Designers Light Forum

Acoustic Lighting: One Solution for 2 Design Problems

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LEDucation

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Learning Objectives

At the end of this course, participants will be able to:

1. Understand the trends driving the need for acoustic lighting

2. Understand different approaches to combining acoustics and lighting and the benefits of using acoustic lighting for open concept designs

3. Understand the most important characteristics of acoustic lighting that contribute to sound absorption and meaningful noise reduction

4. Understand the critical role architects have in implementing acoustic lighting

A Nightmare of Noise

Acoustic Lighting is a REAL THING!

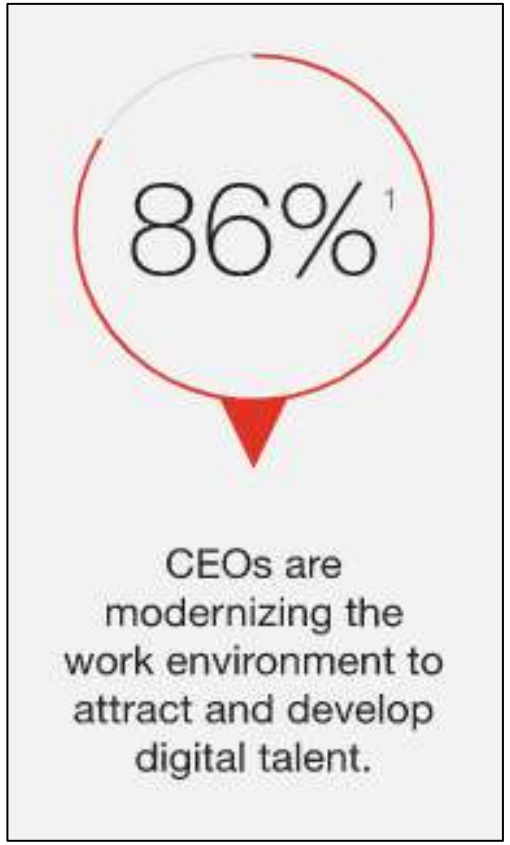
What was once a difficult design (*and budget*) problem is solved!

Addressing Human Needs

This section will cover:

1. New Building Standards are Driving the Need for Better Solutions
2. Lighting and Sound are Key Factors in Designing for Human Needs

Designing For The Needs Of People Is Mandatory For Success



Source: 1. PwC CEO Survey 2019

"Wellness in the workplace has emerged as a critical issue because it is simply too fundamental to be ignored."

"Bodies of evidence from all parts of the globe prove that well designed workplaces are critical for the health and wellbeing of society. The message to the real estate and built environment sector is clear: prioritise health and wellbeing by making spaces human again"

"…More than a 'fad' this is a global socio-political shift – rue the industry that is not moving to address it."

- Cushman Wakefield, Well Work Place: Making Spaces Human Again

"Wellness continues to be a key consideration for companies and landlords when building or redeveloping office spaces."

- CBRE Online Article 2019

"The workplace is the physical manifestation of your company's culture and core values. By better understanding the deep connection between the human experience and real estate, organizations can create more innovative workplaces that drive productivity, experience and business value."

- Ed Nolanm, JLL Workplace Strategy

New Building Standards Are The Mark Of Success

The impact of buildings

Buildings have a substantial impact on the health and wellbeing of people and the planet. Buildings use resources, generate waste and are costly to maintain and operate. Green building is the practice of designing, constructing and operating buildings to maximize occupant health and productivity, use fewer resources, reduce waste and negative environmental impacts, and decrease life cycle costs.

Why use LEED?

Instant recognition for your building
Faster lease up rates
Higher resale value
Healthier indoor space
Lower use of energy, water and other resources
Better for building occupants, the community and the environment
Enhances your brand and establishes you as a leader in green building

Fitwel is the World's Leading Certification System Committed to Building Health for All

New standards for health and well-being mean that wholesome design is no longer an option…it's a mandatory requirement

Good Quality Lighting Is A Critical Component Of Well-being

RESULTS

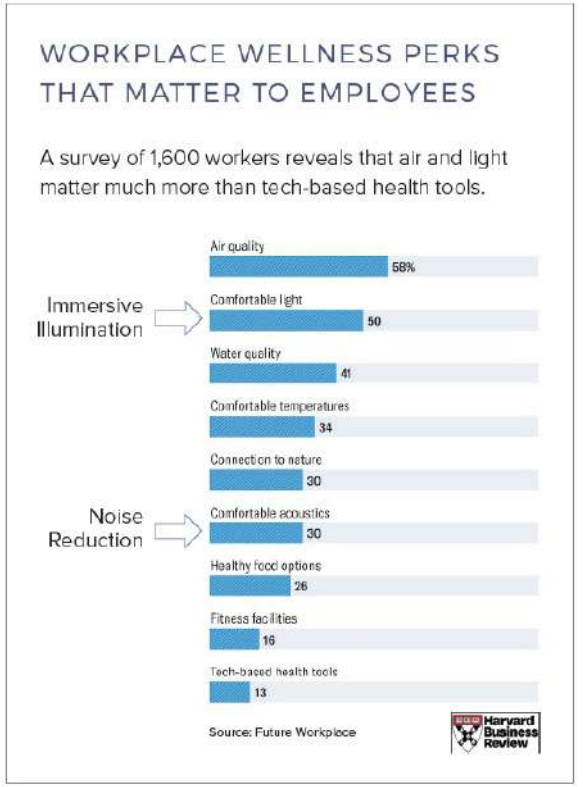
HEALTHY OFFICES RESEARCH

People function and perform significantly better in a healthy work environment. It also makes people more aware of their health and it inspires them to live healthier at home.

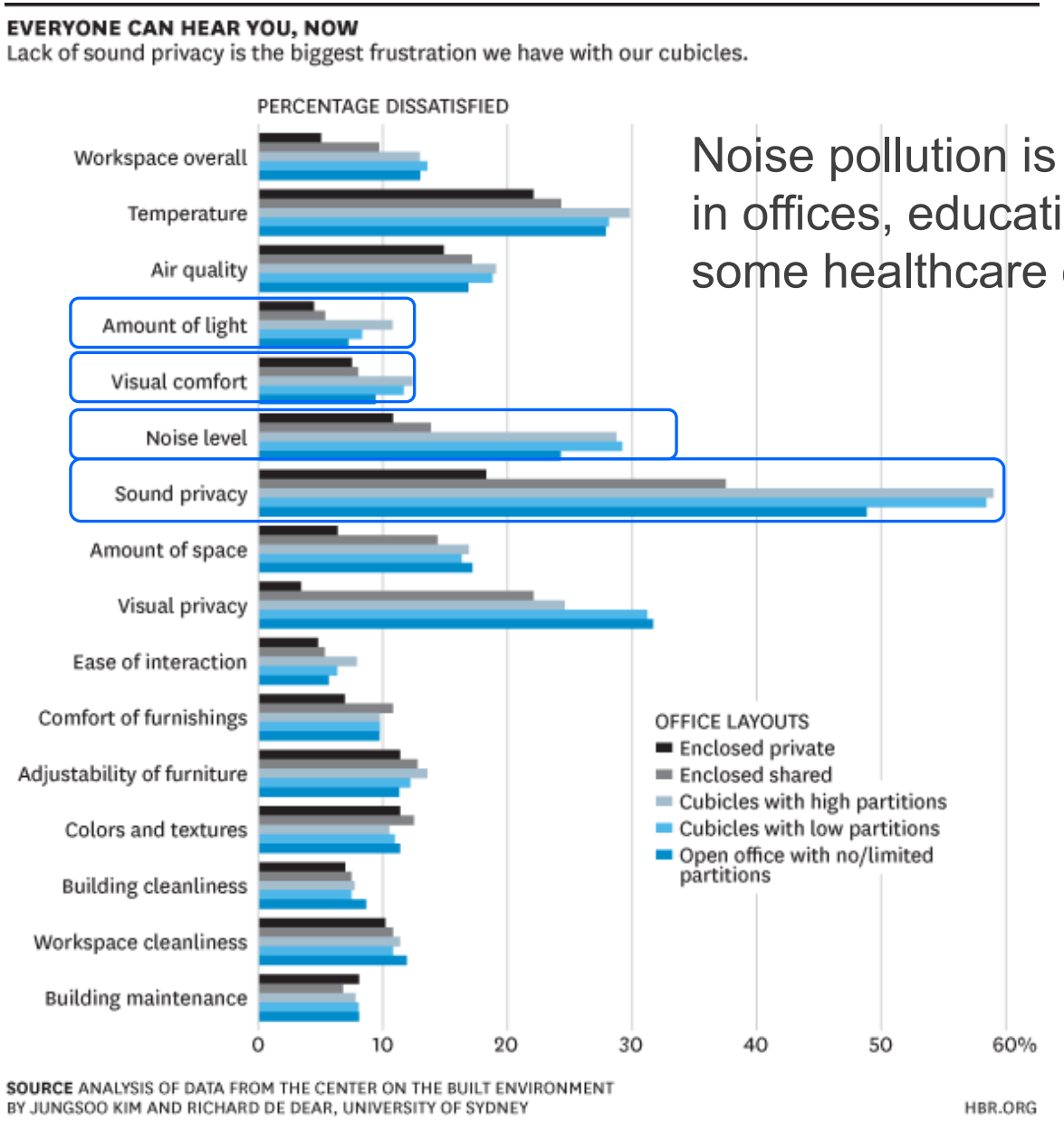
		Improved performance (based on objective experiment)	Improved performance (based on interviews)	Percentage of participant who felt more energised	Percentage of participant who felt happier	Percentage of participant who felt healthier
NATURAL SPACE	MORE PLANTS ON THE WORK FLOOR	+10%	+10%	76%	78%	65%
RIGHT LIGHTING	CIRCADIAN LIGHTING	+12%	+18%	71%	76%	50%
HEALTHY NUTRITION	HEALTHY ALTERNATIVES TO SUGAR AND CAFFEINE	+45%	+20%	78%	66%	52%
MENTAL BALANCE	MEDITATION, YOGA, POWERNAPS AND MASSAGES AT WORK	+30%	+16%	66%	63%	53%
PHYSICAL EXERCISE	LESS SITTING DOWN, MORE EXERCISE	+12%	+11%	65%	36%	71%

Source: CBRE Healthy Offices

Studies of what matters most to people consistently rank “lighting” and “sound” at or near the top of their list



And So Is Noise Control



Noise pollution is a big problem in offices, educational, and some healthcare environments

"Studies indicate that approximately **80 percent of office workers** believe that their productivity would increase if their working environment was more acoustically private."

"A **300 percent increase in perceived 'worker satisfaction'** was reported as a result of the reduction in noise levels from conversational noise. In addition a measured **20% increase in sales productivity** was recorded at the end of the six months following the refurbishment."

American Society of Interior Designers; Armstrong World Industries, Inc.; DynaSound, Inc.; Milliken and Co.; Steelcase, Inc, 2005.

New Standards Recognize the Need for Better Lighting and Noise Control

New building standards recognize the need to provide both good lighting and good acoustic performance

So…What's the Problem?

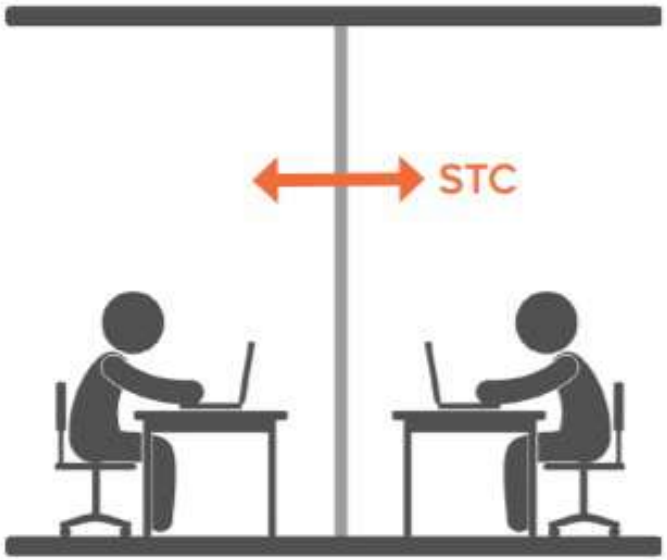
This section will cover:

1. Design Trends are Driving the Need for Acoustic Lighting

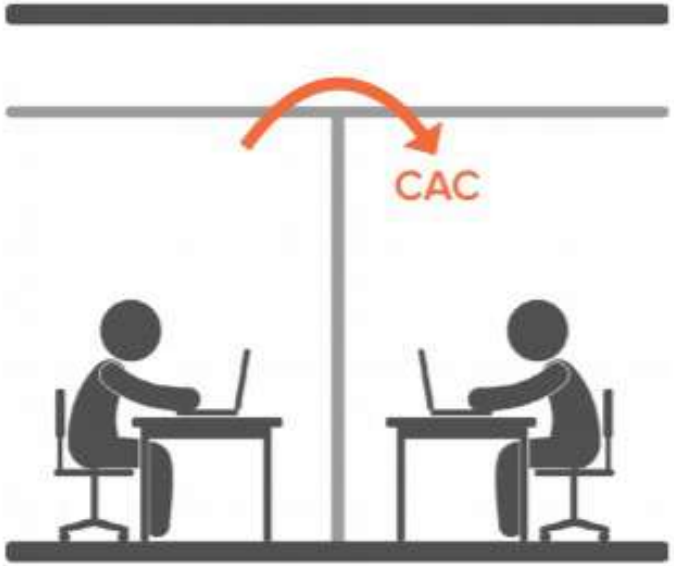
3 Types of Noise Problems

There are 3 types of noise problems:

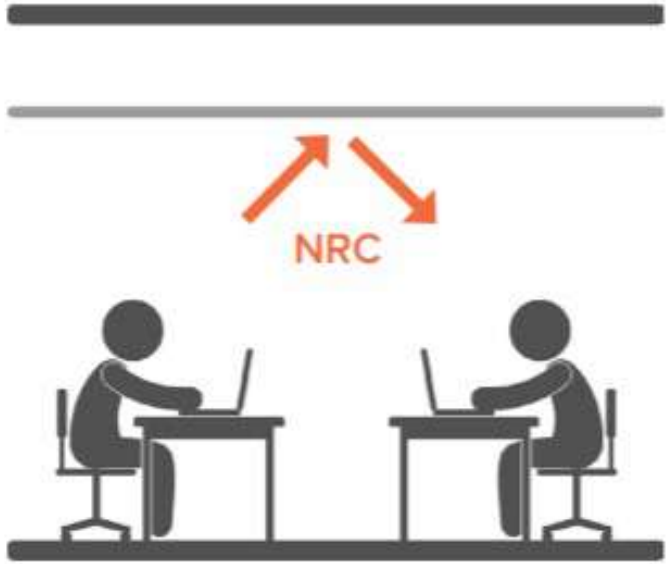
1. Sound that is transferred through walls/barriers
2. Sound that travels from one room to the next through the ceiling plenum
3. Sound that bounces off the ceiling and reflects back into the space



Sound transferred through walls =
Sound **T**ransmission **C**lass (STC)

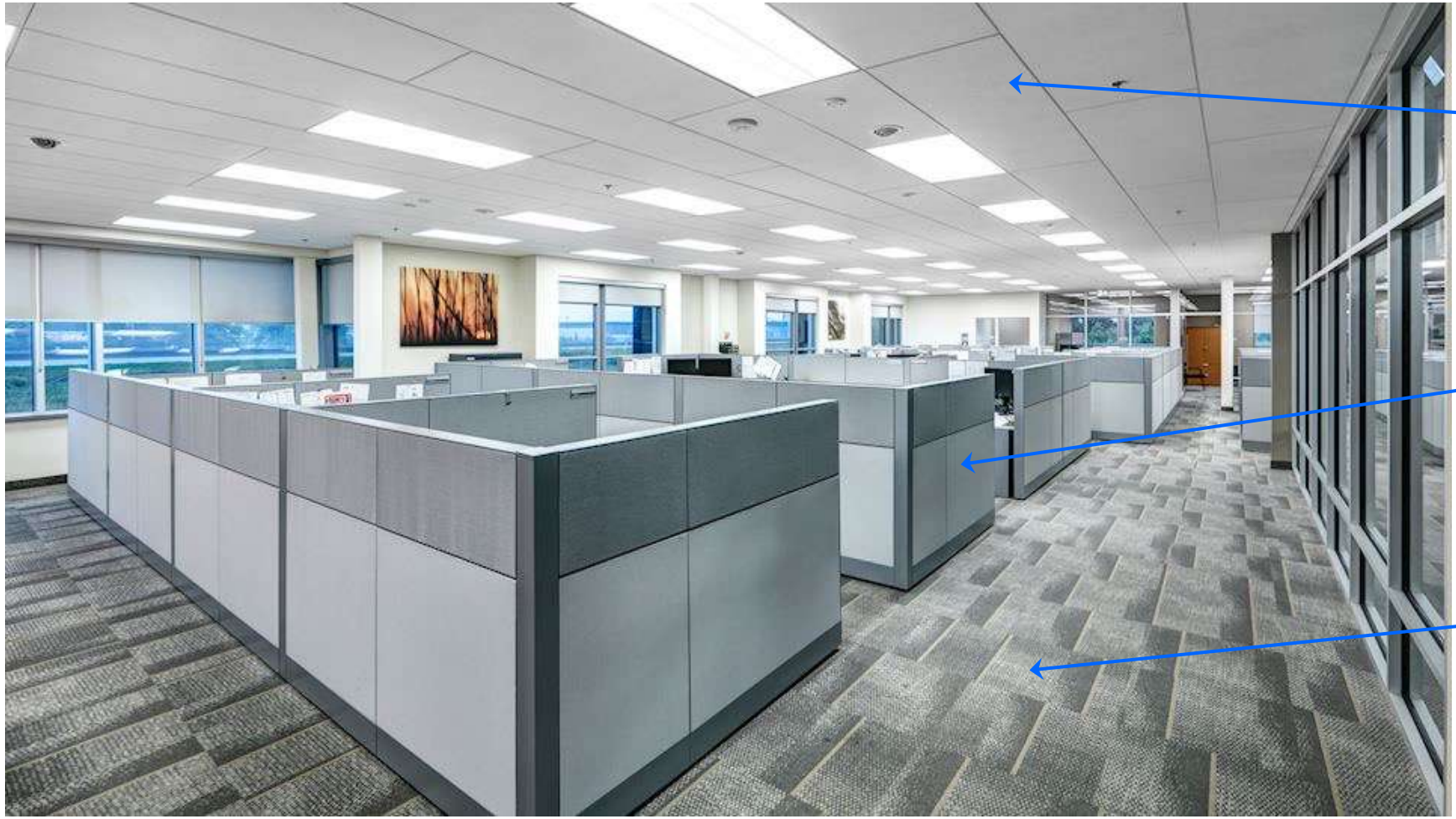


Sound through a ceiling plenum =
Ceiling **A**ttenuation **C**lass (CAC)



Reflected ceiling noise = **N**oise **R**eduction
Coefficient (NRC) or ISO Class (A-E)

Older Design Approaches Managed Light & Sound Separately



Ceiling:
- Typically most of the area is covered with Acoustic Ceiling Tiles (ACT)

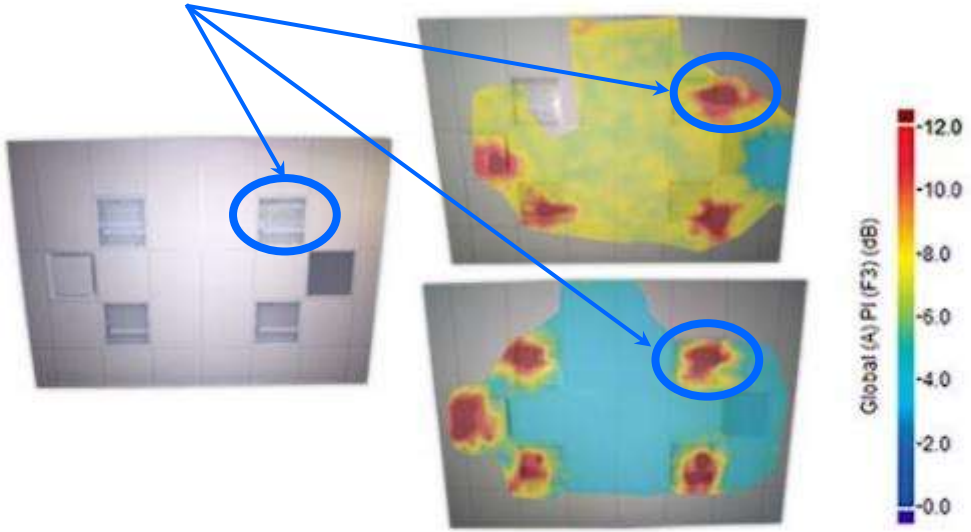
Partitions:
- Some sound is absorbed at the work area

Carpet Floors:
- NRC = 0.20
- Some sound is absorbed

Noise reduction capability is provided by non-lighting components

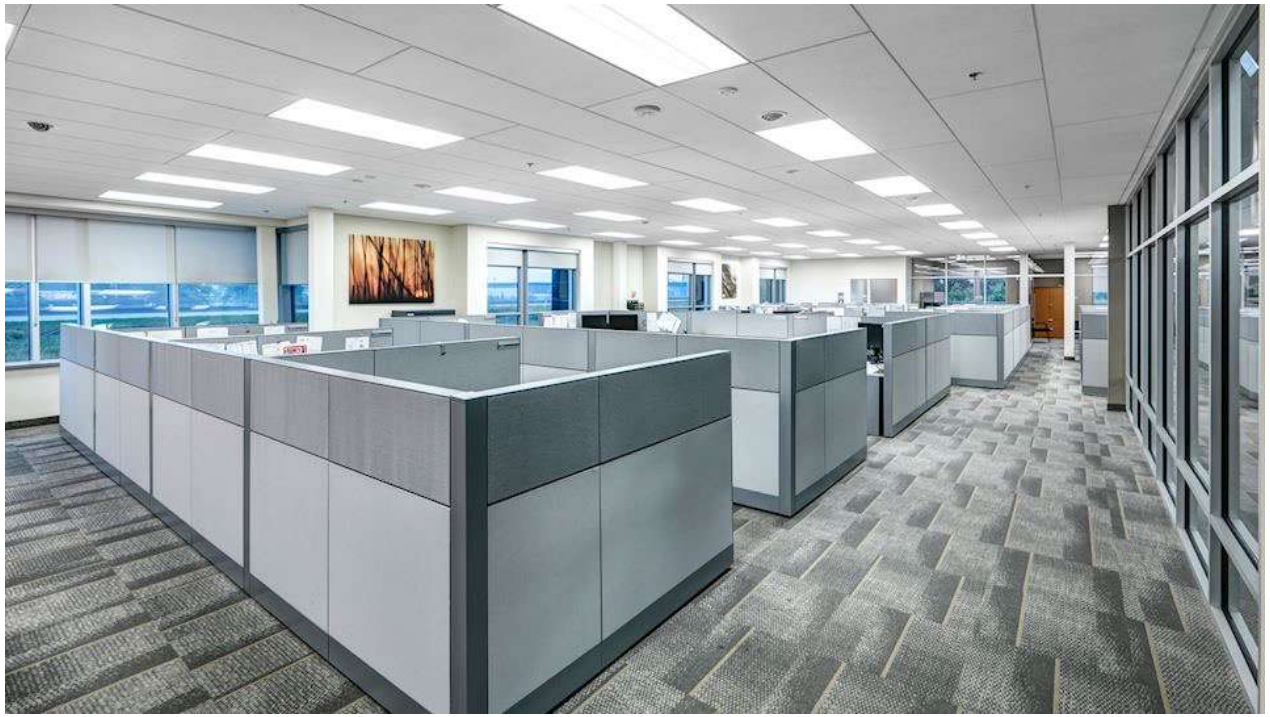
Lighting Was Not Expected to Reduce Noise

T8 Fluorescent
2x2 Troffer



High definition acoustic camera shows noise reflecting off a low NRC 0.60 acoustic ceiling (yellow) and being absorbed by a high NRC 0.95 stone wool acoustic ceiling (blue).

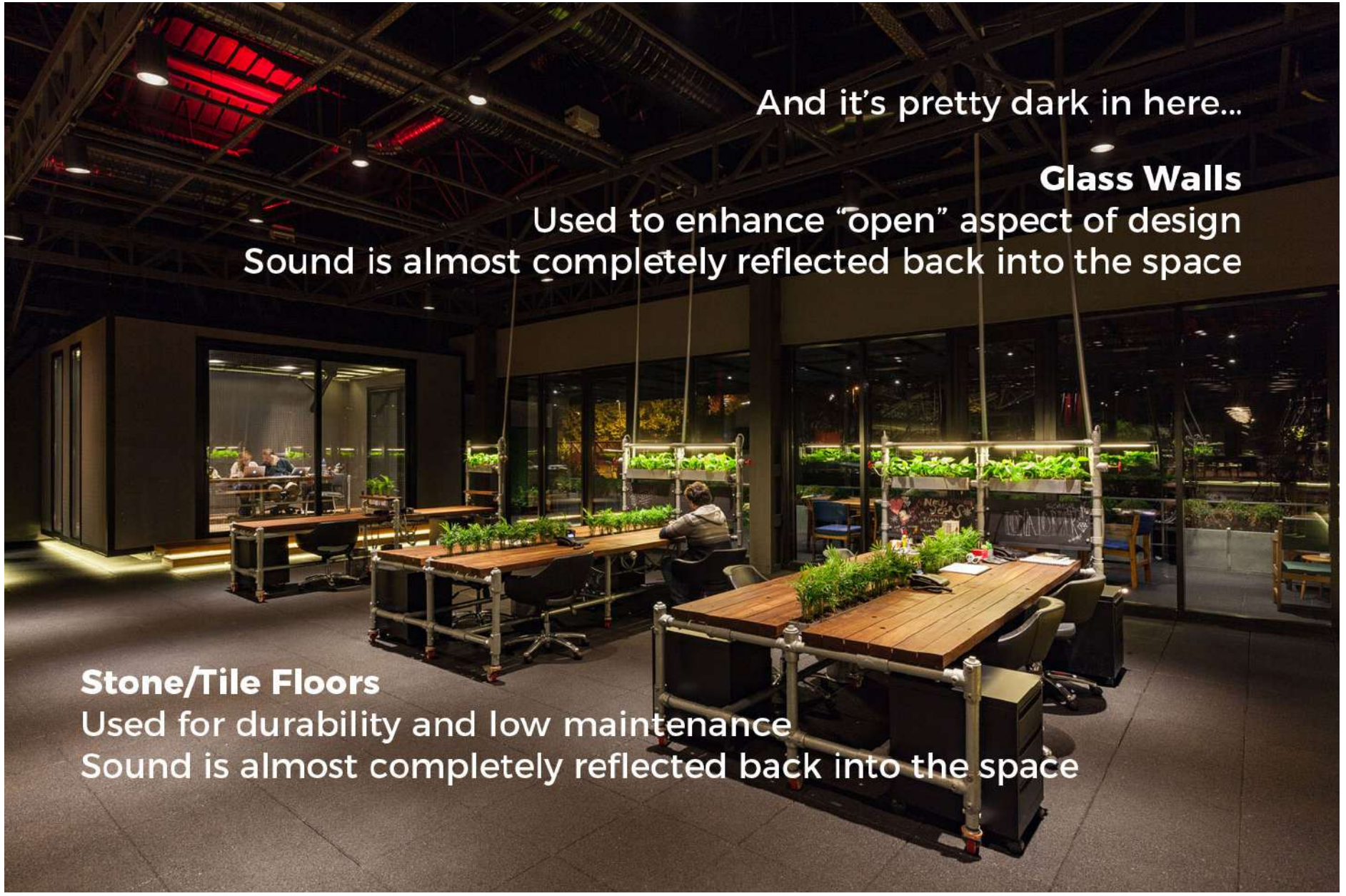
Source: Rockfon White Paper - "Look ~ do you see the noise leaking through that ceiling?"



Traditional luminaires have no noise reduction capability

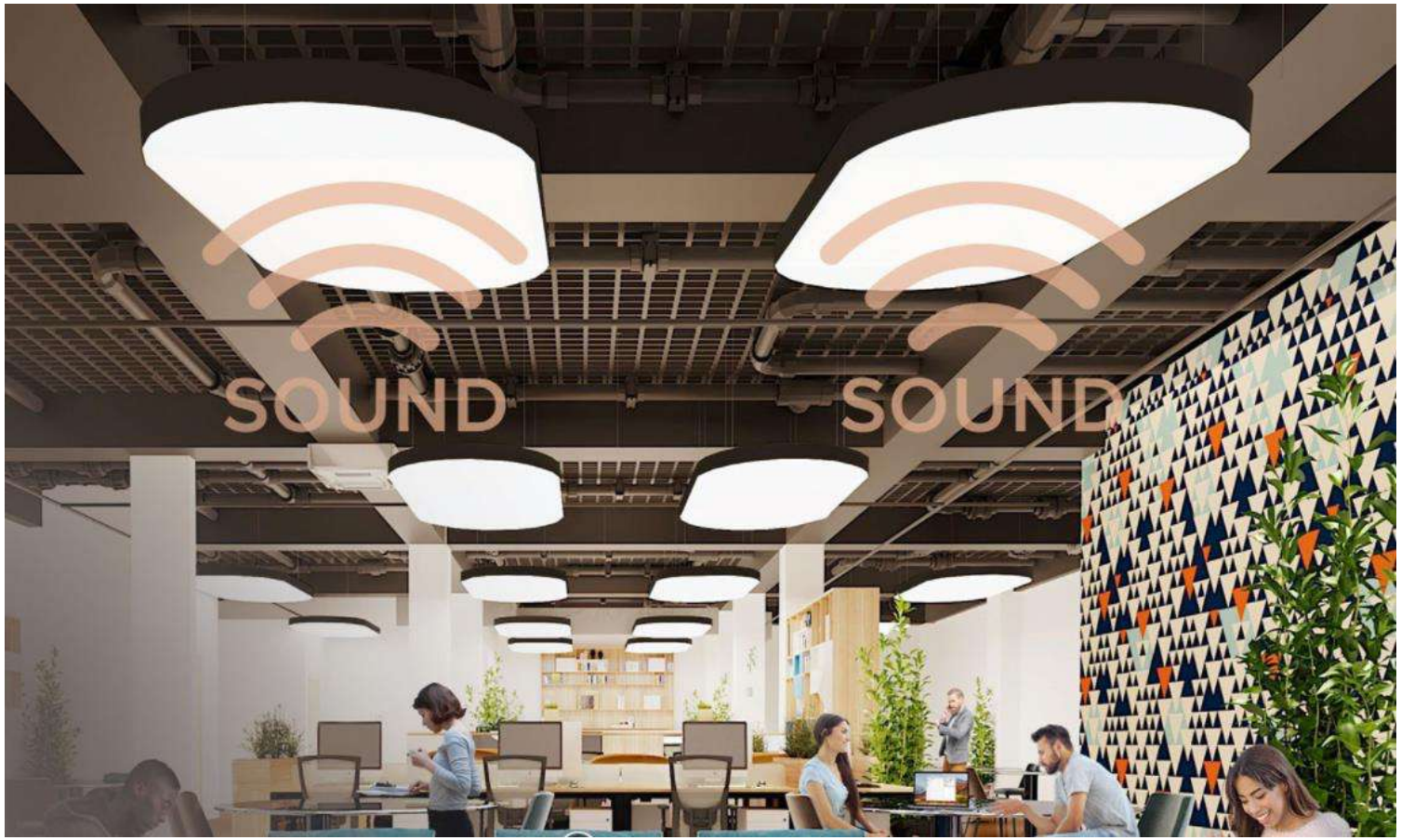
- Blue means sound is being effectively absorbed
- Red means no sound is being absorbed

But the World Wants “Open Concept” Spaces



In open spaces the only location for sound absorbing materials is the ceiling

Acoustic Lighting Helps Solve the Reflected Ceiling Noise Problem



General illumination sources are located in the ceiling…

Why not use those luminaires to absorb sound and reduce the noise?

A Dive Into the Details of Acoustics

This section will cover:

1. Noise Reduction Coefficient
2. Sound Frequencies and Human Response
3. Acoustic Test Reports
4. Size Matters

Noise Reduction Coefficient (NRC): A Simple Metric

NRC=0

At 0 NRC, there is no sound absorption. The sound bounces off of a smooth surface and back into the room, as shown by the red waves.

NRC=0.5

At 0.5 NRC, only 50% of the sound is being absorbed by the acoustic product, while the other 50% is being reflected back into the room.

NRC=1.0

At 1 NRC, 100% of the sound is being absorbed by the acoustic product, and no sound is being reflected back into the room.

NRC value (0-1):

- Average of absorption at 4 frequencies > 250, 500, 1000 & 2000 Hz
- Chosen frequencies approximate sound from human speech but not necessarily music or other sources
- Useful for comparison and indicator of acoustic properties
- Not used for acoustic design

The NRC value provides a good way to quickly understand the average sound absorption properties of materials for comparison with others.

Noise Reduction Coefficient (NRC): Common Building Materials

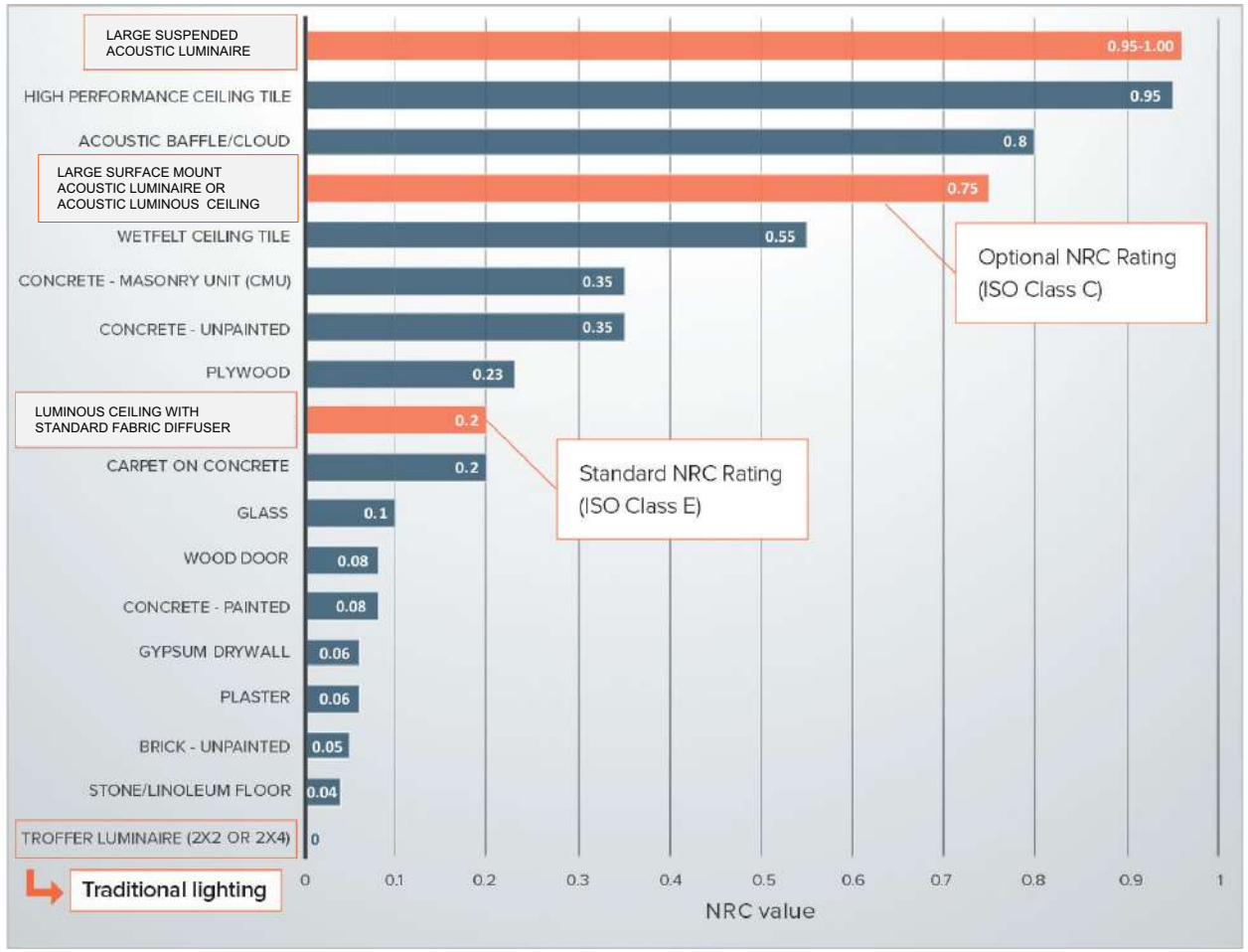
Open Concepts Designs Mean Low NRC Values

- Flooring: stone and tile used because of high durability and attractive design options feature NRC values close to zero.
- Walls: traditional materials (e.g. drywall) and more modern materials (e.g. glass) both have relatively low absorption properties.
- Traditional light fixtures are also typically assigned an NRC value = 0

Typical materials used in **traditional designs**

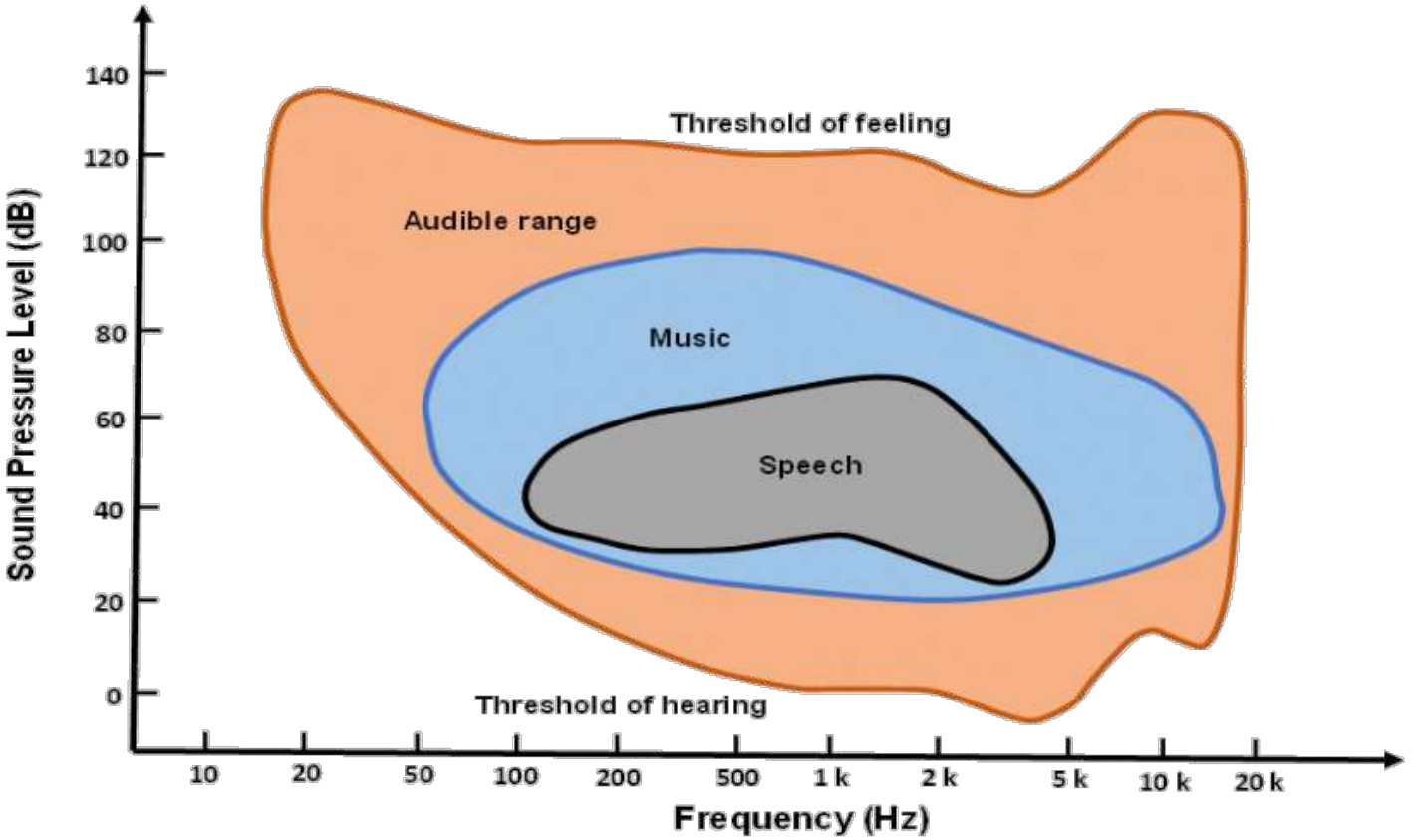
Decreasing sound absorption capability

Typical materials used in **open concept designs**



Typical NRC Values for Common Building Materials

Why the Frequency of Absorption is Important



Source: International Commission for Acoustics

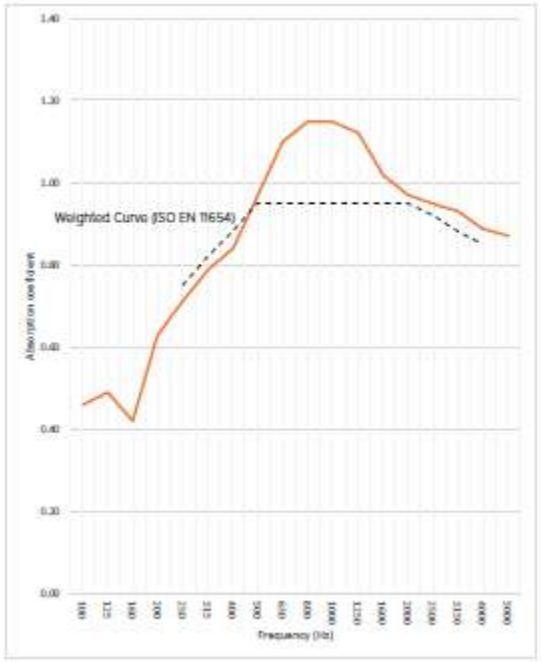
Acoustic Design Requires a Detailed Understanding of Absorption at Different Sound Frequencies

- Different materials absorb sound at different frequencies
- Two materials could have the same NRC value but absorb sound very differently
- Most architectural spaces are concerned with the ability to hear speech – e.g. “speech intelligibility
- As shown, the frequencies of interest are those between ~100Hz – 4000Hz

Acoustic Test Reports: What Acoustic Experts Use

FABRICore Suspended - Grouped*	Frequency (Hz)						Noise Reduction Coefficient	Sound Absorption Average	Weighted Sound Absorption Coefficient (ISO EN 11654)	Sound Absorption Class (ISO EN 11654)
	125	250	500	1000	2000	4000	NRC	SAA	α_w	Class
α_s	0.49	0.71	0.97	1.15	0.97	0.89	0.95	0.95	0.95	A
Sabin Absorption Area (m^2)	0.70	1.01	1.38	1.64	1.38	1.27				
Sabin Absorption Area (sqft)	7.52	10.89	14.88	17.64	14.88	13.65				

*Equivalent to 8'x8' (2.4m x 2.4m) FABRICore luminous cloud. Values shown are per individual luminaire.



Acoustic Test Reports

- Provide sound absorption data at specific frequencies
- Help acoustic designers understand the impact of a product on overall performance of a space
- Are an important indicator of a product suppliers knowledge of acoustic requirements

A formal acoustic design requires more information:

- Sound absorption at specific frequencies
- Total area of sound absorbing materials in the space
- Location of the sound absorbing materials – for suspended luminaires this is related to mounting height
- Location of the source of noise

SIZE Matters

Acoustic engineers use a metric called a “sabin” to quantify sound absorption. A higher sabin value means more sound absorption… equals less noise.

Sabin = Absorption x Area

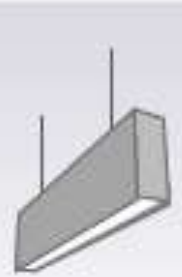
The noise reduction capability of a luminaire is dependent on TWO equally important characteristics:

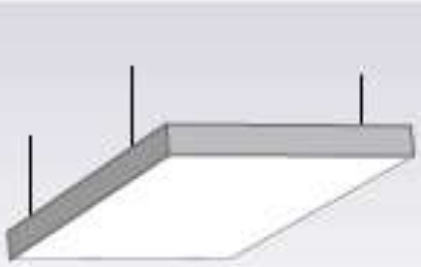
1. Absorption (approximated by NRC)

   AND

2. Luminaire (fixture) Size

SIZE MATTERS





	Linear Pendant	Large Area Luminaire
Length	8' (2.4m)	8' (2.4m)
Absorbing Height/Width	h = 1' (0.3m)/w	w = 6' (1.8m)
Sound Absorbing Area	8 sqft (0.72m²)	48 sqft (4.46m²)
NRC	1.0	0.75
Sabin	8 (0.7)	36 (3.35)
	Equivalent to 1 Acoustic Ceiling Tile	Equivalent to 4.5 Acoustic Ceiling Tiles

This is what matters!

Noise reduction requires high sound absorption and large scale

In Summary

- NRC is a simple but valuable metric to understand general acoustic characteristics
- Most building materials used in open concept spaces have low NRC values = poor absorption characteristics
- Acoustic design requires knowledge of the sound absorption properties of materials at different frequencies
- For most designs, the frequencies of interest are those related to human speech
- Acoustic lighting products should include acoustic reports that provide the relevant data
- Acoustic properties are only half of the equation: SIZE matters!

Acoustic Design Considers a Number of Factors

- Sound absorption at specific frequencies
- Total area of sound absorbing materials in the space
- Location of the sound absorbing materials – for suspended luminaires this is related to mounting height
- Location of the source of noise

Approaches to Acoustic Lighting

This section will cover:

1. Adding Lighting to Acoustic Materials
2. Adding Acoustic Materials to Conventional Lighting
3. Stretch Ceiling
4. True Acoustic Lighting

Starting Point: Not Using Acoustic Lighting…

The problem of noise reduction in open spaces has typically been addressed by trying to combine passive sound absorption materials such as baffles or clouds with luminaires – often of a type not intended for general illumination

Dozens of bright point sources are used to provide general illumination to make room for acoustic panels

Credit: Acoustical Solutions

Lighting and acoustic clouds battle for space, making for a lot of clutter in the ceiling

Credit: Dox Acoustics

A creative approach to acoustics limits the options available to provide general illumination within a space

The results…

- Inappropriate choice of luminaire type
- Cluttered ceilings
- Mismatched aesthetics
- Poor quality illumination

Combining lighting and sound absorption usually results in compromising the quality of the lighting

Adding Lighting to Acoustic Materials Products

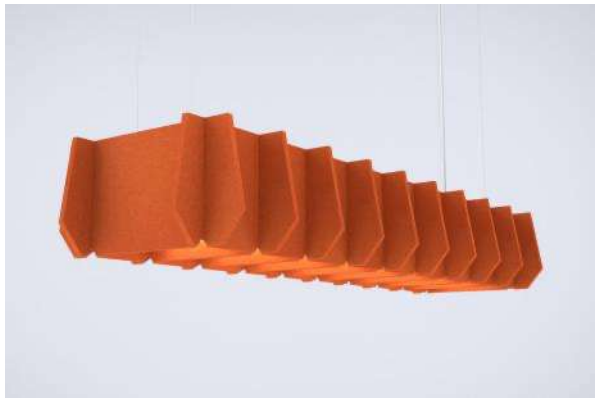
Acoustic materials suppliers are adding lights to their baffles and clouds

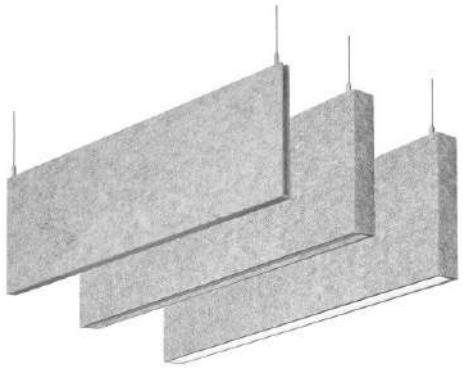
- Effective acoustic materials of appropriate size are fitted with luminaires
- The combination provides the desired effect on noise reduction
- BUT what about the lighting?

Adding luminaires to passive acoustic materials does not guarantee proper illumination

Adding Acoustic Materials to Lighting Products

Lighting manufacturers are wrapping their fixtures with sound absorbing materials

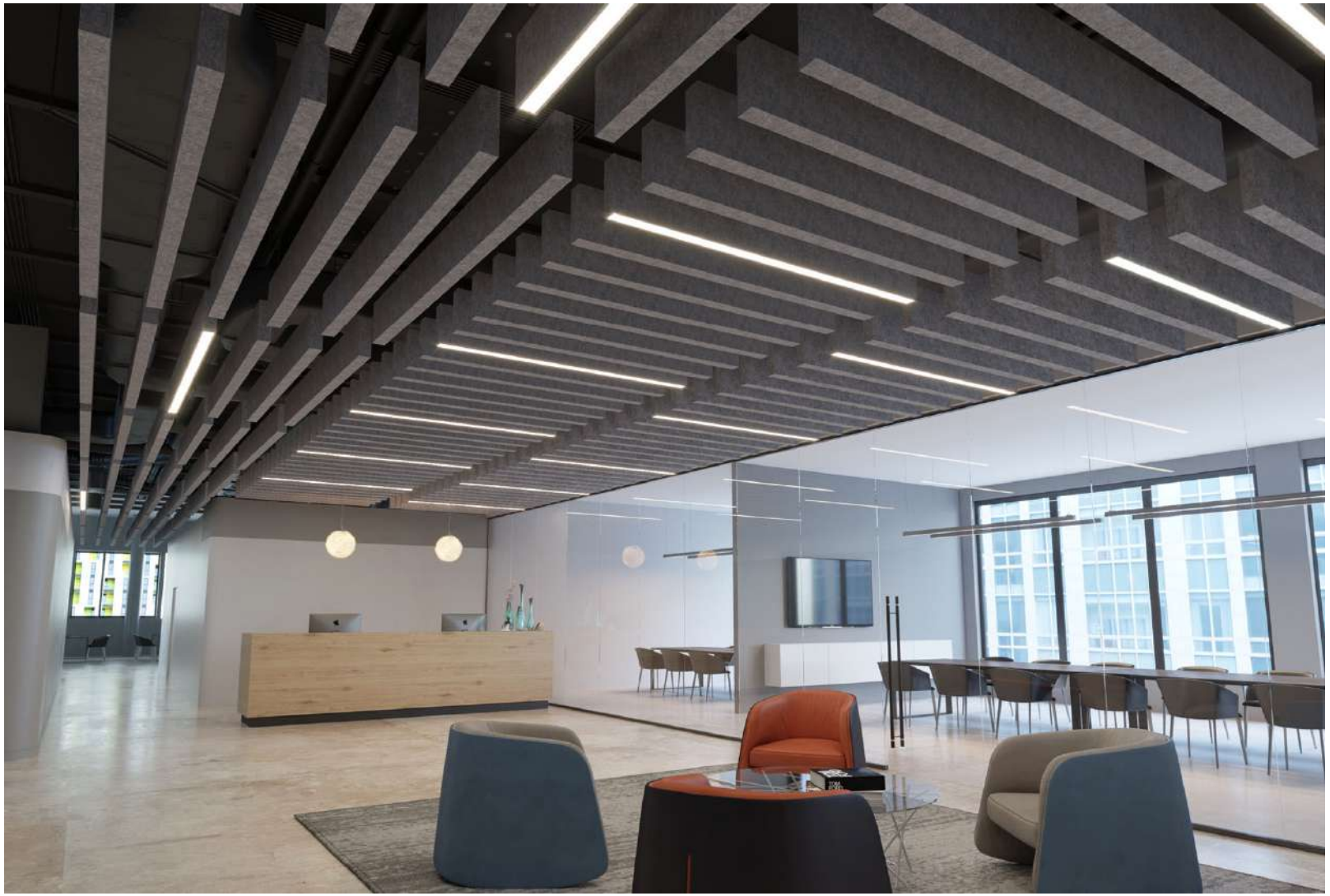





- Pendant luminaires are extended in height and wrapped in acoustic material
- Illumination may be of suitable quantity and quality
- BUT what about the acoustic performance?

Acoustic luminaires generally require additional passive sound absorbing products to provide suitable noise reduction

Is This Really Acoustic *Lighting*?



In this photo you will see..

Number of luminaires = 14

Number of passive baffles = 119!!

Using acoustic linear pendants may help with aesthetics but are there cost savings to be had?

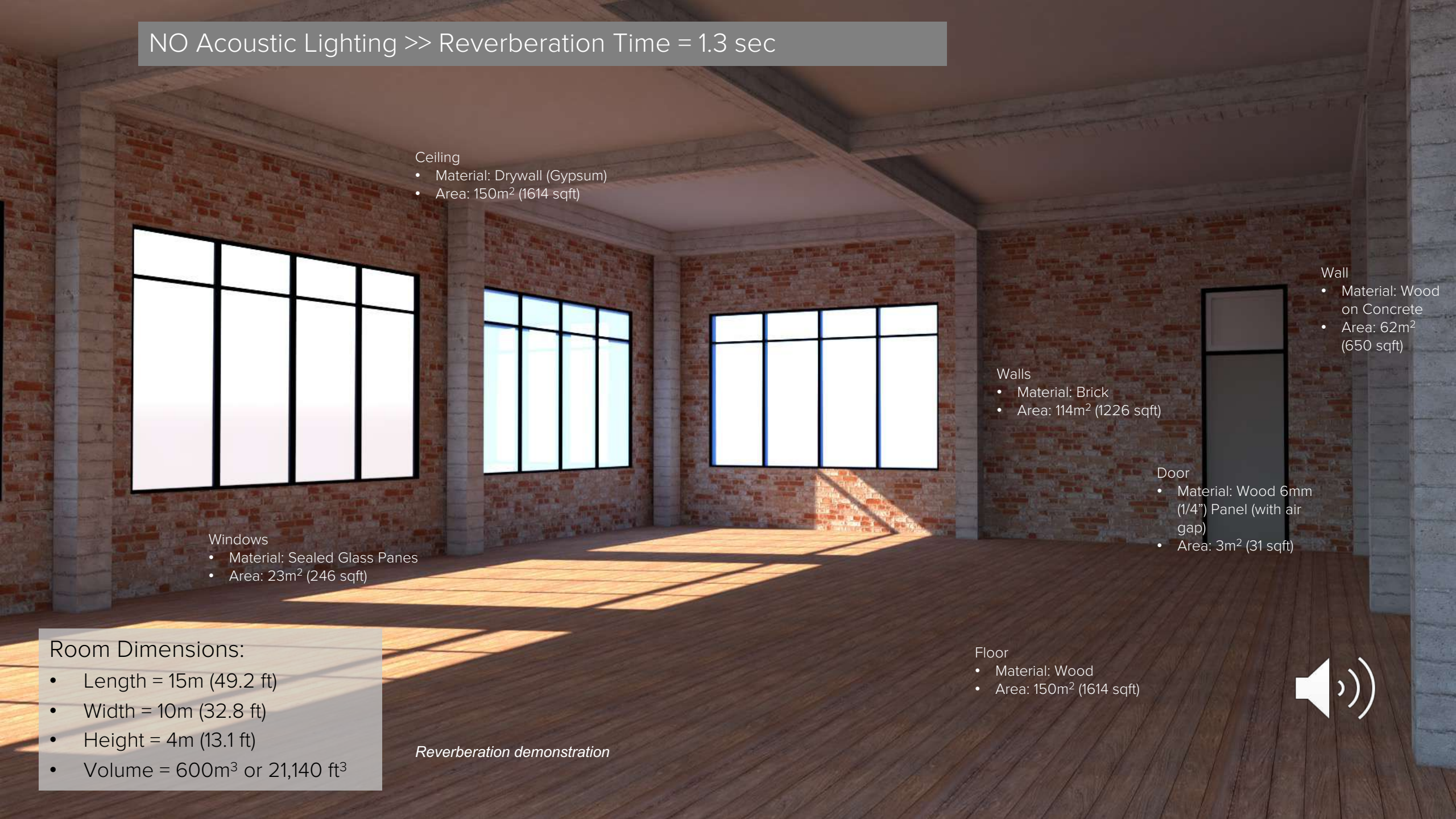
Luminous Stretch Ceilings: Integrating Light and Acoustics

Luminous Ceilings offer a way to do both

Stretch ceilings already offer noise reduction capability…

…so the key to success is ensuring the quality of illumination meets the needs of the people

NO Acoustic Lighting >> Reverberation Time = 1.3 sec



Ceiling
- Material: Drywall (Gypsum)
- Area: 150m^2 (1614 sqft)

Wall
- Material: Wood on Concrete
- Area: 62m^2 (650 sqft)

Walls
- Material: Brick
- Area: 114m^2 (1226 sqft)

Door
- Material: Wood 6mm (1/4”) Panel (with air gap)
- Area: 3m^2 (31 sqft)

Windows
- Material: Sealed Glass Panes
- Area: 23m^2 (246 sqft)

Floor
- Material: Wood
- Area: 150m^2 (1614 sqft)

Room Dimensions:
- Length = 15m (49.2 ft)
- Width = 10m (32.8 ft)
- Height = 4m (13.1 ft)
- Volume = 600m^3 or 21,140 ft^3

Reverberation demonstration

Acoustic Lighting Luminaires >> Reverberation Time = 0.8 sec

Illumination Level (Workplane) = 1034 lux (96 fc)

Acoustic Lighting + Acoustic Panels >> Reverberation Time = 0.6 sec

Acoustic Lighting Luminaires + Acoustic Panels - Illumination Level (Workplane) = 1042 lux (97 fc)

A Case Study

Location: Mezzanine Office Space

Luminaires: 8 @ 4’x4’

- Light Output/Flux: 10,000 lm per luminaire
- CCT: 3500K
- CRI: >90

Lighting Results:

- Illuminance (workplane): 776 lux (72 fc)
- Uniformity: Min/Max = 0.65
- Glare: Max. UGR <19

Acoustic Results:

For 500Hz – 1000Hz (most important for speech)

- Avg. Decrease in Reverberation Time: ~0.8s
- % Increase in Sabins (Absorption Area): 79%

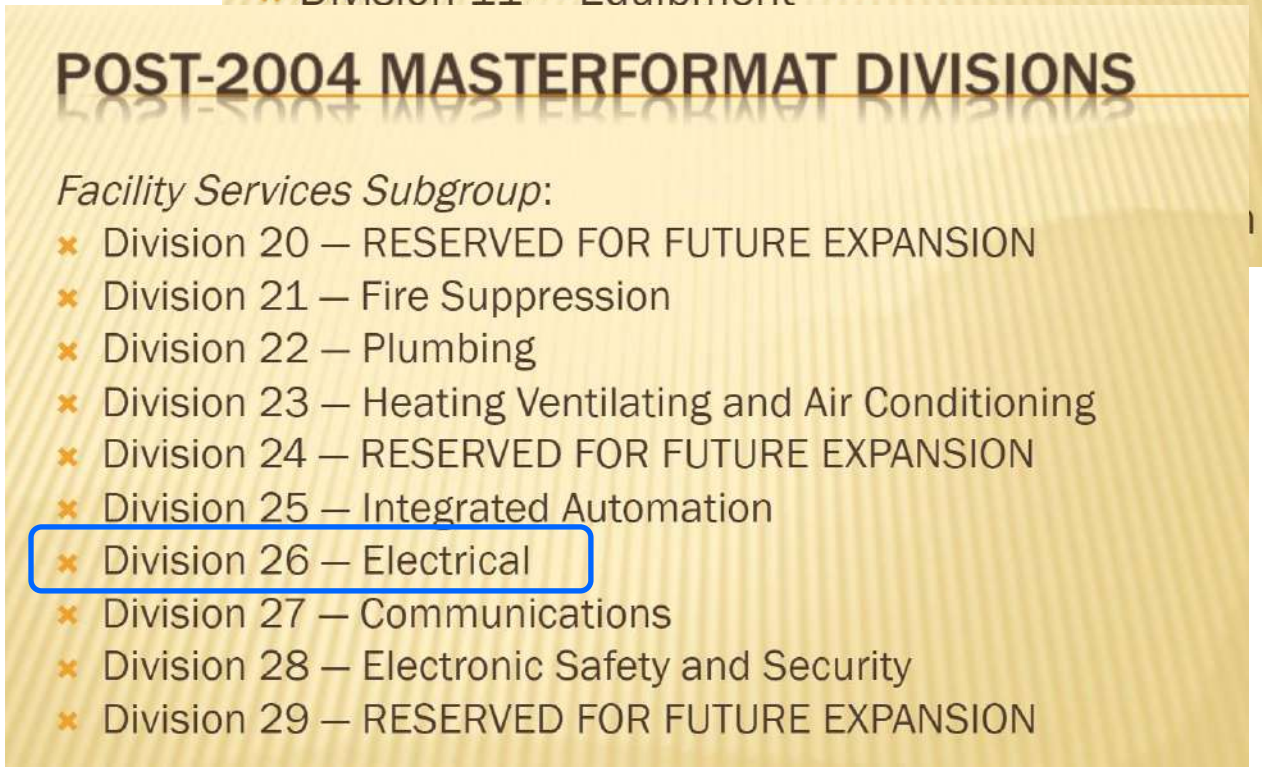
Divisional Rivalry…

Acoustics is usually managed in Division 09 - Finishes

Lighting is usually managed in Division 26 - Electrical

Architects Are Critical for the Successful Adoption of Acoustic Lighting

- Two budgets and two sets of experts but one client paying the bills
- Acoustic lighting solves problems, saves money, and increases the wellness aspect of design
- Only the architect is in a position to coordinate the efforts of the design team to ensure successful adoption of acoustic lighting




Acoustic Lighting is the
Solution to the
Nightmare of Noise

This concludes The American Institute of Architects Continuing Education Systems Course

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