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THE IMPACT OF FLOORING ON ACOUSTIC COMFORT

by KP Acoustics

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Specialising in the crossover between sound reproduction and acoustics he is particularly fascinated by human response to sound, and how sound affects us consciously and subconsciously in both indoor and outdoor environments. Chris currently sits on the Council of the Institute of Acoustics, and is the Chair of the IOA Education committee. He was given an Award for Distinguished Service to the Institute of Acoustics in May 2023 and was awarded Fellowship of the Institute of Acoustics in May 2024.

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WHY DO ACOUSTICS MATTER?

Human hearing is the only sense which is permanently active and fully spatially aware. Our bodies respond to sound instinctively - even relatively low levels of sound can cause our bodies to create a stress response – the fight-or-flight reaction, which releases stress hormones into our bloodstream, resulting in a range of physiological effects including elevated heart rate, increased blood pressure and slowdown of digestive processes.

There is evidence that stress effects from noise continue for some time even after exposure until the noise has stopped. This increase in stress links to long term health effects such as increased rates of cardiovascular disease, with an estimated 48,000 new cases of heart disease in Europe linked to noise exposure each year [1].

The average adult spends 90% of their time indoors – in workplaces, leisure activities or residences. We are subject to a wide range of sounds in the indoor environment from building services to noise generated by ourselves or by other building users. The indoor acoustic environment affects our ability to communicate, focus, learn, socialise or sleep. This means that building acoustics has a huge influence on our quality of life – in everything from workplace productivity to our ability to rest and relax at home.

ACOUSTIC COMFORT

The concept of Indoor Environmental Quality (IEQ) considers aspects of design, analysis, and operation of healthy and comfortable buildings [2]. It takes into account a wide range of psychological, social, behavioural and contextual dimensions in considering what contributes to a ‘comfortable’ environment [3]. The key features of IEQ are thermal comfort, visual comfort, indoor air quality and acoustic comfort.

Acoustic comfort can be defined as ‘the perceived state of well-being and satisfaction with the acoustical conditions in an environment’ [4]. Building design has a significant impact on acoustic comfort with negative outcomes from poor acoustics including increased stress, reduced learning and productivity, physical discomfort and reduction in privacy [5].

On the other hand, good acoustic design can lead to positive outcomes for building users. Acoustic treatment in schools has been shown to reduce noise levels and simultaneously improve both learning and behaviour. Reducing impact noises in dwellings can have a significant benefit to the amenity value of the property [6].

ACOUSTICS IN INTERIOR SPACES

We normally think of sound as travelling through the air as a sound wave – this is airborne sound. However, if a source is in physical contact with the structure of the building (e.g. a TV mounted to a wall, or vibration caused by footfall on a floor), the sound wave is transmitted directly through the structure, and is known as structureborne sound. This then re-radiates as airborne sound at other locations in the building [7].

As an airborne sound wave strikes a surface (e.g. walls, ceiling, floor) some of its energy will be absorbed by the material (sound absorption) as a result of frictional processes, some will be transmitted through the structure, and the remainder will be reflected back into the room (figure 1).

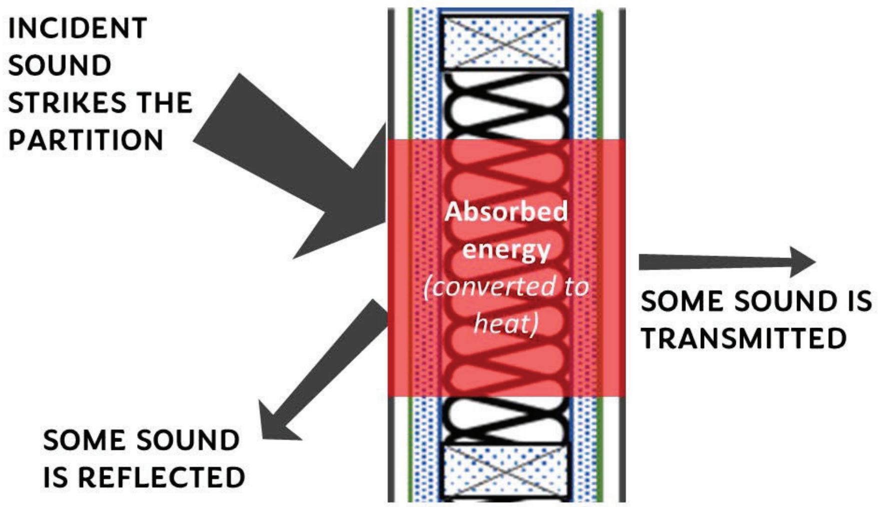

Figure 1: Sound reflection, absorption and transmission

Within the room, the direct sound takes the shortest (direct) path to a listener (figure 2), but as sound travels in all directions from a typical source, other parts of the sound wave will reflect from nearby surfaces before reaching the listener after one or two reflections. These 'early reflections' are used by the listener to identify the size of the room as well as the relative position in the room – a form of echolocation.

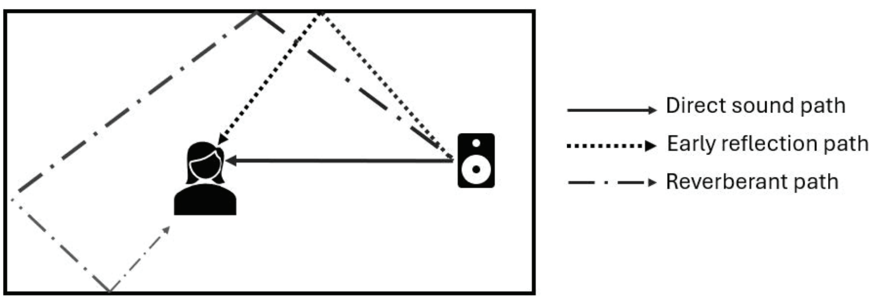

Figure 2: sound paths in an enclosed space

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As there are an infinite number of possible reflective paths between the source and the receiver, sound will carry on reflecting repeatedly until all its energy has dissipated. This process of continuous sound reflection is known as reverberation.

We quantify the reverberation time (figure 3) as the time taken for the sound level in a space to decrease to a millionth of its original amplitude (a decrease of 60 decibels) after the sound source has stopped. For this reason it is often denoted RT60.

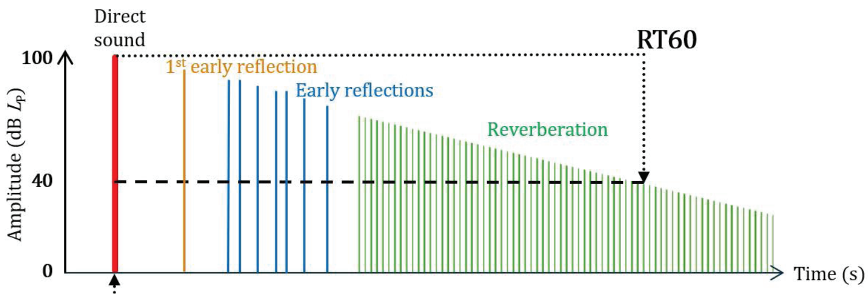

Figure 3: Reverberation time

If a room has a high proportion of absorptive surfaces (such as soft furnishings, carpets and curtains), the reverberation time will be short, while less absorptive materials such as masonry walls or hard flooring will cause longer reverberation times.

The absorption coefficient is defined as the ratio of incident sound energy on a surface which is either.absorbed or transmitted, i.e. not reflected back into the room. Its value is between 0 (no absorption) and 1 (no reflection/perfect absorber).

$$\alpha = \left(\frac{I_a + I_t}{I_i}\right) \text{ where } I_i = \text{incident energy}, I_a = \text{absorbed energy } \& \ I_t = transmitted\ energy$$

Absorption is highly frequency dependent, so for common building materials absorption coefficients are commonly given for each one-third octave frequencies between 100 Hz and 5000 Hz. A ‘weighted’ absorption coefficient is a single number value commonly used to represent the overall level of absorption of a material.

A similar single number value used for absorption is the Noise Reduction Coefficient (NRC), which is generally used in the US and Canada, and is an average of the absorption coefficients at 250 Hz, 500 Hz, 1000 Hz and 2000 Hz.

Some energy will also be transmitted i.e. it will pass through the partition. It does this by driving the partition into motion, at which point the vibrational energy transmits to the other side of the partition. This then acts as a sound source, allowing the sound wave to be propagated into the air into the next space [8].

The transmission coefficient determines the ratio of the transmitted wave amplitude to the incident wave amplitude.

$$\tau = \left(\frac{I_r}{I_i}\right) \text{ where } I_i = \text{incident energy}, I_t = \text{transmitted energy}$$

SOUND IN ENCLOSED SPACES

A design feature in many modern commercial buildings is to use exposed ceilings and concrete, stone, laminated or vinyl floor surfaces. This particularly occurs in public areas such as atria, but increasingly in other rooms as well. The reverberation caused by low absorption can significantly amplify the sound level of any noise in the space - for instance the sound of kitchen appliances, televisions, speech or other activities [7]. This reduces acoustic comfort and increases the risk of noise disturbing other building users.

A typical approach to reducing reverberation time is to use porous absorbers. These work by allowing the sound wave to enter the material through small pores or gaps. As the sound wave makes its way through the pores in the material, sound energy is converted to heat through friction and is absorbed. Porous absorbers typically include fabrics (such as curtains and carpets), open celled foams, pressed or compacted fibres (such as mineral and glass fibre, plastic fibres or even wool).

INTELLIGIBILITY AND PRIVACY

Speech intelligibility and speech privacy are two important considerations of room acoustics particularly in commercial buildings. Speech intelligibility is the degree to which speech can be heard and understood. Good levels of intelligibility are needed in educational settings, conference rooms, healthcare settings and in locations with critical safety requirements (e.g. for emergency announcements).

Speech privacy is the inverse of intelligibility – it is the degree to which speech cannot be understood. Good speech privacy is a key requirement in many office spaces, particularly where sensitive information is being handled, such as banking, insurance and healthcare. By definition, high intelligibility in a space leads to low levels of privacy, and vice versa.

A standard measure of intelligibility is the Speech Transmission Index (STI). The STI is an indirect machine-based measure of how well the information contained in speech is likely to be understood, and is measured using a special test signal with speech-like characteristics. STI values vary from 0 = completely unintelligible to 1 = perfect intelligibility (figure 4).

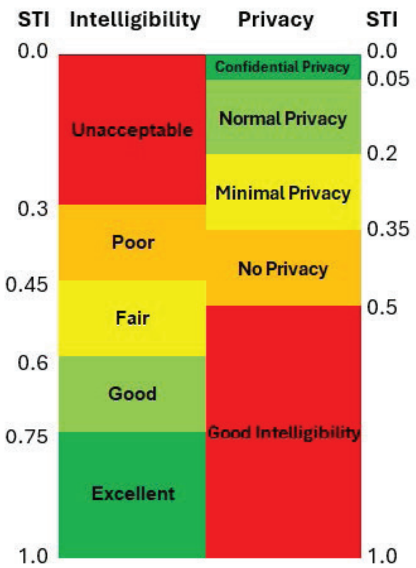

Figure 4 - STI values for Speech intelligibility vs Speech Privacy

Higher levels of background noise ‘mask’ elements of speech reducing intelligibility. Levels of intelligibility can therefore be improved by improving sound insulation (reducing external noise entering the space), and by reducing noise generated in the space (for instance from equipment).

While in some cases reducing background noise may be desirable, the increase in intelligibility in situations such as offices can increase distraction and annoyance from neighbouring conversations.

Increased reverberation time also reduces speech intelligibility as the reverberation muddies the clarity of speech. Absorbing reflected sound more quickly by adding absorptive materials such as carpets, soft furnishings and acoustic panels means that reverberation time is reduced. This results in a reduction in the amplifying effect of the room, reducing overall noise levels, while speech intelligibility and clarity of other sounds such as music are improved.

TRANSMISSION OF SOUND

The transmission between spaces of noise from different sources is affected by the design and structure of walls and floors. This affects both the acoustic insulation from airborne sound (sound that initially travels through the air before striking a partition) and the level of isolation from structurally transmitted sound (or ‘impact’ sound).

Airborne sound insulation is the amount of reduction of airborne sound pressure level across the partition and is measured using the difference in the average sound pressure level on either side of a partition at a range of frequencies.

If the partition can be made to vibrate by a sound wave striking one side, it acts as a sound source on its other side, causing transmission of the sound through the partition. Heavier structures are harder to move – so using more dense materials and larger structures will have higher levels of sound insulation.

We achieve a 6 dB increase in sound reduction for each doubling of the mass. This means that adding mass to a lightweight structure will give a significant improvement, but it quickly reaches a point where it is not economical to use additional mass to increase insulation due to physical constraints and materials cost.

The standard measure of airborne sound insulation is the Sound Reduction Index (R), measured in decibels. This is also commonly known as Transmission loss (TL). As with absorption, transmission is highly frequency dependent, and these values are measured in individual frequency bands to give the performance of a structure at different frequencies.

There are several different methods of classification of airborne sound insulation, with the key metrics being Sound Transmission Class (STC), used predominantly in the USA and Canada, and Weighted Sound Reduction. Index (Rw) which is used worldwide. These are both ‘single number ratings’ which use a single value in decibels to give an overview of the sound insulation performance.

These two measures are not directly comparable as they use slightly different frequency ranges in their measurement. STC ratings will typically be around 3-4 dB higher for the same structure than the equivalent Rw. Both STC and Rw are also derived from idealised laboratory measurements. These values will rarely be achieved in real world situations, and 'field' or in-situ measured values rather than laboratory measurements are specified in many building codes.
It must also be noted that, as sound insulation is highly frequency dependent, these single number ratings do not give a full picture of the level of sound insulation at particular frequencies.

Sound transmission is further affected by 'flanking' transmission, in which the sound wave can bypass structures designed for insulation purposes, for instance due to air gaps around doors, or through ventilation ducting or electrical conduits.

FLOORING AND ACOUSTICS

STRUCTURAL TRANSMISSION
Floors affect the acoustics of a building in several ways. Possibly the most critical is their relationship with structural transmission of sound. In a multi-user space such as an apartment building, office building, school or hospital, there are a lots of different floor impacts such as footfall, movement of items such as trolleys, vibration of machinery or impacts from dropped objects.

The vibrations from these impacts travel through rigid connections into the structure – for instance floor-joist-ceiling – and are re-radiated as sound into the spaces below (figure 5). Impact noise is both directly radiated into the room and transmitted through the structure.

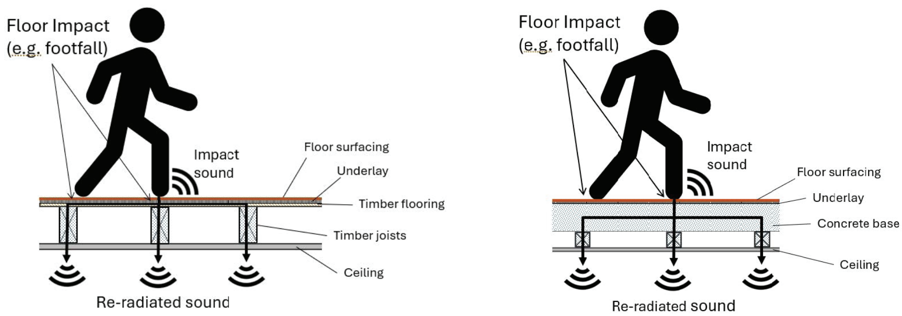

Figure 5 – impact sound transmission paths through common floor structures (left – timber and right – concrete)

Floors are specified with an Rw or STC rating for airborne noise insulation, but in addition they are specified according to how much impact sound is re-radiated into the spaces below, using the weighted normalised impact sound. pressure level (Ln,w) or in the US and Canada the Impact Insulation Class IIC. To reduce noise from impact, the structure needs to dampen the impact and reduce the transmission of vibrations through the structure. Resilient materials - materials which are not fully rigid, and which have some degree of compressibility and bounce back or ‘give’ – play a major part in reduction of structural transmission of sound.

Carpet or softer vinyl floor surfaces reduce the effect of impacts on a surface by compressing slightly, damping the initial impact. This reduces the amount of vibration of the surface itself, and significantly reduces both impact noise and structurally transmitted noise with a typical minimum of 10dB reduction in impact noise.

Well-designed resilient underlays underneath a solid floor surface will significantly reduce noise transmission into the main structural elements (beams and joists or concrete slab), with typical figures of around 15 dB of reduction in structural sound transmission from the addition of an acoustic underlay to a timber floor structure.

Thicker and more dense underlay will further reduce impact noise and sound transmission through a carpeted floor, while a sub-floor laid on acoustic barrier mat or resilient mounts can be used to further reduce impact noise from any floor type. For even more reduction of structural sound, ceiling panels can be mounted on resilient mounts (figure 6).

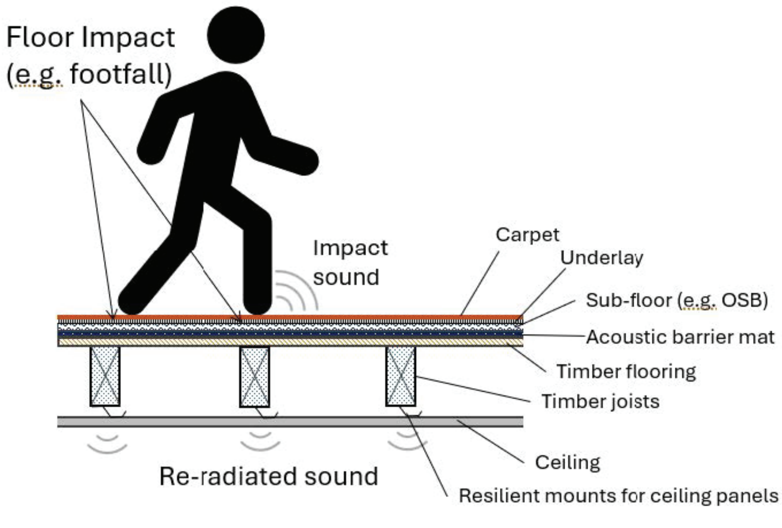

Figure 6 – reduction of impact sound transmission with resilient layers

ABSORPTION AND REVERBERATION

Hard flooring surfaces such as laminate or wood flooring, hard vinyl, stone or concrete all have very low absorption coefficients (figure 7). This increases reverberation times, with the result of increased noise and reduced intelligibility. Absorption by porous materials is directly linked to the thickness of a materials and is highly frequency dependent. Absorption is most effective where the thickness of the material is at least one-quarter of the wavelength of the sound wave, and reduces significantly at lower frequencies where the wavelengths are longer.

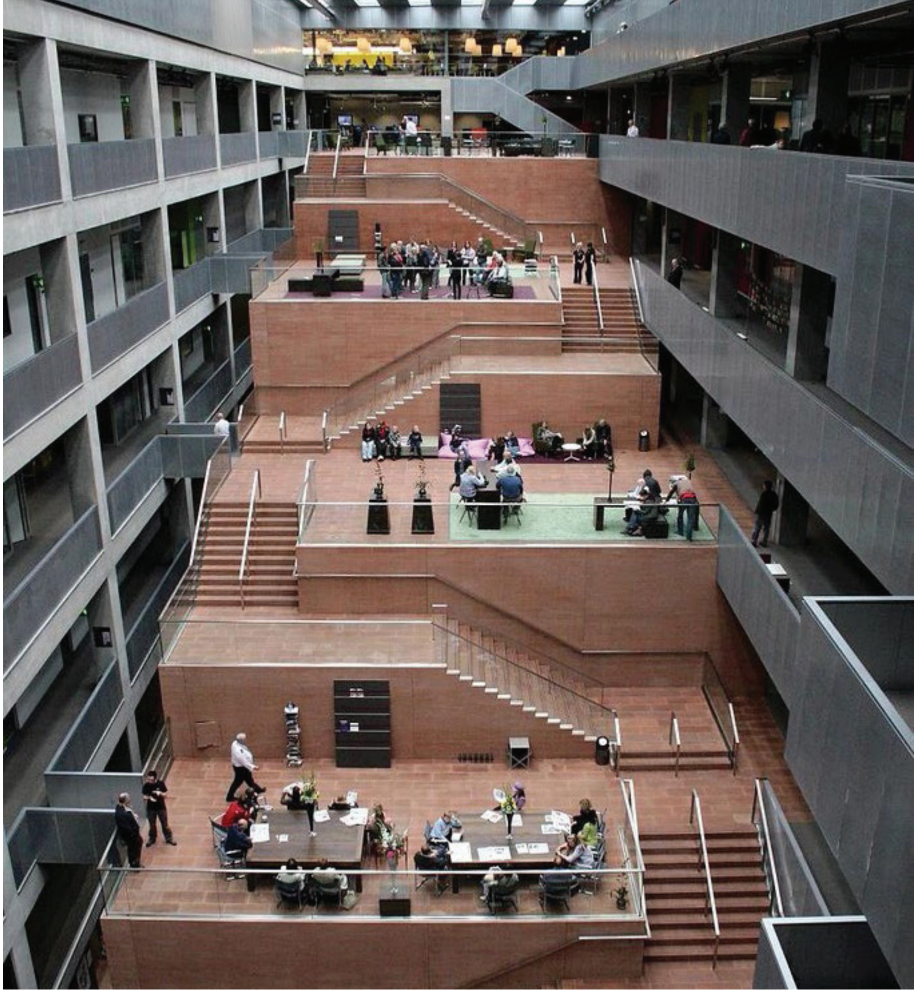

Figure 7: Hard floored Atrium
"The Atrium" by itmpa is licensed under CC BY-SA 2.0.

At the lower end of the speaking voice (around 125 Hz), a quarter wavelength is around 69 cm, so even a fairly thick carpet will offer relatively little absorption at these frequencies (figure 8). However by the mid-frequencies, carpet can be a fairly effective absorber with a 1 cm cut pile carpet laid on concrete giving an NRC of 0.4 at 1000 Hz (i.e. an average 40% of the incident energy is absorbed) and a 4 mm carpet with foam back giving an NRC of 0.25 [9].

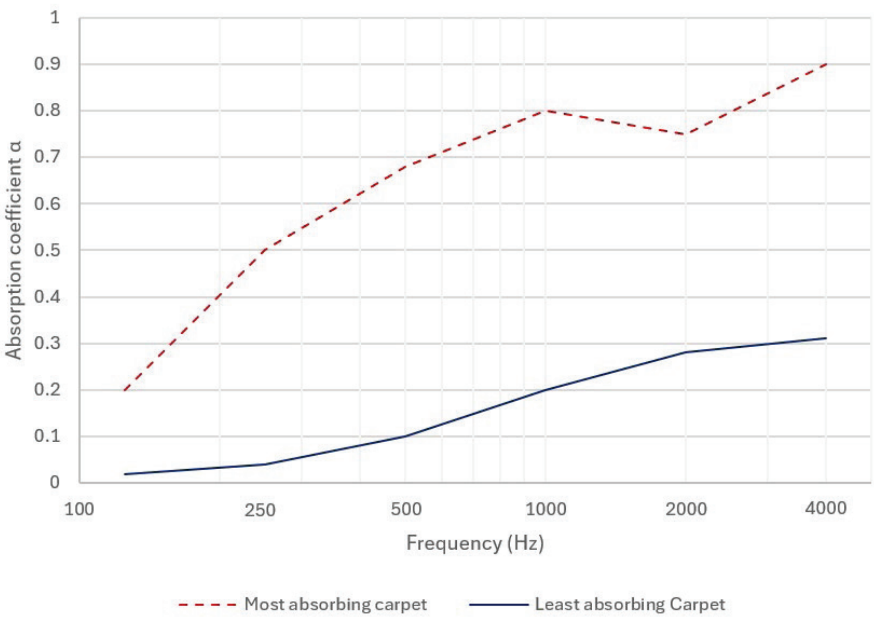

Figure 8: Absorption coefficients of high and low performing carpets. Derived from [10]

While most acoustic treatment is done using ceiling or wall-mounted panels, flooring offers a large amount of surface area, so its contribution to the total amount of absorption in a room can still be significant. As the thickness and density of absorbers affects performance, deeper pile carpets combined with heavy underlay will be more effective than thin carpets with no underlay. A fully carpeted space can reduce the reverberant sound pressure level in the room by around 3 dB compared to a hard floor.

DESIGN CONSIDERATIONS FOR DIFFERENT SPACES

OFFICES

The open plan office is a particular challenge. From the user's perspective, although there are advantages of working in open plan spaces, (e.g. knowledge sharing and ease of interaction), there are a significant number of acoustic challenges which can be detrimental to the use of the space.

Figure 9: Bayer Offices - The Wings

Common complaints include disturbance from other space users and lack of privacy, with conversations, footfall, noise from electronic devices (including phones, computers, printers and more specialised equipment) all reducing the benefits of the space.

If multiple people need to talk in a room, 'Lombard effect' becomes an issue. People raise their voices to be heard above other talkers in a room – in turn causing others to raise their voice so the level in the room continuously increases. A simple means of control of this is to reduce the amplifying effect of room reflections by using absorption, as well as controlling the direct sound travelling between people by using room dividers. Having both a carpeted floor and wall or ceiling mounted absorbers such as acoustic ceiling tiles will reduce reflections from floor and ceiling (figure 10).

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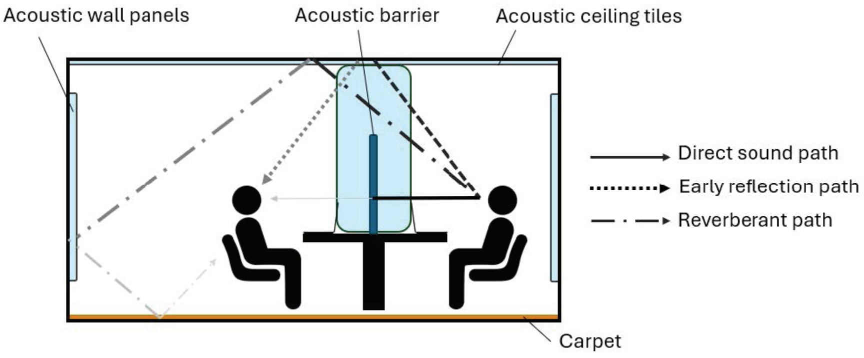

Figure 10: Reducing noise levels from speech using absorption and barriers

HOSPITALITY

Contemporary trends in architectural design in hospitality venues are for an 'industrial' look with exposed ceilings and building services. This tends to result in high levels of reverberation (figure 11). Conversation, music and kitchen noises are all amplified in a reverberant environment, leading to reduced ability to hold conversations. The perception and taste of food can also be affected by the presence and level of background noise [11]. As the major issue is generally excessive reverberation, acoustic comfort can again be improved with the use of absorptive materials such as carpet, curtains and acoustic panels.
Figure

Figure 11: The Nightcar

HEALTHCARE

Hospitals are often noisy places. Noise sources inside a hospital ward include alarms, foot traffic, voices, bins and door closures. Hospitals have noise from plant and machinery, ventilation and specialist equipment, as well as external noise from traffic and sirens. Patients are more vulnerable to stress and disturbance than healthy individuals and annoyance and stress from sound is linked to loss of rest and increased recovery time.

Sound levels are particularly high in high-dependency areas such as Intensive Care Units (ICUs), with average values between 60 and 67 dB(A) (figure 11) [12]. Unlike normal recovery wards, there is relatively little diurnal variation [12]. Night-time sound pressure levels above 55 dBA are considered to be dangerous for patient health [13]. Footfall is a key issue, with hard flooring resulting in increased noise level from impacts, higher reverberation and potential sound transmission to floors below.

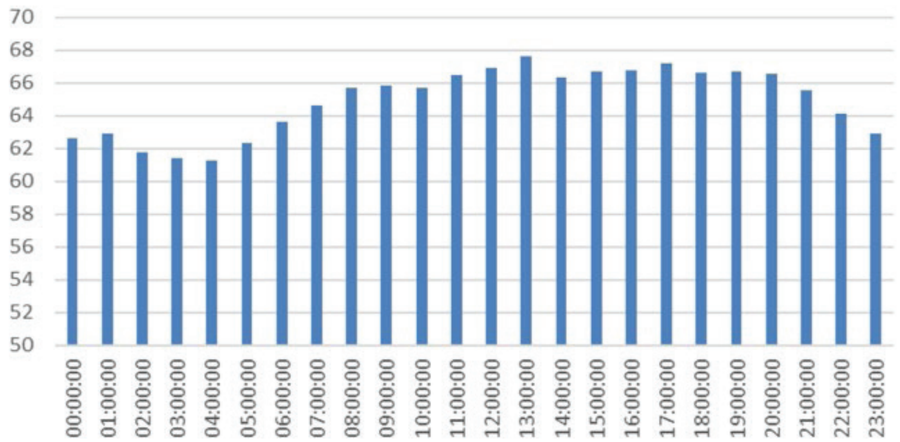

Figure 11: Combined average LAeq by hour of the day in an 18-bed ICU (from [12], reproduced with permission).

EDUCATIONAL SETTINGS

The most critical aspect of acoustics in educational settings such as schools or universities is good speech intelligibility. Between 45 and 75% of student's time in the classroom is spent listening to their teachers or classmates' speech [14]. If intelligibility is poor, instruction is not understood, leading to significant detriment to learning. Poor classroom acoustics can affect a child's listening comprehension, short term memory, higher order cognitive functions and language development.

Sources of background noise include break-in from external noise such as traffic, aircraft and playground activities, noise and vibration from building services such as ventilation and heating plant, and noise and vibration from building users both in the room and in neighbouring classrooms (figure 12).

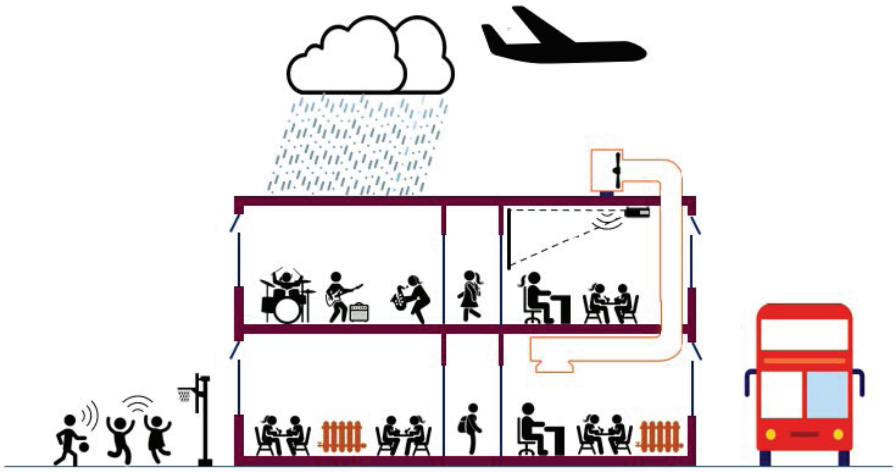

Figure 12 – sources of noise in a school environment (derived from [15])

Children working together in interactive lessons will inevitably make noise – this is known as ‘classroom babble’. In a room with poor acoustics, Lombard effect results in an increase in sound levels over time. This makes communication difficult and makes learning particularly challenging for students with hearing impairments, while for those who may be hypersensitised to sound it can make them extremely uncomfortable, causing heightened distraction.

The use of absorptive materials including carpets, ceiling panels and wall panels can reduce reverberation time, both reducing noise levels and increasing intelligibility. Studies have shown that reduction of reverberation time from ~1s to ~0.5s can significantly improve test scores and retention of information [14].

Vibration from physical activities can travel through the floor and cause disturbance to classrooms below, while airborne sound can transmit through walls, ceilings and floors. Resilient flooring systems such as acoustic underlay or barrier mat, carpet and added mass to the floor will help to reduce the transmission of floor impact.

INDUSTRIAL PREMISES AND WAREHOUSES

In large industrial premises there is a need to control noise primarily for worker safety – both to reduce the risks of excessive noise exposure, and to allow audibility and intelligibility of safety critical systems such as alarms and public address systems.

In these spaces it is impractical to use floor coverings for absorption, so the main means of addressing the acoustic issues is to use the roof and walls of the space to mount absorption panels (figure 13).

Figure 13. Sound absorption panels in an industrial premises

INNOVATIONS AND FUTURE TRENDS IN ACOUSTIC FLOORING

In recent years there have been several developments in acoustic flooring systems, offering significant improvements in acoustic performance while either offering weight or cost reductions, or increased ease of fitting.

ACOUSTIC UNDERLAY AND OVERLAY

Acoustic overlay is a rigid layer such as OSB, plywood or chipboard, with an attached layer of resilient material – most commonly a polymer foam. They offer similar benefits to a sub-floor but with an easier install and a reduced floor thickness, and can be easily overlaid onto existing floors. If the rigid layer is thicker (full flooring thickness), some of these products can also be installed directly to timber joists as a new floor, keeping the floor deck height low (figure 14 – R).

Figure 14: Examples of acoustic underlay – SoundLay® (L) and overlay - SoundDeck Extra® (R).

Acoustic underlays act in a similar way, but are generally constructed from a multi-layer or sandwich material, in which a dense foam or vinyl layer is backed with a more compressible acoustic foam. The top layer is sufficiently rigid to mount floor coverings directly to it offering an easier install and a reduced floor thickness compared to a full sub-floor or an overlay. (figure 14 - L).
New acoustic materials for underlays are improving impact noise reduction, maintaining comfort and durability and increasing sound absorption coefficient from flooring.

ACOUSTIC CARPETS
In a similar way to acoustic flooring, carpets are being offered with acoustic underlay integrated into the product. The backing (figure 15). has a higher density and thickness than conventional carpet backing giving increased reduction of impact noise.

This can also offer a good level of sound absorption so can be useful to control reverberation and ambient noise in rooms. By combining traditional fibres with acoustic foams or aerogels to enhance absorption, absorptive performance is becoming closer to that of wall panels while maintaining a thin product.

Acoustic carpet additionally reduces installation time and cost as only a single floor covering needs to be installed. Supplied as modular acoustic tiles, these are designed for easy replacement and reusability, providing long-term cost savings while maintaining acoustic integrity.

Figure 15: Carpet with acoustic backing – comfortBACK®.

BIOPHILIC DESIGN AND FLOORING

»Biophilia is the deepseated need of humans to connect with nature‹ [16]. Biophilic design aims to help maintain a healthy life experience, reinforcing a connection with nature by utilising patterns and structures from the natural world [17]. Research suggests that exposure to even small instances of nature can be restorative, and so there is increasing interest and use of biophilic design to increase indoor environmental quality.

Flooring is often overlooked in biophilic design (figure 18), but it is important to integrate it into the wider design. Floor surfaces and carpets can help to create a natural feeling environment through the use of colour and patterns in carpet or natural materials such as real wood in solid flooring.

Figure 18: Biophilic elements in design: Planting, real wood, open space and natural colours/patterns in the carpet. (Insight Offices - Sheffield City Centre

By combining a biophilic flooring cover with other acoustic flooring elements such as acoustic underlay, the flooring can contribute to the visual perception of a space as well as the acoustic comfort, helping to increase the overall indoor environmental quality.

SUSTAINABILITY AND ACOUSTIC FLOORING

A high proportion of commonly used acoustic materials are depletable materials derived from mineral extraction or materials with high levels of embodied carbon. These include petroleum-based products such as plastics (PET, Melamine foams etc) and mined or quarried minerals such as gypsum or concrete (which is used to add mass to acoustic particle boards). Acoustic approaches to flooring typically include the use of neoprene or polyethylene for resilience, and concrete or particle board for added mass.

Many sustainable flooring materials can provide excellent absorption and insulation properties. Sheep's wool has been used in the highest quality carpets for centuries, but recycled wool and other quality wool can also be used. Other natural products such as wood furring, cork matting and rubber can provide good levels of impact sound insulation when used as an underlay, while also having good thermal insulation properties. Cork and other sustainable woods such as bamboo can also be used as floor surfacing materials giving reduced impact noise within the space, as well as having a natural look which works well with biophilic design approaches.

Recycled plastics can be effectively turned into carpets or underlays. Biodegradable and recycled materials will become more common, offering high-performance acoustics with minimal environmental impact.

Recycled tyres offer particularly good solutions for flooring. Around 1.5 billion waste tyres are generated worldwide every year. The majority ends up in landfill, posing a significant environmental risk. However, the material can be easily turned into other products by shredding into granules (crumb), chips or powder (figure 19) [18]. In addition to the large supply of raw materials, another advantage is that the energy costs for manufacture are relatively low compared to many recycling processes.

Figure 19: Rubber crumb derived from recycled car tyres (image by Michal Ďurfina is licensed under CC BY-SA 4.0.

Matting constructed from compressed rubber crumb materials produce excellent floor impact reduction [19] - particularly useful in gyms, sports halls and industrial premises. It can also offer good levels of sound absorption (figure 19) [20].

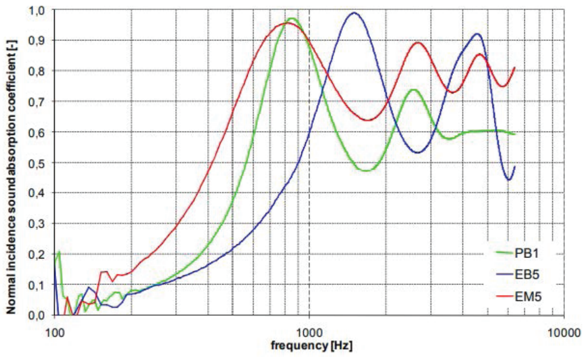

Figure 20: Sound absorption coefficient of 3 rubber crumb materials (48mm, 38mm and 62mm depth). From [20]:37

Natural Polymers (bioplastics) include bio-based vinyl derived from plant and wood oils, and offer more sustainable plastics than those manufactured from petrocarbons. These may be used as independent products including carpets, underlays and acoustic foams, or can be blended with conventional petrocarbon-derived materials to reduce carbon footprint. Bioplastics can also be manufactured through recycling of used cooking oils, industrial waste oils or waste plastics [21].

ACOUSTIC META-MATERIALS

Acoustic Metamaterials are engineered materials which are designed to offer properties or performance not found in conventional materials. A principal aim is to enhance acoustic absorption or sound insulation by offering the performance currently only achieved with a massive structure while being of practicable dimensions and material quantities. This may make use of complex internal structures of a material (such as cellular structures) to dissipate energy more effectively, or use dynamic microstructures which have the ability to change their structure in response to external stimuli.

While there has been a lot of research in the past decade on acoustic metamaterials [22], there are as yet few materials which have made it to market and there is limited literature on the suitability of acoustic metamaterials for flooring. However, as the field is developing rapidly, it is to be expected that metamaterials targeted on reducing structural transmission of sound will become available in the relatively near future.

Metamaterials offer significant potential in terms of sound absorption using ultra-thin materials – this could allow carpets or flooring which incorporates metamaterials to perform as well as traditional wall or ceiling absorbers while integrated into a product which will be installed anyway, reducing overall cost and complexity of installation.

SMART CARPETS AND EMBEDDED SENSORS
Ultra-thin sensor technology is available which is now being installed into carpet materials or underlays. This is able to detect foot traffic and impacts, effectively turning the floor surface into a touchpad – for instance to monitor for falls in a healthcare setting [24], or manage lighting systems. Future systems may be able to monitor noise and vibration levels and integrate with acoustic masking systems or HVAC controls to dynamically control the noise based on occupier levels in a space [25].

CASE STUDIES

BOARDROOM/MEETING ROOM VIDEOCONFERENCING ISSUES
In this project the main meeting room/boardroom (figure 21) for a design consultancy had issues with excessive reverberation, caused by reflective surfaces – including glass walls and wooden flooring. This caused reduced intelligibility for teleconferencing, as well as causing privacy and disturbance issues with neighbouring offices able to hear speech from the meeting room.

As most of the walls were unsuitable for installation of acoustic treatment, reverberation control involved using absorbers in the ceiling and directly around the television to reduce initial reflections, and wall-to-wall carpet with acoustic backing to add further sound absorption.

Reverberation time in the room dropped from 1.1 s to 0.5 s, increasing speech intelligibility and reducing reverberant sound pressure levels.

Figure 21: Meeting room.

GYM FLOOR IMPACT NOISE
Conversion of spaces to gyms are very common, whether in apartment buildings or mixed use spaces. This project entailed a conversion of a commercial use property into a mixed use residential building and gym. The existing site was a stripped out commercial building, with the ground floor being existing residential apartments, the first floor being converted into a gym and second and third floors into residential apartments.

The core issue was to address the impact sound transmission between the gym floor and the residential floor below. A lightweight floating floor using a rigid subfloor over a recycled rubber acoustic underlay was used, with further isolation from acoustic hangers on the ceiling below and a mineral wool layer above double layered acoustic plasterboard to reduce airborne transmission of sound.

Figure 22: Gym floor weight matting

A number of samples of specialist acoustic isolation matting for gyms (figure 23) were tested using weight drops of 23 kg reference weights. This showed a reduction in impact generated noise in the floor below of 21 dB for the best performing structure compared to a bare floor, showing that the lightweight floating floor combined with the isolation matting brought noise in the residential apartment to below criterion levels.

PRACTICAL RECOMMENDATIONS

Best Practices for Choosing Acoustic-Friendly Flooring
Consider the required usage – does it need to be hard wearing, cleanable. Is it a new installation or a refit – does it have to work with existing flooring systems (e.g. does it require an overlay), or can it be laid as a new floor?

Identify your primary requirements – for instance reducing footfall noise in the space, reducing structural transmission to floors below and/or reducing reverberation.

Identify limitations or possible conflicts in design requirements – for instance in healthcare settings, carpet may be impracticable due to infection control requirements. What are your acoustic needs? Adding carpet as a distributed walking surface could broadly reduce the reverberant field by around 3 dB, and reduce the impact noise by a minimum of 10 dB.

Consider the sustainability of materials specified – is it possible to use materials which achieve the same requirements while being more sustainable?

Tips for Collaborating with Acoustics Experts During Design and Specification
Consult with an acoustician early on in the project so they are fully integrated in the design process. Remedial work tends to be very expensive, and including relevant expertise at the beginning of the project will help to identify potential issues early. Make sure that they are aware of any limitations or requirements of the project (for instance if sustainable materials are to be specified). Look for suitable experience and qualifications – such as membership of appropriate professional bodies.

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CONCLUSION

A good acoustic environment is critical to most uses of a building – from learning at school, concentrating or collaborating in an office, recovering in a hospital or resting and relaxing at home, the acoustics of the space have a considerable effect on the function of the space.

Acoustic comfort is an integral part of Indoor Environmental Quality – the overall perception of user comfort in a building. The floor surface is often overlooked when it comes to acoustic design, but it offers a wide range of opportunities to improve acoustic comfort.

Carpets with acoustic underlay can offer significant reduction in reduction of impact sound to the floors below. Acoustic carpet or other materials such as cork or rubber crumb flooring can also offer good levels of sound absorption, and so have a high impact on reverberation and noise control inside a space. Floor coverings can also enhance biophilic design by integrating natural material, colours and patterns into the floor surface, while flooring materials can be increasingly sourced from sustainable materials – from natural wool to recycled rubber and plastics.

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