



Ceiling Systems: Overhead Investments

Preliminary selection guide for lay-in panels

by Michael Chusid, RA, FCSI, CCS

Photo @ Chun Lai Photography

CEILINGS ARE ONE OF THE MOST VISIBLE ARCHITECTURAL SURFACES IN MANY BUILDING INTERIORS. PERFORMANCE REQUIREMENTS FOR CEILINGS CAN BE AS COMPLEX AS THOSE REQUIRED OF WALLS, FLOORS, AND OTHER FINISHES. SELECTING THE RIGHT PRODUCT TO USE OVERHEAD SHOULD BE SEEN AS A WISE INVESTMENT IN BUILDING PERFORMANCE (FIGURE 1).

This article identifies common performance criteria applying to lay-in panels for installation in standard T-bar suspended ceiling systems. It also compares the performance of standard ceiling panel types to help the initial product selection.¹ Panel types selected for this paper are made of mineral fiber, sheet metal, thermoformed rigid vinyl, and wood (Figure 2, page 10). Wide variations occur within types between products by different manufacturers and even with a manufacturer's own product lines, so readers are advised to research specific products before specifying or purchasing them (Figure 3, page 12).

Accessibility above ceiling

Suspended ceilings are an alternative to ceiling products applied directly to a substrate. Suspending a ceiling:

- lowers overhead surfaces for visual purposes;
- puts surfaces within reach for cleaning and maintenance;
- reduces acoustic reverberation time, the amount of air to be tempered, and the volume of space to be illuminated;
- creates a cavity in which HVAC ducts and equipment, conduit and cables, piping, and other building services can be installed;
- conceals unattractive structural systems;
- protects fragile materials such as spray-applied fireproofing systems; and
- enables smoke detection and sprinkler systems to activate at a faster rate.

The ceiling cavity should be accessible to allow inspection, maintenance, and modification of above-ceiling items. Ceiling panels should, therefore, be lightweight and robust enough to survive repeated handling, especially because most of the accessing over the life of a building is likely to be performed by individuals not trained as ceiling installers.

As the term 'lay-in' suggests, the ceiling panels discussed in this article must be raised above the suspension system and then lowered onto the flange of the T-bar grid. Sufficient clearance must be provided between grid and items in cavity. This is especially a concern with rigid panels as flexible ones can be manipulated to fit into tighter spaces.

Acoustics

All ceilings have acoustic properties with varying degrees of noise reduction, transmission, and reflection. Yet, the term, 'acoustic ceiling,' does not have a consistent definition. Hence specifiers should use it sparingly and define what it means for particular projects.

Noise reduction is determined in accordance with ASTM C423, *Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method*, and expressed as a sound absorption average (SAA). SAA was adopted by ASTM in 2000 as a refined replacement for noise reduction coefficient (NRC). A SAA of 0.00 indicates zero sound absorption and SAA 1.00 suggests all impinging noise is absorbed. SAA ratings will usually be close in value to NRC ratings.²

Mineral fiber panels absorb sound by transforming airborne vibrations into heat that is generated by vibration of the fibers. Performance of these panels ranges from SAA 0.45 to 0.95.

Figure 1



Ceiling area (pink) is typically equal to the gross floor area (yellow), but is more visible as a large percent of most floors is covered by furnishings, equipment, and occupants. As room sizes increase, ceilings occupy a relatively greater proportion of a person's visual field because walls recede due to perspective.

Photo © Hanna Chusid

Thin metal and thermoformed panels act as diaphragms and dampen noise by transforming airborne vibrations into the mechanical motion of vibrating panels and by passing sound into the cavity where the viscous mass of air trapped above the ceiling dampens vibrations. For example, suspended thermoformed panels made of 0.33-mm (0.13-in.) thick material have SAA 25. Hard-surface ceiling panels, such as wood, are essentially reflective.

Figure 2

Attribute	Mineral Fiber	Metal	Thermo-formed	Wood	Comments ^{1, 2}
Accessibility	✓	✓	✓	✓	
Acoustic SAA (NRC)	✓	✓*	✓*	✓	* May require perforations and/or added acoustic insulation.
Acoustic STC or CAC	✓	●*	●*	✓	* May require added acoustic insulation.
Appearance	✓	✓	✓	✓	See samples before specifying.
Cleaning, Hygiene, and Impermeability	✗*	✓	✓	●	* Cleanability and hygiene can be improved with use of vinyl-faced panels.
Costs and Life Cycle	—	—	—	—	
Delivery, Storage, and Handling	●	●	✓	●	
Disposal and Recycling	●	✓	●	●	
Strength and Durability	●	✓	✓	✓	
Fire-resistant Assemblies	✓	✗*	✗*	✗*	* Usable beneath rated assembly.
Fire Sprinkler Compatibility	●	✓*	✓*	●	* Option to install beneath sprinklers.
Installation	●	●	✓	●	
Lighting	●	✓*	✓*	●	* Option to install beneath luminaires.
Material Safety	✗	✓	✓	●	

✓ Good candidate
 ● Acceptable
 ✗ See concerns in article
 — Need case by case Consideration

1. See text of article for discussion of each topic.
 2. See samples, test data, and evaluation reports before final product selection.

A comparison of some of the ceiling panel types available in the market.

Images © Michael Chusid, RA, FCSI, CCS

The absorption of wood, metal, and thermoformed panels can be boosted by perforating panels to create resonant sound absorption (Figure 4, page 12). Further, SAA improvements result from backloading panels with an acoustic insulation. In this manner, metal panels with a non-woven acoustic fabric backing can achieve nearly SAA 0.70 and the thermoformed panel with a 38-mm (1.5-in.) thick polyester fiber batt can achieve SAA 0.85.³

Sound transmission losses are expressed primarily in:

- sound transmission coefficient (STC) that indicates noise lost from one side to the other of a wall or floor-ceiling assembly, as determined by ASTM E90, *Standard Test Method for Laboratory Measurement of Airborne Sound Transmission Loss of Building Partitions and Elements*; and
- ceiling attenuation class (CAC) indicating how well ceilings can act as a barrier to sound transmission when the wall between adjacent rooms goes only to the ceiling, as per ASTM E1414, *Standard Test Method for Airborne Sound Attenuation Between Rooms Sharing a Common Ceiling Plenum*.⁴

Products with greater mass typically perform better in STC and CAC tests, which gives mineral fiber and solid wood the advantage over lighter-weight panels. Performance in the field could be degraded by penetrations through a ceiling such as light fixtures and fire sprinklers. Either the ASTM E1414 test should be conducted with representative penetrations or measures must be taken to seal or cover penetrations. In this regard, drop-out and luminous ceilings (discussed later in the article) may be less compromised because luminaires and sprinklers need not penetrate ceiling panels.

Appearance

Designers have a profusion of visual options for ceilings, ranging from smooth, monotone ceiling panels to riots of standard and custom color, relief, pattern, and texture (Figure 5, page 14).

A defining characteristic of suspended ceilings is the rectangular geometry of the suspension system. The grid could be given emphasis by, for example, using finishes that do not match the panel colors. Alternatively, the grid could be camouflaged by integrating it into a patterned scheme formed by decorative ceiling panels (Figure 6, page 14).

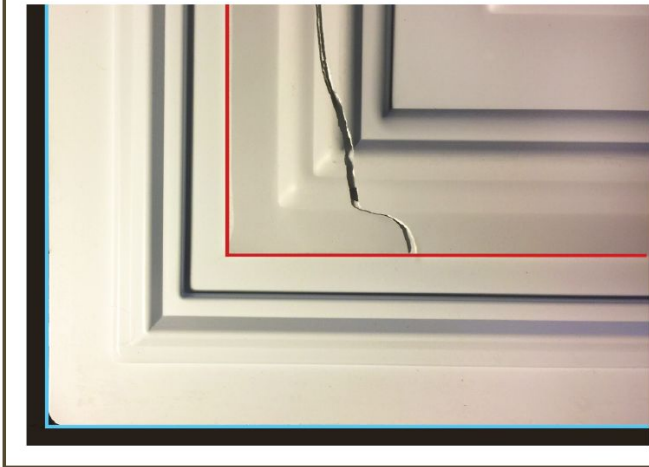
While standard modular sizes are 609 x 609 mm (24 x 24 in.) or 609 x 1219 mm (24 x 48 in.) on center (o.c.), grids can also accommodate different panel sizes to offer changes in visual scale.⁵ The size of mineral fiber and wood panels is limited because of their tendency to sag due to humidity. Some metal panels can be engineered to provide large sizes. Scale can also be modified by grouping tiles to form multipanel patterns or by combining several types of ceiling panels to form supergraphics.

Cleaning, hygiene, and water impermeability

Most interior finishes ‘ugly out’ before they wear out. Cleanability can help preserve a ceiling’s appearance and extend its serviceability (Figure 7, page 16).

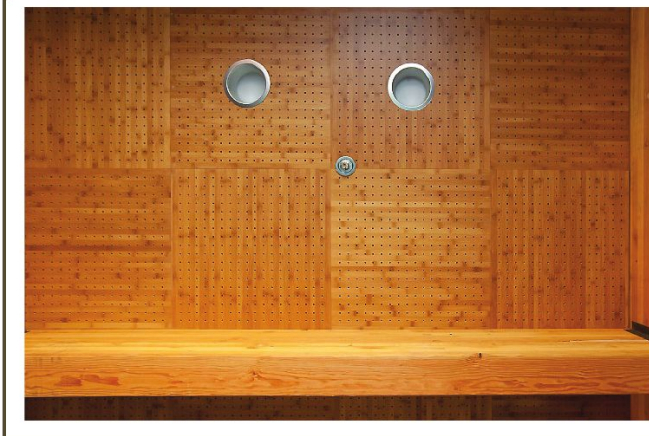
Wood can be cleaned with wood maintenance products or a damp cloth. Metal and thermoformed products offer high levels of stain resistance and can be hosed-off or immersed if necessary. Mineral fiber products can be vacuumed or dusted;

► **Figure 3**



There is a wide range of performance within each product category. The thermoformed panel on top (outlined in red) is cracked. It has a high percentage of filler that makes it brittle and subject to breakage if dropped or flexed during handling. In contrast, the lower thermoformed panel (blue) contains no filler and is supple enough to withstand repeated handling without breaking.

► **Figure 4**



Ceiling panels with real wood veneers are available with a variety of Class A-rated cores or on metal. Faux-wood finishes are available on thermoformed and metal panels. These panels are perforated to boost their sound attenuation average (SAA) and have grooved edges to cover the ceiling suspension grid. The grain direction in adjacent panels are rotated for a decorative checkerboard effect. While the light fixtures are centered in panels, the sprinkler is not. The awkward appearance of sprinklers can be avoided with drop-out panels.

Photo courtesy Madrid

few of them are stain resistant or can actually be scrubbed or washed. It is important to note many wood and mineral fiber products can support mold growth.

Ceilings over food processing areas and in critical healthcare and industrial facilities require an absence of crevices where dirt and contaminants can collect.⁶

Water-resistant panels are useful in buildings where leaks, condensation, and spills are of concern. They also contribute to building resilience by meeting the *International Building*

Code's (IBC's) paragraph 802.4 requirements, "buildings in flood hazard areas..., interior finishes, trim and decorative materials... shall be flood-damage-resistant materials."

Costs and life cycle

The list price of ceiling panels is a small fraction of a panel's life-cycle cost. The calculus includes:

- delivery, storage, and handling;
- installation;
- cleanability; and
- durability.

Delivery, storage, and handling

While distance from point of extraction and manufacture to building site has an environmental and economic impact, other factors can have bigger consequences. For example, pressed metal and thermoformed panels are very thin and nest compactly to allow about five times as many panels to be shipped and be stored in a given volume compared to most mineral fiber or wood panels. Thermoformed panels are also lighter by 80 to 90 percent. Since metal and thermoformed panels are not affected by moisture, they can also be stored onsite and be installed before humidity has stabilized in a new building. Many types of ceiling panels are fragile, prone to breakage, and can be easily damaged during each stage of handling.

Disposal and recycling

Metal panels are readily recycled without downgrading the metal's quality. High quality vinyl panels (Plastic Resin Identification Code 3) are also recyclable without loss of performance and is used to make, among other products, new ceiling panels with 98 to 100 percent recycled content. Thermoformed panels with fillers may have to be downcycled or sent to landfill. Wood panels can be handled in the same manner as other wood scrap and debris.

With careful handling, the metal, thermoformed, and wood panels can be collected and reused. If necessary, they can be collected for disposal or recycling via conventional waste and debris streams. Some manufacturers will also take back their material for reprocessing. Mineral fiber, however, requires special handling and treatment such as palletizing and shipping to ceiling panel manufacturers.

Strength and durability

The introduction to ASTM C367, *Strength Properties of Prefabricated Architectural Acoustical Tile or Lay-In Ceiling Panels*, says, "Materials used for absorbing sound generally have a porous, low-density structure. In comparison with many building materials they are relatively fragile."⁷ This description limits the applicability of the standard to use with mineral fiber panels.

Figure 5



Color, texture, and the geometry of the suspension grid contribute to the appeal of ceiling panels.

Photo courtesy Penryn College

Figure 6



Staggering the suspension system's cross-tees allowed these ceiling panels to be offset, adding interest to the faux wood ceiling panels.

Photo courtesy Cellume

It contains protocols for evaluating panel friability and sag along with hardness and transverse strength. Knowing this information about various ceiling panels would be useful for screening and specifying products, but manufacturers publish limited test data.

According to ASTM C367, friability is, "the susceptibility of an acoustical product to edge and corner damage sustained during shipping, handling, and installation. Products that are friable and soft will erode considerably when subjected to rough treatment."

In this author's experience, mineral fiber panels release fibers even during ordinary handling. This is also attested to by the stringent requirements for personnel protective clothing and equipment found in manufacturer installation instructions (Figure 8, page 16). Further, some researchers argue that fibers can be dislodged by ordinary building vibrations and panel fluctuations due to changes in air pressure.

According to the paper, "Particles and Health: Environmental Forensic Analysis," presented by E. Russ Crutcher, Ken Warner, and H. K. Crutcher at the 2007 Professional Conference on Industrial Hygiene (PCIH) in Louisville, Kentucky, "When a door is opened a pressure pulse may be generated that is translated into vibration and mechanical abrasion, creating wear particles. This is especially the case in buildings with suspended acoustic ceiling tiles. The pressure pulse can lift the ceiling tile slightly and cause it to rub against the T-bar support. The result is abrasion of the edge of the ceiling tile and the creation of millions of particles of glass fiber, resin, perlite, and other debris that sifts down onto the people below."⁸

Sag is also of concern because most mineral fiber panels are prone to damage due to humidity and moisture. Some specialty products come with 30-year warranties against sag. However, statements like 'highly sag resistant' call for identification of a test procedure and results.

Fire safety

Most of the mineral fiber, sheet metal, thermoformed rigid vinyl, and wood panel types are available with Class A surface burning characteristics and can be used in all but the most restrictive building code occupancies.⁹ Additionally, metal panels are noncombustible.

Some mineral fiber panels can be used in floor-ceiling assemblies that are rated to resist the spread of fire from one floor to another. Rated assemblies require use of a suspension grid that is also fire resistant, and penetrations through the ceiling for light fixtures, air supply or return, and fire sprinklers must be protected in an approved manner.

Vinyl is one of the most fire-safe plastics, enabling it to be used for wall and floor finishes as well as ceilings.¹⁰ Thermoformed panels should be self-extinguishing per Underwriters Laboratories (UL) 94, *Standard for Safety of Flammability of Plastic Materials for Parts in Devices and Appliances*, and be in Flame Class V-0. Unlike many other plastics, vinyl does not melt and drip to spread fire. As discussed in the section on fire sprinkler compatibility, thermoplastic panels drop out of ceiling grids when exposed to heat. They fall to the relatively cooler floor where they are less likely to burn. In the worst case, the thin material used for panels would contribute very little fuel.

Ceilings also have an effect on fire spread and firefighting. Fire-resistant and noncombustible ceiling panels, for example, may create a hidden plenum through which fire can spread or

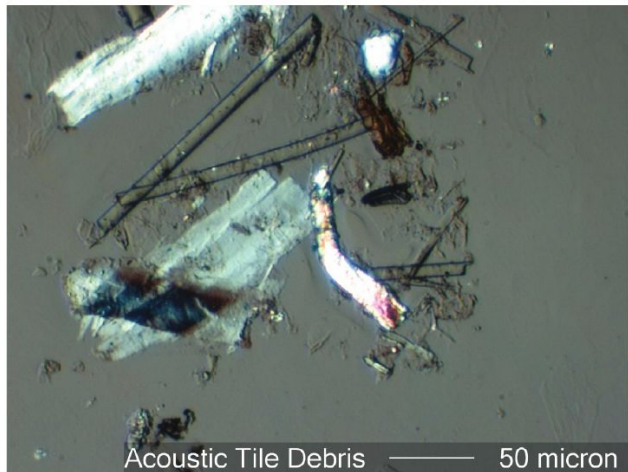
► Figure 7



Particulates in air supply tend to cling to adjacent ceiling surfaces due to Coandă effect. Soot, at this international airport, is particularly hard to remove from crevices and pores in mineral fiber panels.

Photo © Michael Chusid

► Figure 8



This photomicrograph was collected in a classroom where the teacher was complaining of upper respiratory system issues. It shows particles collected from surfaces beneath a mineral fiber ceiling. The ceiling contained glass and paper fibers, epoxy binder, and a calcite mineral filler. Fiber exposure and health complaints dropped significantly after ceiling was replaced.

Photo courtesy Russ Crutcher, Microlab Northwest

conceal fire hotspots in the floor above. Firefighters may have to use pikes to tear down ceiling panels. Falling panels, especially heavy ones, and the razor-sharp edges of metal panels increase the danger to firefighters in the space. In this author's experience, these hazards are reduced when using thermoformed ceilings as they are lightweight and free from sharp edges. Since panels drop out when exposed to heat, they may simplify the firefighter's search for hotspots.

Fire sprinkler compatibility

Most ceiling panels require holes to allow sprinklers to reach the underside of ceiling. Two exceptions, however, are included in the 2019 version of the National Fire Protection Association (NFPA) 13, *Fire Sprinkler Systems*.

Ceilings with large, open areas

According to paragraph 9.2.15 in NFPA 13, ceilings with at least 70 percent open area are referred to as 'open grid' systems and can be installed beneath fire sprinklers (Figure 9). Some metal ceilings can meet this criterion for large, open areas if the remaining metal performs satisfactorily.

Drop-out ceilings

According to paragraph 9.2.16 in NFPA 13, as a fire's heat rises, some thermoformed panels soften, sag, and drop out of the ceiling grid to the cooler floor. This exposes sprinklers in ceiling cavity and allows them to operate without encumbrance. One must look for drop-out panels that have been recognized by Factory Mutual (FM), UL, and code-recognized product evaluation services such as the International Association of Plumbing and Mechanical Officials–Uniform Evaluation Service (IAPMO–UES) or the International Code Council–Evaluation Service (ICC–ES).

Both the open grid and drop-out ceilings can reduce cost of sprinkler installation by eliminating the need to drop sprinklers and coordinate locations of panels and sprinklers. They can also reduce visual clutter from exposed sprinklers and help protect sprinklers from damage and tampering. If desired, the ceilings can still be used with penetrating sprinklers.¹¹

Water from activated sprinklers, as well as from firefighting hoses, can cause extensive damage to building materials and contents, especially when a deluge on an upper floor drains to lower levels (Figure 10). The water does not normally damage metal and thermoformed panels, but fibrous acoustic insulation on top of panels may need to be replaced. Wood panels can be damaged by water but some types could be reused if dried before mold growth. Mineral fiber panels, however, can become saturated with water and fall, creating a soggy mess.

Installation

All types of ceiling panels require standard precautions including the use of eye protection when working overhead and gloves when employing sharp tools. Ladder safety is also important, especially with wood and heavier panel types where repeated lifting and reaching can lead to injuries.

Mineral fiber panels require special attention to airborne fibers and dust.

Metal panels often have razor-sharp edges and corners, especially when cut in field. Panel installers should wear cut-resistant gloves and other protective clothing made from

leather or aramid textiles. Depending on metal and thickness, heavy-duty or power shears and guillotine cutters may be required to trim panels.

Thermoformed panels are lightweight, can be easily cut with aviation snips or scissors, do not have sharp edges, and do not release fibers.

Lighting

Light reflectance values (LRV) are determined primarily by color and reflectivity of a panel's finish. Surfaces with molded or other decorative relief will be accented by highlights and shadows, especially if there is glancing or side light (Figure 11, page 18).

Ceilings can also transmit light. For example, metal panels with large, open areas can filter illumination from above ceiling sources. Thermoformed panels can be made with translucent, frosted, or clear material to create luminous ceilings and special lighting effects such as rear-projected images and dynamic colored light-emitting diodes (LEDs). Clear panels can be installed beneath equipment in the ceiling cavity to allow visual inspection without removal of panels (Figure 12, page 18).¹²

Material safety

While currently produced mineral fiber panels do not pose significant health hazards from asbestos, their vitrified glass fibers, crystalline silica, and other components can readily erode and release dust and fibers associated with health concerns. This is made clear by manufacturer safety data sheets cautioning against breathing dust and coming into contact with skin or eyes and the need to wear protective respiratory masks, gloves, clothing, eye, and face protection.¹³

Even if these precautions are observed by professional ceiling installers, other trades and building maintenance personnel and tenants who need to handle ceiling panels are probably unaware of the hazards. In healthcare facilities, the ceiling's potential to release dust and fibers may have to be addressed in pre-construction risk assessments (PCRA) and infection control risk assessments (ICRA).

Many of these concerns also apply to glass fiber insulation used above other types of panels. It is advisable to encapsulate the insulation in plastic or another material to reduce the potential release of fibers. As an alternative, polyester fiber batts can be used for above panel acoustic insulation. The polymer fibers are much longer and more flexible than mineral fibers, so less likely to erode and become airborne. Their safety is demonstrated by the widespread use of polyester fiber in clothing and household items. Polyester batts with Class A surface burning characteristics are available.

In this author's experience, wood and metal panels use materials with well-established health and safety records.

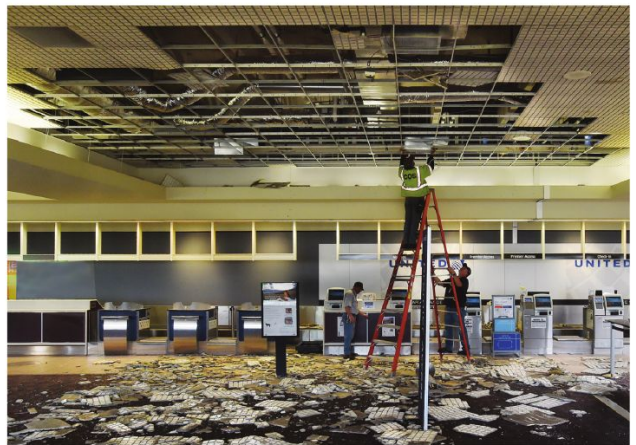
Figure 9



Metal panels with large, open areas are available in the market, thereby allowing sprinklers and light fixtures to be located above the ceiling. For a decorative effect, these panels utilize two layers of metal with spacers in between.

Photo courtesy Arktura

Figure 10



Vulnerability to moisture, whether from leaks, condensation, or firefighting, should be considered when selecting ceiling systems. After a fire in 2018, portions of the airport in Colorado Springs, Colorado, had to be closed due to water damage that required clean-up and replacement of wet and falling ceiling panels.

Photo © Jerilee Bennett/The Gazette via AP

Vinyl is a controversial material. Several organizations have placed polyvinyl chloride (PVC) on their precautionary lists and request specifiers to seek alternatives.¹⁴ Yet, a case can be made vinyl with its durability, washability, recyclability, efficient use of materials, and other benefits can be used responsibly. Some of the concerns expressed about vinyl floors—such as releasing airborne particles due to abrasive foot traffic or dermatological contact by children crawling on floors—do not apply to overhead products.

Figure 11



Visual interest is added to the ceiling by combining patterns and colors and using grid with a contrasting color. Relief patterns on the panel are made more visible by employing glancing light.

Photo courtesy Ceillume

Figure 12



In addition to providing diffused overhead lighting, these luminous thermoformed ceiling panels create scale within the overall plane of the library's opaque mineral fiber ceiling. The ceiling grid members run continuously through both ceiling panel types in order to unify overall composition.

Photo © Steve Miller

Responsible thermoformers:

- source vinyl from suppliers with rigorously clean manufacturing programs limiting the release of toxins into the environment;
- use rigid vinyls free of phthalates or other chemicals of concerns or contain only trace amounts unlikely to migrate to the surface; and
- take back scrap from their panels and recycle it in a closed-loop process to make new products.

Other options

Before choosing a ceiling panel, a designer might also consider the option of not using one and leaving the structure and other overhead building components exposed for an aesthetic many find attractive. The apparent cost saving of omitting a suspended ceiling has to be balanced against the potential for added costs to make exposed services and surfaces visually acceptable



The ceiling of the new dining commons at Mt. Holyoke College, South Hadley, Massachusetts, designed by Bergmeyer, blends mineral fiber panels with several styles of thermoformed panels ranging from shallow to deep coffers. A high sound attenuation average (SAA) was required to control noise levels in the busy facility. Thermoformed panels could be used over food preparation areas because their impervious, washable surface meets health department requirements.

Photo © Chun Lai Photography

(Figure 13). This can include painting and more care in locating and installing services. Omitting the ceiling simplifies maintenance access to overhead surfaces and systems, yet can also increase the maintenance required to keep them looking presentable. Heating and cooling costs may increase due to stratification and the larger volume of air to condition. Exposed, overhead structures may be unattractively dark, or require increased energy to illuminate.¹⁵

Conclusion

With so many ceiling products available, the specifier's selection can be difficult. It is likely to get more challenging as manufacturers reformulate products to improve performance, new types of flat, solid-state lighting fixtures become economic replacements for ceiling panels, and acoustic metamaterials enable one to manipulate sound in unprecedented ways. While 'ceiling' can be a synonym for 'limitation,' one can be confident the construction industry has not reached the ceiling on that ceiling design or performance.

CS

Notes

¹ Suspended ceiling systems are within the scope of ASTM C635, *Standard Specification for Manufacture, Performance, and Testing of Metal Suspension Systems for Acoustical Tile and Lay-in Panel Ceilings*, and ASTM C636, *Standard Practice for Installation of Metal Ceiling Suspension Systems for Acoustical Tile and Lay-In Panels*.

² ASTM C423, *Standard Test Method for Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method*, tests for suspended ceilings should use ASTM E795, *Standard Practices for Mounting Test Specimens During Sound Absorption Tests*, Mounting E. This mount holds the test

specimen above the concrete floor of the reverberation room to simulate installation beneath a ceiling cavity. A 400-mm (16-in.) mounting height is commonly used.

³ For more information, read “Acoustical Uses for Perforated Materials” by Theodore J. Schultz at www.iperf.org/files/1313/9265/8912/The_Acoustical_Uses_for_Perforated_Metals_Handbook.pdf.

⁴ Consult ASTM E989, *Standard Classification for Determination of Impact Insulation Class*.

⁵ Grids with metric modules of 600 mm (24 in.) are available. One must verify compatibility with panels.

⁶ Read *The Construction Specifier* articles, “Hygienic Ceilings: Keeping it clean overhead” and “Hygienic Ceilings: Standards and guidelines,” at www.constructionspecifier.com/hygienic-ceilings-keeping-it-clean-overhead and www.constructionspecifier.com/more-hygienic-ceilings respectively.

⁷ ASTM C367, *Strength Properties of Prefabricated Architectural Acoustical Tile or Lay-In Ceiling Panels*, was initially issued 20 years ago and was updated in 2016, suggesting its validity has been established over time.

⁸ Visit www.researchgate.net/publication/259594793_PDC_10_Particles_and_Health_Environmental_Forensic_Analysis_Particles_and_Health_Environmental_Forensic_Analysis.

⁹ Flame spread ≤ 25 , smoke developed ≤ 450 when tested in accordance with ASTM E84, *Surface Burning Characteristics of Building Materials*.

¹⁰ Consult “Fire and Polyvinyl Chloride” by Marcelo Hirschler at www.vinylinfo.org/sites/default/files/Fire%20Properties%20of%20Polyvinyl%20Chloride.pdf.

¹¹ For more information, read *The Construction Specifier* article, “Thermoformed ceiling panels and tiles: Drop-out ceiling panels installed beneath fire sprinklers,” at www.constructionspecifier.com/thermoformed-ceiling-panels-and-tiles-drop-out-ceiling-panels-installed-beneath-fire-sprinklers.

Figure 13



A suspended ceiling was a practical way to install new lighting and air distribution in Seattle's King Street Station in 1967. Tastes had changed and the suspended ceiling was removed to expose the ornamental ceiling in 2010. The panels that are not seated properly were probably raised to provide access to the above-ceiling cavity, but were difficult to manipulate and reposition correctly due to their stiffness.

Photo © CC BY-SA 1.0 by Bachcell

¹² Read *The Construction Specifier* article, “Ceilings Become Transluminous,” at www.constructionspecifier.com/ceilings-become-transluminous.

¹³ Consult North American Insulation Manufacturers Association's (NAIMA's) “Safe Handling Instructions” at insulationinstitute.org/about-naima/health-and-safety.

¹⁴ Read the Perkins + Will 2015 white paper, “Healthy Environments: What's New (and What's Not) With PVC,” at perkinswill.com/sites/default/files/PerkinsWill_PVC_2015_Whitepaper_2.pdf.

¹⁵ Consult “Life Cycle Analysis: Wall-to-Wall Ceilings and the Open Plenum” by the Ceiling and Interior Systems Contractors Association (CISCA) at www.cisca.org.

ADDITIONAL INFORMATION

Author

Michael Chusid, RA, FCSI, CCS, is a frequent contributor to *The Construction Specifier*, and a consultant to building product manufacturers. He can be reached at www.chusid.com.

Abstract

Ceilings are one of the most visible architectural surfaces in building interiors. Performance requirements for ceilings can be as complex as those required of other finishes and includes consideration of acoustics, above-ceiling access, appearance, cleaning, hygiene, water resistance, cost, life cycle, durability, installation, fire safety, indoor air quality (IAQ), lighting, and other factors. Selecting an appropriate product to use overhead should be seen as a wise investment in building performance.

MasterFormat No.

09 50 00—Ceilings
21 13 00—Fire-Suppression Sprinkler Systems

Unifomat No.

C1070—Suspended Ceiling Construction
D2113—Fire-Suppression Sprinkler System

Key Words

Divisions 09, 21	Mineral fiber
Acoustics	Suspension system
Ceiling	Thermoformed panels
Luminous ceiling	Vinyl
Metal	Wood