

## 6.3 Architectural Components

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### 6.3.4 Ceilings

#### 6.3.4.2 Ceilings applied Directly to Structure

Ceiling finishes such as gypsum board, interior lath and plaster, or exterior stucco soffits may be applied directly to structural elements such as wood ceiling joists, beam soffits, or the underside of structural slabs. These overhead finish materials may pose a falling hazard if the finish materials and any backing substrate are not anchored to the structure with sufficiently strong positive attachments.

### Provisions

#### BUILDING CODE PROVISIONS

Ceilings applied directly to the structure are considered force controlled, and the principal objective of the code provisions is to prevent ceilings from falling.

- Ceiling assemblies of gypsum board and plaster are covered by Chapter 25 of the 2012 IBC, *International Building Code* (ICC, 2012). These are prescriptive requirements, including requirements for horizontal gypsum board diaphragm ceilings.
- Seismic loads for ceilings are determined using ASCE/SEI 7-10, *Minimum Design Loads for Buildings and Other Structures* (ASCE, 2010), Chapter 13.

#### RETROFIT STANDARD PROVISIONS

- ASCE 41-06, *Seismic Rehabilitation of Existing Buildings* (ASCE, 2007) contains specific requirements for ceilings that are surface applied or furred with materials that are applied directly to wood joists, concrete slabs, or steel decking. Compliance with the anchorage provisions of the standard is required when:
  - The performance level is Immediate Occupancy.
  - The performance level is Life Safety and the plaster ceiling is over 10 sq. ft. in area and attached to metal or wood lath.
  - The performance level is Hazards Reduced and the ceiling is located in areas of public occupancy or egress. Such ceilings shall meet the Life Safety Nonstructural Performance Level.
- There are no prescriptive rehabilitation approaches for surface applied ceilings. Lateral forces are computed using ASCE 41-06 Section 11.7.4.

## Typical Causes of Damage

- Vintage lath and plaster ceilings may fall if the wood or metal lath is not adequately secured to the structure above or if the plaster has separated from the lath. Even well secured ceilings may exhibit x-cracking in buildings with flexible diaphragms or cracking around the edges where the ceiling and walls meet or at locations with seismic joints that have not been properly detailed. These ceilings may be particularly vulnerable if they have deteriorated due to roof or plumbing leaks.
- Stucco soffits on exterior surfaces, such as the underside of balconies or canopies, may fall if the wood or metal lath or finish materials are not adequately secured to the structure above or if the attachments have corroded or the components have deteriorated due to long term exposure or leakage from the roofing or decking above. Stucco soffits on cantilevered balconies or canopies may be particularly vulnerable as they often experience higher vertical accelerations than other structures.
- Large expanses of ceiling attached directly beneath flexible diaphragms may be damaged unless the ceiling is properly detailed with two adjacent sides attached and the opposite sides free and is subdivided into smaller areas (<2500 sq ft) with seismic expansion strips. Damage may occur around the perimeter, at changes in elevation, or at corners, columns, or other obstructions.

## DAMAGE EXAMPLES



Figure 6.3.4.2-1 Damage to metal lath and plaster ceiling applied to the underside of the concrete slab in 10-story residential building in the 2010 magnitude-8.8 Chile Earthquake (Photo courtesy of Eduardo Fierro, BFP Engineers). The damage occurred due to pounding at the interface between two wings of the structure.



Figure 6.3.4.2-2 Damage to stucco soffit of historic church in the 2010 Chile Earthquake (Photo courtesy of Eduardo Fierro, BFP Engineers). Stucco applied directly to the underside of the slab above without furring; portion at left has fallen, portion at right delaminated.



Figure 6.3.4.2-3 Damage to soffit paneling and wood framing at hotel in the 2010 Chile Earthquake; panels and wood framing show signs of prior water damage and deterioration. Note also damage to storefront glazing and glass doors (Photos courtesy of Rodrigo Retamales, Rubén Boroschek & Associates).

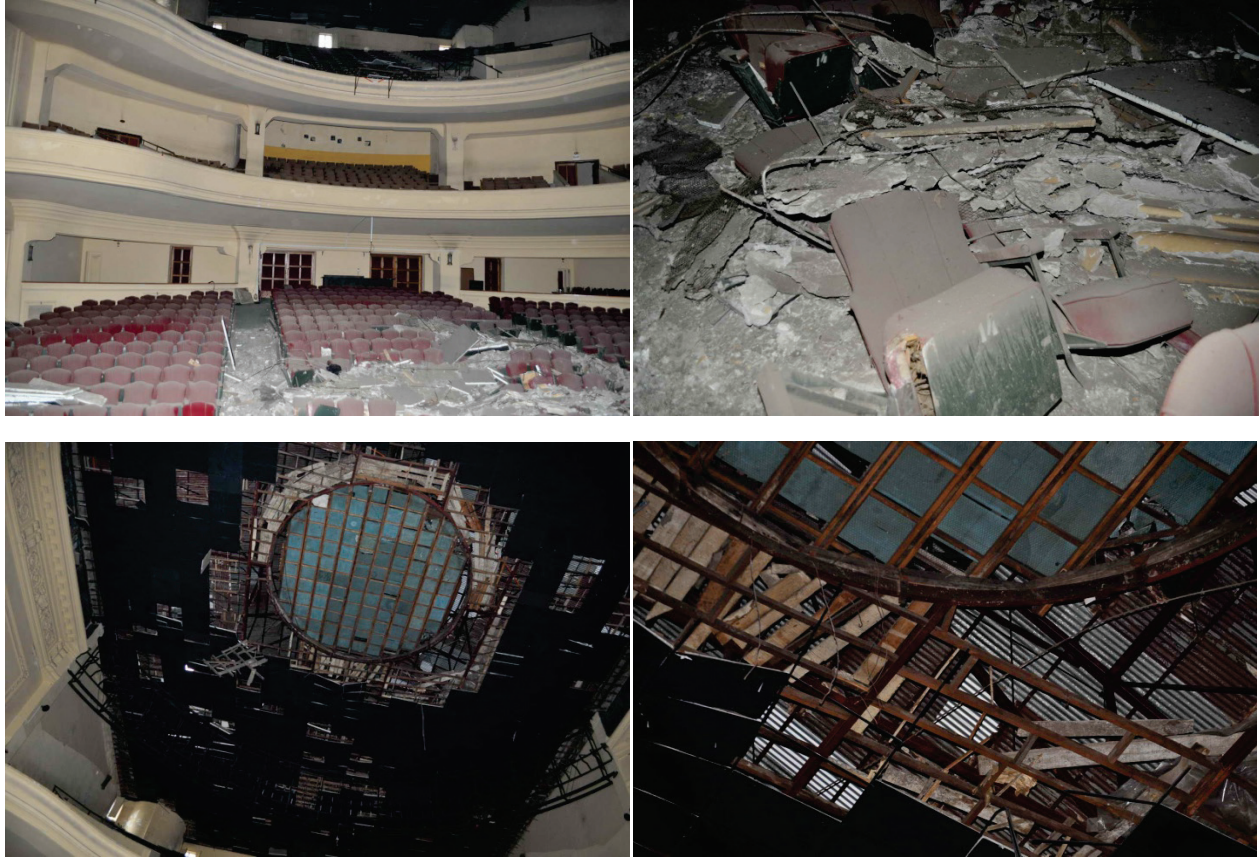


Figure 6.3.4.2-4 Damage to theater ceiling where foam panels and grid came down over orchestra seating and in upper balcony at the Municipal Theater Valparaiso in the 2010 Chile Earthquake (Photo courtesy of Eduardo Fierro, BFP Engineers). A circular section of metal lath and plaster collapsed completely. It appears the metal lath may have only been attached around the perimeter to wood furring added in the plane of the steel framing; circular area of wired glass is in a plane above the level of the wood furring. Black panels are lightweight foam supported by a grid attached directly to the wood furring.



Figure 6.3.4.2-5 Extensive failure of ceiling in the main terminal of the Santiago airport in the 2010 Chile Earthquake. Metal panels with lights and diffusers hung from furring on short metal tabs; these remained in place but detail at lower left shows they also sustained some damage. Furring channels still in place throughout ceiling but majority of lightweight ceiling panels and much of the cross furring came down as shown at lower right photo of exterior soffit with same system (Photos courtesy of Antonio Iruretagoyena, Rubén Boroscchek & Associates).

## Seismic Mitigation Considerations

- Provide positive connections from the gypsum board, plaster or stucco finish materials to the furring and from the furring to the structure above. Protect these connections from water damage or corrosion. Check local codes for specific requirements or exemptions; in many cases these ceilings do not require special seismic detailing as long as the installation meets current industry standards.
- It may be prudent to reduce the standard connector spacing on stucco soffits or finishes mounted beneath cantilevered balconies or canopies which may experience large vertical accelerations during an earthquake. Note that finishes with exterior exposure such as soffits also need to be designed for wind.
- Gypsum board ceilings are frequently used to meet requirements for fire-rating or sound proofing or both. Rated systems may include combinations of metal decking, wood subflooring, wood or metal joists, insulation, resilient furring strips, and one or several layers of gypsum board. While rated systems are typically proprietary, care must be taken to insure that appropriate fasteners are used for each successive layer and that they are installed with adequate penetration into the joists or furring strips. These multi-layer systems get increasingly heavy and also have increased in-plane stiffness. In some instances, care must be taken with the perimeter details to provide seismic expansion joints and to allow relative movement with the walls but maintain the fire-rating. Availability of certified systems with seismic detailing wherever sound or fire proofing is required should be checked and these systems must be installed exactly as specified and as tested otherwise the certification is not valid.
- Vintage lath and plaster ceilings still exist in many older structures. These ceilings should be in good condition with the lath securely fastened to the structure and the plaster secured to the lath. The most reliable way to upgrade these ceilings would be to remove and replace with a code compliant ceiling system. Where it is important to match other vintage finishes, screw attached metal lath with a new plaster finish can be used. As an alternative to replacement, screwing 1x2 wood strips at 16 in centers into the joists from below may serve as a safety net (See Figure 6.3.4.2-9). Some ornate theatre ceilings have been encapsulated from below with netting to reduce the falling hazard; such netting and all its attachments must be designed to contain any falling debris.

## MITIGATION EXAMPLES



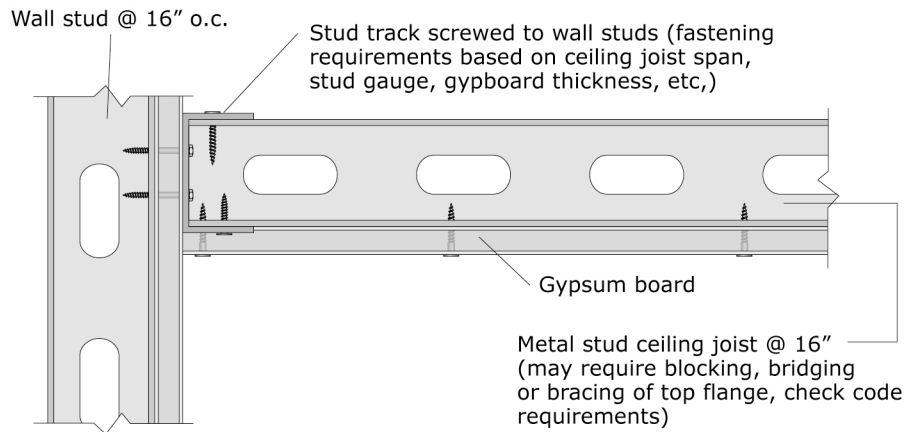
Figure 6.3.4.2-6

Mitigation examples with 1-1/2" hat channels at 16" on centers screwed in place with #12 self drilling screws and furring strips ready to receive gypsum board (Photo courtesy of Excalibur Steel). No special seismic details are required for this type of ceiling where the gypsum board is well secured directly to furring strips.

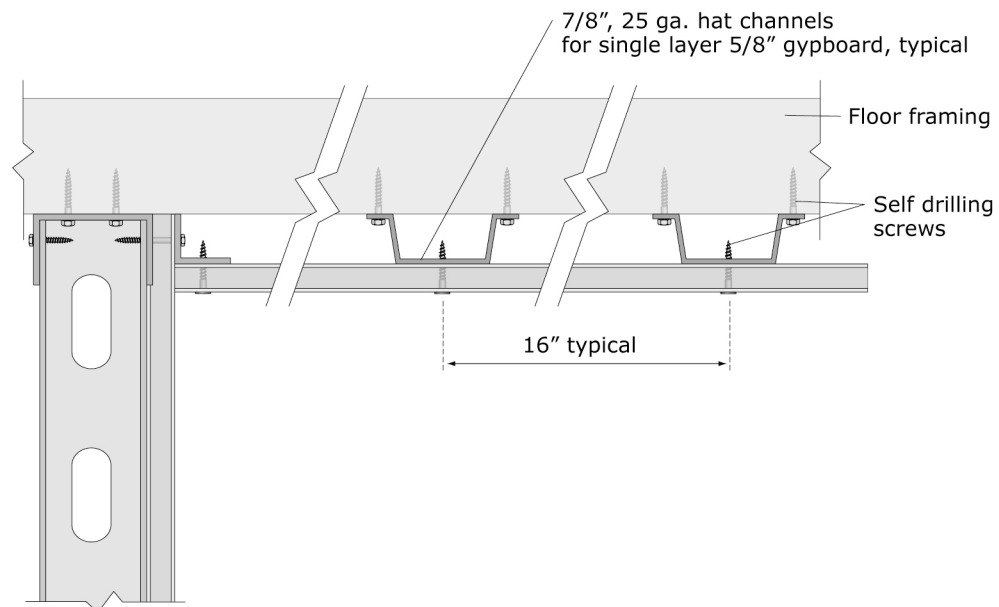


Figure 6.3.4.2-7 View of typical wood lath and plaster ceiling from the 1920's from above (Photo courtesy of Cynthia Perry, BFP Engineers). The wood lath is well nailed to the underside of the ceiling joists. This type of ceiling typically remains intact during an earthquake but may require crack repair and painting. Where the plaster has delaminated from the lath due to age or water leakage, wood strips could be installed from below as in Figure 6.3.4.2-8.

## MITIGATION DETAILS



**a) Gypsum board attached directly to ceiling joists**



**b) Gypsum board attached directly to furring strips (hat channel or similar)**

Note: Commonly used details shown; no special seismic details are required as long as furring and gypboard secured. Check for certified assemblies (UL listed, FM approved, etc.) if fire or sound rating required.

Figure 6.3.4.2-8 Gypsum board ceiling applied directly to structure (NE).

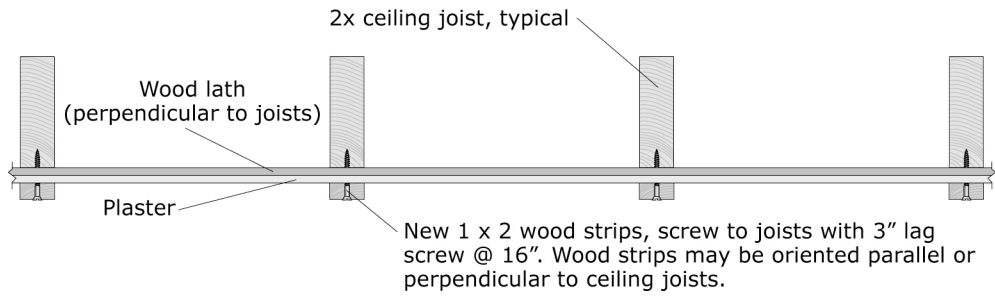


Figure 6.3.4.2-9 Retrofit detail for existing lath and plaster (NE).