6.3 Architectural Components

6.3.4 Ceilings

6.3.4.3 Suspended Heavy Ceilings

This category covers several different types of overhead ceilings suspended from above including dropped furred gypsum board ceilings and suspended lath and plaster ceilings. Suspended ceilings with wood or metal panels would also fit into this category. These systems typically have finish material attached to a two-way furring grid which is suspended from above. In order to reduce damage and prevent falling hazards the finish material must be well secured to the furring grid. Damage can be reduced if the ceiling is attached to the walls along two adjacent sides but separated from the walls along the opposite two sides and the furring grid is laterally braced to the structure above.

Provisions

BUILDING CODE PROVISIONS

Suspended heavy ceiling systems are subject to the force requirements of ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010), Chapter 13, Nonstructural Components. Ceiling assemblies of gypsum board and plaster are also subject to the requirements of the 2012 IBC, *International Building Code*, (ICC, 2012).

- Section 13.5.6 of ASCE/SEI 7-10 contains requirements for special seismic perimeter details and lateral bracing assemblies for suspended ceilings but includes several significant exemptions from these requirements as follows.
    - Seismic detailing is not required for suspended ceilings less than or equal to 144 square feet that are surrounded by walls or soffits that are laterally braced to the structure (this exemption applies to heavy or light suspended ceiling systems).
    - Seismic detailing is not required for suspended ceilings constructed of screw- or nail-attached gypsum board on one level (constructed in a single plane) that are surrounded by and connected to walls or soffits that are laterally braced to the structure above. Note that this exemption does not apply to plaster ceilings or to gypsum board ceilings on multiple levels (constructed in more than one ceiling plane elevation).

- Chapter 25 of the 2012 IBC contains general provisions for horizontal assemblies of gypsum board and plaster, including prescriptive requirements for installation. There are, however, no provisions for lateral design of suspended ceilings.
- The Division of the State Architect sets forth ceiling standards for California schools in DSA-IR 25-3 *Drywall Ceiling Suspension, Conventional Construction – One Layer* (California Department of General Services, 2005b). This document provides general guidance for design and detailing of heavy suspended ceilings.

RETROFIT STANDARD PROVISIONS

ASCE/SEI 41-06, *Seismic Rehabilitation of Existing Buildings* (ASCE, 2007) classifies ceilings into one of four types. Suspended ceiling systems are classified into one of two categories:

- Category b, short-dropped gypsum board sections (less than 2-ft drop) attached to wood or metal furring supported by carrier members.
- Category c, dropped gypsum board sections greater than 2 and suspended metal lath and plaster.

These ceiling systems are considered force and deformation sensitive. Compliance with the requirements of the standard is necessary when:

- The performance level is Immediate Occupancy.
- The performance level is Life Safety or Hazards Reduced in high or moderate seismicity areas.

If the performance level is Hazards Reduced and the ceiling is located in areas of public occupancy or egress, the ceiling must meet the Life Safety performance level.

Note that even if the ceiling system is exempt, light fixtures and air diffusers in the ceiling system may still be subject to support and bracing requirements.

Typical Causes of Damage

- Suspended heavy ceilings may be damaged both by direct acceleration and by deformation. Direct acceleration may cause connectors to become loose or deform, and differential movement of the ceiling relative to structural elements such as columns or walls or nonstructural elements such as partitions, lights, diffusers, or sprinklers may also damage the ceiling.
- As these systems are heavier than acoustic tile ceilings, the consequences of failure may be more hazardous for occupants since both the finish material and the furring grid may

fall. Ceiling failures are often costly because the space underneath may be unusable while the ceiling is repaired or replaced.

- Ceiling finishes may crack unless adequately isolated from the motion of the surrounding structural and nonstructural elements. Crack repair in gypsum board and plaster ceilings is a common expense following earthquakes.

DAMAGE EXAMPLES

Figure 6.3.4.3-1 Damage to ornate wire lath and plaster ceiling in the 2010 magnitude-8.8 Chile Earthquake (Photo courtesy of Eduardo Fierro, BFP Engineers). Wire lath is attached to arches or to wood furring suspended from the roof framing.

Figure 6.3.4.3-2a Complete collapse of a large suspended gypsum board ceiling over a swimming facility in Japan (Photo courtesy of Shojiro Motoyui, Tokyo Institute of Technology). This type of failure has been replicated on the E-defense shake table and occurs when the U-shaped clip holding the cross furring (M-bar) to the main runners (channel) opens into a V-shape and drops the furring grid. This type of failure is not common in the U.S.

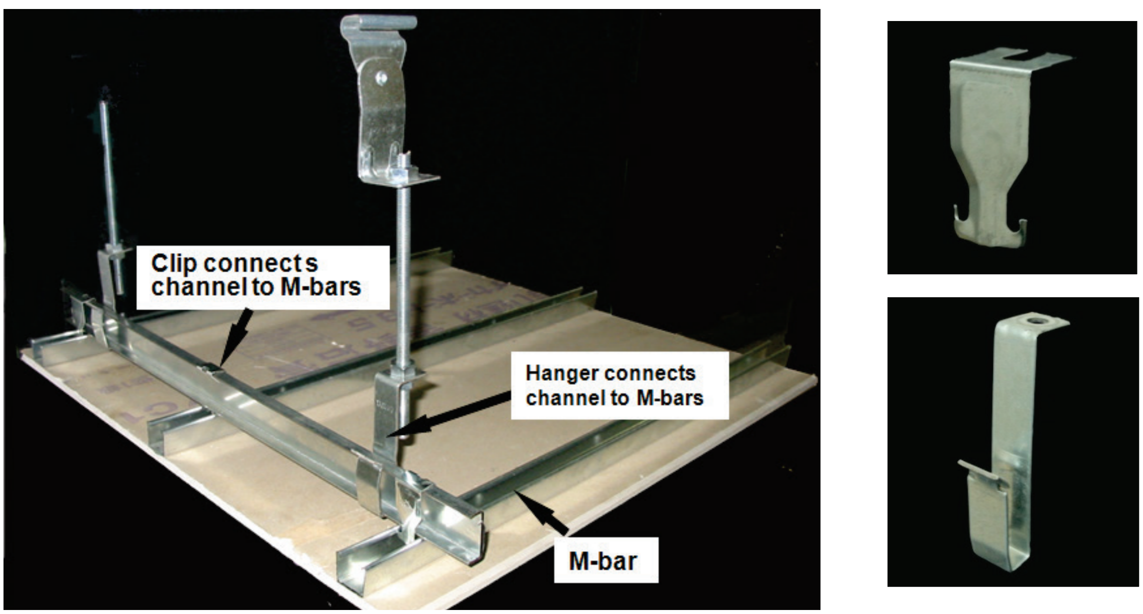


Figure 6.3.4.3-2b Schematic view of Japanese drywall ceiling grid. These ceilings are also typically installed with lateral bracing and 200mm edge clearance. Clip shown at lower right opens when the M-bar slides back and forth relative to the main runner, particularly those located near a diagonal brace. This type of clip is not common in the U.S (Source: "Dynamic characteristics of Japanese style of ceiling," Motoyui, S., Satoh, Y., and Kawanishi, T. *Proceedings 7CUEE & 5ICEE*, March 2010).

Figure 6.3.4.3-3 Collapse of exterior soffit at Jefferson Elementary School in Calexico in the 2010 Baja California Earthquake; approximately 1200 sq ft of soffit collapsed at this school built in the 1960's (Photo courtesy of Baja Earthquake Reconnaissance Team, Earthquake Engineering Research Institute (EERI), published in the EERI July 2010 Newsletter).

Seismic Mitigation Considerations

- Special seismic detailing may be required for heavy ceilings such as plaster, wood or metal panels, or for gypsum board ceilings at multiple levels. For these cases, details are typically configured similar to those used for acoustic ceilings with more frequent bracing and robust members and connections to account for the increased weight. Seismic bracing for suspended heavy ceilings typically includes a vertical compression strut and diagonally splayed wire braces as shown in Figure 6.3.4.3-7. Rigid bracing (strut or cold-formed steel) is sometimes used in lieu of splayed wire bracing and compression posts. Special perimeter details typically include 2" wide perimeter closure angles, fixed attachments on two adjacent walls and clearance of at least ¾" from the two opposite walls as shown in Figure 6.3.4.3-5.
- Details shown in Figures 6.3.4.3-5, 6.3.4.3-6, and 6.3.4.3-7 are based on requirements for schools in California. The Division of the State Architect sets forth ceiling standards for California schools in DSA-IR 25-3 Drywall Ceiling Suspension, Conventional Construction - One Layer (California Department of General Services, 2005b). This standard refers to DSA-IR 25-5 Metal Suspension Systems for Lay-in Panel Ceilings (California Department of General Services, 2009c) for specific details regarding the bracing assembly. These references are useful tools for designing in areas of potentially

severe seismic shaking or in jurisdictions where bracing is required. In California, ceiling bracing assemblies at a spacing of not more than 12 feet in each direction are required in schools and bracing assemblies at a spacing of not more than 8 ft by 12 ft on center, as shown in Figure 6.3.4.3-5, are required in essential services buildings.

- This section provides prescriptive details for suspended gypsum board ceilings where the grid is composed of channel sections for the main runners with hat channels wired below as the cross furring. Check with manufacturers for alternative proprietary systems that use T-bars for both the main and cross runners.
- Vintage lath and plaster ceilings are typically hung with wood hangers and runners without consideration of seismic design forces. Diagonal 45 degree splay bracing wires can be added at select wood hanger locations (for instance, 4 ft by 6 ft) to brace these ceilings. Some jurisdictions, such as the Salt Lake City School District, require that vintage lath and plaster ceilings be removed and replaced with compliant ceiling systems. Where historic preservation considerations require and the local codes permit, replacement plaster ceilings may be constructed with screw-attached metal lath and dedicated bracing. As a lower cost alternative to replacement in wood framed construction, the seismic risk posed by a plaster ceiling can be reduced by screwing 1x2 wood strips at 16" centers into wood joists from below (oriented perpendicular to the joists) to serve as a safety net. Some ornate theatre ceilings have been effectively encapsulated from below with netting to reduce the falling hazard; such netting and all its attachments must be designed to contain any falling debris.
- Ceiling anchorage needs to be coordinated with the anchorage for lighting, air diffusers, and sprinkler lines. All recessed or drop-in light fixtures and diffusers must be supported directly by main runners or by supplemental framing with positive attachment to main runners. In order to minimize their potential falling hazard, lights, diffusers and similar items are required to be independently supported by the structure, typically with a minimum of two wires, as discussed in Sections 6.4.6.2 and 6.4.9.3. In some locations and occupancies, penetrations for sprinkler heads in ceilings braced with splayed wire bracing are required to have a 2 inch oversized opening to allow for free movement of 1 inch in all horizontal directions. Check local code requirements.
- Mechanical connectors between the component parts of the ceiling assembly must be chosen carefully to avoid failures. Catastrophic failures of ceiling systems in Japan have been replicated during shake table testing because the U-shaped mechanical clip used to hang the cross furring from the main runner can open during an earthquake, dropping the cross furring and drywall as shown in Figures 6.3.4.3-2.

MITIGATION EXAMPLES

Figure 6.3.4.3-4 Details of suspended and braced plaster ceiling,. Rigid bracing and compression posts (highlighted) are provided at 6 ft by 8 ft on center. Note cross furring saddle tied to black channel (main runner) from below; supplementary framing for lights runs parallel to cross furring and saddle tied to main runner from above (Photo courtesy of Maryann Phipps, Estructure).

MITIGATION DETAILS

Per ASCE 7-10, suspended ceilings constructed of screw- or nail-attached gypsum board on one level that are surrounded by and connected to walls or soffits that are laterally braced to the structure above are exempt from any special seismic design requirements.

The exemption above does not apply to suspended plaster ceilings, other heavy ceilings or to gypsum board ceilings at more than one level or that are not adequately supported by surrounding walls; these may require bracing assemblies and special edge details such as those shown here. Check applicable code requirements. Details in Figures 6.3.4.3-6, 7, and 8 are adapted from California DSA IR 25-3 (revised 7-21-05) that provides prescriptive details for a single layer of suspended gypsum board; check with DSA for additional details and the latest requirements (http://www.dsa.dgs.ca.gov/Pubs/IRManual.htm). These details are shown with standard steel shapes; proprietary T-bar systems are also available.

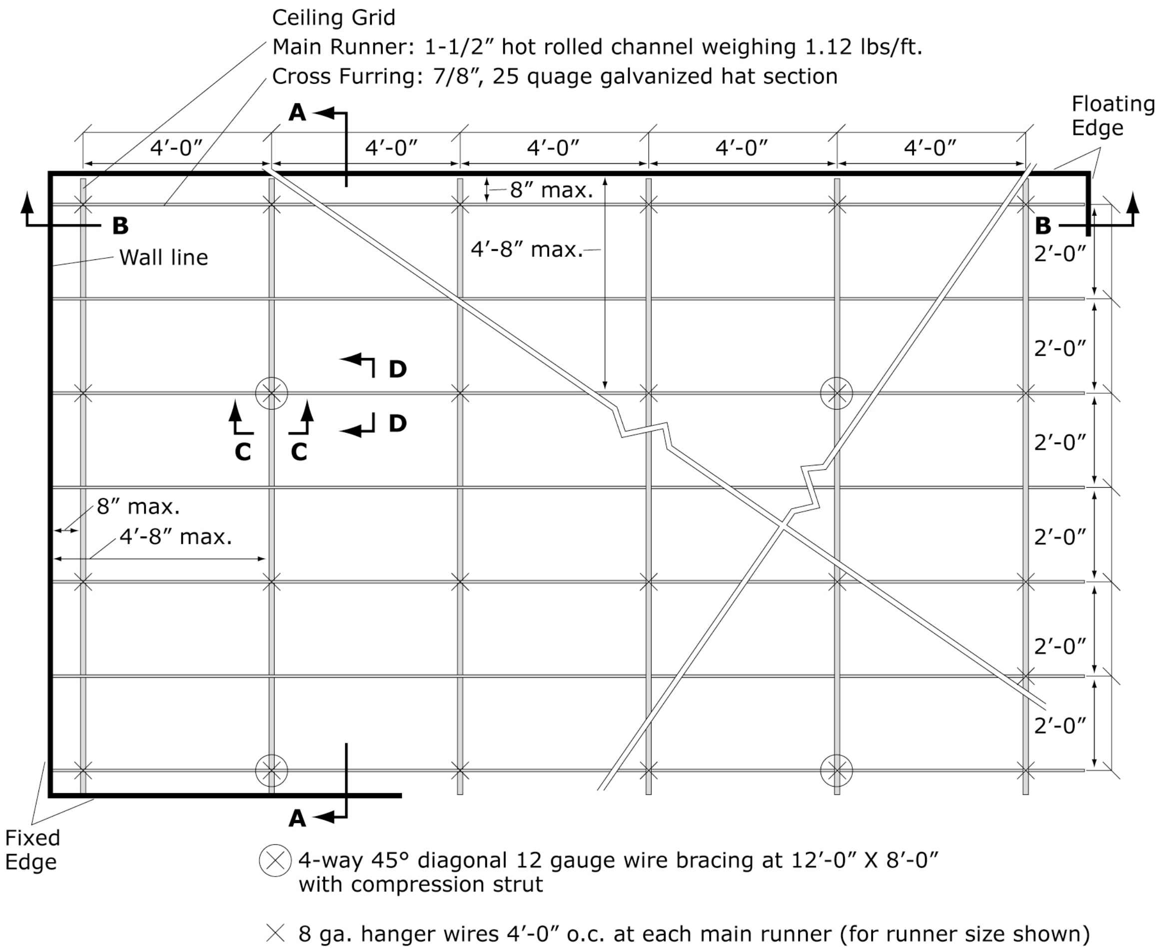
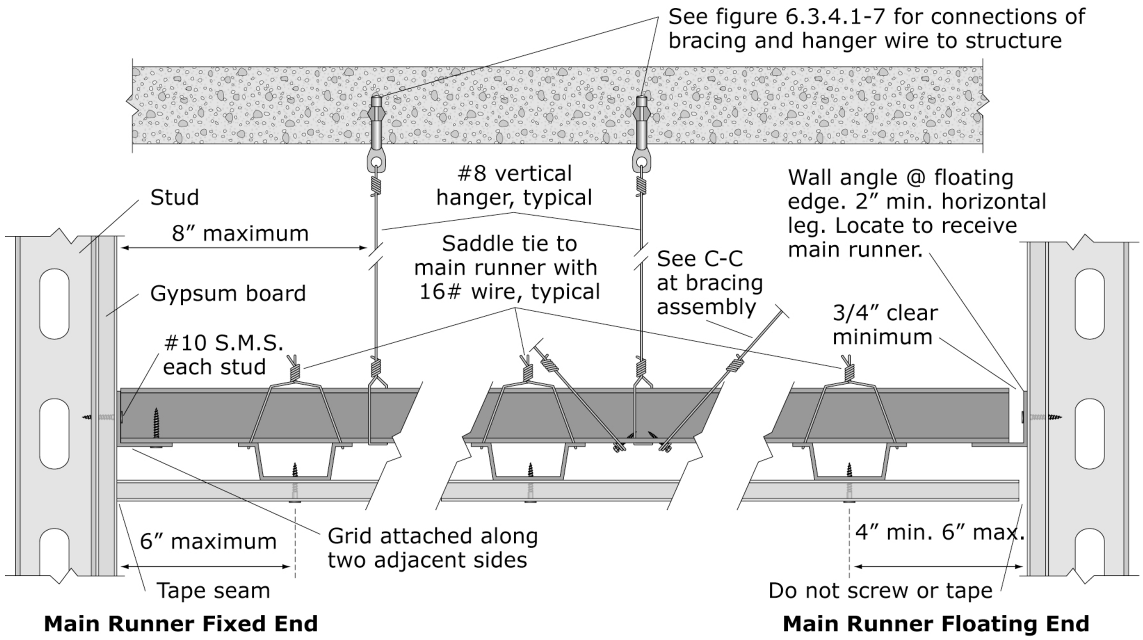
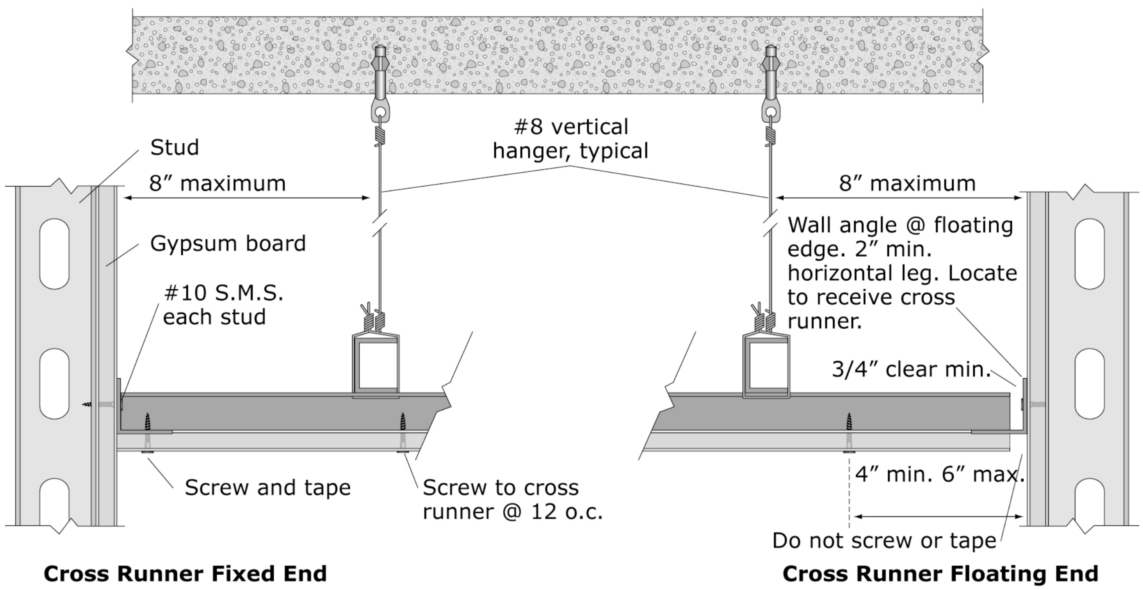


Figure 6.3.4.3-5 Diagrammatic view of suspended heavy ceiling grid and lateral bracing (PR).

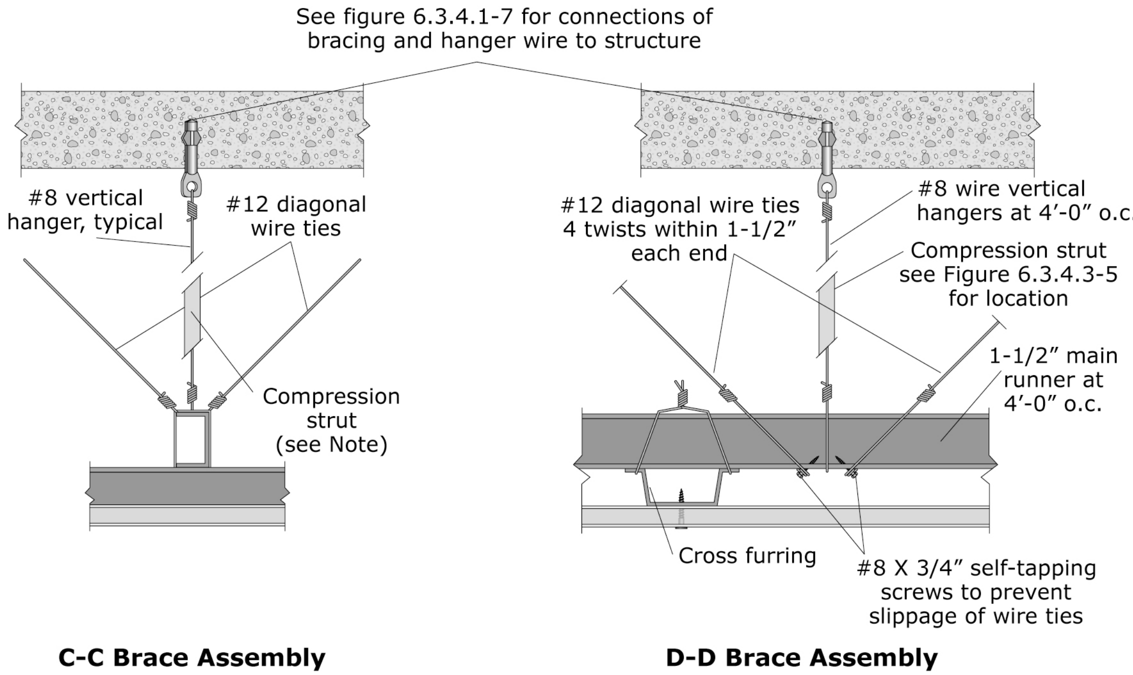


A-A Main Runner at Perimeter



B-B Cross Runner at Perimeter

Figure 6.3.4.3-6 Perimeter details for suspended gypsum board ceiling (PR).



Note: Compression strut shall not replace hanger wire. Compresion strut consists of a steel section attached to main runner with 2 - #12 sheet metal screws and to structure with 2 - #12 screws to wood or 1/4″ min. expansion anchor to concrete. Size of strut is dependent on distance between ceiling and structure (l/r ≤ 200). A 1″ diameter conduit can be used for up to 6′, a 1-5/8″ X 1-1/4″ metal stud can be used for up to 10′. See figure 6.3.4.1-6 for example of bracing assembly.

Figure 6.3.4.3-7 Details for lateral bracing assembly for suspended gypsum board ceiling (PR).