CENTRAL BUILDING RESEARCH INSTITUTE, ROORKEE-247667 (INDIA)

BUILDING RESEARCH NOTE

B.R.N. 33

NOISE AND ITS CONTROL

Introduction

The notable growth in engineering sciences the development of new sources of power, the uses of mechanical equipments and the increasing degree of automation and mechanism have increased the noise problems in every sphere of life. Noise is a by-product of civilization. Industrial progress has brought in its wake noiser machines and economy in buildings construction has given rise to lighter walls and partitions. With consequent loss in insulation against noise. Noise is produced in almost all mechanical and industrial operations. A part of the mechanical energy applied in these operations is consumed as heat and a small portion is radiated as noise. The transmission of sound from its source to the recepient may take place in a number a ways depending upon whether it is air borne. In the former it is transmitted from one part of the building to the another by direct air path e.g. through windows and doors etc. in the latter it is transmitted by means of energy carried by the structures e.g. impact noise through floors etc. in Fig. 1.

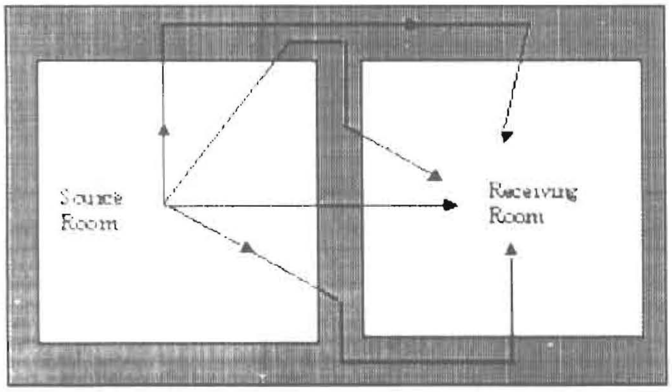

Fig. 1 Air-borne and structure-borne noise transmission through a partition

This Research Note deals basically with household noise, traffic noise, and industrial noise:

Properties of Noise

Noise may be broadly as unwanted sound. It may be intelligible or un-intelligible depending upon whether it is described as speech or sound of a machine. The annoyance caused by noise is purely a subjective phenomenon. Sometimes, even a low noise is a matter of great concern because the overall sound pressure levels do not give a true indication of the annoyance and hence one must determine the frequency composition of the noise. Noise composed of low frequency sounds may be as annoying as the whine due to high frequency sounds. Narrow band noise is more disturbing than broadband noise of equal loudness as, for instance, the sound of an automobile horn in the midst of continuous broadband traffic noise on the road. Most of the noise produced in industrial operations is un-intelligible but because of its large sound pressure levels and complex frequency content, it becomes a cause of much annoyance and fatigue. On the other hand, intelligible sounds cause interference in conversation and the speaker has to talk in a raised or loud voice.

Measurement of noise

Noise is usually measured and expressed in terms of sound pressure level (SPL). If p is the pressure of the sound wave its SPL is expressed in decibels as

$$SPL = 20 \log_{10} p/pr \text{ dB}$$

Where pr (2×10^{-5} Pascal) is the reference pressure and also lowest sound pressure that an average human ear can perceive. Decibel is a convenient unit for expressing the SPL and the noise reduction achieved by sound absorbing materials at various frequencies may be represented in the form of a graph between SPL and frequency. This is called spectrogram gives the distribution of sound energy among the various frequencies comprising noise. Noise can also be analysed in half or third octave bands in order to obtain greater details of energy distribution.

A sound level meter is used to measure overall sound pressure levels. It is used in environments where noise is steady, or where the fluctuations in levels are not very large. Alternatively, noise can be recorded on magnetic tape for subsequent analysis in the laboratory.

Origin and Types of Noise

Most of the noise produced in urban residential areas in is airborne such as radio, T.V., schools, rail and aircraft noise etc. This noise interacts with the performance of human beings and causes discomfort and distraction. Where the noise is intelligible and interferes with conversation, speech, interference levels become important parameters to be seen. Wideband noise in the frequency range 600-4800Hz masks speech frequencies and thus reduces speech intelligibility. Table I shows speech interference levels which barely permit reliable conversation at the distances and voice levels indicated.

TABLE I

Speech interference levels (in dB) which barely permit reliable conversation at the distance and voice levels indicated

Distance between talker and listener (meter)	Voice level (decibels above 0.0002 micro-bar)			
	Normal	Raised	Very Loud	Shouting
0.15	71	77	83	89
0.30	65	71	77	83
0.60	59	65	71	77
0.90	55	61	67	73
1.2	53	59	65	71
1.5	51	57	63	69
1.8	49	55	61	67
3.6	43	49	55	61

Depending upon the type of activity, maximum permissible background noise levels are recommended as noise criteria loads. Table II shows NC levels for various activities. Table III shows maximum permissible octave band levels for background noise for different activities given in Table II. It becomes necessary therefore to measure the overall noise levels existing in a place and then compare it with the appropriate NC curve to know the amount of acoustical insulation needed for a particular activity. Typical partitions and their insulation values are given in Appendices A & B.

One of the most common problems in buildings is the 'impact noise'. It is caused by an object striking or sliding on a wall or floor structure, such as footsteps, dropped toys or cooking pans, moving furniture, door slamming etc. In all these cases, the floor is set into vibration by direct impact or by mechanical contact and sound is radiated from both the sides of floor.

The technique of constrained layer damping is generally applied for isolation of impact noises.

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	49	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

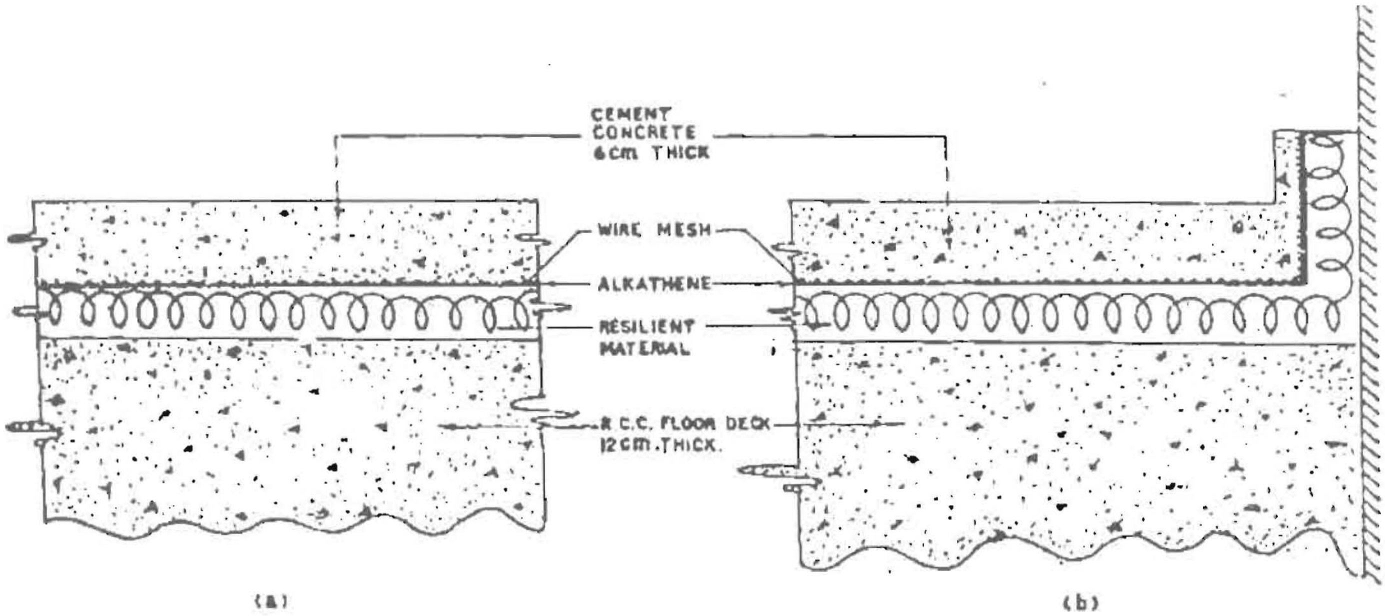

Fig. 2 VISCOELASTIC OR SANDWICHED CONSTRUCTION BETWEEN THE VIBRATING STRUCTURE & LOWER STRUCTURAL SLAB

Basically, this technique provides for dissipation mechanical energy in the form of heat generated by physical distortion of a layer of viscoelastic material sandwiched between the vibrating structure and the lower structural slab, as shown in fig.2. Various resilient materials such as Bartex, Kurlon, Fiberglass etc. have been tested and their relative performance is given in Table - IV. An Impact Noise Rating of 'zero' means satisfactory performance of a resilient floor. A rating of 'plus' or 'minus' sign indicates better or worse performance of a floor respectively.Quite different class of noise is produced by machines and processes associated with the production and handling of goods in industries. In case where the process itself is quiet, noise from common equipments such as fans, blowers, furnaces, etc. may be quite high. When

Table IV : Impact Noise rating of sandwiched resilient materials

Material	Thickness cm.	Impact Noise Rating (INR) According to Indian Standard	
		Laboratory	Field
Bare Concrete	—	- 16	- 13
Bartex	2.00	- 1	+3
Kurlon	4.00	+12	—
Fibreglass	1.27	+5	—
Fibreglass	5.00	+11	+5*
Spintex	2.50	+7	—
Thermocole	2.50	- 5	—
Linoleum	0.42	- 7	—
Hollow-pan units	6.00	—	- 8
Asbestos	1.27	+5 to +15#	—
Mineral wool	2.50	+10	—

* Thickness of fibreglass in the field test was 4.0 cm (unloaded).

\# The variation in rating of asbestos is due to the different qualitles tested.

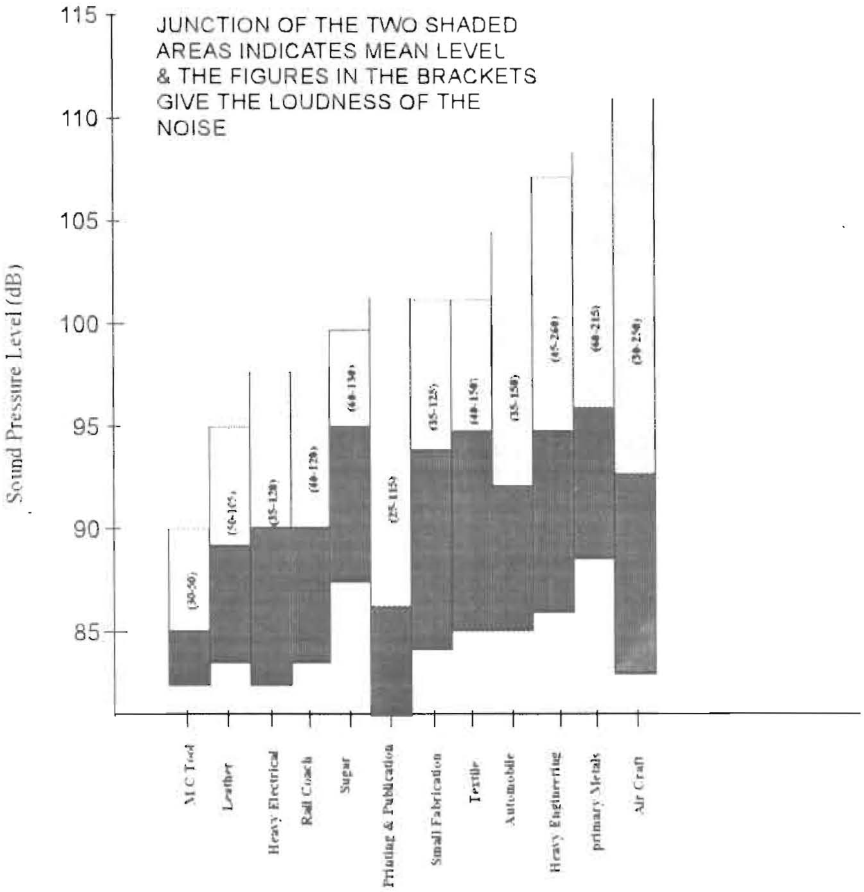

Fig. 3 RANGE OF NOISE LEVELS OF WORK AREAS OF SOME INDUSTRIES

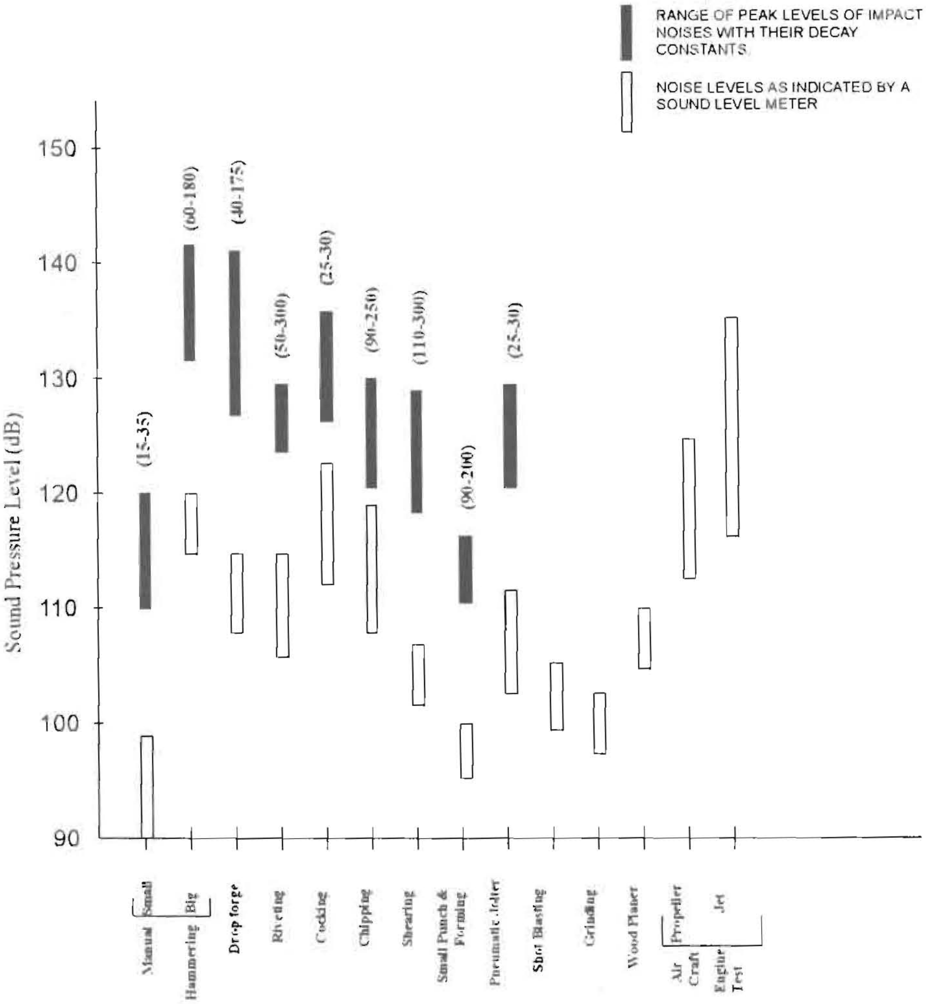

Fig. 4 NOISE LEVELS IN EXCESSIVELY NOISY INDUSTRIAL PROCESSES

Located close to a residential area noise due to processes like riveting and forging or from a service equipments like compressor and exhaust fans can be a major source of nuisance to residents. Noise levels in production areas of some major industries are shown in Fig. 3.

Fig. 4 depicts noise levels measured workers ear during various operations.

Factory noises are either continuous transient. Continuous noises may again be steady or fluctuating. A transient noises may consist of a sharp burst of sound, quickly dying off, or a number impulsive sounds repeated at short intervals of time.

Continuous and steady noise in factories are generally produced by (i) machines rotating at constant speeds like motors, compressors etc, (ii) reciprocating and vibrating machines like shake out and foundries and sieves in coke batching; and (iii) escaping gases like exhaust from pneumatic tools or hissing noise from spray guns, fans, etc. Machines usually produce low and middle frequency noises corresponding to their r.p.m. and harmonics, whereas exhaust gases give rise to high frequency noise with both level and frequency increasing rapidly with escape velocity.

Continuous but fluctuating noise is commonly found in machine shops and metal fabrication and material handling areas. In such areas miscellaneous noise due to cutting, hammering or metal parts hitting against one another are heard above the steady back ground noise produced by motors, furnace etc. Steady noise in these areas generally consist of low frequency sounds while the superimposed noise often contains middle and high frequencies.

Secondary effect of such noise are also seen when the impact of noise is transmitted without much attenuation along the factory floor to distant parts of the building throwing windows and loosely fitted tin roofs into vibration.

Methods of Noise Control

Noise should be taken as an important consideration at every stage of a building design. While planning noise control measures in advance entails only small increase in construction cost, corrective measures are often very expensive. Following measures should be taken

a) Careful location of the site.
b) Choosing appropriate insulation.
c) Reducing the noise at source.
d) Enclosing the source of noise.
e) Use of sound absorbing material.

Location of building should be chosen very judiciously with reference to the surrounding environment; for example an auditorium close to a noisy thoroughfare or a rotary press above or close to the editorial room should be avoided. Similarly an industrial set up should not be planned in a residential colony. 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.

Once anticipated or measured ambient noise levels are known in an area adequate exercise must be done to achieve recommended acoustical conditions within the space by properly choosing sound insulating partition or wall. Choice of a sound insulating partition should be made from a knowledge of the characteristics of the prevailing noise and the desired degree of quietness on the other side of the partition. Criteria for quietness for different activities are given in Table II & III.

Reducing noise at or near the source is obviously the most effective and economical method of noise control. Since the level of noise produced by a source is directly proportional to its amplitude of vibration, sizeable reduction in noise can be effected by using the minimum power necessary to drive the source. It should be seen that the maintenance of machinery is regularly done at appropriate interval of time. Reduction of structure borne noise and vibration can be achieved by interrupting the rigid path between the source and the other parts of the structure by resilient materials like felt, glass wool or rubber or shock absorbing devices like steel springs or other proprietary mountings.

Low frequency noise and its transmission to other areas in multistoryed factories can be reduced by anti vibration devices. The machine may also be mounted on a heavy concrete base floating on resilient mounts and isolated from the rest of the floor by a cork or loose sand filled gap around the perimeter. It is important that the resilient material used is not loaded beyond its elastic limit.

Most common way of controlling the noise is to completely enclose the source by a highly insulating structure. Dimensions of the enclosure depend on the size of the source, work progress involved and material handling requirements etc. In choosing a partition for an enclosure its average sound transmission loss, which is the average insulation in the frequency range 125-4000 Hz, should be taken as guide (see Appendices A & B). Acoustical absorbers are poor sound insulators and hence should be used only for lining the inside of enclosure to increase its efficiency. All joints should be carefully sealed to avoid direct air leakage path. In some cases instead of enclosing the whole machine, only covering its noisy part has been found to be sufficient. Where it is not possible to cover a machine partial enclosures and non-porous barriers lined with sound insulating material on the noisy side can be used. Noise in highly reverberant areas (such as large halls etc.) can be controlled by the use of sound absorbing materials applied on walls ceiling of the building or by employing functional sound absorbers. Functional absorbers are most effective in shops, where machines are closely spaced. Appendix C gives a few sound absorbing materials with their sound absorption coefficients.

Prolonged exposure to very high noise levels may result in permanent and incurable hearing loss and lead to what is known as 'industrial deafness'. Even brief exposure to noise levels of 90 to 95 dB is known to cause temporary loss of hearing. It is generally agreed to that where an individual is exposed to continuous noise of 90 dB for 8 hours, the risk of damage to hearing exists. For every 5 dB increase in the level, the exposure time should be halved to avoid hearing loss. In case of very high noise levels use of ear plugs or the other protective measures must be made. Exposure to sounds of 135 dB and above even for a few seconds has been known to cause instantaneous rupture of the ear drum.

APPENDIX A

Specification for Walls

SOUND TRANSMISSION LOSS VALUES IN dB

Sr. No.	Name of the Material with designed Specification	Total thickness (cm)	Mass density Kg/m^2	STL in DB
1.	Single leaf walls or partitions weighing more than 390 kg/m^2			
	Brick wall	22.8	488	50
	With modular bricks	30.48	590	53
	-- Do--	35	707	53
	Dense concrete	25.4	634	52
	-- Do--	38	927	55
2.	Cavity wall each leaf weighing approx. 95 kg/m^2			
	Two 11.4 cm brick leaves with 5cm Cavity, (wire ties)	27.8	488	50-53
	Double 10 cm clinker block with 5cm cavity, thin wire ties, 1.25cm plaster on both sides	27.5	312	50
3.	Single leaf masonry wall weighting more than 176 kg/m^2			
	11.4 cm brick wall with 1.25 cm plaster on both sides	13.9	268.4	45
4.	Cavity walls each leaf weighing approx. 75 kg/m^2 or more			
	a) Double 5cm clinker block with 5 cm cavity, thin wire ties, 1.25cm plaster on both sides	17.5	185	47
	b) Double 7.6 cm clinker block with 5cm cavity, thin wire ties, 1.25 cm plaster on both sides	22.7	244	49
5.	Staggered Stud Walls Gypsum wall board 1.25 cm on opposite sides of staggered 5 x 10 cm wood studs 40.6 cm D.C. Wood fiber blanket 2.28 cm thick Stapled to studs in one set	10	67	45
6.	Single leaf masonry of weight at least 110 kg/m^2			
	a) 7.5 cm clinker block 1.25 cm with plaster on both sides.	10	120	30-41
	b) 10 cm clinker block 1.25 cm with plaster on both sides.	12.5	165	38-43
	c) 20cm hollow clinker block 1.25 cm with plaster on both sides.	22.5	--	35-42
7.	Cavity wall with each leaf weighing at least 50 Kg/m^2			
	Double 5 cm wood wool slab with 5 cm cavity, thin wire ties, 1.25 cm plaster on both sides.	17.5	97.6	42

8.	7.6 cm Hollow clay block with 1.25 cm plaster on both sides or 7.6 cm clinker with 1.25 cm plaster on one side or 5 cm clinker block with 1.25 cm plaster on both sides.	7.5-10	108-122	36-39
9.	3 mm single glass panes	0.3	8	28
10.	Double wall glass pane 3 mm each with 2.5 cm air gap	0.85	16	34
11.	Coconut Husk slab	2.5	10	23
12.	Plibastos Buildings Boards	0.4		23.8
13.	Wood wool Boards	3.75	15-20	20
14.	Isobar Glass, double layers	3.1	30-40	35
15.	a) Mica based steropole Panel 2.5 cm thick with 3 mm plywood on both sides.	3	19.2	20
	b) Mica based steropole Panel 2.5 cm thick with 2 mm aluminium on both sides.	2.7	48.8	22
16.	Polyurethene foamed panel	3.8	15	28
17.	a) Bison PanelCement Bonded Wood Particle Board	1.6	20	38
	b) Bison PanelCement Bonded Wood Particle Board	1.2	15.6	35
18.	Expanded Polystyrene Composite Door shutter without frame.	2.5		24.5
19.	Red mud polymer Hallow Core Door Plane surface without frame.	4.0	40	33
20.	Top line ceiling tile	1.2	8.4	27
21.	a) PVC Integral Sheet	1.4	--	23
	b) PVC Integral Foam Sheet	1.9	--	25.6
22.	AAC Blocks (Aerated Autoclaved Concrete)			
	a) Without plaster	10	62.5	38
	b) With 15 mm plaster on both sides.	13	67	44
	c) Without plaster	20	125	42
	d) With 15 mm plaster on both sides.	23	130	47
23.	a) Fibre reinforced plastic panel	2.5		32.5
	b) Fibre reinforced plastic panel with lead sheet on one side and wire mesh on other side.	2.5		34.5
24.	22.8 cm C-Brick with 1.25 cm plaster on both sides.	25.3		47.0
25.	Double leaf C-Brick wall, 2.5 cm air gap.	27.8		52.0

26.	a) Particle Board	1.2	8.4	27.0
	b) Particle Board	2.5	17	31.7
27.	a) Gypsum Board	5	45	31.0
	b) Gypsum Board	10	90	35.0
28.	Heavy Wooden Door (Rubber gasket around sides)	6	62	29.5
29.	Conventional Door	3.7	40	26.6
30.	Double door (10 cm gap)	17.4	80	31.7
31.	Poly Carbonate twin wall Sheet	6	1.33	11.39
32.	Acrylic Sheet	3	3.18	18.04
33.	Poly Carbonate Transparent Sheet	3	3.61	19.16
34.	Coloured Glass Sheet	4	7.88	25.94
35.	Coloured Glass Textured Sheet	3	7.93	27.99
36.	Plain Glass with Black Film	3	8.64	28.74
37.	Heat Reflecting Glass Sheet	5	12.66	32.07
38.	Heat Reflecting Glass Sheet	6	13.45	32.07
39.	Plain Glass Sheet	6	13.53	30.62
40.	Heat Reflecting Glass Sheet	6	15.36	33.73
41.	Reinforced Glass Sheet	6	16.06	34.11

APPENDIX B

Air borne sound insulation of windows

	Situation where used	Type of window	Transmission loss (decibles)
1.	Bed rooms or lecture theatres facing arterial roads, major roads with heavy traffic, side roads within 18 to 45 m of heavy traffic.	Double window of 730 gm or 900 gm glass spacing 20.3 cm tightly sealed with absorbent in reveals. (better insulation against low frequency rumble if 1.25 cm plates are used).	40
2.	Marginal for the above situation and and living rooms, class rooms facing thoroughfare.	Same as (I) but spacing 10 cm.	35
3.	Bed rooms, class rooms facing residential roads with local traffic or minor roads, living rooms facing heavy traffic.	Single 0.5 cm plate glass window, all edges sealed.	30
4.	Lecture theatres and bed rooms facing quiet areas, living rooms facing residential road traffic.	Single 730 or 900 gm 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
Sound Absorbing materials with their Noise Reduction Coefficient

Sr. No.	Materials	Manufacturers	Thickness mm.	Density Kg/m³	NRC Range
1.	Twiga Fibreglass	M/s UP Twiga Fibreglass Ltd., Sikandrabad, Bulandshahr, U.P.	50	32	
2.	Spintex (Resin Bonded)	M/s Punj & Sons Pvt. Ltd. New Delhi	50	65	0.90 to 0.98
3.	Fibreglass Crown 200 RB-3	M/s Fibre glass Pilkington Ltd., Mumbai	50	32	
4.	Fibrosil	M/s Indian Rockwool Co. Ltd. Delhi - 6	50		
5.	Twiga Fibreglass	as above	50	24	0.80 to 0.89
6.	Spintex	as above	50	65	
7.	Fibreglass Crown 150 (RB-2)	as above	50		
8.	Twiga Fibreglass,	as above	50	24	
9.	Miheral fibre resin bonded	M/s Lloyd Insulation (I) Ltd. New Delhi	50	25	0.70 to 0.79
10.	Fibrosil	as above	25		
11.	Spintex	as above	25	49	
12.	Fibreglass Crown 100 (RB)	as above	50		
13.	Fibreglass Crosn RB-2 & RB-3	as above	25	24	
14.	Fibreglass rigid board	as above	25		0.60 to 0.69
15.	Supercera Ceramic Fibre	M/s LLoyd Insulation (I) Ltd. New Delhi	40		
16.	Minwool Insulation Board	15-9-495 Mahaboobganj, Hyderabad	50	120	
17.	Uniformly/Randomly perforated Jolly Board	M/s Gurind Sales 60, Janpath, N. Delhi	13	300	
18.	Fibreglass Crown 100 (RB-1)	as above	25	16	
19.	Wood wool insulation board	Fibrecrete Woodwool Insulation Board, Paharganh, New Delhi	25	350	0.50 to 0.59
20.	Duratex woodool board	M/s B.K. Industries, Netaji Subhash Marg, New Delhi	25	400	
21.	Cerool blanket	M/s Orient Carwool Ltd., Nehru Place, New Delhi	30	128	
22.	Thermotex	M/s Vijay Udyog, Industrial Area, Bulandshahr Road, Ghaziabad	25	375	
23.	Armstrong Ceiling Tiles	M/s Inarco Ltd., East Patel Nagar, New Delhi	15	250	0.40 to 0.49
24.	E-glass needle mat	M/s Maharaja Exhaust Product Pvt. Ltd. Rani Jhansi Marg, New Delhi	15	160	

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