ACOUSTICS
DESIGN IMPACTS
Research Brief

PARTNERSHIP INITIATIVE
INTEGRATED DESIGN LAB
at the Center for Integrated Design

Figure 1:
A technician installs biodegradable batt insulation made from plant roots that combines thermal performance, fire resistance and sound absorption.
Source: https://www.archdaily.com/889176/eco-friendly-insulation-offers-thermal-performance-sound-absorption-and-fire-resistance-at-the-same-time/

Keywords:
Design, classroom acoustics, reverberation, well-being, noise exposure, materials, job satisfaction, fatigue

CONTENT OVERVIEW

ACOUSTICS + DESIGN IMPACTS SUMMARY

Whether it be for connection or isolation, stimulation or serenity, acoustics' place in architecture is vital. Finishes, soundscapes, systems, and program are design considerations that cannot be overlooked if a space is to be comfortable, safe, and beautiful.

I. Finishes

Material and product selections have simple, but significant impacts on the performance of a space. Acoustic measurements (equivalent sound pressure level) were taken throughout a hospital ward continuously for one week to compare sound reflecting to sound absorbing ceilings. (Blomkvist 2005 6)

	Reverberation time (s)		Equivalent sound pressure level (L_{Aeq})		Speech intelligibility (RASTI value)	
Area	Sound reflecting	Sound absorbing	Sound reflecting	Sound absorbing	Sound reflecting	Sound absorbing
Central area	0.8	0.4	57	56	0.72/0.68*	0.88/0.83*
Patient room 4	0.9	0.4	56	50	0.67	0.87
Patient room 7	–	–	56	51	–	–

–, not measured.
*Measurements performed in two different positions.

Figure 2: Comparison of sound reflecting ceilings vs. sound absorbing ceilings; acoustic measurements in three areas of a hospital ward (reverbaeration time, sound pressure level, and speech intelligibility)
Source: Blomkvist 2005

Industrial Noise Mitigation

Local government is thinking creatively about industrial noise mitigation while simultaneously interrupting waste streams. In Phoenix, more than 200 miles of highway have been resurfaced with concrete that utilizes pieces of old tires as sound dampening admixture, according to Doug Nintzel, spokesperson for the Arizona Department of Transportation. "It means millions of tires have been recycled and kept out of landfills" (Fetterman 2018)

Some of these strategies depend simply on different finishing methods. In Texas, "quieter concrete" is raked with grooves that run in the same direction as traffic and results in a drop of highway noise by 5.8 decibels on average, according to Emily Black of the Texas Department of Transportation. (ibid.)

Pioneering Products

Emerging materials and products are continually being developed for high acoustic performance. One such example comes from scientists at the Mokpo National Maritime University in South Korea and the Korea Institute of Machinery and Materials. They have designed a sound resonance chamber in which the resonant forces oppose any compression. With careful design, this leads to a negative bulk modulus for a certain range of frequencies. Their resonance chamber is actually very simple—it consists of two parallel plates of transparent acrylic plastic about 150 millimetres square and separated by 40 millimetres, rather like a section of double-glazing about the size of a paperback book. In tests with a 3x4x3 "wall" of building blocks, they say their window reduces sound levels by 20-35 decibels over a sound range of 700 Hz to 2,200 Hz. (MIT 2013)

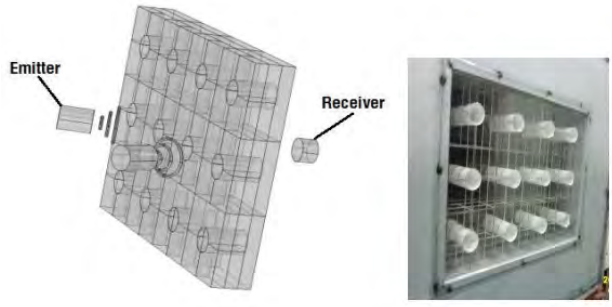

Figure 3: Assembly Detail of the acoustically insulated glazing system designed by MNMU and KIMM
Source: MIT 2013

Finishes Cont.

Bespoke textures

Finishes have acoustic characteristics that can further shape experience. At times, those finishes are a hand-blended and applied with intention to create completely unique effects. Johannes Girardoni on Olson Kundig's design of The Infinite Room: "The finished lime plaster absorbs moisture just like adobe. It is breathing skin against which sounds reverberate eerily...people seated inside seem to get a heightened awareness of being alive because of the changing light and the acoustics...some guests slip inside to chant or meditate. Others cry when they can hear echoes of their own breath behind them, and still others beg to leave." (Sardar 2017)

II. Soundscapes

Acoustics are becoming recognized as environmental determinants of health. Governments are shifting toward mandating or encouraging building that takes this into consideration. The United Kingdom's Department of Health and Social Care wrote in their Healthcare Environment 2007 article that "Careful use of colour, light, texture and sound combine to create a healing environment...Designers should ensure that patient areas are located away from external sources of noise, such as road traffic since the healing process is slower when patients are exposed to noise for long periods... Noisy spaces, such as restaurants and day rooms, should not be located next to quiet spaces, such as bed areas." (Brown, 2014)
The ideal soundscape is one of a hi-fi environment, where "all sounds may be heard clearly, with whatever detail and spatial orientation they may have...hi-fi environments presenta a high degree of information exchange between its elements and the listener is involved in an interactive relationship the environment." (ibid.)

III. Acoustic Building System Design

To Conceal

The most gain can be achieved least expensively, most quickly and with the least disruption by employing a low-voltage electro-acoustic background sound system of proven quality that has been designed and installed by qualified professionals to improve "speech privacy." These systems are available in two types: older-style "plenum systems" (i.e., installed above ceiling tiles and radiate sound upward into the plenum), and "direct-field systems" (these are installed in the ceiling plane and radiate sound downward into the occupied space; recent research reported at the 2003 annual meeting of the Acoustical Society of America, indicates that significantly better privacy can be achieved at lower decibel levels using "direct field" systems). (Sykes 2009 4)

To Reveal

Acoustic integration into building systems can do more than mask mechanical noise, it can also connect patrons of art and sporting events with the feats performed in front of, but far away from, them. Of the Golden 1 Center, "absorbent and directional speakers offer better acoustics. The sound of on-court sneaker squeaks is piped in to luxury suites for an enhanced game-watching experience." (Baker 2016)

IV. Programming for Acoustic Control

Benefits to customers

Soundproofing specific rooms would allow hotel owners to have lively communal space as well as quiet private rooms. Clustering "quiet rooms" together in the hotel plan to create quiet-zone floors is a simple way to make these accommodations. (Rosenbloom, 2015)

Open-Plan Considerations

The simultaneous use of absorption materials, sound- absorbing screens and speech masking sound would produce the lowest STI, thus, best speech privacy in open-plan offices. The open-plan office lacked sufficient masking sound and absorption materials. The background noise level of ventilation was LA,eq 1⁄4 39 dB while the recommended noise level is 42 dB. Absorption materials were placed only to the ceiling and their absorption efficiency was too low. The walls and furniture were strongly sound reflecting. (Kaarela 2009 1439)

Programming for Acoustic Control Cont.

In programming space, open-plan offices can be used for non-intensive and dynamic work or traveling workers, but anonymous private rooms should be provided because of incidental periods of concentration-demanding work, paired work or private conversations. The use of alternative workstation types in the same office building should be encouraged because this facilitates the selection of workstation according to the current work task and this improves the feeling of control over the work environment. (Kaarela 2009 1442)

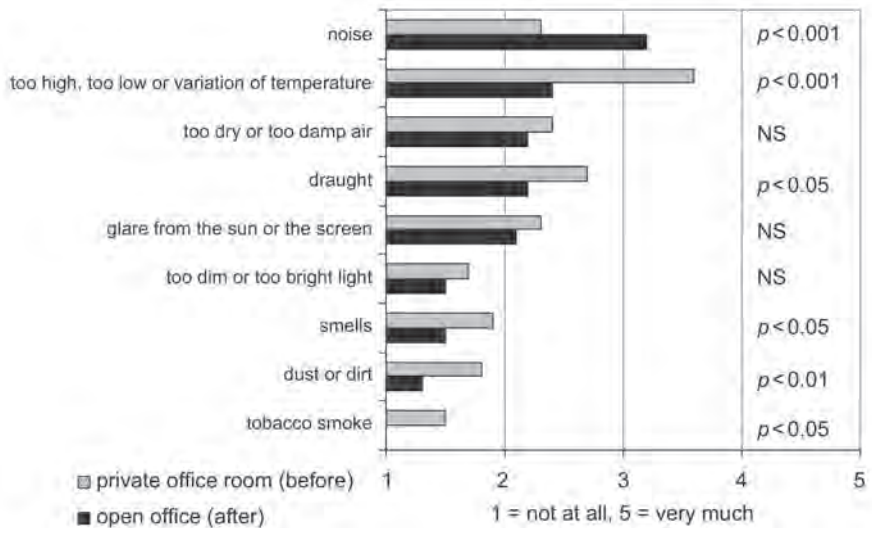

Figure 4: How much have the following indoor environmental factors disturbed you at your workstation during the last 3 months? Mean values and the significance of change (p-value)

Source: Kaarela 2009

V. Over-Treatment

It is possible to "overdo" acoustic baffling. Subjects perceived the noise in the constructed sound-absorbent office as louder than in the real open-plan office, even though the objectively measured sound level in the sound-absorbent office was lower. A possible explanation of this effect is that the acoustic treatment of the office reduces the overall noise level and therefore cancels the masking effect of noise from sources at a distance. The close sources become more apparent, which causes more annoyance, more disruption and an increase in dissatisfaction with noise in the space. (Balazonva 2008 8)

VI. KEY REFERENCES

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- "How to Get a Peaceful Hotel Room"- The Seattle Times
- "Noise Exposure is Becoming 'the New Secondhand Smoke'"- The Seattle Times
- "Designing a Home Without Disrupting the Land's Healing Energy" - The New York Times
- "Redesigned Window Stops Sound but Not Air, Say Material Scientists" - MIT Technology Review
- "Eco-friendly Insulation Offers Thermal Performance, Sound Absorption and Fire Resistance"- ArchDaily