BUILDING DIGEST

CENTRAL BUILDING RESEARCH INSTITUTE INDIA

NOISE AND ITS CONTROL

Part I—Community Noise

Introduction

Noise is a by-product of civilisation. Modern living has packed us together in crowded industrial towns. Industrial progress has brought in its wake noisier machines and economy in building construction has given rise to lighter walls and partitions with consequent loss in insulation against noise.

Noise may be air-borne or structure-borne. In the former it is transmitted from one part of the building to the other by direct air paths, e.g., open windows, doors and other openings and in the latter it is transmitted by means of energy carried by the structure. In general, the structure is excited either by an air-borne sound field such as speech, radio and other similar household noises or directly by impacts such as foot steps, furniture movement, dropping utensils or other hard objects on the floor and the energy thus imparted to the structure is re-radiated as another air-borne sound somewhere else. The manner in which air-and structure-borne sound is transmitted through partitions is shown in fig 1.

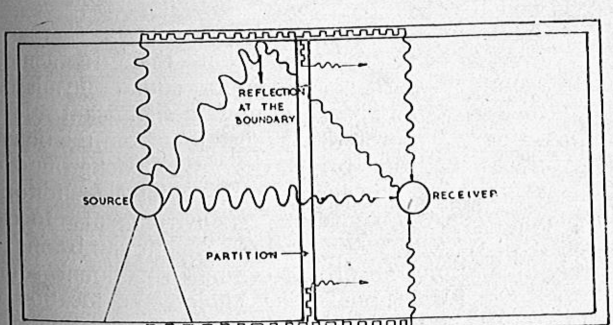

FIG. I AIR-BORNE AND STRUCTURE – BORNE NOISE TRANSMISSION THROUGH A PARTITION

This digest deals with community noise such as household noises, traffic noise, noise due to low flying aircraft and noise infiltrating from adjacent industrial areas.

Subjective effects of Noise

Subjective reaction to noise varies widely but there is general agreement that noise can cause annoyance, fatigue and loss of efficiency. The extent to which an individual is disturbed by intruding noise is determined by the following factors :

(a) the nature of the noise and its spectrum—whether it is continuous, impulsive or made up of pure tones and whether it occurs by day, by night or both ;

(b) the psychological state of the individual exposed to noise and his state of health ;

(c) nature of the environment—whether it is quiet or noisy ; and

(d) in many cases the circumstances under which noise is produced, whether it could be avoided etc.

Often overall sound pressure levels alone do not give a true indication of the annoyance and hence one must determine the frequency composition of the noise. Noise composed mainly of low frequency sounds may not be as annoying as the whine due to high pitched noise. Narrow band noise is more disturbing than broad band noise of equal loudness as, for instance, the sound of an automobile horn in the midst of the continuous broad band traffic noise on the road. Passing of a low flying aircraft overhead or banging of a door are examples of undesirable noise. Here noise is least expected and occurs suddenly and fades away thus causing unpleasantness.

Speech versus Noise

To make conversation possible or to convey information by speech sounds in a noisy surrounding the speaker has to talk in a raised or loud voice. Wide band noise in the frequency range 600-4800 c/s will mask speech frequencies and thus reduce speech intelligibility. The arithmetic average of noise levels in the three octave bands 600-1200, 1200-2400, 2400-4800 c/s is called speech interference level. Where speech communication is essential (as in a conference room or a lecture hall) speech interference level will determine the maximum permissible background noise. Table I shows the speech interference levels which barely permit reliable conversation at the distances and voice levels indicated.

Methods of noise reduction

Noise can be reduced by (a) careful location of areas in buildings for minimum transmission from one area to the other ; and (b) choosing insulating partitions and floors or acoustical treatment.

Location of areas

Noise should be an important consideration at every stage of building design. While planning noise control measures in advance will entail only small increase in construction cost, corrective measures are often very expensive. Therefore, as far as possible locating a building on a noisy site, viz., an auditorium close to a noisy thoroughfare or a rotary press above or close to the editorial room should be avoided. Within the building itself placement of noisy and quiet areas must be done with great care and wherever possible the type of activity anticipated in a particular area must be clearly laid down in the beginning itself. Also, critical areas such as bedrooms, studies, etc., of adjacent buildings must be provided with adequate insulation or buffer zones like bath rooms, kitchen and living rooms of the individual buildings. The blue print showing details of construction of walls, floors, etc., must be strictly followed. Unfortunately this important aspect is frequentlv neglected resulting in poor insulation against noise. Examples can be often found in cases where windows, doors and other openings are provided in a highly insulating wall thus defeating the very purpose.

Insulation of air-borne noise

Air-borne sound insulation rating of a partition is usually made on the basis of the net sound transmission loss provided by the partition and its efficiency as a barrier for speech sounds. Considerable insulation can be obtained by employing a massive and impervious partition wall or floor. Doubling the weight of the partition will increase the average insulation by only 5 decibels (The decibel (db) is a convenient acoustical unit for specifying the sound transmission loss of partitions). For nonporous walls, painting or plastering will not make any significant increase in the insulation value. On the other hand, light-weight porous walls are known to yield higher sound insulation values when the pores are thoroughly sealed by paint or plaster. Even sealing the pores on one side of the wall is adequate and the resulting sound insulation is equivalent to that of a solid wall of the same superficial weight (mass per unit surface area).

Choice of a sound insulating partition is made from a knowledge of the characteristics of the prevailing noise and the desired degree of quiet on the other side of the partition. In certain cases, where high frequency noise is to be reduced, partial barriers are used to provide the acoustic shadow. Criteria for quietness for different activities are given in Tables II and III. For insulation against most of the household noise a party wall having 50 db. transmission loss can be considered adequate. This insulation may be achieved with a few common partitions and is suitable for separating critical areas of adjacent dwellings. Data on a large number of partitions are available in the literature.

For office noises where ease of speech communication is the main criterion thinner walls can be used. Also, within buildings and between non-critical areas of adjoining buildings partitions having 45 db transmission loss or less can be used. Typical partitions and their ratings are given in Appendix A.

Windows and air-borne sound insulation

An open window provides virtually no insulation against noise and even a closed window will usually provide a leaky path for sound. This shortcoming is more pronounced when such windows are located in walls facing external sources of noise like traffic noise from a busy road. Double glazed windows with leaves spaced widely apart and the inner periphery lined with sound absorbing material provide a high insulation. Sound insulation values of commonly used windows are given in Appendix B.

Impact noise insulation

In recent years noise due to impacts has been judged as one of the most disturbing features of living in flats. Careful attention to constructional details of structures transmitting impact noise is very necessary. The floor is the commonest path for transmission of impact noise. Impact ratings of floors is normally made on the basis of the efficiency of the floor to reduce the transmitted level of impact to a prescribed level. Bare concrete and timber floors are not suitable as impact isolator. In many cases a carpet with a heavy underlay or tiles backed by foam pads have been found to provide a highly satisfactory impact insulation. A floating floor (resting on a resilient material like hairfelt, soft board, mineral or glass wool batts, thick rubber, cork, etc.) coupled with a suspended ceiling also provides an effective barrier against impacts. In addition to reducing impact noises, floors will have to provide necessary airborne insulation between areas. Details of floors are available for reducing impact noise transmission and some typical constructions are given in Appendix C.

Acoustical treatment

It should be clearly understood that, in general, good sound absorbers are poor sound insulators. Nevertheless, sound absorbers play a significant role in reducing noise by preventing reflection from the bounding surfaces and thus bring down the background or ambient noise levels in living rooms, cafetaria, auditoria, large office spaces, and similar environments to the acceptable values. Acoustical treatment can be in the form of a sound absorbent ceiling, functional sound absorbers or furnishings. The choice and location of the acoustical materials and the extent of treatment (Appendix D) should be decided after consulting an acoustical expert. When employing suspended acoustical ceilings open paths above partitions should be closed by extending the partition right upto structural ceiling. Any service connections or ventilation ducts should be properly designed and isolated from the structure to prevent them from acting as sound channels. Mechanical contrivances for air movement such as air conditioners, ventilators, etc., should be designed to operate under quiet conditions though some amount of noise from them will act as beneficial background noise either to mask some of the intruding undesirable noise or to provide speech privacy to those in the adjoining areas.

TABLE I

Speech intereference levels (in db re 0.0002 micro-bar) which barely permit reliable conversation at the distance and voice levels indicated

Distance between talker and listener (ft)	Voice level (decibels above 0.0002 micro-bar)			
	Normal	Raised	Very Loud	Shouting
0.5	71	77	83	89
1	65	71	77	83
2	59	65	71	77
3	55	61	67	73
4	53	59	65	71
5	51	57	63	69
6	49	55	61	67
12	43	49	55	61

TABLE II

Types of activities and the criteria for background Noise (NC)

NC 20-30	Broadcast studios, large conference rooms, hospitals, libraries, houses (sleeping areas), apartments and hotel rooms.
NC 30-40	School rooms, music rooms, assembly halls, quiet office, small conference rooms.
NC 40-50	Large engineering and drafting rooms, restaurants
NC 50-60	Business Machine rooms.

TABLE III

Maximum permissible octave band levels of background noise for different activities shown in Table II

Frequency band	Sound pressure level in decibels re : 0.0002 micro-bar							
	37.5-75	75-150	150-300	300-600	600-1200	1200-2400	2400-4800	4800-9600
NC-25	57	47	39	32	28	25	22	21
NC-35	63	55	47	41	37	35	33	32
NC-45	69	62	56	50	47	45	43	42
NC-55	76	69	64	59	57	55	53	52

APPENDIX A

Specification for Walls

A. *Average Transmission Loss 50 db and more*

I. Single leaf walls or partitions weighing more than 80 lbs/sq. ft.

	Weight lb/sq. ft.	*Av.T.L. in db*
(a) 9″ brick wall ...	100	50
(b) 12″ ,, (with modular bricks) ...	121	53
(c) 13½″ ,, ...	145	53
(d) 10″ dense concrete (used in the reduction of high intensity noise) ...	130	52
(e) 15″ ,, ,, ...	190	55

II. Cavity wall—each leaf weighing approx. more than 20 lb/sq. ft.

(a) Two 4½″ brick leaves with 2″ cavity (wire ties) ...	100	50-53
(b) Double 4″ clinker block with 2″ cavity, thin wire ties, ½″ plaster on both sides ...	64	50

III. Stud wall-2 by 4-in. studs; on each face ½″ gypsum lath mounted with resilient clips, ½″ sanded gypsum plaster; paper wrapped mineral or glass wool batts between studs.

IV. Staggered stud wall-2 by 3″ studs at 16″ centres on

(a) gypsum plaster ¾″ on expanded metal lath on opposite sides of staggered 2×4″ wood studs 16″ O.C.

(b) ½″ gypsum lath and ½″ sanded gypsum plaster on opposite sides of staggered 2×3″ studs at 16″ O. C. on 2×6″ plate: paper wrapped mineral wool batts between one set of studs.

V. Composite wall : Basic wall masonry weighing at least 22 lb/sq. ft. ; on one side of basic wall an additional leaf consisting of ½″ gypsum lath mounted with resilient clips, ¾″ sanded gypsum plaster.

B. *Average Transmission loss 45 db to 49 db*

I. Single leaf masonry wall weighing more than 36 lb/sq. ft.

	Weight lb/sq. ft.	*T.L. in db*
(a) 4½″ brick wall with ½″ plaster on both sides ...	55	45
(b) 8″ hollow dense concrete block with ½″ plaster on both sides	50	45

II. Cavity walls—each leaf weighing approx. 15 lb/sq. ft. or more

(a) Double 2″ clinker block with 2″ cavity, thin wire ties, ½″ plaster on both sides ...	38	47
(b) Double 3″ clinker block with 2″ cavity, thin wire ties, ½″ plaster on both sides ...	50	49

Staggered Stud Walls :	Weight lb/sq.ft.	T.L. in db
(a) Gypsum wall board, ½″ on opposite sides of staggered 2×4″ wood studs 16″ O.C. Wood-fiber blanket 0.9″ thick stapled to studs in one set ...	13.8	45
(b) Staggered 2×4″ wood studs each set 16″ O.C. and spaced 8″ O.C. with ½″ offset from the other set. On each side 3/8″ plain gypsum lath and ½″ gypsum vermiculite plaster; air space filled with vermiculite fill of 6.3 lb/ft³ density ...	12.9	47

Composite wall—as in A. V except gypsum lath supported on wood furring.

C. *Average Transmission Loss 40-44 db*

Single leaf masonry of weight at least 22 lb/sq. ft.

	Weight lb/sq. ft.	T.L. in db
(a) 3″ clinker block with ½″ plaster on both sides ...	—	30-41
(b) 4″ clinker block with ½″ plaster on both sides ...	—	38-43
(c) 8″ hollow clinker block with ½″ plaster on both sides ...	—	35-42

II. Cavity wall with each leaf weighing at least 10 lb/sq. ft.

Double 2″ wood wool slab with 2″ cavity, thin wire ties. ½″ plaster on both sides ...	20	42

D. *Average Transmission Loss 35-40 db*

I. (a) 3″ hollow clay block with ½″ plaster on both sides or 3″ clinker block with ½″ plaster on one side or 2″ clinker block on ½″ plaster on both sides ...	22-25	36-39

II. Stud wall—2×3″ or 2×4″ studs, 3/8″ gypsum lath and ½″ sanded sypsum plaster.

APPENDIX B

Air borne sound insulation of windows

Situation where used	Type of window	Transmission loss (decibels)
Bed rooms or lecture theatres facing arterial roads, major roads with heavy traffic, side roads within 20 to 50 yards of heavy traffic.	Double window of 26 or 32 oz. glass, spacing 8″, tightly sealed with absorbent in reveals. (better insulation against low frequency rumble if ½″ glass plates are used)	40
. Marginal for the above situation and living rooms, class rooms facing thoroughfare.	Same as (1) but spacing 4″	35
. Bed rooms, class rooms facing residential roads with local traffic or minor roads, living rooms facing heavy traffic.	Single ¼″ plate glass window, all edges sealed.	30
4. Lecture theatres and bed rooms facing quiet areas, living rooms facing residential road traffic.	Single 26 or 32 oz. glass window, all edges sealed.	25
5. General offices facing heavy traffic or executive offices facing minor traffic (or living rooms).	Same as (4), in wood or metal frames-openable.	20

APPENDIX C

Specifications for impact noise reducing floors*

a) Flat concrete slab ; floated concrete floor.

Basic constn. : 5″ rcc slab

Floor finish; 2″ rcc screed on 1″ glass fiber blanket. ⅛ linoleum cemented to screed. Ceiling ½″ plaster (without the linoleum this floor will not meet the standard)

b) Flat concrete slab; floated timber or hard wood raft.

Basic constn. : 6″ rcc slab

Floor finish : ¾″ T & G floor board on 1½″×2″ battens resting on ½″ pads of soft board, fiber board, asbestos or cork. Ceiling two coat plaster.

c) Wearing surface and floating screed 2″ pcc 1: 3: 6 with sand cushion of 1-2″ thickness on structural floor.

d) Parquet floor (¾″) on mastic resilient layer (3/32 or 1/8″) over structural floor.

e) Floor board on light weight concrete screed (1″) on structural floor (linoleum covering on this floor can also be used).

* These floors provide high insulation against air borne noise also.

APPENDIX D

Procedure for the calculation of Noise reduction

The total absorption in a room can be calculated from the experimentally measured reverberation time (time required for the reverberant sound energy to decrease to one-millionth of its initial value after the source is stopped) (T) by employing the following expression.

$$A=\frac{0.049\ V}{T}$$

Where V = volume of the room in cu. ft.

and A = total equivalent absorption in sq. ft. units $= \Sigma S_1 \alpha_1$

where S_1 is the area of an absorbing surface and α_1 the noise reduction coefficient (average of sound absorption coefficient at 250, 500, 1000 and 2000 c/s to the nearest multiple of 0.05)

[In the metric system the above equation becomes

$$A = \frac{0.16\ V}{T}]$$

The amount of noise reduction that can be obtained by acoustical treatment is a function of the total absorption before and after the treatment, i.e.,

noise reduction $= 10 \log \frac{A\ \text{after}}{A\ \text{before}}$ db. The maximum noise reduction will be of the order of 8-10 db.

A list of some of the commonly used sound absorbing materials with their noise reduction coefficients is given below :

SOUND ABSORBING MATERIALS AND THEIR NOISE REDUCTION COEFFICIENTS

No.	Description of material	Thickness (in)	Weight (lb/ sq.ft)	Method of Mounting	NRC
	Acoustic Plasters and Granular Materials				
1.	Vermiculite mattresses in calico and wire netting.	1½	2.5	Laid on floor	0.75
2.	Vermiculite slabs	2	—	,,	0.50
3.	Light-weight concrete slabs, expanded clay (¼ in. to 1 in) aggregate	6	—	,,	0.60
	Fibrous Materials				
1.	Asbestospray	1	—	On ¼″ thick asbestolux sheets laid on floor	0.65
2.	Central sprayed asbestos	1	—	On ¾″ thick plaster-board supported 3″ above floor in 1″ timber frames 60″ square	0.60
3.	Fibreglass sewn sheets (two layers 1″ and ½″ thick)	—	1.2	On 2″×1″ battens vertical at 24″ centres, horizontal at 30″ centres	0.85

No.	Description of material	Thickness (in	Weight (lb/sq. ft)	Method of Mounting	NRC
4.	Scrim mat fibreglass	1	0.4	Laid on floor	0.80
5.	—do—	2	0.8	,,	0.95
6.	Fibreglass bitumen-bonded mat (2 layers each 1″ thick)	2	0.6	,,	0.75
7.	Fibreglass resin-bonded board	1	0.5	Screwed to wall	0.60
8.	Muslin covered slagwool in wire netting.	2	1.9	,,	0.80
9.	Muslin covered cotton felt blanket	1	0.25	Hung against wall	0.85
10.	I. C. I. flexible polyurethane foam (type M422-3)	2	0.4	Stuck on concrete slabs laid on floor	0.80
	Boards, Panels & Perforated Tiles				
1.	L.W. (Lloyd wool)	$1\frac{1}{4}$	1.3	On 2″×1″ vertical battens at 24″ centres	0.50
2.	Fibreboard tiles, 12″ square, 441 holes per tile, 3/16″ dia. 1″ deep	$1\frac{1}{4}$	1.7	Stuck on wall	0.70
3.	Concealed fixing panels, 24″ fibreboard, 1764 holes per panel, 3/16″ dia., 7/16″ deep	$\frac{3}{4}$	1.0	Suspended ceiling construction Front surface 6″ from wall	0.50
4.	Fibreglass resin-bonded mat (5lb/cu. ft) covered with 1/8″ hardboard perforated 3/16″ dia. holes, 219 per ft.², 4% open area	2	—	Fibreglass between 2″×2″ vertical and horizontal battens at 30″ centres. Cover screwed to battens	0.60
5.	Plasterboard perforated 5/16″ dia. holes, 256 per ft², 14% open area, backed with bitumen-bonded fibreglass 1″ thick	$\frac{3}{8}$	—	On $3\frac{1}{2}$″ vertical battens at 16″ centres. Fibreglass between battens close to fibreboard	0.65
6.	Wood panels, plywood 16″×36″×$\frac{1}{2}$″ perforated 3/16″ dia. holes, 864 per ft², 16.9% open area with fibreglass sewn sheet 2-3/8″ thick between mounting battens	$\frac{1}{2}$	—	Held in grooves in rails and stiles at $39\frac{1}{2}$″ and $19\frac{1}{2}$″ centres respectively. Rails and stiles on battens. Panels 2-3/8″ from wall	0.75
7.	Perforated panels 2′×2′×$\frac{3}{4}$″ thick 21 lb/cu. ft., 3/16″ dia. penetration, 3/8″ depth	$\frac{3}{4}$	0.13	With rigid backing	0.60

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