ASCE 7 are intended to cover direct-hung acoustical panel and lay-in panel ceiling systems.

The following suspended ceilings are exempted from the suspended ceiling requirements of the ASCE 7 as defined by ASTM E580.

- Screw or nail attached gypsum board ceilings of one level, surrounded by walls that connect to the building structure

- Ceilings less than 144 square feet (13.4 m^2) that are surrounded by walls that connect to the structure above.
- Island ceilings (suspended from chains ASTM E580)

The following ceilings require custom solutions as they are not exempt, but cannot be constructed by using the prescribed construction method.

- Indirect-Hung Ceilings
- Curved Ceilings
- Lath and Plaster Ceilings

Changes in suspended ceiling systems ASCE 7-10 from ASCE 7-05

- ASTM E580 is specified in ASCE 7-10 instead of the two previous CISCA Standards
- Much of the specification in ASCE 7-05 has been eliminated as it is also contained in ASTM E580
- These two changes make determining the requirements much simpler, as virtually all requirements are contained in E580, instead of spread out over ASCE 7 and two CISCA documents
- When dividing a very large ceiling into 2,500 square feet (230 m^2) such as using seismic separation joints or other means, the aspect ratio is now limited. The ratio of the longest dimension to the shortest must be less than or equal to four
- Power actuated fasteners are now permitted to be used for loads not greater than 90 lbs. (400 N) in concrete and not greater than 250 lbs. (1000 N) in steel. This makes them suitable for suspension wires, but not for lateral bracing. Lateral bracing connections must be capable of holding at least 250 lbs. (1000 N). This is the equivalent of the 180 pound (800 N.) connection force at 45 degrees. Lath and Plaster ceilings are no longer exempt and will require custom solutions

Seismic Design Category

The requirements for a suspended ceiling are determined by the buildings Seismic Design Category. Determination of the Seismic Design Category is complex and must be determined by a Registered Architect or Professional Engineer and should be found in the construction documentation.

The Seismic Design Category is determined from the following parameters:

- The design force of the earthquake, which is determined by the location of the building with relationship to known earthquake faults
- The soil the building foundation rests on
- The Occupancy Category (use of the building)

Seismic Design Categories are given letter classifications A, B, C, D, E, and F. The following table lists the requirements for suspended ceilings.

Categories A & B	No Requirements
Category C	Island Ceilings Described in Seismic Design Category C
Categories D, E, & F	Braced Ceiling Described in Seismic Design Category D, E, & F

Seismic Design Category C

— Design Intent

Damage has been observed in moderate earthquakes to suspended acoustical tile ceilings. Failure typically occurs at the perimeter of the ceiling. Unbraced ceilings are significantly more flexible than the floors or roofs to which they are attached. The ceilings therefore will sway independent from the floor or roof, typically resulting in the runners at the walls breaking their connections. This construction method is designed to avoid this type of damage when the anticipated earthquake movements are small. The ceiling is isolated from the perimeter so no forces will be transferred from the walls to the suspended ceiling. Thus, the building is free to move without contacting the ceiling. The vertical hanger wires will transfer very little force or movement from the supporting structure to the suspended ceiling. Thus, the ceiling will not experience any significant forces. For this method to function, no other attachments that may transfer force to the ceiling can be made. Structural components such as columns must be isolated from the suspended ceiling similar to the surrounding walls. Other non-structural components such as ceiling-height partitions, sprinklers, etc., must also be isolated from the suspended ceiling.

IBC 2012 SEISMIC DESIGN CATEGORY C	
Code Section	ASCE 7-10. Section 13.5.6.2.1
ASTM C635 Duty Rating	Intermediate or Heavy Duty Load Rating grid as defined by ASTM C635
Grid Connections	Minimum main runner splices and cross runner intersections strength of 60 lbs. (270 N)
Vertical Suspension Wires	Vertical hanger wires must be a minimum No. 12 gage Vertical hanger wires maximum 4 feet (1200 mm.) on center unless justified by calculations or test results For field tied connections, vertical hanger wires must be sharply bent and wrapped with three turns in 3 inches (75 mm) or less (Figure 1) 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. (Figure 2)
Lateral Force Bracing	Lateral force bracing is not permitted
Perimeter	Perimeter closure (molding) width must be a minimum of 7/8 inch A minimum clearance of 3/8 inch (9.5 mm) must be maintained on all, four sides (Figure 3) Grid ends on all four walls must be free to move When a closure angle with a supporting shelf less than 7/8 inch is used, perimeter runners must be supported by vertical hanger wires not more than 8 inches 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 (Figure 3 at right)

— Technical Illustrations Not To Scale —

Figure 1

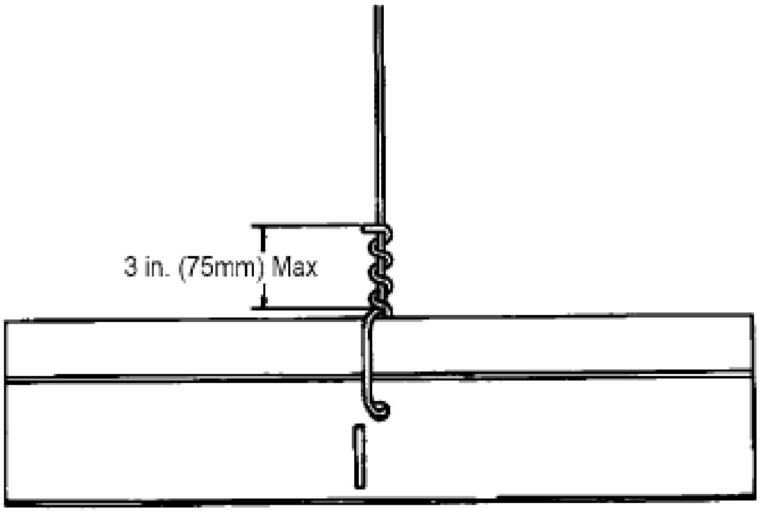


Figure 2

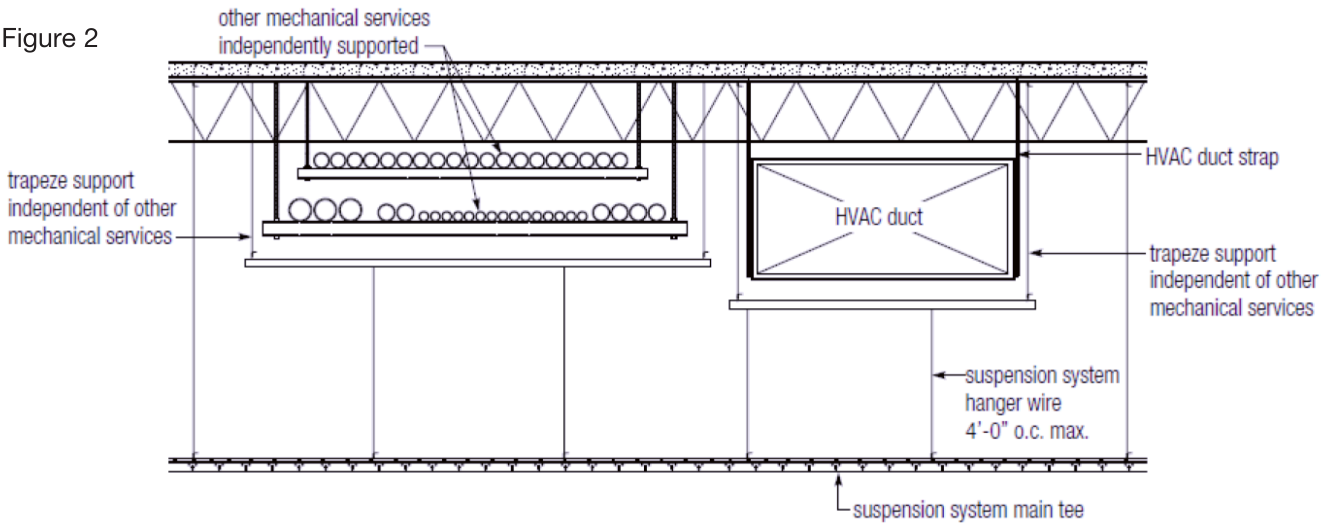
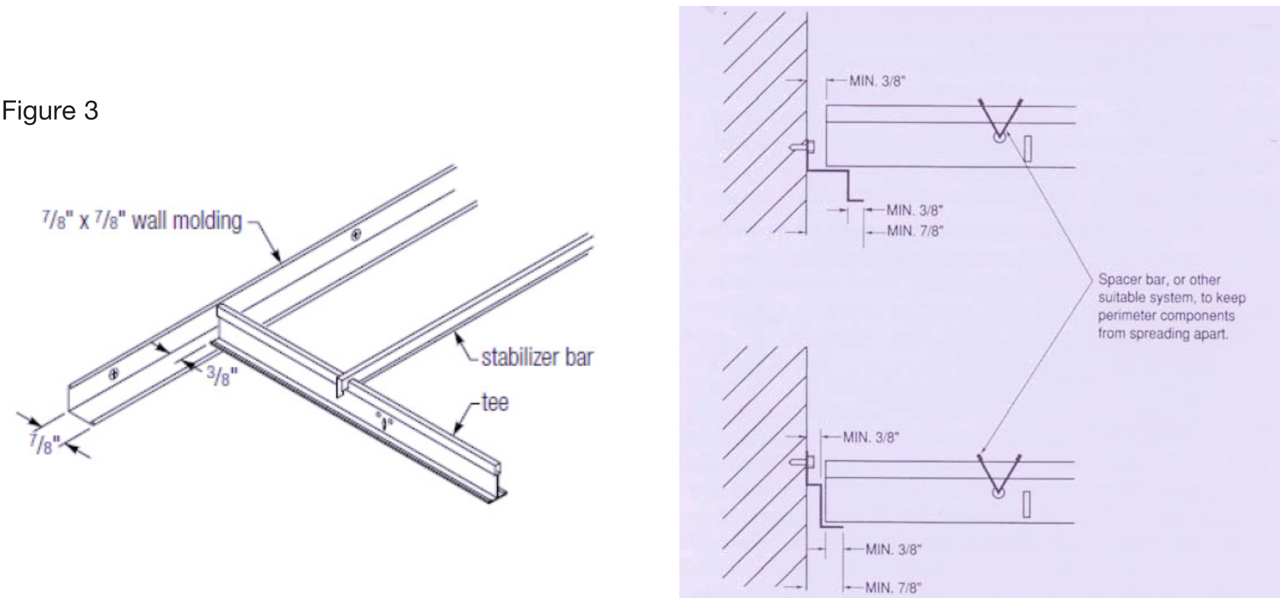


Figure 3



Common Problems and Suggested Solutions

Temporary Installation Connections

It is often difficult to install the ceiling without any perimeter restraint. Temporary connections at the perimeter may be used as long as they are removed when construction is complete.

Island Ceilings - ASCE 7-10, Section 13.5.1 and ASTM E580 1.8 exempt island ceilings from compliance with seismic requirements with the following language:

> EXCEPTION: Components supported by chains or otherwise suspended from the structure are not required to satisfy the seismic force and relative displacement requirements provided they meet all of the following criteria:
>
> 1. The design load for such items shall be equal to 1.4 times the operating weight acting down with a simultaneous horizontal load equal to 1.4 times the operating weight. The horizontal load shall be applied in the direction that results in the most critical loading for design.
> 2. Seismic interaction effects shall be considered in accordance with Section 13.2.3
> 3. The connection to the structure shall allow a 360° range of motion in the horizontal plane

But ASCE 7 also states in section 13.2.3:

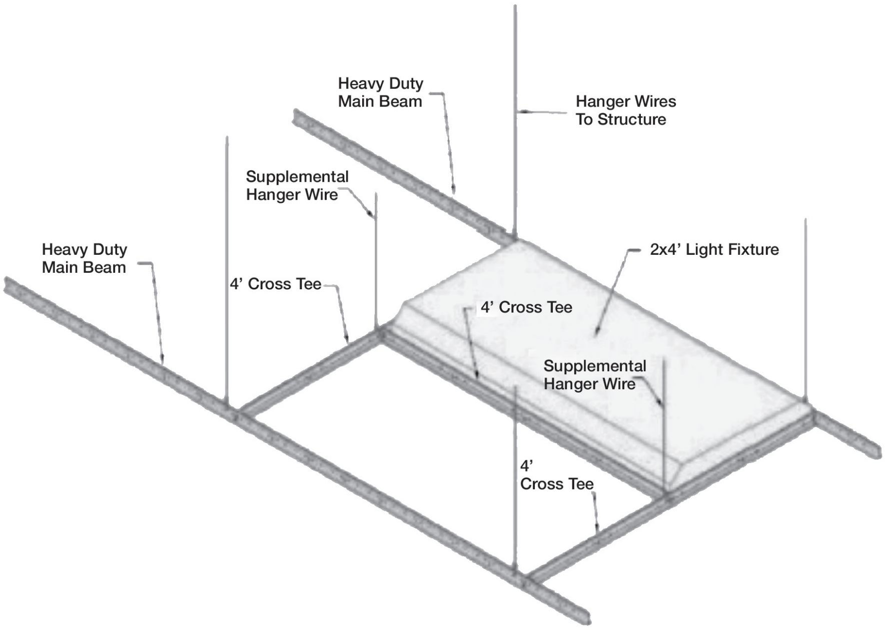
> The functional and physical interrelationship of components, their supports, and their effect on each other shall be considered so that the failure of an essential or nonessential architectural, mechanical, or electrical component shall not cause the failure of an essential architectural, mechanical, or electrical component.

This must also be considered with island ceilings.

IBC 2012 SEISMIC DESIGN CATEGORY C	
Light Fixtures	**Lighting fixtures must be positively attached to the grid 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 grid (Figure 4 at right)** **Clamping devices for surface mounted lighting fixtures shall have safety wires to the suspension system or the structure above** **Lighting fixtures and attachments weighing 10 lbs. (4.5 kg.) 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 greater than 10 lbs. (4.5 kg.) but less than 56 lbs. (25.5 kg) 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 56 lbs. (25.5 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**
Mechanical Services	**Flexibly mounted mechanical services weighing less than or equal to 20 lbs. (9 kg) 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 20 lbs. (9 kg.) but less than 56 lbs. (25.5 kg) require two No. 12 gage (minimum) hanger wires. These wires may be slack.** **Flexibly mounted mechanical services 56 lbs. or greater require direct support from the structure**
Special Consideration	**All ceiling penetrations must have a minimum of 3/8 inch (9.5 mm) clearance on all sides. (Figure 5 at right)**
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**
Exceptions	**The ceiling weight must be 2.5 lbs. / square foot (12.2 kg. /square meter) or less. For ceilings over 2.5 lbs. / square foot (12.2 kg. /square meter) the prescribed construction for Seismic Design Categories D, E, and F must be used.**

— Technical Illustrations Not To Scale —

Figure 4



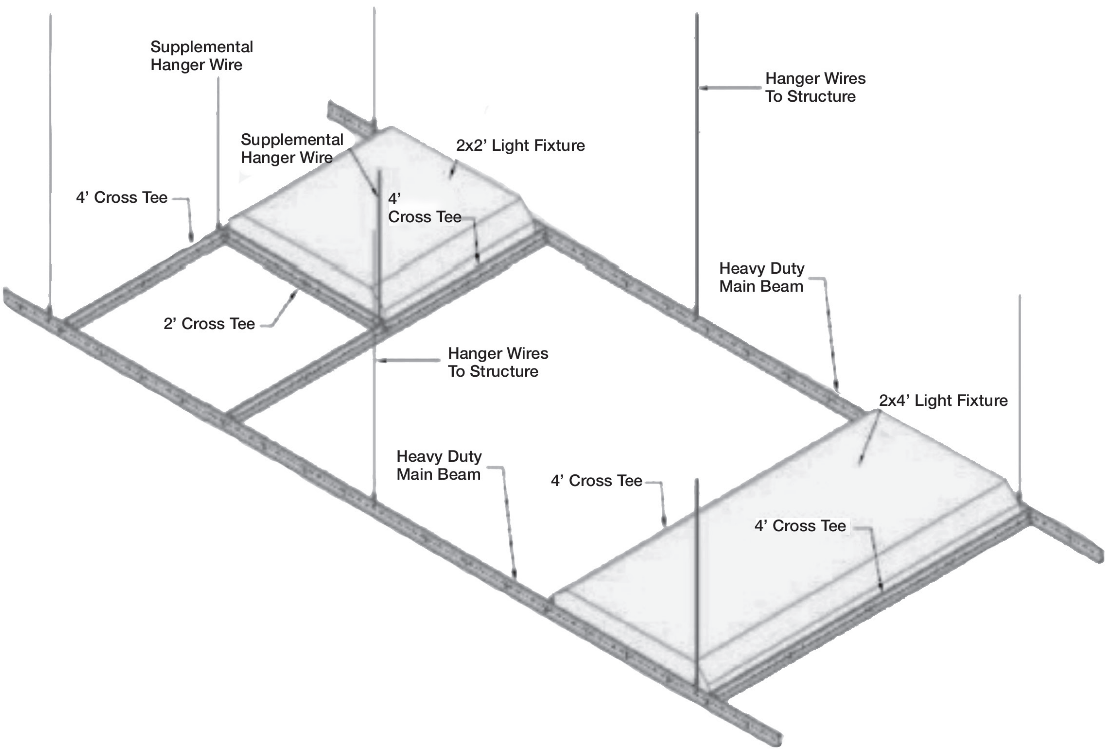
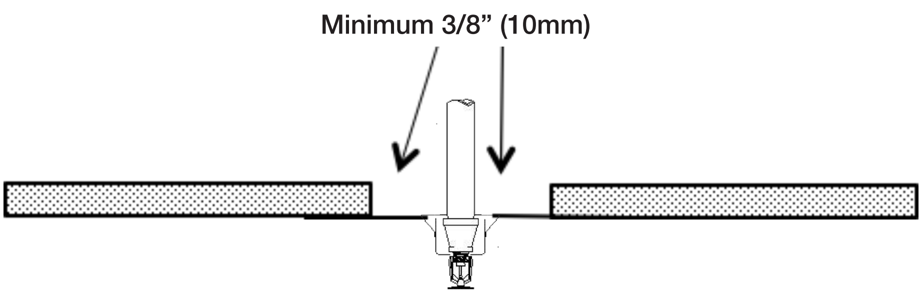


Figure 5



Seismic Design Categories D, E, & F

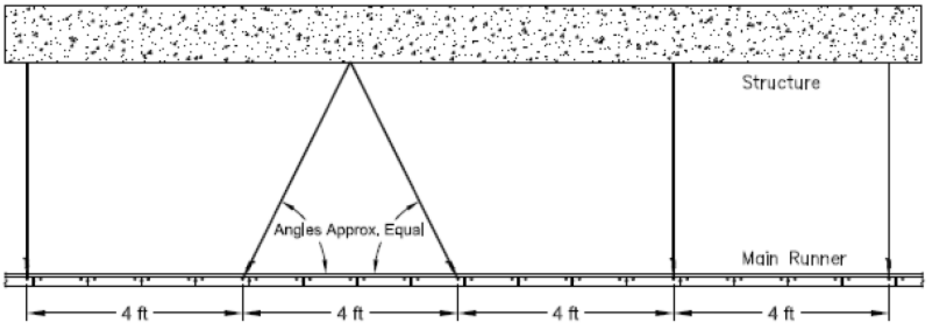
— Design Intent

For the majority of buildings, the non-structural components represent a high percentage of the total capital investment. Failure of these components in an earthquake can disrupt the function of a building as surely as structural damage, and can pose a significant safety risk to building occupants as well. Past earthquakes have dramatically illustrated the vulnerabilities of the nonstructural components. Apart from the falling hazard posed by the light fixtures, non-structural failures can create debris that can block egress from the building, and hamper rescue efforts. The basic objective of seismic design is to provide an adequate level of safety, supplying protection that is appropriate for the seismic hazard and the importance of the component or system.

Beyond this basic level of safety, which protects occupants from life threatening injury or death, higher levels of performance may be demanded to limit damage or protect against loss of function. Essential facilities, such as hospitals, police and fire stations, and emergency command centers may be designed with the intent that they meet the immediate occupancy or operational performance objectives. Structures designed to these performance objectives are expected to be functional during or after an earthquake. Prevention of panic is also an important goal. When ceiling components fall from the ceiling, inhabitants have been known to flee in panic, even if the building structure is not in danger of collapse. There are numerous instances of panic causing injuries and deaths when no physical danger was actually present.

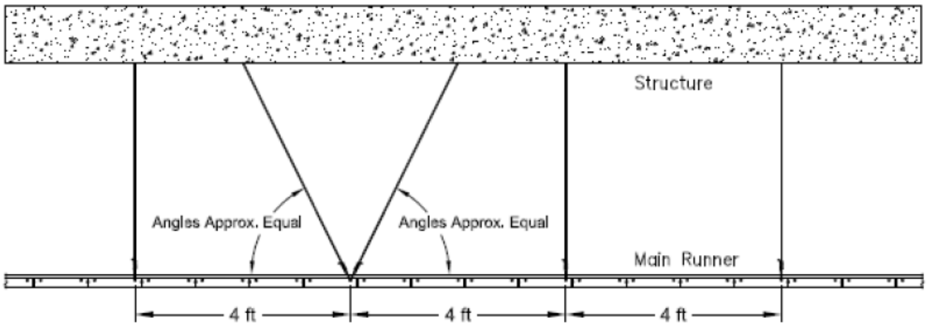
A common failure observed in a moderate earthquake occurs to suspended acoustical tile ceilings. Failure typically occurs at the perimeter of the ceiling. The prescribed construction of Seismic Design Categories D, E, & F, is designed to tie the suspended ceiling system to the structure so that all seismic forces are transferred and dissipated through the building structure. Vertical compression posts are also required at the location of the diagonal wires to resist the upward component of force caused by the lateral loads.

IBC 2012 SEISMIC DESIGN CATEGORY D, E, & F	
Code Section	ASCE 7-10. Sections 13.5.6, 13.5.6.2 and 13.5.6.2.2
ASTM C635 Duty Rating	Heavy Duty Load Rating as defined in ASTM C635 is required
Grid Connections	Minimum main runner splices and cross runner intersections strength of 180 lbs. (801 N)
Vertical Suspension Wires	Vertical hanger wire must be a minimum No. 12 gage Vertical hanger wires maximum 4 feet (1200 mm.) on center 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 3 inches (75 mm) or less. (Figure 1) All vertical hanger wires may not be more than 1/6 out of plumb without having additional wires counter splayed (Figure 6) A device used to secure the hanger wire to the structure above must sustain a minimum load of 90lbs (40 kg.) Power actuated fasteners are now permitted to be used for loads that do not exceed 90 lbs. (40 kg.) in concrete and do not exceed 250 lbs. (110 kg.) in steel Wires may not attach to or bend around interfering equipment. Use trapezes to avoid such obstacles(Figure 2)
Lateral Force Bracing	Lateral force bracing is required for all ceilings greater than 1000 square feet (90 m2) Where required, lateral force bracing (splay wires or rigid bracing and a compression post) must be located within 2 inches (50 mm) of the main runner / cross runner intersection and splayed approximately 90° apart in the plan view, at a maximum 45° angle from the horizontal and located 12 feet (3600 mm) on center in both directions, starting 6 feet (1800 mm) from two adjacent walls (Figure 7) Lateral force bracing must be spaced a minimum of 6 inches (150 mm) from unbraced horizontal piping or ductwork Lateral force bracing connection strength must be a minimum of 250 lbs. (110 kg.) Rigid bracing must be designed to limit deflection to less than ¼ inch (6.5 mm)

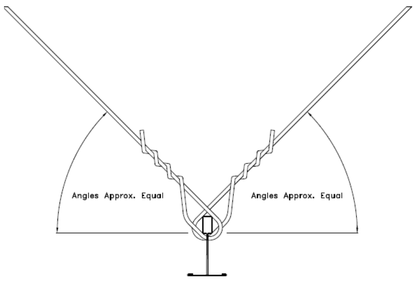


Method 1 - Countersplay In-Vertical-Plane of the Main Runner with Common Point at Building Structure

Figure 6

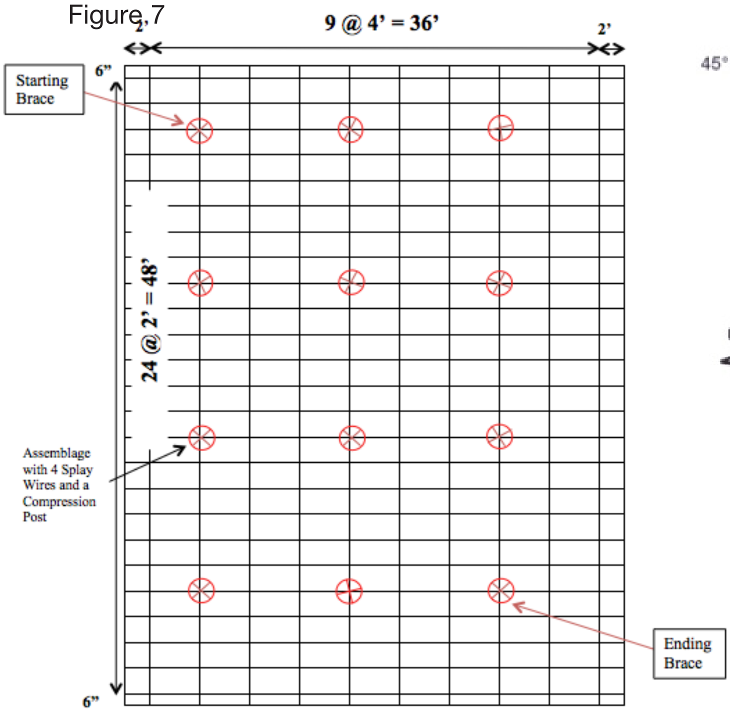


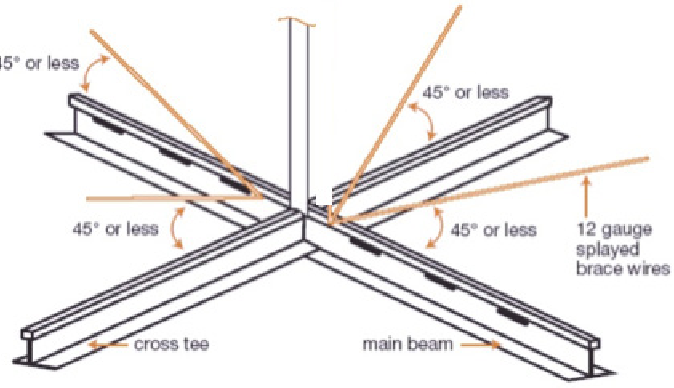
Method 2 - Countersplay In-Vertical-Plane of the Main Runner with Common Point at Main Runner

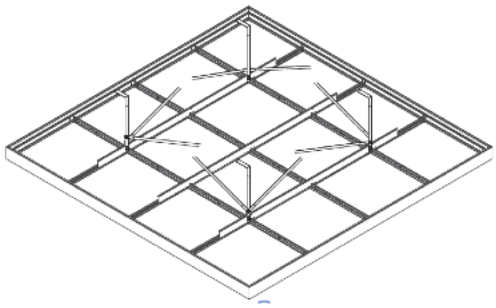


Method 3 - Countersplay Out-of-Vertical-Plane of the Main Runner

Figure 7







Comments

Heavy Duty Grid

The Duty Classification of a Heavy Duty grid system is defined by ASTM C635 as main runners that can sustain a load of 16 lbs. /foot (24 kg / m) with a deflection of less than or equal to .133” (3.4 mm) (L/360) over a 48 inch (1200 mm) hanger wire spacing. Cross runners are limited to L/360 deflection. All manufacturers offer cross runners with a variety of load performance.

Many grid systems may not have a Heavy Duty main. In these cases, the Authority Having Jurisdiction (AHJ) may allow the system to be used when hung on shorter centers, such as 36 inches (900 mm). Be advised, that since ASTM C635 defines Heavy Duty as a main runner’s load performance over a 48 inch (1200 mm) hanger wire spacing, hanging on closer centers, while increasing load performance, does not actually change the Duty Classification of a main runner.

Lateral Force Bracing

The exemption from lateral force bracing for ceilings less than or equal to 1000 square feet (90 m2) should not be confused with the exemption for ceilings less than or equal to 144 square feet (13.5 m2). The 144 square feet (13.5 m2) exemption is a blanket exemption from all seismic force requirements, 2 inch (50 mm) wall angle, heavy duty main runners, lateral force bracing wires and compression posts.

The lateral force bracing consists of both the splay wires and the compression post. The compression post is used to offset the vertical force induced by the splay wires as they resist the lateral movement of the ceiling. Exempting lateral bracing exempts both the splay wires and the compression post.

The lateral force bracing must start within 6 feet (1800 mm) of two adjacent walls. It is not necessary to end the lateral force bracing within 6 feet (1800 mm) of the opposite two walls. The last lateral force brace must only be within 12 feet (3600 mm) of the opposite walls.

IBC 2012 SEISMIC DESIGN CATEGORY D, E, & F	
Lateral Force Bracing Cont.	**Unless rigid bracing is used or calculations have shown that lateral deflection is less than ¼ inch (6.35 mm), sprinkler heads and other penetrations shall have a minimum of 1 inch (25 mm) clear space in all directions (Figure 8)**
Perimeter	**Perimeter closure (molding) width must be a minimum of 2 inches (50 mm) (Figure 9 & 10)** **Proprietary solutions using approved perimeter clips may utilize perimeter closures less than 2 inches (50 mm)** **The grid must be connected to the perimeter on two adjacent sides (Figure 9)** **A minimum clearance of ¾ inch (20 mm) must be maintained on two, unattached adjacent sides (Figure 10)** **Perimeter runners must be supported by vertical hanger wires not more than 8 inches (200 mm) from the wall (Figures 9 & 10)** **Unattached perimeter runner ends must be tied together to prevent spreading (Figure 10)**
Lighting Fixtures	**Lighting fixtures must be positively attached to the grid 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 grid** **Clamping devices for surface mounted lighting fixtures shall have safety wires to the grid or the structure above** **When cross runners with a load carrying capacity of less than 16 lbs./foot (24 kg. / meter) are used, supplementary hanger wires are required (Figure 4)** **Lighting fixtures and attachments weighing 10 lbs. (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 greater than10 lbs. (4.5 kg.) but less than or equal 56 lbs. (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 greater than 56 lbs. (25 kg) 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.**

Figure 8

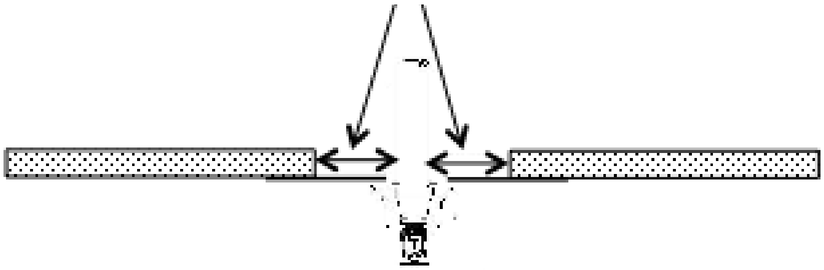


Figure 9

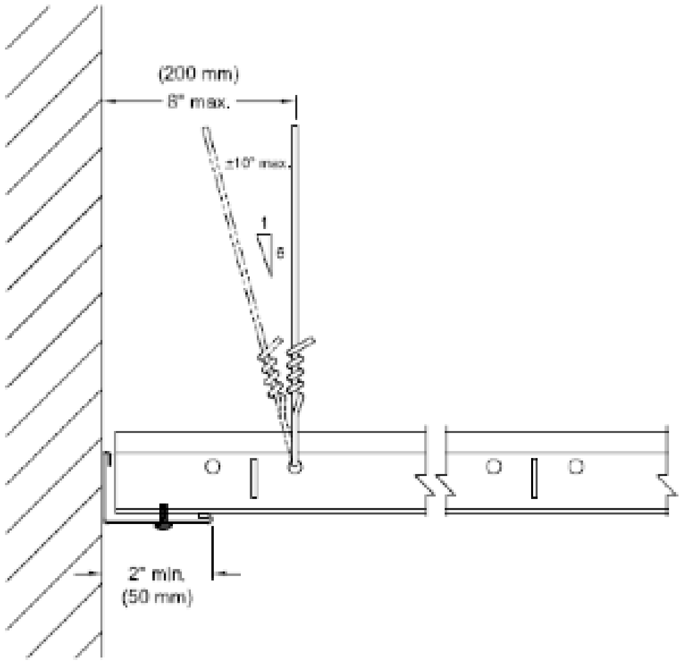


Figure 10

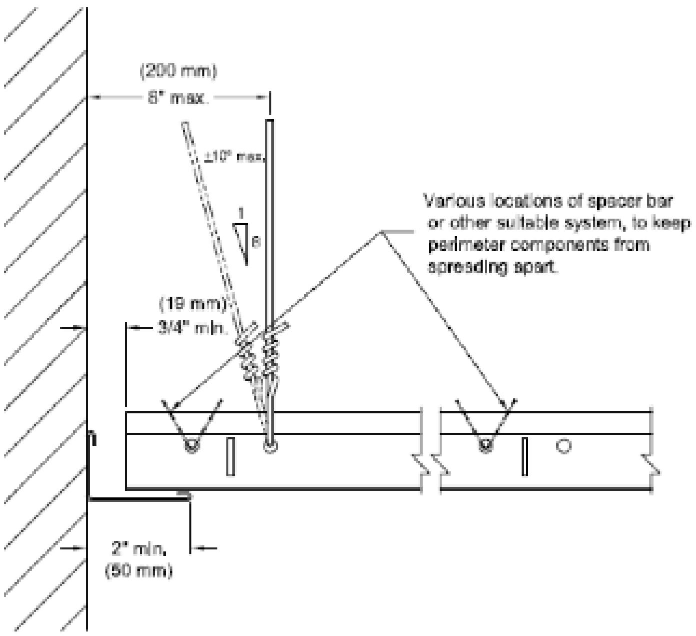
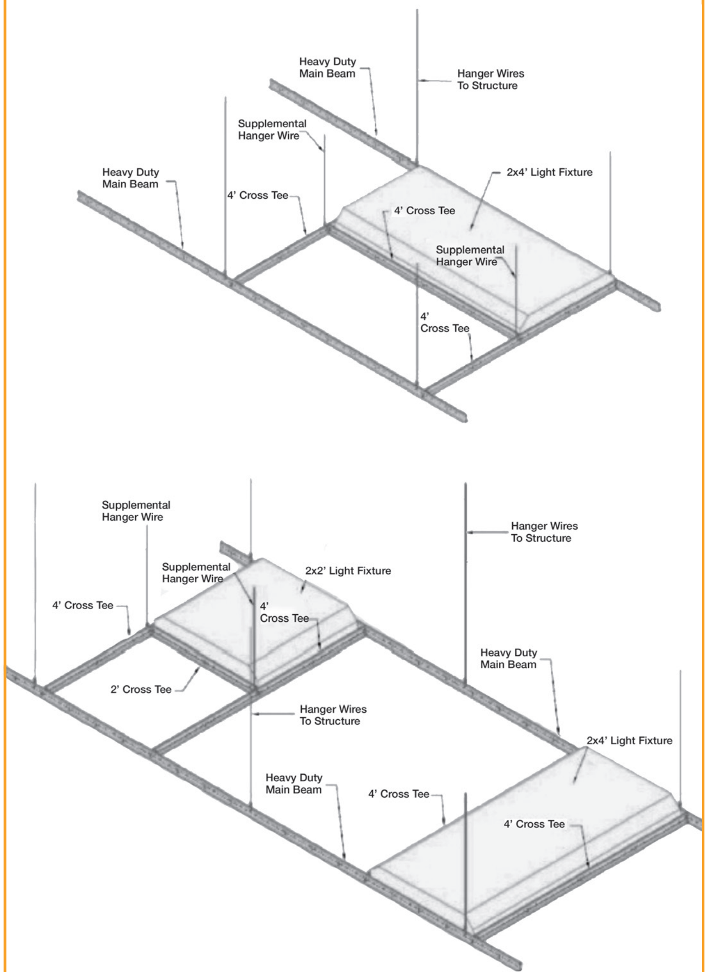


Figure 4



It is not necessary to run the lateral force bracing wires parallel to the grid layout in plan view. They can be at any, arbitrary angle. It is also not necessary that all the lateral force braces have the same orientation.

Lateral force bracing must be as taut as possible to function correctly.

Perimeter

The purpose of the 2 inch (50 mm) perimeter closure is to allow the free ends of the unattached runners to move back and forth without impacting the wall or falling off the end of the closure. An approved clip may be used in lieu of the 2 inch (50mm) closure. Perimeter wires are still required for safety or redundancies in many jurisdictions.

The unattached runner ends must be connected to prevent spreading. This can be accomplished in a variety of ways, including, but not limited to, pop rivets, stabilizer bars, cross runners, main runners, perimeter clips, hanger wires, etc.

Lighting Fixtures

In most ceilings, lighting fixtures pose the largest threat to injury as they are generally the heaviest component in the ceiling.

The two slack wires on opposite corners are intended as a safety measure to keep lighting fixtures from striking occupants in the case of failure of some or all of the ceiling components.

Rigid conduit is not permitted as there is always some movement of the ceiling system and rigid conduit may damage the ceiling components.

Slack wires are not required for any light fixtures supported by four wires to the building structure.

Mechanical Services

The two slack wires on opposite corners are intended as a safety measure to keep mechanical services from striking occupants in the case of failure of some or all of the ceiling components.

Slack wires are not required for any mechanical services supported by four wires to the building structure.

IBC 2012 SEISMIC DESIGN CATEGORY D, E, & F	
Mechanical Services	Flexible mechanical services weighing less than 20 lbs. 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 20 lbs. (9 kg), but less than 56 lbs. (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 greater than 56 lbs. (25 kg) require direct support from the structure
Special Considerations	Direct concealed systems must have stabilizer bars a maximum of 60 inches (1500 mm) on center with stabilizer bars within 24 inches (600 mm) of the perimeter Bracing is required for ceiling plane elevation changes (Figure 11) 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 grid 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 break the ceiling into areas less than or equal to 2,500 square feet (230 m2) (Figure 12) Areas divided into 2,500 square foot (230 m2) sections as above, must have a ratio of the long side to the short side of less than or equal to 4:1 (Figure 13) All ceiling penetrations and independently supported fixtures or services must have closures which allow for a 1 inch (25 mm) movement A licensed design professional must review the interaction effects of non-essential ceiling components on essential ceiling components to prevent their failure
Partitions	Partition bracing must be independent of ceiling (Figure 14 at right)

Figure 11

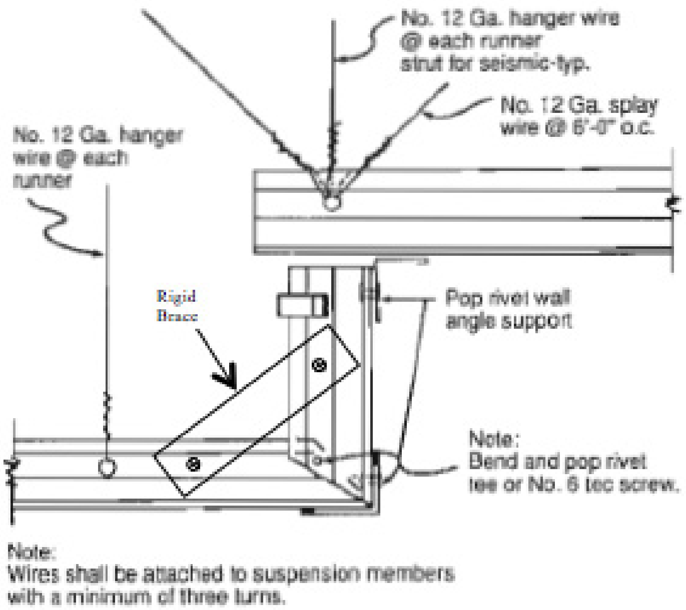


Figure 13

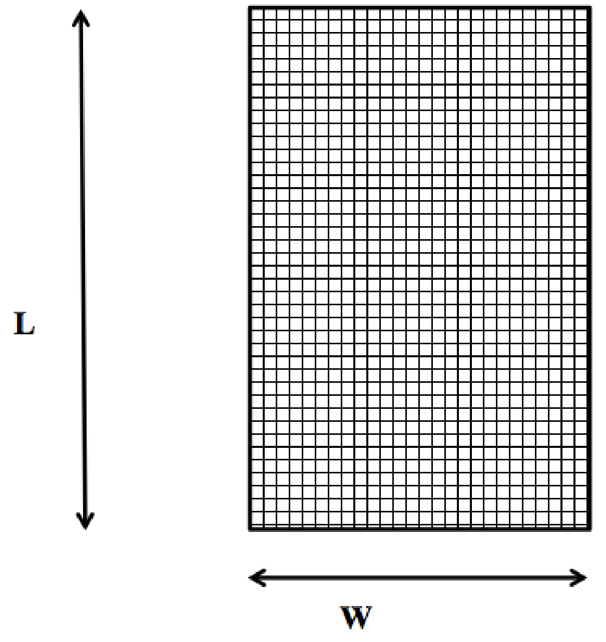


Figure 12

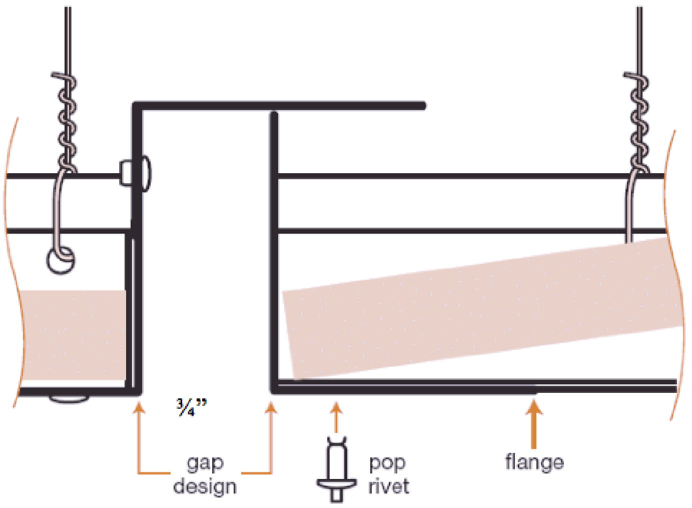
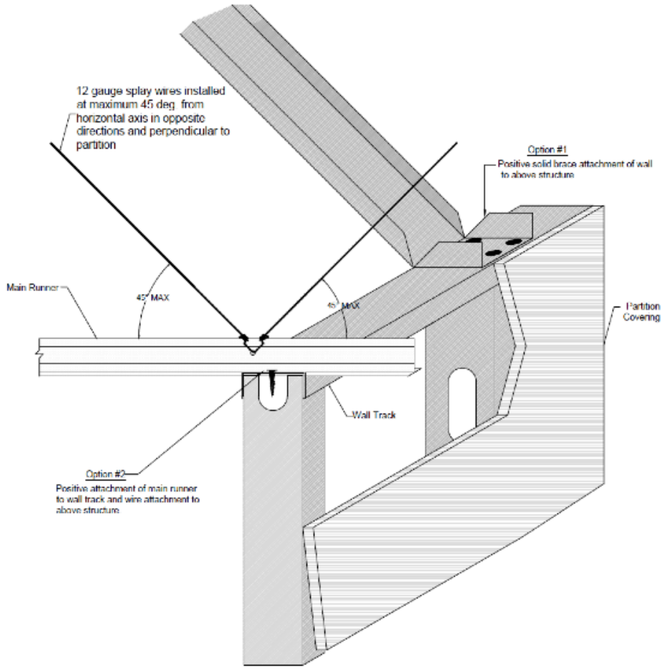


Figure 14



Special Considerations

Direct Concealed Ceilings - The requirement for stabilizer bars in concealed ceilings stems from the fact that these systems often do not have cross members.

Ceiling Elevation Changes - Ceiling elevation changes should always be braced, even in areas with little to no seismic activity, as ceiling components are not typically designed to be used vertically or to resist lateral bending or twisting (One example is shown in **Figure 11** on page 13).

Cable Trays and Conduits - The bracing for suspended ceilings is designed to resist seismic loads typically found in suspended ceilings. It cannot accommodate additional, unknown loads from other systems.

Integral Construction – This section acknowledges that a licensed design professional may design a custom system to replace the prescribed construction.

Seismic Separation Joint – Since there is always some movement in a ceiling, a very large ceiling could transfer significant load to the perimeter. Breaking the ceiling into areas no larger than 2500 square feet (230 m2) is intended to keep large forces from accumulating at the perimeter and causing damage to surrounding walls. The border of a seismic pod created by seismic separation joints shall not be considered a perimeter. Perimeter treatment (as listed on page 10) is not applicable.

Aspect Ratio Limited to 4:1 – Very long and narrow ceilings would still have the potential to transfer significant loads to the perimeter as noted above (**Figure 13** on pg. 13).

1 Inch (25 mm) for Penetrations – This is intended to prevent damage to the ceiling or the penetration from penetrations that do not move with the ceiling, similar to the ¾ inch (19 mm) perimeter space (**Figure 6** on page 9).

A review by a licensed design professional is needed with any facility containing essential functions that may be damaged by the ceiling or its components.

Partitions — Partition bracing may be connected to the suspension grid as long as it is in addition to 12 feet x 12 feet (3600 mm x 3600 mm) ceiling bracing. Partition requirements vary widely from location to location. You must check with your local building code official. This can be accomplished either with rigid bracing or splay wire bracing, as shown in **Figure 16** below.

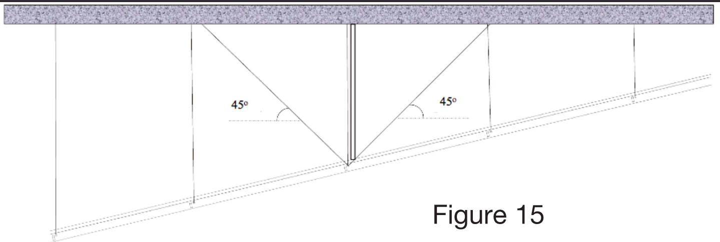


Figure 15

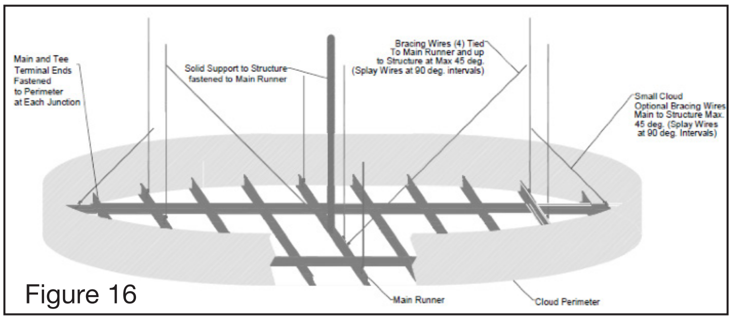


Figure 16

Common Problems and Suggested Solutions

Very Shallow Plenums — Shallow plenums, such as those less than 6 inches (152 mm), make it difficult to nearly impossible to make the standard lateral force bracing arrangement. Suggested solutions are:

1. Use one rigid lateral brace to replace all four splay wires and the compression post. Since the plenum is very short, a light gage stud will have plenty of compression strength. The stud can be fastened to the web of the runner with sufficient fasteners to keep it from rotating. This will keep the ceiling from moving.

2. Use all rigid suspension hangers. Fasten the hangers to the web of the runners every 12 feet (3600 mm) on center to prevent rotation.

3. Obtain an exemption for the lateral force bracing from the local building code official (prior to installation). Very short plenums will have very little lateral displacement and, hence, very small lateral forces. This results from the fact that small lateral movements will result in large angular displacement of the wires. This will exert a force opposite to the movements. This type of bracing exemption is codified for similar, non-structural systems such as HVAC ducting.

Very Deep Plenums — Deep plenums, such as those greater than 12 feet (3600 mm), require very large compression posts, as the strength of the compression post decreases exponentially with length. The required size and weight of a compression post quickly grows to a size that is difficult to install and becomes a bigger safety hazard than the ceiling it is intended to protect. A structural engineer should be consulted for lengths great than 12 ft. (3600mm).Suggested solutions require the approval of a design professional.

1. Build a substructure spanning structural walls or full height partitions. The ceiling then can be braced to the substructure. This can be a costly solution. The ends of the substructure can be braced horizontally to prevent damage to the walls while the dead weight of the wall prevents vertical movement.

2. Design a custom solution bracing to the structural perimeter

3. Alternate solutions by a design professional.

Very Heavy Ceilings — When ceilings are heavier than 4 psf (19.5 kg / sq. m), a custom engineered solution may be required as the forces generated by these ceilings may be greater than those anticipated for the prescribed construction for Seismic Design Categories D, E, & F.

Sloped Ceilings — (Figure 15) – There is often confusion as to where to measure the maximum 45º angle for the lateral bracing. Unless the structural ceiling and or walls are also slanted, the forces generated on the ceiling are parallel to the ground and the angle should be measured from the ground. If the ceiling itself is slanted more than 45º to the horizontal, suggested solutions are:

1. Rotate the splay wire assembly in the plan view from the grid layout. This may allow the splay wires to reach the structural ceiling without interference from the suspended ceiling.
2. Request an exemption of the maximum angle for the bracing wires from the local building code official prior to installation. As long as the angle is less than 60 degrees, the splays will still function. They're just not very efficient. Additional splays could be installed to reduce the applied load on each splay if the building official is uncomfortable with just waiving the requirement.

Island Ceilings — ASCE 7-10, Section 13.5.1 and ASTM E580 1.8 exempt island ceilings from compliance with seismic requirements with the following language:

EXCEPTION: Components supported by chains or otherwise suspended from the structure are not required to satisfy the seismic force and relative displacement requirements provided they meet all of the following criteria:

1. The design load for such items shall be equal to 1.4 times the operating weight acting down with a simultaneous horizontal load equal to 1.4 times the operating weight. The horizontal load shall be applied in the direction that results in the most critical loading for design.
2. Seismic interaction effects shall be considered in accordance with ASCE 7-10 Section 13.2.3.
3. The connection to the structure shall allow a 360° range of motion in the horizontal plane.

Just because these ceilings are exempt from seismic bracing requirements, it does not mean they do not need any lateral force bracing. Inspectors will often waive bracing requirements, but not all island ceilings can or should be exempt from bracing. Some conditions that will cause island ceilings to need bracing are:

1. Size – Large ceilings can generate significant forces and movement. While there is no definitive size limit, small island ceilings such as less than 144 square feet (13.4 m2) may not need bracing. Large ceilings such as over 500 square feet (46.4 square feet) will often need bracing.

2. Plenum Depth – As island ceilings are often used as accents under conventional suspended ceilings, they often have drops of 12 inches (305 mm) or less. As discussed before, a ceiling with a very shallow plenum will not move very far before the hanger wires generate a force opposite to the earthquake force. Ceilings with deeper plenums will experience larger displacements and can generate larger forces.

3. Weight – The larger the mass of a ceiling, the more seismic force it can generate. This can cause damage to adjacent structures or components and the island ceiling.

4. Services in the Island Ceiling – Islands containing services such as sprinklers, lights, and mechanical services may not be able to move without damage to these services or having them fall into the occupied space.

5. Damage to adjacent, essential services – Sprinklers, exit signs and other essential services must not be damaged by impact from the island ceiling.

When an island ceiling requires bracing, it is generally desirable to minimize the visibility of the bracing. Several methods to accomplish this are:

1. Use lighter gage, high strength wire
2. Place wire bracing at the perimeter angled towards the interior of the island (Figure 16)
3. Rigid bracing placed to minimize visibility

Note that bracing in the center of an island is ineffective and should not be the sole lateral force bracing.

Please note that any of the suggestions to minimize the visibility of island bracing, such as those suggested above, require the approval of the inspector or local building code official.

National Publications and Standards

ASCE 7 -
Minimum Design Loads for Buildings and Other Structures

This standard establishes load requirements for buildings and other large structures. This includes earthquake, snow, and wind loads along with many other loads found in buildings. ASCE 7 is published by the American Society for Civil Engineers.

ASTM C635 -
Standard Specification for the Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings

This standard governs the manufacturing and performance requirements for lay-in suspended ceiling grid.

ASTM C636 -
Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels

This standard governs the installation requirements for lay-in suspended ceiling grid.

ASTM E580 -
Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions

This standard governs the installation and performance requirements for lay-in suspended ceiling grid.

CISCA Metal Ceilings Technical Guidelines

This standard governs the manufacture and installation of metal ceilings. The Technical Guidelines are published by the Ceilings and Interior Systems Construction Association.

IBC - International Building Code

This is the model building code used as the basis by virtually all governmental bodies in the United States that are responsible for establishing building code requirements. The IBC is published by the International Code Council (ICC).

Regional Publications and Standards

IR 25-2.10 -
Metal Suspension Systems for Lay-In Panel Ceilings

This standard is used for hospital, school, and prison construction of lay-in panel ceilings in the State of California. It is published by the Division of the State Architect, California.

California Building Code

This standard is used for general construction, excepting schools, hospitals and prisons, for the State of California. It contains any exceptions to the IBC. It is published by the California Building Standards Commission.

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