Sound Thinking: Practice of Acoustics

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Tekton
Volume 4, Issue 2. September 2017
pp. 70 - 79

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In this practice essay, Roy brings into focus the issues of designing for sound in buildings, importance of which for a healthy indoor environment has not been properly understood and thus confined to a rarefied arena of highly specialized buildings like auditoriums. Acoustics and noise control must occupy our architectural sensibilities and in the absence of which any practice of architectural acoustics faces several challenges- some of which are elaborated in this essay.

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How aware are we of the sense of sound?

One can say with some certainty that the sense of 'seeing' is uppermost while developing architectural concepts during the design phase of a building. Also considered are climatic conditions, thermal comfort, inclusion of natural light and air within the spaces and a play of light and shadows. Upon further detailing the internal spaces, how much attention is paid to internal acoustics or comfort related to sound?

> *"From the very outset in any building development, the selection of the site, the location of buildings on the site, and even the arrangement of spaces within the building can, and often do, influence the extent of the acoustical problems involved. The materials and construction elements that shape the finished spaces will also determine how sounds will be perceived in that space as well as how they will be transmitted to adjacent spaces."*
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> -William J. Cavanaugh and Joseph A. Wilkes, Architectural Acoustics, Principles and Practice (1999).

There is a certain way the architectural education and practice focuses specifically on the sense of seeing though we talk a lot about the 'designing for the senses'. Before you read further, I invite you to try to recollect from your memory the following scenarios and select the appropriate response which will then define your level of comfort & experience.

A) Try completing a task in your work environment, assess the time taken to complete the same.

1. In an open plan office
2. In the conference room
3. At your workplace when a colleague's phone keeps ringing in the next cabin and you can hear her/him despite the doors being closed.

B) Listening to your favourite piece of music or work of your favourite musician.

1. In your office cabin
2. In your bedroom
3. In a car with windows closed
4. In the washroom
5. In a live in concert

C) Try meditating in one of the following spaces.

1. Inside a gym –a room with high ambient noise, impact noise of weights being handled or noisy air-conditioner.
2. In your bedroom with windows open to peak time traffic noise, honking or aircraft noise.
3. Outdoors in a silent environment with the sound of running water.

D) Try singing in one of the following spaces.

1. Bathroom
2. Living room
3. In a car with windows closed
4. A square room
5. A rectangular room
6. Under a dome ceiling

The experience in each of the scenarios mentioned above is subjective and cannot be generalized. Yet, they define a sense of general well-being. Aspects related to sound or aural comfort is a vital part of overall quality of indoor environments but is paid least attention. Acoustics impacts everything from

Image 1: *A community hall where corrective measures were implemented to reduce the high reverberation time that caused undesirable conditions and low speech intelligibility.*

how effective a teacher is in a classroom, or employee productivity in office settings, or

> **Aspects related to sound or aural comfort is a vital part of overall quality of indoor environments but is paid least attention. Acoustics impacts everything from how effective a teacher is in a classroom, or employee productivity in office settings, or performance quality in auditoriums, toeven the market value of apartments.**

performance quality in auditoriums, to even the market value of apartments. Acoustical design criteria for an office conference room will differ greatly from that of a primary school classroom. The acoustical parameters differ for every space based on its function. Recognizing this and designing for auditory comfort has tremendous value.

Built Environment and Acoustics

In the existing built environment, the users encounter several problems due to poor acoustics requiring an intervention. The chief benefit of acoustical consultation for an existing problem is the assurance of a solution that works from the outset, thus saving time and money because a client won't have to try multiple unsatisfactory solutions. In the case of any new construction or a building renovation,acoustical analysis can result in recommendations that avoid surprises once the building is in use.

> *"Since acoustical success is based on both objective measures and subjective impressions, guarantees cannot be made that all users will come to the same conclusion regarding the acoustic quality of a particular design. However, just as in judging the quality of architectural design, the risk of dissatisfaction is greatly minimized by applying good acoustical analysis and design in collaboration with the entire project design team."*
> - Excerpt from The Architect's Handbook of Professional Practice, 13th edition, 2000.

In the initial stages of design, the acoustic designer or consultant's advice would be vital to finalize the shape, proportions and noise control systems for a room. The target reverberation

Image 2: A listening setup specifically designed for an audiophile - Picture courtesy Chetan Vakharia

time can be ascertained to match the usage of the room. Designers can also simulate and assess the impact of wall angles, materials selection, and can predict what problems may occur.

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Identifying these issues early in the process at the design stage will allow changes to be made on the drawings rather than retrofitting completed construction at additional cost.

The acoustical design criteria depend on the program or function of each space. For example, a dedicated concert hall would need a very low noise criterion (NC-20) and the reverberation time relatively long (RT60 about 2.2 seconds). If the space is to be used for musicals that have reinforced sound systems, the criteria could be NC-25 with RT60 of 1.2 seconds. Which means that one solution cannot fit all purposes. There are common sense approaches to acoustical sensibilities in designing buildings which go a long way, yet the last mile requires technical expertise.

Noise control is important too. Similar criteria are established for determining how much outside sound can enter a space (or is allowed to escape it) without causing a problem. Again, the programmatic use of the space dictates the acceptable limits. An outdoor amphitheater that hosts music concerts next to a residential complex would require an extreme amount of sound mitigation, while an office building next to the same residential complex might not require any noise control measures.

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Acoustics in Architectural Practice

In India, there is a general lack of understanding about the technical nature of designing for sound amongst clients as well

Image 3: A mixing mastering studio. Picture Courtesy R. Roy

Image 4:Acoustic Assessments being done during mid-construction stages of a project

as architects. The practice of acoustics as a specialized field is not mainstream here but solution providers for the sound related needs are many. There are bye-laws and standards related to sound but are not specifically adhered to or even understood by the general practitioners in design or construction field. The guidelines and standards for acoustics in India (Indian Standard) had been laid out by a team of prominent scientists and faculty in the late sixties and seventies until the late seventies. Construction methods for interior spaces have changed with modular systems coming into place. Surprisingly,these standards haven't been revised or updated since. In most cases, the client ends up requesting the audio-visual consultants or providers of equipment to 'sort' the sound/noise related aspects within the space even though they might not be qualified to provide an effective solution.

Some practitioners within the field have backgrounds in science, maths, engineering or system integrators who are not specifically from the field of design & construction, but have gained good experience to deal with those related to it. However, architectural acoustics is an interdisciplinary field involving

many aspects of the arts and the sciences. A broad background is needed, including understanding of music, theatre, architecture, building construction techniques, and other disciplines inherent to the building design process. Electronic sound reinforcement and enhancement design requires further background in electrical engineering or electronics.

Major credit of creating an 'awareness' regarding the 'need for acoustics' in Indian context goes to the product vendors & manufacturers, who have made their presence known in the market mainly since the nineties. The need for acoustic intervention gained more popularity in India with the advent of commercial & corporate spaces that were largely based on 'column-free' office spaces – more popularly known as 'open-plan' spaces. The solution for controlling internal noise within such spaces was the need of the hour & modular ceiling tiles with absorption characteristics became the main selling point for most manufacturers. The products for building partition walls and false ceiling also evolved, taking into consideration the properties of the materials used in it. Suddenly parameters like NRC (Noise Reduction Coefficient) and STC (Sound Transmission co-efficient) made their way into product specifications. These single number values made it easier for consultants and architects to choose certain products based on the function of the space. The consultation came as 'complimentary' from the manufacturers to the architects based on the product line they were pushing to sell. There is also a need for isolation and privacy in office spaces which require efficient planning of services and construction methods.

Apart from office spaces, experts are required to plan, design and balance the acoustical and noise control solutions being proposed within purpose built indoor spaces for entertainment, theatre, healthcare and hospitality and even sports. Good examples are the Jamshed Bhabha Theatre and the Tata Theatre in Mumbai- they have been purpose built to host orchestral performances and musicals. The aural and visual sight lines have been worked out quite well here in these two performance spaces. Detailed assessments and tests are carried out periodically within these spaces to measure the parameters at every seat and constant enhancements are carried out for improvements as per the type of performance being hosted within.

> **In most cases, it is due to an insufficient budget that acoustical expertise is brought on board during the phase of execution or post-completion. When brought in at such a late point, a consultant may have to critique or evaluate a design that has reached finalisation instead of participating in its creation. The introduction of a new team member late in the process may also cause a rift in the working relationship among the project team members.**

Practice of Acoustics and its Challenges

As a practicing consultant, I have come across several projects that need correction after the project has been executed. In such projects, the limitations are plenty and the challenge is to meet the specific acoustic design criteria without altering the structure and aesthetics of the space. In most cases, it is due to an

Image 5: Environmental noise measurements to monitor road traffic noise and its impact.

insufficient budget that acoustical expertise is brought on board during the phase of execution or post-completion. When brought in at such a late point, a consultant may have to critique or evaluate a design that has reached finalization instead of participating in its creation. The introduction of a new team member late in the process may also cause a rift in the working relationship among the project team members.

The story doesn't end there, as the client comes with very limited budget but expects a considerable improvement. In such cases, it is necessary that the concerned space be assessed and interpreted in the form of technical reports before & after treatment. It is wiser to avoid any assumptions and the client be made clear before execution about the percentage of improvements that can be achieved within the specified budget. Auralization & simulation tools are an effective way to present the same, however very few clients understand the effort and man hours that go into working out an effective solution within these layers of limitations. For performing arts spaces such as theaters and auditoriums, qualified theatrical consultants should be considered for the design team right at the inception. A close working relationship between all consultants in a team is essential for proper co-ordination, revisions or modifications and the success of the final design.

There are also cases where a certain proposal has been worked out by acoustic consultant on the basis of the architect's aesthetic requirements for a project, the estimation of the project is finalized and the execution begins. But halfway through the project, the client decides to

Acoustically absorptive materials tend to be frequency-selective, which means that some materials will absorb only high frequency sounds while others will absorb both high frequencies and the mid-range frequencies that span human speech. It is important to ensure that the materials selected for wall coverings, window treatments, acoustical baffles etc. absorb the intended frequencies in just those areas where absorption is required.

enhance or change their requirements and the architect's team is advised to amend the acoustic construction details and specifications to make way for the new enhancements within the same budget. Since most of the infill treatment related to acoustics is hidden behind the surfaces and not visible, it is ignored and changed willy nilly. Acoustically absorptive materials tend to be frequency-selective, which means that some materials will absorb only high frequency

Image 6: Minimal and effective placement of acoustic elements within the room to achieve the best listening position in an Audio boutique at Goa. Picture courtesy - Roopak Bhagwat

sounds while others will absorb both high frequencies and the mid-range frequencies that span human speech. It is important to ensure

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that the materials selected for wall coverings, window treatments, acoustical baffles etc. absorb the intended frequencies in just those areas where absorption is required. There are other treatments like diffusers and reflective surfaces that split up the sound waves which would also be included within the design composition. Besides the acoustical properties that define quality of the space, we also must consider noise control & isolation within the acoustic design proposal to effectively reduce the transmission of external noise into the space and vice versa.

There are layers of information detailed out within a specific space and each time a revision is made in the acoustic proposal of a project, we are looking at a widely altered space with respect to the aural experience. The space simply wouldn't function the way it was designed to be thus making it prone to negative feedback by the end users. Most general contractors or execution teams are not trained to execute acoustical details, making it important to communicate to them what can go wrong if the designs are not properly implemented. Hence, the consultant has to plan strategically scheduled site inspections to inspect construction that is vital to sound isolation but may be covered up early in the construction process. Site visits for inspections are necessary to help contractors understand how

the construction details relate with the proper acoustics of the end product.

Better Future

Speaking about the present times, I would say that the situation is changing for the better. In last few years, I have personally observed a drastic change in the approach of architects and designers, I cannot comment if 'the positive change' is on a larger scale or only the people I have come across. Thermal conditioning, lighting and acoustics are specifically being planned before the commissioning of a well-designed project, the reason being there are quite a few global players that have entered the construction industry and the standards laid are quite stringent. The products are being specifically tested, certified and modified to withstand Indian conditions of temperature and relative humidity-factors which affect system performance.

In academia, acoustics is one of the most researched areas at the moment, and is being directly related to the health of teachers and students as well. Some of the references I generally use during my lectures or seminars are a couple of TED talks- 'Why architects need to use their ears' by Julian Treasure(2012) and 'Design with the blind in mind' by Chris Downey (2013). They have done their research on the numbers that quantify the need for acoustics to the general audience.

Unlike the previous decade, the product and material choices has also improved and many quality products are now available in India. With the increasing need, it also suggests that there will certainly be an improvement in the test facilities and services. A holistic design approach needs to be imbibed in the students which helps them to see the system as an interconnected whole. In which considerations of aural comfort (as well as thermal and visual comfort) are not relegated as just secondary to primary considerations in the problem solving aspect of architectural design.

The scenario is changing for better and the ear is also gaining a place in the domain where the eye has been ruling over the years' (pun intended). ■