

Study on Effective Usage of New Construction Materials to Reduce the Construction Time and Cost Along With an Optimal Acoustic Condition

Abraham Samuel

Student, Civil, S.R.M. University, Chennai, India

ABSTRACT: Various means of adopting cost and time effective construction techniques are available. The project study mainly focuses on the acoustic construction scope and features of various acoustical materials like sound absorbers, sound diffusers, noise barriers and fabrics. Each material have its own attributes that can provide the environment better dimensions of handling noise pollution if appropriately and optimally utilized. The study also brings insight on new technologies used in Acoustic construction. The scope of the project is to bring out cost and time efficient techniques in construction. Learn the techniques for producing better output levels of sound in a building and optimum utilization of acoustic materials for positive sound usage in buildings. This project also provides scope to perform a comparative survey of conventional building construction and acoustical building construction and finding out means to reduce distortion, echoes and vibration in a building.

KEYWORDS: Acoustic construction, noise barriers, sound absorbers, sounds diffusor.

I. INTRODUCTION

Reduction of the cost of construction is a constant goal for the building industry. One way of reducing the construction cost of buildings is to develop building technologies that will give increased productivity, reduced construction time at the building-site and waste of materials and resources has to be reduced. Improvement of construction management not only can aid the construction industry, but may also be the engine for the national and world economy. If we are to make meaningful improvements, we must be able to manage its operating environment and the institutional constraints affecting its activities like the cost and time constraints.

One goal of acoustical construction is the reduction of unwanted noise, which is referred to as noise control. Unwanted noise can have significant impacts on animal and human health and wellbeing, reduce attainment by pupils in schools, and cause hearing loss.

II. MATERIAL AND METHODOLOGY

A. Sound Absorbers

i. Acoustical foam panels

Acoustical foam panel attenuates airborne sound waves by increasing air resistance, thus reducing the amplitude of the waves. The energy is dissipated as heat. The objective of acoustic foam is to improve the sound quality by removing residual sound in any space.

Acoustical foam typically deals more with the mid and high frequencies. To deal with lower frequencies, much thicker pieces of acoustic foam are needed; large pieces of acoustic foam are often placed in the corners of a room and are called acoustic foam corner bass traps

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ii. White paintable acoustical wall panels

These Paintable Surfaced Acoustic Panels help to absorb sound to slow down echo and reverb within a room.

The method of installing this type of products requires dealers to draw vectors outward from the center-channel speaker in a home theater setting to the nearby walls and seating area to control first-order reflections. There are so many brands of acoustical panels in the market today that it can be quite confusing to choose which one will serve you well. But the important thing to remember is you pick what you can afford and what blends well with the design theme of your room. Acoustic panels are effective in absorbing sound and controlling noise.

iii. Fabric wrapped panels

Fabric wrapped panels with Air Renew technology improve indoor air quality by removing potentially harmful VOCs from the air. When acetaldehyde, ammonia or formaldehyde come in contact with a fabric wrapped panel, a unique chemical reaction takes place and the potentially harmful pollutants are rendered harmless, improving indoor air quality. Mount panels to walls using mechanical, adhesive, magnetic or hook and loop fastening.

iv. Acoustical wall coverings

A few key points to be noted are

- When selecting wall coverings the first variable to consider is the amount of traffic the area will receive.
- Paper and natural wall coverings are most appropriate where traffic is minimal. They are more delicate than their vinyl counterparts yet offer ample durability and a special style to a variety of placements.
- Vinyl and synthetic textiles, with their maximum durability and ease of cleaning, are especially appropriate for hospitals, sporting arenas, schools and other high traffic situations.
- While wall coverings are categorized by residential and contract segments, it is not uncommon to use residential wall coverings in contract settings, like assisted living facilities for a homey feel, for instance, or to use contract wall coverings in some of today's more avant-garde homes.

A special category of wall coverings is used in highly specialized circumstances or for areas of light traffic. Many of these types of wall coverings have been replaced by vinyl wall coverings that simulate the same look with greater durability. Nonetheless, many of the types of wall coverings outlined below have historical importance, and can be produced by specialty manufacturers or custom firms. They are highly decorative, and appropriate for use in any contract area where a dramatic look is desired.

String Effects – wall coverings that have very fine vertical threads laminated to a paper type substrate. Most suitable for offices, boardrooms and areas of light traffic.

Natural Textile Wall coverings – natural textiles usually laminated to a backing to enhance dimensional stability and to prevent the adhesive from coming through to the surface. These backings are usually acrylic or paper. Textiles are manufactured in a variety of widths and are constructed of natural fibers. Natural textiles can be finely designed or coarse in texture depending on the desired look.

Polyolefin/Synthetic Textile Wall coverings – woven and non-woven looking wall coverings developed to give the aesthetic appearance of a natural textile while adding an increased value in stain and abrasion resistance. These products are generally put up with an acrylic or paper backing. Many of these products are comprised of polyolefin yarns, which are olefin fibers made from polymers or copolymers of propylene. These types of wall coverings are appropriate for higher traffic areas.

Acoustical Wall coverings – designed for use on vertical surfaces, panels, operable walls and any place sound reduction is a primary factor such as meeting rooms, offices, theaters, auditoriums, restaurants as well as corridors and elevator lobbies. These products are predominantly made of man-made polyester and olefin fibers, and are tested for a special sound absorption rating known as a Noise Reduction Coefficient (NCR) rating. This rating indicates the amount of sound absorbed into the wall. The higher the number, the more noise absorption.

Cork and Cork Veneer – it comes with variegated texture with no definite pattern or design. Cork veneer is shaved from cork planks or blocks and laminated to a substrate that may be colored or plain. Offers some degree of sound resistance; can be used as bulletin boards.

Digital Wall covering – Borders, Murals, and Wall covering. Unlimited supplies of designs, ideas, and colors. Digital wall coverings allows the person the freedom to express any theme, style or design on a ground of their choice.

Wood Veneer – wood wall coverings mostly laminated to fabric backing. They are usually made in sheets 18 to 24 inches wide and provided in any length up to 144 inches long. Due to characteristics relative to environmental and

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grain matching, wood veneers are used mostly in the office or conference room environment along with some other specialty areas, such as large columns.

Foils – a thin sheet of metallic material with a paper or fabric substrate. It was popular in the 1960s and 70s. Require a very smooth surface and extreme care when installing. Usage is limited; highly decorative.

Mylar (by DuPont) – wall coverings ground made of vacuum-metallized polyester film laminated to a substrate. It offers a highly reflective surface with an appearance similar to foil with less stiffness.

Flocks – resemble cut velvet and very popular in the 16th and 17th centuries. It was popular in the 1970s. It is produced by laminated shredded fibers to paper, vinyl, Mylar or foil. It is highly decorative, period wall coverings; limited abrasion resistance and used in low traffic areas.

Underliner – blank stock-type wall coverings. It comes in different weights such as light, medium and heavy. It can be plain paper stock or a non-woven type material. Liner can be used on almost any wall surface, such as plaster, sheetrock (drywall), paneling and cinder block. Its purpose is to provide a smooth surface for the installation of wall coverings.

v. Ceiling tiles

The advantages of using acoustic ceiling panels are that these products are highly sound absorbent, they take away the harshness out of your hard ceilings, they reduce echo, they improve the quality of sound in your rooms, they reduce noise levels that permeate from one storey of the building or house to another, they are humidity and fire resistant, the suspended ceilings also offer coverage of unsightly wires and pipes and provide easy accessing the event of repairs or remodelling work at homes.

vi. Acoustic baffles and banners for ceiling

Acoustic ceiling baffles and banners can be hung from existing ceiling structures in a wide variety of applications to reduce room reverberation and control echo. Acoustic Banners are high efficiency flexible banners that provide exceptional sound absorption in comparison to their cost.

The most economical are the PVC covered baffles that can be used in restaurants, indoor swimming pools, animal shelters, gymnasiums, and many more. applications..

vii. Fibre glass blankets and roll

These fibre glass blankets are fire resistant, and won't settle over time. They are good for retrofitting an attic if there isn't a lot of obstructions, just lay it on top of the existing insulation, and take care not to leave gaps or skimp out around the eaves. Fiberglass is inexpensive when compared to cotton batts, spray-foam or rigid insulation.

B. Sound Diffusors

Diffusors are used to treat sound aberrations in rooms such as echoes. They are an excellent alternative or complement to sound absorption because they do not remove sound energy, but can be used to effectively reduce distinct echoes and reflections while still leaving a live sounding space. Compared to a reflective surface, which will cause most of the energy to be reflected off at an angle equal to the angle of incidence, a diffusor will cause the sound energy to be radiated in many directions, hence leading to a more diffusive acoustic space. It is also important that a diffusor spreads reflections in time as well as spatially. Diffusors can aid sound diffusion, but this is not why they are used in many cases; they are more often used to remove coloration and echoes.

i. Quadra pyramid diffusors

This diffuser generates a uniform polar response over a broad frequency range using a pre-rotated pyramidal pattern to create 16 angles of reflection

ii. Pyramidal diffusors

Pyramidal diffusors quickly and easily eliminate floor to ceiling standing waves. They reduce flutter echo while maintaining a warm room sound. Molded in a one-piece pyramid shape, their offset apex provides four different angles of reflection.

iii. Maximum length sequence diffusors

Maximum length sequence based diffusors are made of strips of material with two different depths. The placement of these strips follows an MLS. The width of the strips is smaller than or equal to half the wavelength of the frequency where the maximum scattering effect is desired

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C. Noise Barriers

The acoustical science of noise barrier design is based upon treating an airway or railway as a line source. The theory is based upon blockage of sound ray travel toward a particular receptor; however, diffraction of sound must be addressed. Sound waves bend (downward) when they pass an edge, such as the apex of a noise barrier. Further complicating matters is the phenomenon of refraction, the bending of sound rays in the presence of an inhomogeneous atmosphere. Wind shear and thermocline produce such inhomogeneities.

i. Noise barrier composites

Barrier Composites are thin, rugged, high-performing, flexible acoustical quilt and vinyl composites designed to solve noise control applications where sound absorption and sound blocking must be increased.

ii. Vibration control

Vibration control products are used to absorb vibration energy and prevent structural noise transmission. These include vibration damping compounds and vibration pads, isolation hangers, and resilient clips.

Types of barriers

- Precast reinforced concrete post and panel systems are preferred; however, if unusual site conditions prohibit the use of a post and panel system, another noise barrier type may be considered (such as aluminum or lightweight proprietary systems for bridges). Determination of the type of barrier and architectural treatments to be used at a site prior to the design of the barrier will be made by the Authority. The Designer shall obtain the necessary information regarding barrier type and architectural treatments from the Authority and shall refine and incorporate this information into the design.

- In most cases, foundations for noise barriers shall be drilled shafts; however, in cases where shallow rock formations exist, spread footings will be unavoidable. The designer shall select the most cost-effective foundation based on a thorough geotechnical investigation. Noise barriers on bridges shall be mounted on the parapets or attached directly behind the parapet. In a retrofit or rehabilitation situation, where it is determined that the existing or rehabilitated structure cannot accommodate the noise barrier loading, a separate supporting structure for the noise barrier may be considered. Sound leakage between the parapet and noise barrier shall be prevented by the use of flashing or other mechanical means.

- A number of proprietary sound barrier systems are available for use on bridges or where unusual site conditions prohibit the use of a post and panel system. The materials, load carrying mechanisms and capabilities vary with each system; however, these systems shall conform to the criteria outlined in Subsection I as well as the current Standard Specifications and applicable project Special Provisions. Proprietary wall systems shall be approved prior to the design of the barrier.

3.3.2. VIBRATION CONTROL

Vibration control products are used to absorb vibration energy and prevent structural noise transmission. These include vibration damping compounds and vibration pads, isolation hangers, and resilient clips.

The Vib-X Vibration Isolation Pad absorbs vibration energy and thus prevents the transmission of shock or vibration from one surface to another surface. Vib-X Padding may be used to mount noisy machinery or to attach an independent 'floating' stud wall for room-within-a-room isolation.

The cross-ribbed construction acts as an efficient energy absorber, enabling large horizontal forces to be generated without slippage or "walking" occurring.

- Reduces structure borne acoustic noise
- Decouples machinery vibration from structure
- Floats sound studio and theater walls
- Easy to cut to size with common tools

IsoHangers are used to absorb vibration energy and help prevent the structural transmission of sound. They can be used to hang speaker boxes, ceilings and ceiling grids, air ducts and piping. They're constructed of 11 gauge cold drawn steel wire and zinc plated to prevent corrosion. It include rubber collar to prevent metal to metal contact. It has clearance for 3/16" diameter rod.

Resilient clips improve sound transmission loss, reduce impact noise and structural noise transmission in most ceiling and wall constructions. Resilient clips are used to isolate using standard furring channels (hat track) when mounting gypsum board, drywall, or sheetrock. Resilient Clips eliminate the need for RC-1 and other acoustical mats and can

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improve STC up to 20 points.

Floor Underlayment provides floor isolation to prevent sound transmission, structural noise transmission and impact noise. Floor underlayment is constructed of a flexible non-lead loaded solid mass barrier fusion-bonded to a ¼" 8-10 lbs. density closed-celled PVC foam decoupler. The foam layer of this carpet underlayment decouples the layers of floor materials to prevent floor vibrations from transmitting structural or airborne sounds from noise sources.

Vib damp vibrating surfaces are often dampened by applying visco-elastic materials directly to the surface, thus converting the vibration energy to heat. The flexing of the damping material provides the energy dissipation and "decay" to reduce noise. Metal no longer "rings" when it is struck or excited by airborne noise.

D. Fabrics

i. Sound channels wall fabric

Acoustic fabrics are simply versatile, easy to retrofit, cost-effective with outstanding noise absorption qualities. Acoustic fabrics can be wrapped on acoustic board and other panel materials like other fabrics they may find in the acoustic market. However, it is developed to also uniquely be fitted to any solid wall and still achieve outstanding NRC values. The clear advantages of acoustic fabric are its simple easy, installation and ability to retrofit in virtually any existing commercial space as well as it is inexpensive. Where speech intelligibility is critical, this fabric is an excellent choice for any conference room, classroom, commercial or office space.

ii. Guilford of maine

This type uses 100% polyester fabric and it is acoustically transparent. It is post-consumer recyclable and cost effective. These fabric are high performance fabric. They have aesthetic benefits along with their varied acoustic aspects.

III. COST EFFECTIVE APPROPRIATE TECHNOLOGIES

A. Rat-Trap Bond Technology

The rat trap bond is a masonry technique, where the bricks are used in a way which creates a cavity within the wall, while maintaining the same wall thickness as for a conventional brick masonry wall. While in a conventional English bond or Flemish bond, bricks are laid flat, in a Rat trap bond, they are placed on edge forming the inner and outer face of the wall, with cross bricks bridging the two faces. The main advantage of Rat-trap bond is reduction in the number of bricks and mortar required as compared to English/Flemish bond because of the cavity formed in the wall. Thus in acoustic construction it proves to help reduce the raw material cost.

B. Filler Slab Technology

Filler slab is a variation of conventional reinforced cement concrete slab in which part of the concrete is replaced with a filler material which can be a waste material to ensure economical advantage.

C. Aluform Technology

Aluform technology is majorly used technique in current construction scenario; it is simple and easily adaptable. Due to the easy adaptation of the technique it is very suitable for the Indian construction as it is labour intensive and India has abundant labours. The formwork is pre-engineered and pre-planned to the finest details. Being made up of aluminium, it is light weight and can be easily carried manually. This technique leads to a monolithic construction, where walls, columns and slab are cast in one continuous pour. It involves initial investment for manufacturing of forms but due to its higher repeatability than the conventional formwork (around 250) it is more feasible.

D. Gypsum Area Separation Wall

Gypsum panel products shall not be used where there will be direct exposure to water or continuous high humidity conditions. Such areas include but are not limited to saunas, steamrooms, gang shower rooms, and indoor pools. Gypsum panel products shall not be used where they will be exposed to sustained temperatures of more than 125°F (52°C) for extended periods of time. In single layer gypsum panel product systems, end joints parallel to and on the same side of framing members shall be staggered between alternate courses of gypsum panel products and from joints on the opposite side of the framing.

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E. Polypropylene Fibre

Polypropylene is the first stereo regular polymer to have achieved industrial importance. The fibres from Polypropylene were introduced to the textile arena in the 1970s and have become an important member of the rapidly growing family of synthetic fibres. Today Polypropylene enjoys a fourth spot behind the “big three” fibre classes, i.e. polyester, nylon and acrylic. However, as opposed to other commodity fibres, its use as apparel and household textiles has been rather limited; the bulk of the fibre produced is used for industrial applications.

F. Steel Fibre

Steel fibres are short, discrete lengths of steel with an aspect ratio from about 20 to 100, and with any of several cross sections. Some steel fibres have hooked ends to improve resistance to pull out from a cement-based matrix. Various types of steel fibre like Hooker end steel fibre, Round steel fibre and flat crimped steel fibre

G. Glass Fibre

Glass fibre also called fibreglass. It is a material made from extremely fine fibres of glass. Fibreglass is a lightweight, extremely strong, and robust material. Although strength properties are somewhat lower than carbon fibre and it is less stiff, the material is typically far less brittle, and the raw materials are much less expensive. Its bulk strength and weight properties are also very favourable when compared to metals, and it can be easily formed using moulding processes. Glass is the oldest, and most familiar, performance fibre. Fibres have been manufactured from glass since the 1930s.

H. Carbon Fibre

Carbon fibre is the reinforcement material of choice for “advanced” composites. Carbon fibre exhibits excellent fatigue resistance which will not suffer from stress rupture compared with other fibres. Carbon fibres can be supplied in tows and may vary from 1000 fibres per tow to hundreds of thousands per tow. Untreated carbon fibres do not wet easily, so adhesion to the matrix will be achieved by mechanical interference coupled with surface treatment and chemical bonding between the fibre and the matrix.

IV. AREAS OF ACOUSTICAL CONCERN

A. Sound Isolation

The doors, window walls, floors, ceilings and ventilation ducts are often at the root of the sound isolation problems.

B. Interior Room Acoustics

i. Loud rooms

Sound absorption panels, when properly applied, are a way to quiet a room. To be effective across a broad frequency range they should be at least 3" thick can be used. Absorptive panels are also used to treat a number of other acoustic problems and must always be used in conjunction with diffusive surfaces.

ii. Boomy, bass-heavy room

Installing absorption panels at least 3" thick can be effective. The thicker the absorber, the more the loudness of bass frequencies is reduced.

C. Mechanical Noise

Ductwork that is channelling sound can be quieted with sound absorptive linings or baffles called “sound attenuators”. Quietening noisy light transformers and ballasts is easy and saves energy.

i. Doors and windows

The doors which are not sound rated must be replaced with sound-rated products. For poorly constructed doors, it is possible to increase the sound isolation ability by adding mass with materials like 3/4" plywood or sheet metal applied to both sides. There may be interference with the lever set, hinges and jamb. To eliminate sound leaking through a single pane of glass, consider adding a second pane of laminated glass. Use glass that is at least 1/4" thick and separate the two panes as far apart as possible.

ii. Ceiling, floor and ventilation

Sealing the walls at the ceiling, floor and around window and door frames is very important and often overlooked during construction. These gaps can be as large as a few inches or just a fraction of an inch and are often hidden under trim strips. For large gaps, usage of material that is dense and solid — like gypsum board as opposed to just stuffing

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the space with fiberglass would be appropriate. For small gaps the only solution may be a silicone caulking.

D. Reverberation

When a sound stops abruptly, the sound level in the room takes some time to drop to background levels.

E. Sound Absorption

To reduce reverberation, sound-absorbing materials are placed in the room or on its surfaces. Typical materials that absorb sound are carpets, ceiling tiles and furnishings. Calculating reverberation time for an ordinary room from the sound absorptions of the materials placed in it is a comparatively simple procedure. However, in many rooms (classrooms, meeting rooms, etc.) the placement of the material is important. Special spaces, such as open-plan offices, concert halls and drama theatres need expert consideration of how sound propagates in the space and the correct positioning of sound-reflecting and sound-absorbing materials.

The rating used to rank sound absorbing materials is the sound absorption average (SAA). The same material with different air cavities behind it can provide quite different SAA values, so a method of installation for testing must be specified that is similar to the intended final installation.

V. CONCLUSION AND FUTURE ENHANCEMENT

A short observation was done on the various means of reducing unwanted sound and noise. New technology of acoustic construction was learnt along with various acoustic materials which can be alternately used with competitive advantage. Factors such as time and cost of installation was also observed and conclusions were derived on various produced and technologies that could be used to reduce the same. Further studies can be done to find out the latest acoustical improvisations that could be implied.

REFERENCES

- [1] L. Beranek, H. Sleeper, "The Design and Construction of Anechoic Sound Chambers", The Journal of the Acoustical Society of America, 1946.
- [2] Oded Hochman, "Costs of Adjustment and Demolition costs in Residential construction and their effects on Urban growth", Journal of urban economics, Vol. 7, Pp. 2-19, K.M., 1980.
- [3] E. Cremer et al., "Principles and Applications of Room Acoustics", London: Applied Science Publishers, 1982.
- [4] T. Williams, "Predicting changes in construction cost indexes using neural networks", Journal of construction engineering and management, ASCE, Vol. 120, No. 2, pp. 306-320, 1994.
- [5] S. Dai, and J. Labuz, "Damage and Failure Analysis of Brittle Materials by Acoustic Emission." J. Mater. Civ. Eng., 9(4), 200-205, 1997.
- [6] D. Blackstock, Fundamentals of Physical Acoustics, Wiley, 2000.
- [7] S. Kumar, "A perspective study on fly ash-lime-gypsum bricks and hollow blocks for low cost housing development", Construction and building materials, Vol 16, Pp. 519-525, 2002.
- [8] T. Ijatuyi Olufunto, J. Oyeku Mobolaji, O. Odubena Olawale, "Acoustic Properties Of Building Materials", 2003.
- [9] R. Muehleisen, C. Beamer IV, B. Tinianov, and D. Houghland, "Acoustic and Illumination Design of Conference Rooms", Architectural Engineering 2003: Pp. 1-5, 2003.
- [10] D. Bradley, and L. Wang, "Room Acoustics in Coupled Volume Spaces", Building Integration Solutions: Pp. 1-6, 2006.
- [11] R. Maran, S. Rajendran, S. Kalidindi, "Material cost & escalation clauses in Indian construction contracts", Proceedings of ICE-construction materials, Vol. 164, Issue 2, Pp. 95-108, 2011.
- [12] C. Boutin, "Effect of Inner Resonators on Acoustics of Rigid Porous Media", Poromechanics, Vol. 2, Pp. 1973-1980, 2013.
- [13] D. Calquin, and M. Trebilcock, "Using Building Performance Information in the Design of Floor Plans", Computing in Civil and Building Engineering: Pp. 609-616, 2014.
- [14] Matthew J. Patterson, "Recent Changes To The Sound Insulation Provisions Of The Building Code Of Australia", 2014.
- [15] Anuja Rajguru And Parag Mahatme, "Effective Techniques In Cost Optimization Of Construction Project: An Review", 2015.