Suspended ceiling or open plenum?

Making the right choice.

Recent studies illustrate the positive impact of suspended ceilings on life cycle costs, fire safety and the acoustic environment.

bright GREEN

www.armstrongceilings.eu

Inspiring Great Spaces™

Armstrong® CEILING SOLUTIONS

Take a look above your head. What do you see? Chances are it's an acoustical ceiling panel suspended in a metal grid system. That's because this type of ceiling is still the most popular system used in commercial spaces ranging from office buildings to schools to hospitals.

However, an architectural design trend referred to as the "exposed structure" or "open plenum" is becoming increasingly popular.

It's exemplified in part by the "warehouse" look in which an overhead HVAC system and roof deck are fully exposed and presented as an integral part of the interior space, thereby providing a feeling of spaciousness and economy.

In a traditional overhead HVAC system, a suspended ceiling is used, in part, to cover unsightly equipment, but in this case, it is neither needed nor wanted. In addition, no provision is generally made for the absence of the performance benefits that were "taken for granted" when a suspended acoustical ceiling was used.

Multiple Research Studies Conducted

In order to substantiate the impact of suspended ceilings on such performance aspects as life cycle costs, energy savings, fire safety and acoustic environment, a number of studies have been conducted.

The most recent was initiated by the Ceilings & Interior Systems Construction Association (CISCA) and conducted by the construction consulting firm of Barry Donaldson & Associates, Croton on Hudson, NY.

The study evaluated life cycle costs by looking at the initial construction costs of suspended ceiling versus open plenum designs, as well as their annual operating costs, including HVAC and lighting costs; maintenance costs such as periodic maintenance, repair and cleaning; and the cost of reconfiguration.

Construction Costs

The Donaldson study found that for its prototype office space, initial construction cost of a suspended ceiling can range from almost 15% to 22% more than for an open plenum, depending on geographic location.

It also found that, in general, the additional cost of the suspended ceiling, flexible ducts, and cable tray is only partially offset by the additional cost of a return fan, return air ductwork, and conduit for the open plenum design. Moreover, the cost of recess mounted light fixtures in the suspended ceiling is relatively close to the cost of pendant mounted light fixtures in the open plenum design.

Thus, to justify the additional cost of the suspended ceiling design, it must be offset by enhanced performance and reduced cost of operations, such as lower energy costs, easier maintenance, and decreased cost of renovation and reconfiguration.

Energy Costs

The Donaldson study found that the energy use in its open office plan examples in various geographic locations was lower for suspended ceiling designs than that of open plenums. (See Figure 1.)

Figure 1: Energy Savings

	Chicago		Oklahoma		City Orlando	
	Ceiling	Plenum	Ceiling	Plenum	Ceiling	Plenum
Energy (Btu/sf/yr)	51,433	55,175	47,314	51,724	46,609	51,668
Energy Cost ($/sf/yr)	$1.53	$1.68	$1.09	$1.21	$1.75	$1.95
Energy Cost Savings	9.0%	—	9.7%	—	10.3%	—
Simple Payback	7.0 yrs	—	5.0 yrs	—	4.1 yrs	—

1,400 m^2 open plan space with 2.7 metre high suspended ceiling

One reason is the use of a return air plenum with low static pressures and fan horsepower instead of a ducted air return with high static pressures and fan horsepower. A suspended ceiling with a return air plenum is also more effective in removing the heat generated by lighting, thereby reducing the air conditioning load on the space.

Based upon the relatively short simple paybacks, the study concluded that the energy savings alone could justify the use of a suspended ceiling system.

Armstrong® CEILING SOLUTIONS

Light Reflectance

The study also noted that suspended ceilings typically have a higher, more uniform, light reflectance than open plenums with layers of equipment. Open plenum designs, with uneven and somewhat darker surfaces, usually have a light reflectance around 50%, while suspended ceilings typically provide a reflectance of at least 70%.

And, this is a key factor, because increasing the reflectance of a ceiling can have a very positive impact on the lighting and HVAC energy use of a building, especially when used in conjunction with an indirect lighting system.

To determine that impact, Brinjac Engineering of Harrisburg, PA, studied two suspended acoustical ceilings, one with 75% light reflectance, the other, 90%.

It found that, compared to the 75% reflective ceiling, the 90% reflective ceiling achieved an average reduction of nearly 24% in lighting energy costs when used with indirect lighting. (See Figure 2.)

Figure 2: Lighting Energy Cost Savings

Ceiling Light Reflectance	Work Plane Illuminance (Footcandles)	Reduction in Lighting Energy Costs
75%	52.0	Baseline
80%	56.1	7.9%
85%	60.2	15.8%
90%	64.4	23.8%

1,000 m^2 open office, 3.65 metre luminaire spacing.

In addition, the 90% reflective ceiling allowed spacing between indirect luminaires to be increased, thus reducing the total number of luminaires needed to achieve light levels similar to the 75% ceiling.

It also found that reducing the number of lighting fixtures lowers the heat load on the cooling system.

Compared to the 75% reflective ceiling, the 90% reflective ceiling reduced the annual HVAC energy costs up to 9.1% for an indirect lighting system and up to 7.4% for a 600 x 600 recessed parabolic troffer system, depending on geographic location.

In addition to energy savings, high light reflectance ceilings can also contribute to LEED® points in the Energy and Atmosphere category.

In the Brinjac study, for example, energy points were achieved by simply increasing the light reflectance of the ceiling.

Maintenance Costs

In regard to maintenance costs, the Donaldson study noted that although it is difficult to define different requirements and costs of maintenance for a suspended ceiling versus an open plenum design, there may be savings by not having to periodically clean ducts, pipes and raceways that collect dust; by not having to paint or finish exposed equipment and systems; and by less overhead maintenance activities in general.

Assuming a painted open plenum design, the study's cost analysis estimates an increase of 10% in the maintenance cost of cleaning and repainting an open plenum.

This finding is corroborated by a similar study conducted by Project Time and Cost, a cost consulting firm based in Atlanta, GA. Their research notes maintenance costs of suspended ceilings are generally known and budgeted. However, that is not currently the case with open plenums because of a lack of real life cost data, although Project Time and Cost also estimates them to be approximately 10% higher.

They say one reason for the higher costs is that all repair and maintenance work is exposed to view and thus must meet a greater level of aesthetically acceptable "finish".

They also note that suspended ceilings prevent dust and small leaks from reaching occupied spaces below, where they can affect desks, computers and merchandise.

Reconfiguration Costs

In addition to the reduced cost of maintenance, the Donaldson study also found the reduced cost of reconfiguration or "churn", including simple moves to and from existing workplaces, relocation of furniture, and changes in offices or workstations, can be significant.

According to the study, suspended ceilings provide an adaptable and accessible interior finish that allows for easy reconfiguration of building systems to accommodate changing work and space requirements.

In office spaces, for example, the use of flexible ductwork, modular power and telecommunications cabling, light fixtures with modular "pigtail" connections, and return air troffer light fixtures allows for easier and less costly changes and reconfigurations.

On the other hand, fixed components found in open plenums, such as rigid metal ductwork, rigid metal conduit, hard-wired power and telecommunications connections, and mounted light fixtures, are far more difficult and costly to move and reconfigure.

Fire Safety

Yet another performance benefit that a suspended ceiling can provide is an extra margin of fire safety.

That's because the ceiling represents a significant percentage of a room's surfaces, and is critical to controlling the growth of a fire within a room or space.

When a suspended ceiling is eliminated from a building, there is no longer a physical separation between the elements of the building services, such as the ductwork and piping, and the occupied room or space below.

In contrast to an exposed structure design, an Underwriters' Laboratories (UL) fire resistant rated ceiling system not only provides that separation but also a known, specified fire resistance period.

However, even a conventional acoustical ceiling can provide a limited degree of fire resistance. That's because most fires start small, and may be controlled early by the sprinkler system. A conventional ceiling may thus remain intact and provide resistance to the movement of smoke, fire gases, and spread of flame into the space above.

Smoke Detector/Sprinkler Activation

A recent study on smoke detector and sprinkler activation time by Hughes Associates of Baltimore, MD, a leading fire protection engineering and consulting firm, demonstrates the difference ceiling height makes.

It found that in building spaces where a suspended ceiling is not in place, the height of the space is greater and the size of the fire will thus be larger at the time of smoke detector or sprinkler system activation. (See Figure 3).

When a suspended ceiling is used at a typical ceiling height, smoke detection and sprinkler systems will activate faster, providing earlier warning for escape and allowing the sprinklers to react to a much smaller fire.

Armstrong® CEILING SOLUTIONS

In addition, sprinklers are generally designed to be installed under a continuous ceiling without obstructions like those created by the ductwork, pipes, etc. in open ceiling areas. Sprinklers installed in a continuous ceiling thus improve the chances of reliable performance during a fire.

Figure 3: Activation Times*

	Boutique Retail	School/ Restaurant	Big Box Retail
Increase in ceiling height	From 4.5 metres to 7.6 metres.	From 2.7 metres to 6.1 metres	From 4.5 metres to 7.6 metres.
Fire growth rate	Medium/Fast	Slow/Medium	Medium/Fast
Average time for smoke detector activation	60-70% longer	80-100% longer	83% longer
Average time for sprinkler activation	21% longer	29% longer	30% longer
Average fire size at activation	48% larger	55-68% larger	73% larger

1,000 m^2 open office, 3.65 metre luminaire spacing.

Acoustic Environment

Over the years, study after study that has measured employees' satisfaction with their workplace environment has continued to point to noise as a major cause of reduced effectiveness, higher stress and declining job satisfaction.

Exposed structure designs that use no ceiling and reveal the building service elements can cause acoustic problems because sound reflecting off the deck above can result in excessive reverberation.

Any large space of this type will usually need some sound absorption to control overall noise levels. In addition, if the exposed deck is less than 4.5m high, reflections between open plan cubicles can cause distractions for the occupants.

Many noise issues related to exposed structure designs can be addressed through the use of acoustical canopies and clouds, two types of "freefloating" ceilings.

Figure 4 documents the difference in reverberation time and the overall level of sound that the installation of acoustical canopies and clouds can make in an exposed structure space.

(Reverberation time is a measure of the time required for loud reflected sounds such as a handclap to become inaudible.)

The results for a continuous or "wall-to-wall" ceiling are also included for comparative purposes.

Figure 4: Reverberation Time

	Reverb Time	Reverb Reduction	Sound Reduction
Exposed structure (No ceiling)	3.4 seconds	Baseline	Baseline
Acoustical canopies (25% ceiling)	1.6 seconds	55%	1.7 decibels
Acoustical clouds (50% ceiling)	1.1 seconds	67%	2.0 decibels
Continuous ceiling (3m height)	0.5 seconds	85%	5.0 decibels

465 m^2 open plenum, 4.6 metre to deck, windows 2 sides, commercial carpet

Looking Up

Originally introduced during the 1920s as an alternative to plaster ceilings, acoustical ceiling systems have continued to evolve, both aesthetically and in performance. As a result, they have remained the mainstream in commercial applications. The low life cycle costs, extra margin of fire safety, and enhanced acoustic environment they provide will ensure that.

04/2015 - PX1215 - Armstrong Building Products - RCS Besançon B 784 131 575