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Kaizen: Acoustics 01

Good vibrations: How to control the hidden costs of acoustics in specialist spaces

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Good vibrations: How to avoid the hidden costs of acoustics in specialist spaces

Step into a space and it's easy to see what you like – or don't like. But the sound of the space takes time to unfold – making acoustics something of a hidden science.

A good acoustic outcome is critical for occupant comfort. In some settings this is obvious. Think theatres, galleries and court rooms. But the sound of a chair leg scraping across the floor of a classroom, the strained conversation in the crowded café or the endless noise distractions in a busy office are all signs that acoustics weren't a careful consideration during the design process.

There's another sign that acoustics weren't considered from the outset – the budget bottom line. Ensuring acoustic requirements are considered early and integrated into the design instead of 'add-ons' is the most direct way to control costs.

Spatial planning can reduce the need for high levels of acoustic treatment. Locating noisy spaces like plant rooms, foyers or bars away from noise sensitive spaces such as theatres or rehearsal rooms is the easiest way to avoid some of the costs that can come with 'add on' acoustic treatments.

In this paper we offer a refresher of basic acoustic concepts, unpack some of the additional measures used in specialist spaces, and examine the costs associated with common high-performance products and acoustic treatments. We also share four case studies with actual costs.

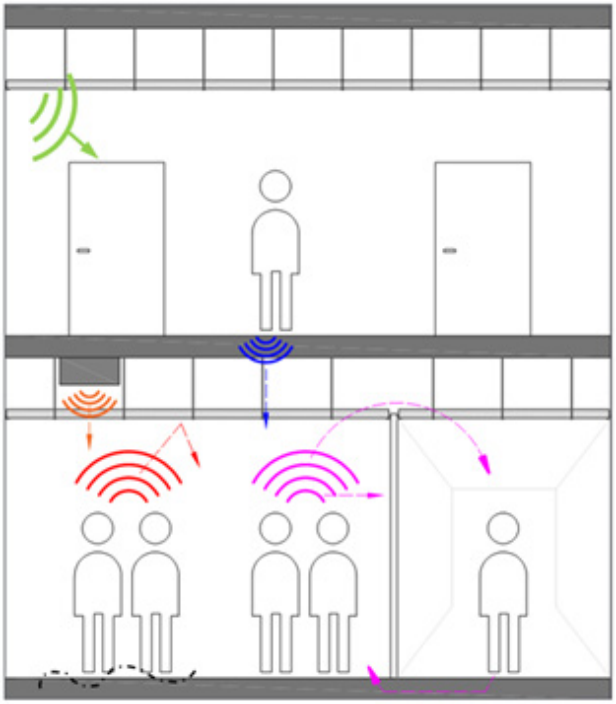
Engagement with your acoustic consultant and quantity surveyor will help you to achieve best value for money and avoid costly pitfalls. The result? Spaces with smart but hidden solutions and more funds for the things people can see and touch.

Image:
Bendigo Law Courts
John Wardle Architects

Basic acoustic concepts

When discussing acoustics, a variety of terms are used to describe how sound is treated within and between spaces. The key concepts and their parameters are as follows:

Criteria	Description
Internal sound insulation	The sound level difference between rooms, which is a measure of how much sound is reduced when travelling from one room to another. The higher the rating, the better the sound reduction performance.
External noise intrusion	The amount of noise capable of getting into a building from external sources. The louder the external noise environment, the greater the requirement for sound reduction measures within the building envelope.
Services noise	Background noise level from plant and equipment. Services noise can be continuous or intermittent. A lower sound level represents a quieter space.
Reverberation time	Reverberation time describes the acoustic 'liveliness' in a space and is measured as the time taken for the sound level to decay in the space. A room with a low reverberation time can be described as 'dry', while a room with a high reverberation time may be termed as 'lively'.
Impact noise	Impact noise describes sources such as footfall noise, or furniture being moved. The impact noise can be influenced by the floor covering or the ceiling in the space below. A lower number means better impact isolation.
Vibration	Vibration is effectively sound that occurs at very low frequencies, that is 'felt' rather than 'heard'. It can be quantified in terms of acceleration (mm/s2), velocity (mm/s) or displacement (mm), can be measured as a peak, average or as a root mean square (RMS or vibration average) level, and analysed in terms of frequency.



The acoustic environment

The acoustic environment can be influenced through

- Spatial planning
- Wall, floor, door, ceiling and roof build-ups
- Vibration isolation
- Structural breaks
- 'Box-in-box' construction
- Internal finishes and furniture selections and placement
- Technology
- Services design including selection of placement of plant; and critically
- Attention to detail when constructing seals, penetrations and junctions.

Acoustic extras for specialist spaces

Specialist spaces – like auditoriums, music venues or where speech intelligibility is critical such as courtrooms or education spaces – have higher needs for controlling acoustics. The qualities that are considered to control the aural experience are as follows:

Acoustic quality	Aural experience
Acoustic intimacy	Improves the sensation of proximity to a performance and increases the feeling of 'being part' of the action.
Reverberation time	Adds fullness to sound quality, resulting in the blending of orchestral sound and the buildup of speech levels in foyers, bars and noisy restaurants.
Acoustic envelopment	Creates an immersive sound experience created by reflections arriving from the side surfaces.
Acoustic clarity	Reflections that arrive at a short time interval after the direct sound reinforces the initial response of our hearing. This improves perception of details in the sound such as enhanced speech clarity or hearing musical details without difficulty.
Loudness	A room with good loudness will allow a greater range of dynamics to be experienced. This can enhance the most subtle pianissimos and allow enhanced drama for the strongest parts of a performance.

To control these qualities, key treatments include the shape of a room, its volume, as well as the type and location of absorption and diffusive surfaces within it. These interventions can be fixed (i.e. insulation backed perforated plasterboard ceilings or acoustic wall panelling) or variable (i.e. operable wall banners).

Acoustic absorption can be used to control particular reflections, or to reduce the reverberation time. Areas of absorption in most locations will reduce reverberation time, but the control of unwanted reflections requires specific locations and types of absorption.

Strong or focused reflections can distort the apparent source location – a phenomenon known as 'image shift'. This is controlled by spreading out and reducing the strength of the reflected sound energy, achieved by diffusing the sound with articulation on the reflective surfaces, faceting of surface finishes, or including specific geometries on the interior reflection surfaces of a room (i.e. curved forestage reflectors in a theatre).

The bottom line is simply that the application of acoustic treatments is more a science than an art.

In addition to treatment of in-room sound reflections through absorption or diffusion, elements commonly incorporated into acoustically high-performance venues include:

Item	Standard	Acoustic
Spatial planning		Free
Acoustically rated doors	$1,500-2,500/no	$5,000-20,000/no
Floating floors	Not required	$400-$1,000/m2
Low noise plant selections and vibration isolation	N/A	+25-50% typical
Reduced air velocity through ducts	Not required	$180/m2
Control joints	$25/m	$100/m
High performance partitions	$150-250/m2	$400+/m2
Technology	Not required	Varies
Acoustic panelling	$150-200/m2	$600-1,000/m2
Critical attention to detail	-	Varies

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Case Study: Bendigo Law Courts

Court rooms can be noisy places but speech intelligibility is critical. People nervously chatting in a corridor or an adjoining room, footsteps on hard surfaces, traffic from the street and loud air-conditioning systems can impair the court room's acoustics and impede people's ability to hear the proceedings clearly.

The redevelopment of Bendigo Law Courts, once complete, will deliver state-of-the-art court facilities to the community of Bendigo and the wider Loddon Mallee region. Important acoustic considerations for the project include:

- Speech clarity
- Privacy
- External noise control, and
- Services and background noise levels, which, depending on the use of a given space, are required to be carefully balanced to support adequate speech clarity and speech privacy.

Courtroom 7, located on the top floor of the building adjacent to a rooftop plant deck, required additional treatment to adequately control the transmission of airborne and structure borne services noise into the space, and the environmental noise breakout. This was achieved through careful design of the roof build-up, utilising acoustic isolation clips and multiple mass linings.

Other outcomes delivered through acoustic design include:

- Airborne sound insulation through high performance partitions and the introduction of airlocks
- Enhanced speech clarity through careful design of the wall and ceiling geometry, placement and ratios of reflective and absorptive materials, the introduction of a high-quality sound reinforcement (AV) system, and minimisation of mechanical services noise
- Room geometry and control of reflection of sound in all courtrooms to ensure clear sound projection from the judge

The following elements incorporated for the space is summarised as follows:

Item	Cost
High performance partition (Rw60)	$400/m2
Extra over costs associated with roof to control low frequency noise	$150/m2
Wall finishes	$1,050/m2
Ceiling finish	$850/m2
Sound reinforcement systems	$450/m2

Image:
Bendigo Law Courts
John Wardle Architects

"The bottom line is simply that the application of acoustic treatments is more a science than an art"

Case Study: Alexander Theatre

Since opening in 1967, Alexander Theatre has played a defining role in the history of performing arts at Monash University. In its heyday, the 'Alex' hosted performances by the Melbourne Theatre Company and the Bell Shakespeare Company.

Following a major revitalisation, the building reopened in 2018 with an increased audience capacity and the ability to accommodate a greater range of performing arts – from spoken-word to musical theatre and ballet to contemporary music performance. Such a broad range of uses is atypical for a theatre of this size, so a state-of-the-art active 'Acoustic Architecture' system was selected.

The system works with the natural acoustics in the theatre to:

- Create appropriate conditions for the audience
- Create a virtual stage shell
- Improve sound projection across all areas of the theatre including the auditorium, orchestra pit and stage
- Allow customised acoustic conditions, integrated with the theatre's sound reinforcement system, to support contemporary and experimental performance styles

To enable the system to operate effectively, the reverberation time across the theatre needed to be as even as possible. This was achieved by modifying the location of ceiling reflector panels, and through the installation of acoustic absorption to the rear wall and recesses of the side walls of the auditorium.

The cost of these interventions is summarised as follows:

Item	Cost
Curved ceiling reflectors	$1,030/m2
Acoustic Architecture & Sound Reinforcement systems	$3,600/m2
Auditorium absorptive wall paneling	$1,820/m2
Flytower wall lining	$650/m2
Auditorium and flytower roof	$1,070/m2

"Such a broad range of uses is atypical for a theatre of this size, so a state-of-the-art active 'Acoustic Architecture' system was selected"

Image:
Alexander Theatre
Monash University

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Case Study: The Ian Potter Southbank Centre, Kenneth Myer Auditorium

The University of Melbourne's Ian Potter Southbank Centre is home to the Melbourne Conservatorium of Music and the pinnacle of the University's Southbank campus transformation.

Constructed between 2017 and 2019, the facility contains studios, tutorial and rehearsal rooms, and three vertically stacked recital spaces: the Kenneth Myer Auditorium, Hanson Dyer Hall and Prudence Myer Studio. There is also an outdoor performance area beneath a 13-metre concrete cantilever.

The University presented acoustic specialists with a clear brief. Create a warm, ambient environment where sound from corridors and open plan areas could be audible but not intrusive. No monastic halls within these walls, was the message.

Hanson Dyer Hall is a 400-seat concert hall with a fixed stage an a choral balcony for 35. The double height room is located on level 3 of the Ian Potter Southbank Centre, and cantilevers out 12m over the adjacent Linear Park.

Design challenges included its adjacency to the level 3 foyer, its location between two other highly noise-sensitive spaces (Hanson Dyer Hall and the Prudence Myer Studio), and vibration caused by trams passing on Sturt Street. The character of the sound inside the room was designed to suit non-amplified music and voice performances where the blending of sound is critical, as well as lectures where enhanced speech clarity is important requiring a flatter sound. Background noise levels low enough to support professional level recording were a briefed requirement.

The key acoustic elements and their associated costs are summarised as follows:

Item	Cost
Fixed seating	$1,600/seat
Diffusive surfaces	$800/m2 walls, $615/m2 ceiling
Operable banners	$2,100/m2
Box-in-box construction comprising:	
– Floating slab on spring mounts	$1,040/m2
– Box-in-box walls with vibration isolation mounts	$690/m2
– Box-in-box ceiling with vibration isolation mounts	$340/m2
Airlocks with acoustic doors	$15,000/door

Image:
Trevor Mein, courtesy of University of Melbourne

Case Study: Union Theatre

The University of Melbourne's new Union Theatre, completed in June 2022, is a multi-use 401-seat proscenium arch theatre, presentation space and cinema. Acoustically, the theatre needed to be sensitive enough to sustain communication with unamplified voices, but robust enough not to be overloaded by amplified music. It needed to provide high sound quality in both diction and unamplified music, and low levels of external noise intrusion.

The design closely controlled the level of reverberance in the space and creates an enveloping sound that draws the audience in. This was achieved by specifying the amount and layout of absorptive materials, and through selection of internal surfaces and the use of reflector panels.

Because the auditorium is located above a bar and the stage itself is positioned above food and beverage outlets, a concrete floating floor was introduced to limit noise intrusion.

These requirements were met by incorporating the following items into the design:

Item	Cost
Box-in-box construction comprising:	
– Floating slab	$600/m2
– Box-in-box walls	$250/m2
– Ortech roof system / ceiling	$800/m2 (excl. steelwork)
Wall panelling	$820-900/m2
Fixed theatre seating	$1,000/seat
Forestage reflectors	$580/m2
Rw55 single airlock doors	$5,000/no

Image:
Union Theatre
University of Melbourne
Lyons Architects

Conclusion

Achieving high quality acoustic outcomes is a complicated science, but doesn't need to be expensive – provided it is considered as part of the design process. Good spatial planning can mitigate many of the expensive add-ons frequently associated with acoustically high performing buildings, and not all acoustic treatments have to be high cost.

Early engagement with your quantity surveyor and acoustic consultant will achieve the best value for money and leave more money in the budget for the things people can see and touch.

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About Slattery and Kaizen

Slattery is a property and construction advisory firm specialising in quantity surveying, cost management and early phase project advisory, with an outstanding history spanning more than 40 years.

We work hand-in-hand with governments, institutions and organisations as well as planners, developers, architects and design teams on a broad range of property and construction projects.

A commitment to excellence and innovation, and an ability to become an integral part of the project team has earned Slattery the trust and respect of clients and project teams alike. Slattery adds value by taking control and ownership of the cost management process from the outset. We understand the importance to drive innovation and productivity.

Slattery's Kaizen Papers focus on sharing knowledge, ideas and pertinent cost information related to our industry. Kaizen is the Japanese word for improvement, and a business philosophy that strives for continuous improvement in process. We produce papers across the sectors we work with, which are shared with our clients and made available on our website for all to view.

We invite you to explore our knowledge sharing further at www.slattery.com.au/thought-leadership

About our contributor, Marshall Day Acoustics

Marshall Day Acoustics (MDA) is one of the world's leading independent acoustic consultancies, providing the highest standard of architectural and environmental acoustic consulting.

For over 40 years, they have been providing innovative acoustic designs, working on major projects in over 15 countries and employ over 90 professional staff in offices throughout Australia, New Zealand, China, Hong Kong, and France. They are at the cutting edge of development in the acoustic industry, committed to being at the forefront of research and development, investing significant time, energy and resources into ongoing development of in-house and commercially available tools across a range of sectors including concert halls, building acoustics, environmental noise modelling, intelligent noise loggers, underwater acoustics and more.

Their strength in acoustic design comes from the diversity of their team members who have been drawn from engineering, architectural, musical, design and academic backgrounds, with one common focus; to provide exceptional acoustic designs. With a collaborative approach to their designs, they work with the project team to develop acoustic criteria and treatment that meets the desired project outcomes, whatever they may be. Recognising commercial realities and achieving an appropriate balance between quality and cost objectives is something they take very seriously. MDA is committed to improving their delivery of quality and enhancing their reputation as suppliers of acoustic consulting services, in all of their markets.

Find more information at marshallday.com

Slattery carbon planning

Slattery is proud to be the first quantity surveying firm in Australia to launch a carbon planning service.

Our service is available in conjunction with cost planning to assist our clients in achieving their net zero and sustainability targets. The focus of the carbon plan will address and educate clients on the embodied carbon of their current and future developments.

Read more about Slattery's carbon planning offering at www.slattery.com.au/carbon-planning

Our team is pleased to hold memberships to the following industry groups:

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