A

Seminar report

On

NOISE CONTROL OF BUILDINGS

Submitted in partial fulfillment of the requirement for the award of degree
Of Civil

SUBMITTED TO: **SUBMITTED BY:**

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Acknowledgement

I would like to thank respected Mr…….. and Mr. ……..for giving me such a wonderful opportunity to expand my knowledge for my own branch and giving me guidelines to present a seminar report. It helped me a lot to realize of what we study for.

Secondly, I would like to thank my parents who patiently helped me as i went through my work and helped to modify and eliminate some of the irrelevant or un-necessary stuffs.

Thirdly, I would like to thank my friends who helped me to make my work more organized and well-stacked till the end.

Next, I would thank Microsoft for developing such a wonderful tool like MS Word. It helped my work a lot to remain error-free.

Last but clearly not the least, I would thank The Almighty for giving me strength to complete my report on time.

Preface

I have made this report file on the topic **NOISE CONTROL OF BUILDINGS CONCRETE;** I have tried my best to elucidate all the relevant detail to the topic to be included in the report. While in the beginning I have tried to give a general view about this topic.

My efforts and wholehearted co-corporation of each and everyone has ended on a successful note. I express my sincere gratitude to …………..who assisting me throughout the preparation of this topic. I thank him for providing me the reinforcement, confidence and most importantly the track for the topic whenever I needed it.

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INTRODUCTION

The acoustical design issues for buildings involve the principal issues like site noise considerations, including the control of noise transfer to a project's neighbours, particularly if they are residential, establishing noise standards for each use space, including limitation of excessive ventilation noise, room acoustics considerations, sound isolation between various use spaces, vibration control for mechanical equipment, audio/visual system considerations.

Building planners should develop objective acoustical standards for library projects as an important component of the project program. The information contained in this article about library acoustics is intended as a source for these standards.

As the architectural and engineering design of the project evolves, the design should be reviewed in light of the agreed upon acoustical programmatic requirements for the building project. Since acoustics is typically not a code requirement, a city or state building official cannot be expected to comment on the correctness of the acoustical design in the contract documents.

Therefore, it is the responsibility of the facility's planners, user groups, architects, engineers, and others involved with the project to assure that the project acoustical needs are delineated and that there is follow-through, particularly for verification testing after the ventilation system has been installed and balanced.

Sound and Noise

Sound waves in air result from a physical disturbance of air molecules, such as when a truck drives by a building or when guitar strings are plucked. Sound waves combine and reach a listener via numerous direct and indirect pathways. The listener's inner ear contains organs that vibrate in response to these molecular disturbances, converting the vibrations into changing electrical potentials that are sensed by the brain, allowing hearing to occur.

Acoustical analysis involves not only the sound source but also the listener and everything in between on the path of the sound. The perception of the receiver can be influenced by the treatment of either the path or the source. Some source sound is desirable, for example a lecturer's voice, and some source sound is undesirable, such as the sound output from an idling truck outside a window. Undesirable sound is usually called noise.

Unless it is a pure tone, a sound wave is typically made up of vibrations at different frequencies. Like the impact of a stone in a lake, ripples in the water are created that are analogous to sound in the air. The frequency is basically the number of waves that pass a single point in one second, moving at the speed of sound in air. One wave per second is a frequency of one hertz (Hz). A frequency of 1,000 hertz is a kilohertz (kHz).

Human speech contains frequencies between 200 Hz and 5 kHz, while the human ear can actually hear sound generally between 25 Hz and 13 kHz, a wider range. Frequencies below 20 Hz can be sensed as a vibration, though not audible to most people.

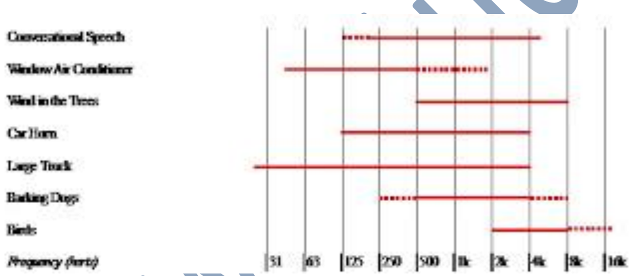


Figure2.1 Frequency Range of Typical Sound Sources.

Sound and noise are described using a metric called the decibel. The decibel scale is logarithmic, similar to the Richter scale used to describe seismic events, and translates a wide range of sound pressure levels that affect the human ear to a logarithmic scale. The range of decibels most commonly encountered in acoustics extends from 0 to 140 dB. Figure 2.2 correlates the sound pressure levels of common sound sources to the logarithmic decibel scale.

Sound pressure (Pa)	Sound pressure level (dB)	Example sound source
200.0	140	Threshold of pain
20.0	120	Near a jet aircraft engine
2.0	100	Near a jackhammer
0.2	80	Typical factory
0.02	60	Normal speech level
0.002	40	Quiet living room
0.0002	20	Quiet recording studio
0.00002	0	Threshold of hearing

Figure 2.2 Comparison of sound pressure and dB SPL for typical sound sources.

When designing new library buildings or correcting deficiencies of existing library spaces, materials and constructions are selected to control noise and other unwanted sound. The human ear does not perceive all frequencies of sound to the same degree, however, being less sensitive to lower frequency sound pressures than to middle or higher frequency sound pressures. People tend subjectively to measure their perception of the loudness of sounds based more on the SPL of these middle and higher frequency sounds. Design criteria and sound measurement devices are therefore weighted toward these upper frequencies in order to reflect the subjective perception of people in the space.

The term dBA, or A-weighted decibel, is often used to describe noise levels in spaces because this type of decibel measurement averaged over the range of frequencies within the range of hearing correlates well with people's subjective perception of the loudness of the noise. Sound level meters, which average the SPL across frequencies, usually have a setting for A-weighting, so that measured noise levels correlate to the human perception of the differences in noise level.

The NC Rating is an acoustic design criterion for the target level of background noise in a room. This criterion is based on the fact that human hearing is less sensitive to lower frequencies than to higher frequencies, so that a specific criterion for the SPL of background noise in a space varies with the frequency of the noise spectrum. Figure 2.3 shows the Noise Criteria (NC) used in acoustic design. The loudest frequency region of the background noise sets the NC-curve that applies to the space.

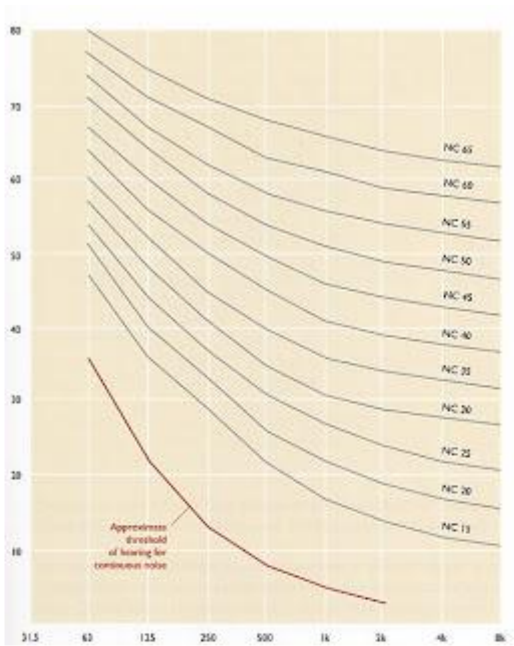


Figure 2.3 Noise Criteria Curves.

To meet the criteria of NC-25, for example, the measured loudness of all frequencies must fall at or below the NC-25 curve.

A new building program should list the acoustic criteria for each space. These criteria will usually include an NC Rating requirement, which depends on the appropriate level of background noise to the tasks and activities in the space. Some typical NC Ratings for library spaces are given in Figure 2.4.

Space Type	NC Rating
Open Public Areas (Circulation, Reference)	35-40
Computer Work Areas	40
Private Offices	30-35
Open Staff Work Areas	35-40
Copy Rooms	40
Teleconference Rooms	max 25
Reading Rooms	25-30
Classrooms, Training Rooms	25-30

Figure 2.4. Typical recommended background noise levels in public spaces.

ROOM ACOUSTICS

Room acoustics pertains to the physical characteristics of a space for the hearing of direct and reflected sound. In libraries, the principal issue for room acoustics is speech intelligibility and control of background noise levels. Rooms with a high level of reflected sound may have poor room acoustics depending on the use of the room since the persistence of the sound creates unwanted background noise and interferes with the ability to understand speech. Such rooms are said to have a high reverberation time, the time required for the sound to be absorbed gradually and reduced below hearing levels.

Therefore, design principles for room acoustics in library spaces typically focus on the locations and extent of sound absorbing material, to reduce reverberation and the interference with speech, as well as the shape of rooms to achieve acceptable acoustic characteristics in meeting and presentation rooms.

Multi-purpose rooms require special room acoustics design since these spaces often must accommodate speech and musical activities at different times. For speech activities, the reverberation time should be low enough to allow syllables of parts of speech to be readily understood. Longer reverberation time is preferred for musical functions, since the musical sounds need to reverberate properly. A room having reverberation time of more than 1.5 seconds may be acceptable for music listening but would probably create interference with speech intelligibility. A room having a reverberation time of less than 1 second would probably be judged acceptable for speech intelligibility but musicians may complain about the room being too “dead”. The different methods of noise and sound control in buildings are

Sound Absorption

All materials have some sound-absorbing properties. Sound energy that is not absorbed must be reflected or transmitted. A material’s sound-absorbing property is typically described as a sound absorption coefficient at a particular frequency range. Sound absorbing materials used in buildings are rated using the Noise Reduction Coefficient (NRC), which is basically a type of average of sound absorption coefficients from 250 Hz to 2 kHz, the primary speech frequency range. The NRC theoretically can range from perfectly absorptive (NRC = 1.0) to perfectly reflective (NRC = 0.0).

Adding sound-absorbing materials to a space usually becomes an interior design issue in the library. Many options are possible to provide sound absorption on walls and ceilings, which are attractive and maintainable. Absorptive materials are often covered with acoustically transparent surfaces such as fabric, perforated metal and spaced wood slats. These surfaces allow the sound energy to pass through and be absorbed by the material located behind. Figure 3.1 shows the example of a wood slat panel treatment that effectively screens the acoustic blanket and creates a handsome ceiling in a public area.

Perforated metal panels, as shown in Figure 3.2, are commonly used to create a certain finish appearance. For best results, the material should be as thin as possible, with the smallest hole diameter and the greatest open area (the greatest number of holes).

Some absorptive materials are attractively designed to be exposed to view, such as normal suspended ceiling tiles. Generally, thicker porous materials provide better sound absorption. 5/8-inch thick ceiling tiles have an NRC of 0.50 when mounted in a lay-in grid ceiling. A 1-inch thick glass fiber ceiling tile can have an NRC rating of 0.80 or greater. Figure 3.3 illustrates the appearance of a suspended acoustical tile ceiling.

Another approach to adding acoustic absorption to the space is to suspend acoustic baffles as shown in Figure 3.4

Figure 3.1 Wood slat ceiling.

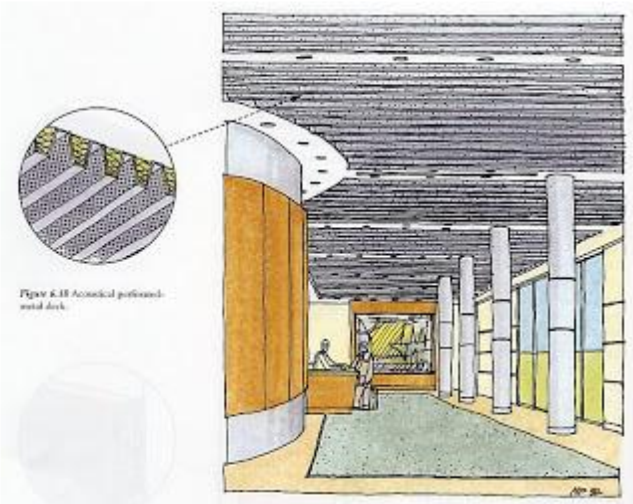


Figure 3.2. Acoustical perforated-metal deck.

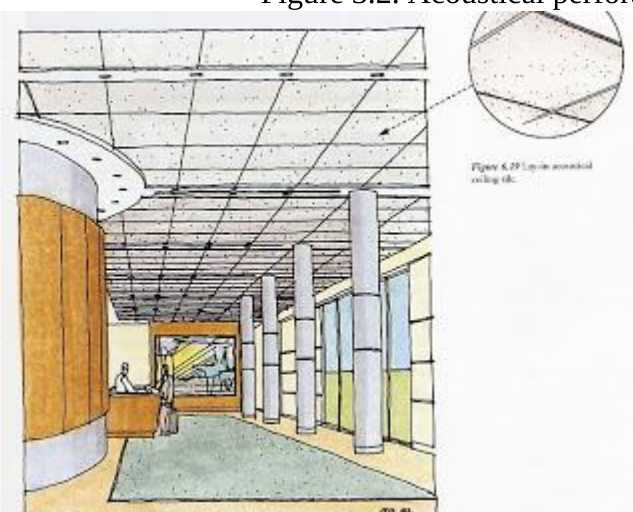


Figure 3.3 Lay-in acoustical ceiling tile.

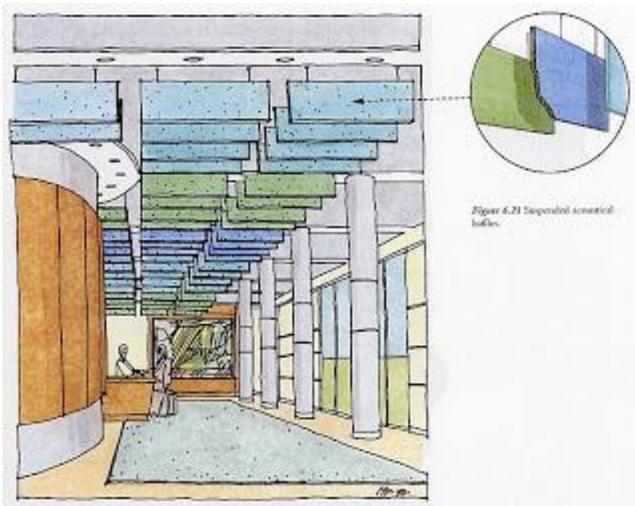


Figure 3.4 Suspended acoustical baffles.

Open-cell foam panels are effective sound absorbers because they have increased surface area due to the contoured surface of the foam. Figure 3.5 illustrates an application near an open copy machine area. Figure 3.6 shows another type of fabric-covered absorptive material.

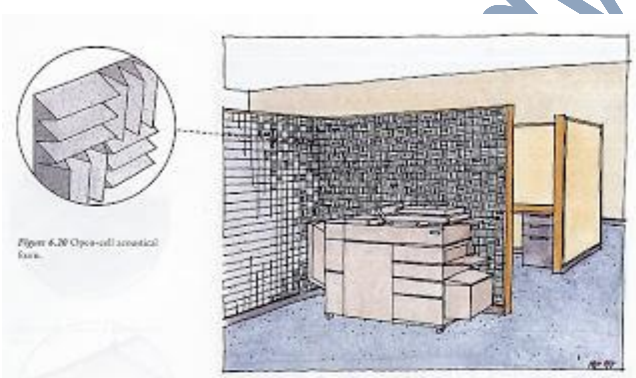


Figure 3.5 Open-cell acoustical foam.

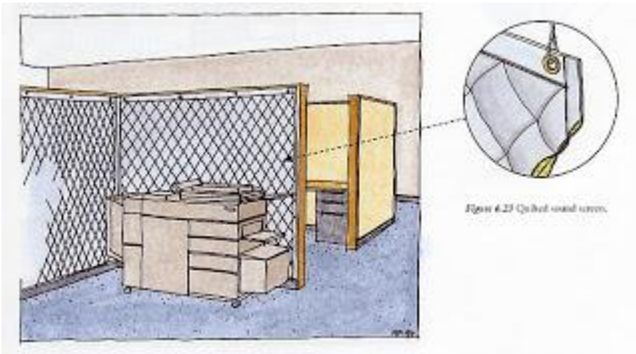


Figure 3.6 Quilted sound screen.

Sound Insulation

Everyone has experienced unwanted sound intrusion – a television in the next room, a loud neighbour walking on the floor above, or a jet flying over. Measures are often required to reduce intrusive noise. One of the most essential techniques in acoustics is reducing the transmission of sound through solid barriers in buildings. This form of sound reduction is referred to as Sound Insulation.

Principles of Sound Insulation

The reduction of sound energy from one building area to another by absorbing it or reflecting it with an intervening solid panel of material is called sound transmission loss (TL). Typically, building materials attenuate more high frequency noise than low frequency noise. The higher the mass or weight of a wall, the more force is required to make it vibrate. For this reason a massive wall has higher TL at all frequencies than a lighter panel.

Another way to increase the transmission loss of a panel or construction, such as a wall, is by increasing its thickness and isolating one side of the construction from the other. This is commonly done by using two panels separated by an air cavity, and is known as a dual panel partition. Doubling the air space width increases the TL by about 5 dB. Usually, the dual panel approach is more effective and lower cost than increasing wall mass.

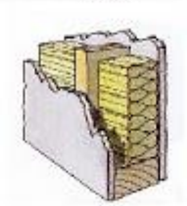
These sound reducing partitions are needed between spaces with different acoustic requirements or spaces that require acoustic privacy. They are also necessary in some cases as part of the exterior building envelope, if environmental noise at a site is a particular concern. Walls, floors and ceilings enclosing spaces where unwanted noise is generated, such as mechanical rooms, normally require a high standard of sound reduction.

Sound Insulation Construction

In the U.S., the standard way of describing sound isolation of constructions is a metric called STC, or Sound Transmission Class. The STC rating of a wall, floor or ceiling is determined by the components of the construction and how they are assembled.

Wall Construction

A standard partition used to separate rooms in a building is typically a single stud wall and one layer of gypsum board on each side, and it has an STC rating of 35. The acoustic performance of the standard wall can be improved by using light gauge (25 gauge) metal studs instead of wood studs. There are some conditions in a library where more sound isolation will be required, which can be accomplished by adding insulation within the wall cavity, providing a second layer of gypsum board on each side of the partition, or possibly using staggered stud construction. These program areas include conference rooms and offices requiring confidential speech privacy, where STC ratings in the range of STC 45-50 are recommended. To control noise transfer from rooms having amplified sound systems such as meeting rooms into other library spaces, the surrounding walls should have a minimum rating of STC 55-60. These wall constructions are illustrated in Figure 3.7.



Wall Type	Description	STC Rating
	2X4 wood studs with 5/8” gypsum board on each	35

2X4 metal studs (3-5/8") with 5/8" gypsum board on	39
2X4 wood studs with 5/8" gypsum board on each	40
2X4 wood studs staggered on either edge of a 2X6	55

It is important to note in general that the high STC rating of any wall construction can be compromised in a number of ways. Care should be taken during actual construction of these sound-rated partitions to ensure that common construction errors do not occur. These compromising circumstances could be the following:

1. Air or sound leaks through cracks. A small air gap can completely compromise the effectiveness of the wall construction. Long cracks, such as those that normally occur at the base and top of a wall are especially detrimental. For this reason, flexible acoustic caulking should be used at the perimeter of a sound partition to seal all edge cracks.

2. Air or sound leaks through normal openings in the wall. Electrical and data outlet boxes or other penetrations of the wall for plumbing or sprinkler piping must also be carefully sealed with flexible acoustic caulking. A common error is to place electrical outlet boxes for two rooms back-to-back in the intervening sound partition. These boxes should be located in different stud spaces to prevent sound transfer between the rooms.

3. Structural connections between double stud partitions. The wood studs in each partition frame of a double stud wall must not be structurally coupled to the other frame in any way. No plumbing or electrical lines should be located in the open space of the air gap between the two partition frames.

4. It is important to seal both faces of a concrete masonry wall with paint or plaster in order to control possible sound leaks.

In meeting rooms and classroom spaces in libraries, movable partitions are often considered as solutions for flexibility in space utilization. The sound insulation properties of these walls are always an important issue to ensure that sound from a resulting adjacent area is not distracting.

There are two types of operable partitions; accordion and folding panel, and these are illustrated in Figure 3.8. Most accordion walls are not tested for sound isolation, and are intended for visual rather than acoustic privacy. However, some manufacturers have made modifications to their standard products and can achieve sound isolation ratings of 30 to 37 when installed in a building, which is still a marginal performance. (This number represents the equivalent of an STC metric, but accounts also for field conditions of the building and space, not just the laboratory-tested properties of the partition itself.)

Panel operable walls provide better sound insulation than accordion partitions because they are heavier and their perimeter seals are more effective. However, even the best models have only moderate sound isolation ratings (42 installed in the building is a typical rating). Operable partitions can be electrically or manually operated. Electrically operated doors move into position and back into storage automatically with the flip of a switch, while manually operated doors may take twenty minutes or more to move into place. Manually operated walls are more reliable for sound insulation than electrically operated doors, because they have special hardware for compressing the perimeter seals.

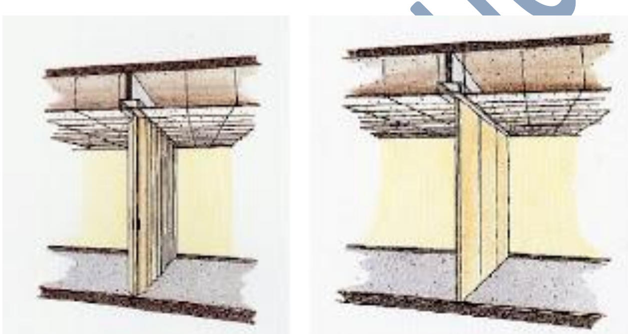


Figure 3.8 Accordion-type operable wall (left) and Panel-type operable wall (right).

Note in the illustrations of Figure 3.8 that a plenum barrier is installed above the operable wall, extending from the top of the wall to the underside of the structure above. This plenum barrier is required in order that the sound insulation value of the wall is maintained, and not short-circuited through sound travelling over the top of the partition.

Floor Construction

Floor and ceiling assemblies perform two acoustical functions. Like walls, they provide acoustical separation between adjacent spaces (airborne sound insulation), but they also reduce the sound of footfalls and other impact sounds from an upper floor (impact insulation).

Impact insulation and airborne insulation can be upgraded by decoupling ceilings from the structure and by altering floor finishes. A base assembly consisting of plywood subfloor, joists and gypsum board can be upgraded from STC 37 to STC 58 by adding a lightweight concrete topping slab, fiberglass batt insulation, resilient channels and a second layer of gypsum board, as illustrated in Figure 3.9.

The concrete topping slab reduces impact noise from footsteps heard in the space below. Using a carpet and pad or a resilient floor underlayment improves the impact insulation.

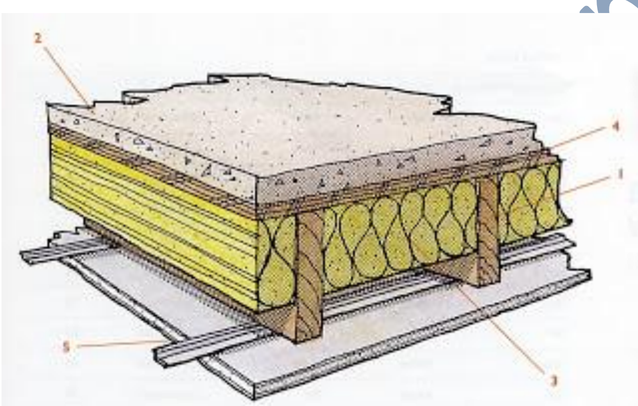


Figure 3.9 Wood framed floor and ceiling construction having an STC rating of 58.

Noise Control of Mechanical and Electrical Systems

When designing a building, it is important to control the noise and vibration of its mechanical and electrical equipment. Without adequate consideration during design, the very equipment that provides thermal comfort and electrical power can generate annoying noise and vibration. Proven techniques are available for mitigating noise and vibration from this equipment. The recommended acoustical design sequence for a building project is:

- Select noise criteria for each space in the building.
- Organize spaces to avoid adverse adjacencies of noisy equipment with quiet spaces.
- Provide adequate noise and vibration control for equipment.

SPACE PLANNING

Space planning can be the most cost-effective noise control technique. Avoid locating mechanical equipment rooms and electrical transformer rooms near spaces (either vertically or horizontally) that require low background noise levels. If this location is unavoidable, it will be necessary to introduce costly sound isolation methods such as a floating floor as shown in Figure 4.1 or heavy masonry walls, if proper sound insulation is to be achieved. A floating floor consists of a second concrete slab installed on neoprene pads and a layer of insulation.

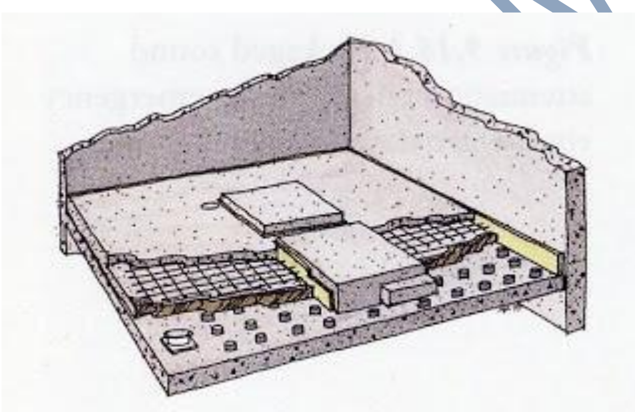


Figure 4.1 A Floating Floor construction.

NOISE CONTROL FOR MAIN BUILDING EQUIPMENT

Large fans used as part of the air conditioning system in a building are sources of a significant amount of unwanted noise. The quietest type of fan that will satisfy the operating requirement should be selected whenever possible to reduce the need for mitigation measures. The cost of mitigation may exceed the cost savings for a less expensive but noisier fan.

A down discharge fan on the rooftop should be located only near spaces that allow a noise goal of NC 45 or higher, since noise is inevitably transmitted to the space below, as shown in Figure 4.2. For such a location, a side discharge fan with long lengths of rectangular ducts on the roof should be used so that as much noise as possible is dissipated before entering the space below.

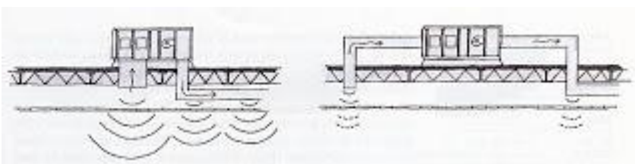


Figure 4.2 Noise paths for down discharge fan and side discharge fan with long rectangular ducts, in a rooftop fan unit installation.

Fan noise transmitted into a room is generally either duct borne noise or breakout noise as shown in Figure 4.3. Duct borne noise can be described as fan noise that is carried within a duct and then transfers into a room through a register. Breakout noise is fan noise that passes through the walls of a duct and through the ceiling into a room.

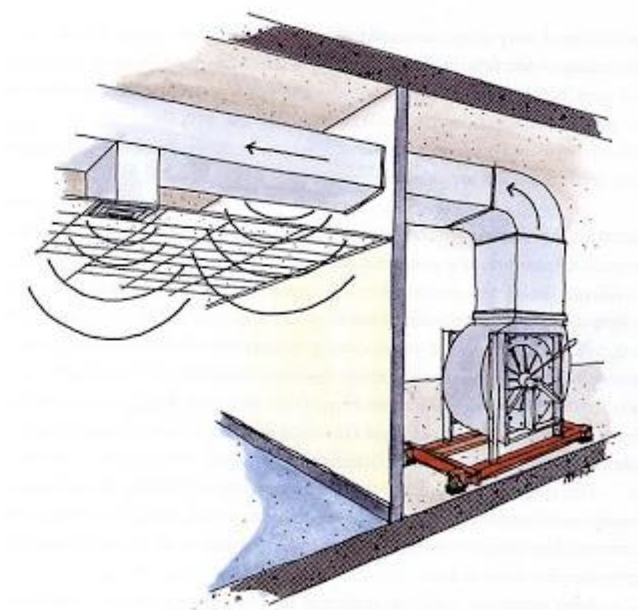


Figure 4.3 Duct borne noise (from the register) and breakout noise (through the walls of the duct).

Absorption of fan-generated noise and mitigation of air turbulence are the strategies for reducing unwanted mechanical noise in a building. To reduce fan-generated noise, provide long duct lengths between fans and the nearest air register serving a room and treat the duct internally with duct liner. Fifteen feet of lined duct inserted after the fan can reduce fan noise by 10 dB.

Air turbulence can be minimized by using ducts with ample cross-sectional area and keeping duct runs as straight as possible. Round ductwork allows very little breakout noise in contrast to rectangular ductwork. Internal duct lining and external insulation do not significantly reduce breakout noise.

Noise between adjacent spaces served by common ducts is known as crosstalk. To reduce crosstalk, main duct runs should be located above corridors, with individual branches extending to each space. Return air transfer ducts to plenum spaces above ceilings should have duct liner installed, and there should be an elbow in the duct as shown in Figure 4.4.

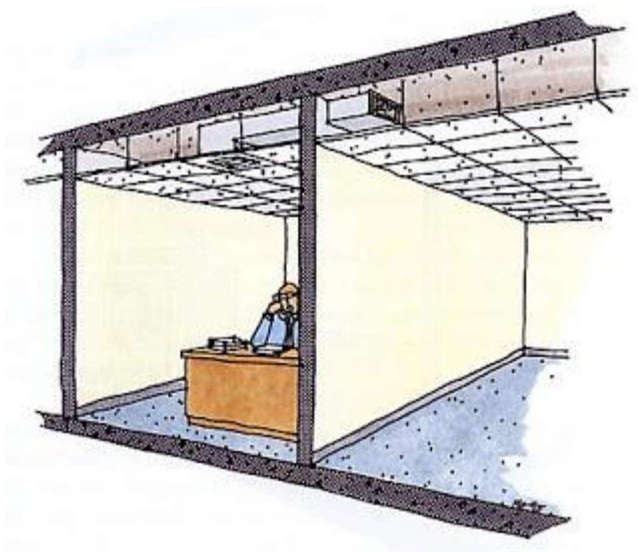


Figure 4.4 Internally lined return air transfer duct above ceiling (with one elbow) to control crosstalk.

Silencers are also called sound attenuators, mufflers, or sound traps. As air flows through silencers, fan noise is reduced. They are usually placed between sections of ducts but can also be located inside an air-handling unit or adjacent to a louver.

Duct lagging is usually specified as part of a design or as a retrofit to solve an existing breakout noise problem. As shown in Figure 4.5, duct lagging may include enclosing the duct in gypsum board or insulation wrapped in sheet lead.

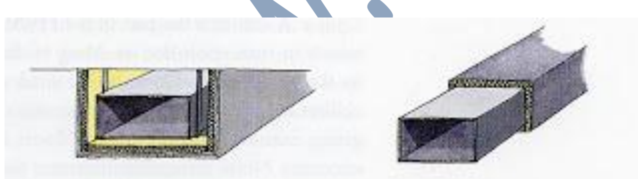


Figure 4.5 Duct lagging using a gypsum board enclosure (left) or lead-wrapped around insulation (right).

Variable speed drives adjust the fan speed to match the ventilation needs of a room. When the fan slows down, the noise level generally decreases. Mechanical variable speed drives can be noisy when speeds are being changed. Electrical variable speed drives and their cabinets are often noisy. The cabinets should be vibration isolated and never attached to a partition adjacent to an acoustically sensitive room.

A chiller is the part of the HVAC system that cools the refrigerant, which in turn cools the air. Most of the noise and vibration is generated by the chiller compressors. The tonal noise produced can be intrusive. If chillers are installed adjacent to acoustically sensitive spaces, mitigating measures such as floating floors and double-stud or masonry wall constructions will be necessary.

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