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Noise Control in Multistoreyed Apartment Buildings

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The problem of noise pollution in multistoreyed apartments in urbanized and industrial environments is considered. Control measures are suggested for two types of noises: (i) air borne noise produced by radio, TV, etc., and (ii) noise produced by footsteps, dropped objects and other impacts, which is transmitted through vibration of the building structure. It is concluded that most of the acoustical problems can be avoided by taking into consideration the various acoustical factors in the building design itself.

THE current trend in favour of light weight structures, the increasing concentration of dwellings in urban areas and the increasing noisy environments have led to a growing number of complaints for inadequate sound insulation in multistoreyed dwellings. Noise pollution has come to be recognized as one of the major nuisances for an urbanized and industrialized society. The present paper is concerned with the control of two types of noises in multistoreyed buildings. One is the air-borne noise produced by the radio, TV, etc., of the neighbours, while the other is the impact noise made by the sound of footsteps, dropped objects and other impacts which are transmitted throughout a multistoreyed building by vibration of the building structures. Most of acoustical problems can be avoided if the acoustical factors are taken into consideration early enough in the design.

Acoustical problems with respect to air-borne noise

There can be three distinct types of acoustical problems. Firstly, there are rooms, such as auditoria, lecture halls and class rooms in which the primary function is to hear. In these rooms, the primary need is to direct the useful reflections of sounds towards the occupants. In contrast, in large offices, restaurants, factories, etc., various unwanted sounds are produced which must be reduced to acceptable levels. The criterion of acceptability[1] depends upon the circumstances (Table 1). In a factory one may be content to ensure that the workers' hearing is not impaired, whereas in dwellings, offices or restaurants, people feel comfortable if they can converse without shouting. Finally, there is the problem of a noisy area adjacent to one where one wishes to be quiet. Here, one may build a good enough sound barrier between the two spaces. In this paper, methods of solving the acoustical problems faced by the residents in multistoreyed buildings are discussed.

Some suggestions concerning dwelling design

In a flat or dwelling, one is concerned with internal as well as external noises. It is realized here that a little effort at the conceptual stage of a dwelling design can lead to considerable reduction in the unwanted noises to the acceptable limits. The following are some of the suggestions which, if followed, can lead to reduced transmission of air-borne noises from any dwelling to the neighbouring dwellings: (i) The loudspeakers of radios and TVs, record players, etc. should be kept in such a location in a room opening to outside that minimum sound goes out of the dwelling through windows and other openings. (ii) Bed rooms and other rooms which require quiet locations should be placed in that area of the dwelling which is not adjacent to a road or any other noise disturbance source. The insulation of bath rooms, toilets, staircases and lift ducts from other areas is important. The staircases, if enclosed, can act as very good transmitters of disturbances in the vertical direction within a building. Attempts should be made to stagger the staircases in high-rise buildings, as it is beneficial from the point of view of preventing both noise pollution and fire. (iii) The living room should be designed for good acoustics.

Walls of the room where radio or TV, etc. are to be located should be somewhat more reflective than those around the listening end. It is often possible to provide the optimum reverberation time by careful selection of floor coverings, hangings and furniture. About three-fourth of the floor covered with carpet, one-sixth of the wall area covered with curtains and two or three pieces of furniture might fulfil the requirements. Book shelves, pictures and other wall irregularities should be used to facilitate diffusion of sound and to suppress flutter echoes.

Impact noise insulation

Impact noise 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 sides of the floor.

The technique of constrained layer damping is generally utilized for the isolation of impact noises in dwellings[2]. Basically, this technique provides for the dissipation of mechanical energy in the form of heat generated by the physical distortion of a layer of viscoelastic material sandwiched between the vibrating structure and the lower structural slab, as shown in Fig. 1.

The standard method[3] of measuring impact noise is to generate by an ISO tapping machine

Table 1 — Maximum permissible octave band levels of background noise for different activities

[Values represent the maximum permissible octave band levels]

	Frequency band range, Hz								Activity
	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	Broadcast studios, large conference rooms, hospitals, libraries, houses (sleeping areas), apartments and hotel rooms
NC-35	63	55	47	41	37	35	33	32	School rooms, music rooms, assembly halls, quiet offices, small conference rooms
NC-45	69	62	56	50	47	45	43	42	Large engineering and drafting rooms, restaurants
NC-55	76	69	64	59	57	55	53	52	Business machine rooms

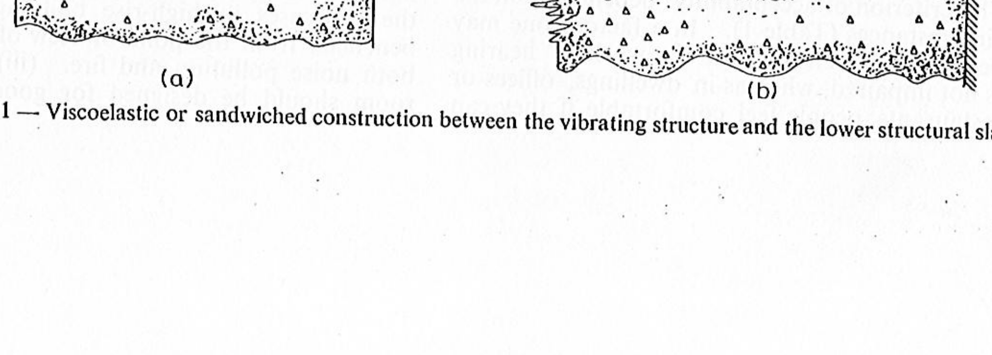

Fig. 1 — Viscoelastic or sandwiched construction between the vibrating structure and the lower structural slab

a series of impacts at a uniform rate on the floor under test.

The resilient material to be tested is laid on the floor deck. It is then finished with a surface layer of cement concrete about 6 cm thick. Besides acting as a protective cover for the resilient slab, the upper layer provides the desired static load on the material. The thickness[4] of the cement concrete slab is, therefore, so chosen that the depression of the resilient material with further loading is well within the prescribed limit of 5.5 mm at 0.1 kg/cm².

The noise produced in the lower room due to the ISO tapping machine depends not only on the floor construction, but also on the sound absorbing material in the lower room. To make the data comparable with the other measured data, the measurements have to be made under some standard conditions of absorption in the receiving room. Most of the countries have adopted normalization of the receiving room to a standard reverberation time of 0.5 sec. Normalization is done according to the equation :

$$L_N = L + 10 \log_{10} \frac{0.5}{T}$$

where L is the measured sound level in any of the octave bands; L_N, the sound level normalized to 0.5 sec reverberation time; and T, the reverberation time of the receiving room in the band concerned.

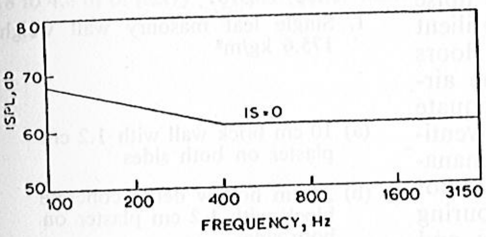

Fig. 2 — Derived Indian standard curve for the measurement of impact noise ratings of resilient materials.

The spectrum of noise through the floor is then compared with the standard requirement curves, which are different for different countries. The standard curve for India is shown in Fig. 2. A floor is said to provide enough isolation when the impact sound pressure levels in the receiving room are at frequencies less than or equal to the values given in the requirement curve.

To observe the subjective reactions of the above tests conducted in the laboratory, two resilient materials, Bartex and fibreglass, were sandwiched in two newly constructed houses. These were separately used on two floors of about 150 sq m each. The resilient material and alkathene sheet are raised on the walls up to about 20 cm and then while finishing the floor with 6 cm cement concrete, a skirting has to be applied rising on the walls up to about 10 cm height, as shown in Fig. 1(b). After complete curing

Table 2 — Impact noise rating of sandwiched resilient materials: Impacts produced by the ISO tapping machine

MATERIAL	UNLOADED THICKNESS cm	IMPACT NOISE RATING (INR) ACCORDING TO INDIAN STANDARD		INCREASE IN COST OF FLOORING %
		Laboratory	Field	
Bare concrete	—	—16	—13	—
Bartex	2.00	—1	+3	48
Kurlon	4.00	+12	—	—
Fibreglass	1.27	+5	—	69
Fibreglass	5.00	+11	+5*	—
Spintex	2.50	+7	—	60
Thermocole	2.50	—5	—	50
Linoleum	0.42	—7	—	60
Hollow-pan units	6.00	—	—8	—
Asbestos	1.27	+5 to +15	—	7-30†
Mineral wool	2.50	+10	—	20

*Thickness of fibreglass in the field test was 4.0 cm (unloaded).
†The variation in rating of asbestos is due to different qualities tested.

of the floors, the materials are subjected to field tests for the determination of INR. The reverberation times of the receiving rooms furnished and occupied were determined by first recording the warble tones on a tape recorder and then replaying it in the rooms, the reverberation time of which was to be determined. The ratings of these materials as well as of some other indigenous materials are given in Table 2. Subjective reactions of the occupants confirmed that noise was reduced substantially by the floor treated with such materials.

The overall reduction in sound pressure level in the lower rooms was found to be 25 and 30 db in the case of Bartex and fibreglass respectively. The noise received in the lower rooms after such treatment can thus be classified as being "not objectionable".

Conclusions

It is recommended that while choosing the structure of a multistoreyed building, care should be taken to study beforehand the noise transmitting properties of the structure. Resilient materials should be used on different floors if the economy permits. Concerning the airborne noise, it is very important to give adequate attention to the placement of windows, ventilators and doors in such a way that noise emanating from one dwelling is checked and does not create disturbances in the neighbouring dwellings. The absorbing capacity values and noise reduction properties of different materials, especially those which have been recently developed by this institute, e.g. hollow-pans, coconut husk slabs and wood wool boards, are given in Table 3.

Table 3 — Average transmission loss of some of the sound insulating materials developed

MATERIAL	THICKNESS cm	DENSITY kg/m³	TL db
Hollow-pan units	10	1000	45
Coconut husk slab	5	550	23
Wood wool boards	3.7	400	20

References

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2. CHOUDHURY, N. K. D. & BHANDARI, P. S., *Acustica*, 26 (1972), 135-40.
3. International Organisation for Standardization, ISO, recommendation R-140, *Field and laboratory measurement of air borne and impact, sound transmission*, January 1969.
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Appendix 1

A. Specification for walls having transmission loss 50 db and more

I. Single leaf walls or partitions weighing more than 390.4 kg/m²

	Wt kg/m²	Av. TL db
(a) 23 cm brick wall	488.0	50
(b) 25 cm dense concrete (used in the reduction of high intensity noise)	634.4	52

II. Cavity wall—each leaf weighing more than 97.6 kg/m²

(a) 10 cm brick leaves with 5 cm cavity (wire ties)	488.0	50-53

III. Composite wall : basic wall masonry weighing at least 107.36.kg/m²; on one side of the basic wall an additional leaf consisting of 1.2 cm gypsum lath mounted with resilient clips, 4.4 cm sanded gypsum plaster

B. Specification of walls having 45-49 db transmission loss

I. Single leaf masonry wall weighing more than 175.6 kg/m²

	Wt kg/m²	TL db
(a) 10 cm brick wall with 1.2 cm plaster on both sides	268.4	45
(b) 20 cm hollow dense concrete block with 1.2 cm plaster on both sides	244.0	45

II. Cavity walls—each leaf weighing 73.2 kg/m² or more

	Wt kg/m²	TL db
(a) Double 6 cm clinker block with 5 cm cavity, thin wire ties, 1.2 cm plaster on both sides	185.4	47
(b) Double 7.6 cm clinker block with 5 cm cavity, thin wire ties, 1.2 cm plaster on both sides	244.0	49

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

C. Specification of walls having 40-44 db average transmission loss

I. Single leaf masonry of weight at least 107.3 kg/m²

	TL db
(a) 7.6 cm clinker block with 1.2 cm plaster on both sides	30-41
(b) 10 cm clinker block with 1.2 cm plaster on both sides	38-43
(c) 20 cm hollow clinker block with 1.2 cm plaster on both sides	35-42

		Wt kg/m²	TL db
II.	Cavity wall with each leaf weighing at least 488 kg/m²		
	Double 5 cm wood wool slab with 5 cm cavity, thin wire ties; 1.2 cm plaster on both sides		42
D.	Specification of walls having 35-40 db transmission loss		
I. (a)	7.6 cm hollow clay block with 1.2 cm plaster on both sides or 7.6 cm clinker block with 1.2 cm plaster on one side of 5 cm clinker block on 1.2 cm plaster on both sides	107–122	36–39

Appendix 2 — Air-borne sound insulation of windows

Sl No.	Situation where used	Type of window	Transmission loss db
1	Bed rooms or lecture theatres facing arterial roads, major roads with heavy traffic, side roads within 18 to 4.6 m of heavy traffic.	Double window of 0.75 kg or (0.90 kg) glass, spacing 20.0 cm tightly sealed with absorbent reveals (better insulation against low frequency rumble if 1.27 cm glass plates are used)	40
2	Marginal for the above situation and living rooms, class rooms facing thoroughfare.	Same as (1), but spacing 10.0 cm	35
3	Bed rooms, class rooms facing residential roads with local traffic or minor roads, living rooms facing heavy traffic.	Single 0.6 cm plate glass window, all edges sealed	30
4	Lecture theatres and bed rooms facing quiet areas, living rooms facing residential road traffic.	Single 0.75 kg or 0.90 kg 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