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CODE OF PRACTICE FOR SOUND INSULATION OF NON-INDUSTRIAL BUILDINGS

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BUREAU OF INDIAN STANDARDS
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI 110002

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CODE OF PRACTICE FOR SOUND INSULATION OF NON-INDUSTRIAL BUILDINGS

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(*Continued from page* 1)

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CODE OF PRACTICE FOR SOUND INSULATION OF NON-INDUSTRIAL BUILDINGS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 29 May 1962, after the draft finalized by the Functional Requirements of Buildings Sectional Committee had been approved by the Building Division Council.

0.2 This standard is one of a series of codes being prepared by the Functional Requirements of Buildings Sectional Committee which has under its purview the preparation of codes to cover comprehensively the functional aspects of buildings in relation to their structural safety, fire safety, heat and sound insulation, ventilation, daylight and orientation. This code is intended as a simple and convenient guide to the engineer and architect in the field in dealing with noise reduction and sound insulation problems.

0.3 Investigations on the effect of noise on human comfort and annoyance have revealed that high noise conditions not only result in uncomfortable living conditions, fatigue, inefficiency and mental strain but prolonged exposure to such conditions may cause temporary deafness or nervous breakdowns. Considerable attention has, therefore, been paid to quietness in working and living conditions in certain countries. This code is essentially based on the data obtained from the experimental work and field studies carried out in certain countries abroad such as Britain, Sweden, Holland and Denmark. Absence of similar data on noise levels in relation to human comfort and field tests to determine suitable types of construction to obtain comfort conditions in India, makes it difficult to verify all the recommendations of this code under the conditions obtaining here. It may however be mentioned that while the code was being finalized, the National Physical Laboratory, New Delhi was requested by the Sectional Committee to undertake noise survey in some of the important cities of India. They have since conducted this survey in Delhi and Bombay and the data thus obtained has been very useful in arriving at the recommendations made in this standard.

0.4 The Sectional Committee responsible for the preparation of this code, recommends strongly that a programme of noise survey, noise comfort conditions, experimental research, and field tests should be undertaken by appropriate authorities in the country so that reliable and factual information can be made available for the design and construction of buildings which would provide comfortable living conditions in respect of noise and sound insulation.

0.5 It is difficult to reduce outdoor noises coming into a building. It is, therefore, desirable that during the planning of the layout of a town or a suburb, the location of the residential areas, in particular, should be so arranged that they are away from the traffic, industrial and other noisy surroundings and are set off from the various roads according to the average noise level which may emanate from them at any time. Residential buildings situated on roads carrying heavy traffic would need similarly to be set off from the road adequately and suitably oriented so as to attenuate the noise to the required degree.

Indoor noises may be either due to the tenants on the upper floor moving their furniture or children dancing and playing or a "flushing cistern" working or other similar causes; such noises are particularly annoying during the night. Adequate attention should be paid to the arrangements of rooms in any single apartment or house and to the design of the party walls between two dwelling units. Similarly, the construction of floors and ceilings of buildings having two or more storeys should provide for the attenuation of impact noises to the desired degree of quietness.

Some buildings are more vulnerable to noise than others. Broadcasting and recording studios, audition rooms and certain types of scientific laboratories, can be put out of action by noise; parliament houses, council chambers, law courts, schools and colleges, may be made almost useless because of noise. This specially is the case in hot climates where open windows is the rule. Thus close and urgent attention to proper zoning, particularly in the location of air-ports, factories and such other sources of noise, should be given before it becomes too late.

0.6 In the formulation of this standard, the Committee has considered the recommendations and practices in vogue in other countries with regard to sound insulation of buildings. These considerations have led the Committee to derive assistance from B.S. CP 3 : Chapter III : 1948 Code of Functional Requirements of Buildings : Sound Insulation (Houses, Flats and Schools), issued by the British Standards Institution.

0.7 Wherever a reference to any Indian Standard appears in this code, it shall be taken as a reference to the latest version of the standard.

0.8 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960 Rules for Rounding Off Numerical Values (*Revised*). The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

0.9 This standard is intended chiefly to cover the technical provisions relating to sound insulation of buildings, and it does not include all the necessary provisions of a contract.

1. SCOPE

1.1 This code lays down acceptable noise levels and sound insulation standards in non-industrial buildings such as, dwellings, schools, hospitals and office buildings, and recommends methods of minimizing transmission of air-borne and structure-borne noises. It does not include standards for industrial buildings.

2. GENERAL PRINCIPLES

2.1 Noise — Noise is defined as ' sound not desired by the recipient ', that is, unwanted sound. This unwanted sound may be of single frequency and of constant or varying intensities or it may be a combination of various frequencies of different intensities. The annoyance effect of noise depends not only on the frequency but also on the intensity and wave-form of the noise. Thus, the noise may be due to either of the factors, frequency and intensity, or both; high frequency sounds are more annoying and harmful than low frequency sounds.

2.2 Indoor and Outdoor Noises — Noises may be of outdoor or indoor origin. Outdoor noises are caused by road traffic, railways, aeroplanes, lifts, blaring loudspeakers and various types of moving machinery in the neighbourhood or in adjacent buildings. As far as indoor noises are concerned, conversation of the occupants, footsteps, banging of doors, shifting of the furniture, operation of the cistern and water-closets, playing of radios, gramophones, etc, contribute most of the noise emanating from an adjacent room or an adjacent building. Noise conditions vary from time to time; a noise which may not be objectionable during the day may assume annoying proportions in the silence of the night when quiet conditions are essential.

2.3 Measurement of Noise

2.3.1 The range of variation of intensity of noise is very large. The loudest and almost painful noise is about 10^{13} times the intensity of sound which is just audible. On account of the wide range of noise levels and the importance of the effect of increase in noise produced on the human ear a ' logarithmic scale ' is used. Experiments have shown that the ear does not respond in proportion to the intensity of the sound, and that its response is approximately proportional to the logarithm of the intensity of sound. For example, sound intensities varying in the proportion of 10 : 100 : 1000, cause aural effect in the ear proportional to the logarithms of 10 : 100 : 1000, that is, 1, 2 and 3. The unit for comparing two noise levels is a ' bel ' which is the logarithm of the ratio of the two intensity levels. For example, if the two noise levels are represented by I_1 and I_2, the ratio of the two levels expressed in bels is

$$\log_{10} \frac{I_1}{I_2}$$

The 'bel' is a large unit and therefore for practical measurement, a 'decibel' equal to 1/10 of a 'bel' is used. The ratio of the levels expressed in decibels is therefore

$$10 \log_{10} \frac{I_1}{I_2}$$

2.3.2 The scale of intensities of audible sound commonly met with covers a range of 130 db. From the physiological point of view, this scale is not satisfactory as the sensitivity with regard to loudness perceived by the ear varies with both the frequency and the intensity of sound. Sounds of equal intensities but of different frequencies may appear to the ear to have different loudness, except in the middle frequency range, where equal percentage increase in intensities levels produce equal increases in loudness. Taking into account the sensitivity of the ear the more representative unit 'phon' is used which represents the level of equal loudness at all frequencies. Sound is measured in phons by comparing it aurally with a standard pure-tone of a thousand cycles per second adjustable in intensity. Starting from zero decibel, that is the threshold of audibility (reference sound pressure of 0·000 2 dynes/cm^2), the level of intensity of sound of thousand cycles tone is adjusted so as to be equally loud to the ear as a given noise. The level of the noise in phons is equivalent numerically to the intensity level in decibel of 1 000 cycles tone found to be equally loud to the ear. For the sake of convenience in practice, however, all values are expressed in decibels referred to threshold of audibility.

2.3.3 Some typical sound levels are given in Table I.

TABLE I TYPICAL SOUND LEVELS

SOURCE	SOUND LEVEL db
Aeroplane noise, pneumatic drill (threshold of pain)	130
Auto horn, thunder, artillery	120
Pneumatic rivetter	110
Tram passing, boiler factory	100
Heavy road traffic, noisy factory	90
Truck passing, printing press, very loud radio music	80
Stenographic room, very noisy restaurant, automobile passing	70
Average conversation at one metre	60
Average office	55
Quiet house	45
Whisper	30
Rustle of leaves	20
Threshold of audibility	0 (Reference sound pressure of 0·000 2 dynes/cm^2)

2.4 Transmission of Noise — Any noise whether of outdoor or of indoor origin, is transmitted through walls, frames, ceiling or floor of an enclosure and/or through air (*see* Fig. 1). Such transmitted noise is of two types, namely air-borne noise and impact noise. Structure-borne noise is caused by impact and is transmitted as air-borne noise.

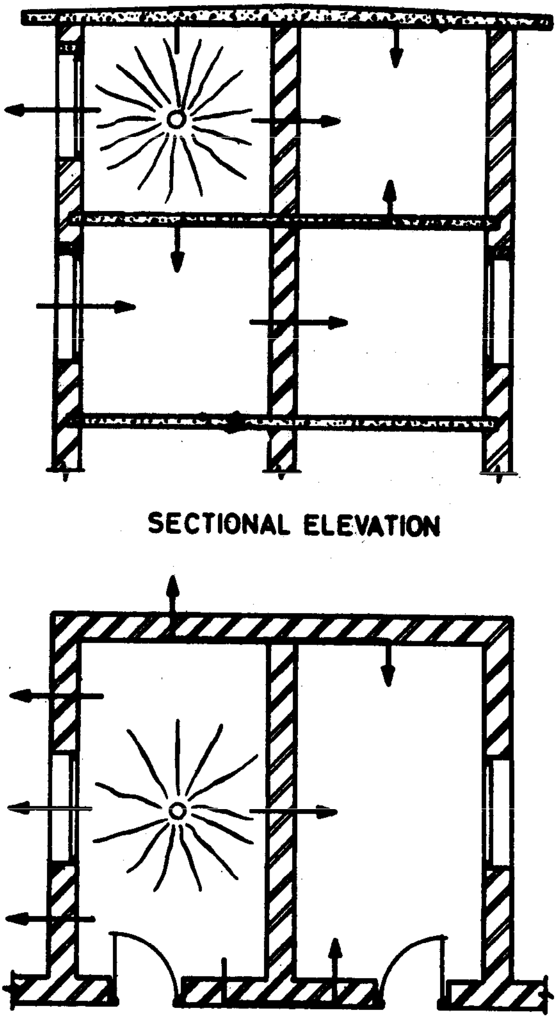

Fig. 1 Transmission of Air-Borne Sound by Direct and Indirect Paths

2.4.1 *Air-Borne Noise* — Air-borne noise may be transmitted into an enclosure by:

a) Air vibration through doors, windows, ventilators, and ventilating ducts, and other openings, holes and cracks; and

b) Vibration of the structure as a whole, which allows transmission of sound from one portion of the building to another. It is found that room structure or large portions of the structure such as walls, floors and the ceiling vibrate like diaphragms resulting in the creation of sound waves on the other side.

2.4.2 *Impact Noise* — Impact noise is generated in solid structures and is transmitted as air-borne noise. Noise of footsteps, slamming of doors, etc, cause vibrations in solid materials and are conveyed over comparatively long distances. Denser the solid material, more readily does the sound travel through it.

2.5 Transmission Loss — During transmission of air-borne noise through a structure a reduction in sound intensity takes place. This is termed 'Transmission Loss' (TL) and is numerically equivalent to the loss in intensity of sound expressed in decibels. The efficiency of sound insulation of a partition is expressed in terms of the transmission loss of air-borne sound that occurs while sound is being transmitted through it. Thus if 80 db and 40 db are the sound levels measured on either side of a wall, the transmission loss or sound insulation of that wall is 80 − 40 = 40 db. Sound insulation offered by a structure depends on the materials used and the method of construction employed. This value, however, varies with frequency and is high for the high frequencies and low for the medium and low frequencies. Adequate idea of the performance of a partition as a sound insulator cannot, therefore, be obtained from the transmission loss at one frequency. In practice the average of a number of such values in the range of about 200 to 2 000 cycles per second gives an adequate idea of noise reduction.

3. OUTSIDE NOISE LEVELS

3.1 Traffic Noise — Most prevalent and important source of noise in the residential as well as in the industrial areas is due to traffic either in close vicinity or at a distance. The main types of traffic noises encountered are:

a) Noise due to *heavy traffic conditions*, such as those existing
   1) in commercial and industrial areas,
   2) on main or arterial roads and routes which carry heavy and high speed traffic during the day and night, and

3) road corners where automotive vehicles take a turn and accelerate speed.

b) Noise due to *medium traffic conditions* — due to conditions similar to the above but less in severity, and

c) Noise due to *light traffic conditions* — due to relatively less traffic and plying of heavy vehicles at low speeds.

The traffic noise levels due to average conditions of the above three categories are given in Table II.

TABLE II TRAFFIC NOISE LEVELS (AVERAGE CONDITIONS)

(*Clause* 3.1)

SL No.	TRAFFIC NOISE	OVERALL NOISE LEVEL IN db	REMARKS
i)	Light traffic	60 to 70	Measured at about 3 m from the vehicles
ii)	Medium traffic	70 ,, 80	
iii)	Heavy traffic	80 ,, 90	

3.2 Industrial Area Noise — These are due to industries in the area and related traffic. Generally two distinct conditions of noise are obtained in the industrial area, namely where a particular industrial noise may be above that of the background traffic noise, and where the background noise, usually due to traffic, may be above the industrial noise. The overall noise levels range from about 60 to 80 db. At night, these noise levels are likely to be lower by about 10 to 15 db because of the reduced traffic. In winter and in cold regions, a similar noise reduction, attributable to windows of the factories being kept closed, is obtained.

3.3 Residential Area Noise — These are usually due to (a) distant industrial or traffic noises, (b) local traffic noise, (c) children at play, and (d) other local noises from trade hawkers, dogs, etc. Typical residential area noise levels are indicated in Table III.

TABLE III RESIDENTIAL AREA NOISE LEVELS

SL No.	SITUATION	NOISE LEVELS IN db
i)	Residential areas with background of industrial noise or an average noise from heavy traffic	65 to 80
ii)	Other areas	60 to 70

4. MAXIMUM ACCEPTABLE NOISE LEVELS

4.1 The maximum acceptable noise levels inside buildings from the point of view of comfort, economy and practical considerations under the conditions prevailing in this country may be taken as in Table IV.

TABLE IV MAXIMUM ACCEPTABLE NOISE LEVELS

SL No.	TYPE OF BUILDING	NOISE LEVELS IN db
i)	Offices	50 to 60
ii)	Dwellings (houses and flats)	45 ,, 55
iii)	Schools (class rooms or lecture rooms)	45 ,, 50
iv)	Hospitals	40 ,, 50

5. RECOMMENDED SOUND INSULATION STANDARDS

5.1 The desirable sound insulation required to be provided for various types of buildings are given in Table V.

TABLE V SOUND INSULATION FOR VARIOUS BUILDINGS

SL No.	TYPE OF BUILDING	INSULATION FOR AIR-BORNE NOISE		INSULATION FOR IMPACT NOISE (FLOOR/CEILING CONSTRUCTION) db
		Noisy 90 db Level	Quiet 70 db Level	
i)	Hospitals	50	30	50 to 60*
ii)	Schools	45	25	45 ,, 50*
iii)	Dwellings	45	25	45 ,, 55*
iv)	Offices	40	20	40 ,, 50*

*The higher values correspond to concrete, stone or similar solid floor/ceiling construction.

5.2 When windows of a building, particularly those of bedrooms in apartments or flats, wards in hospitals and teaching rooms in schools, face roads carrying heavy traffic or other noises of the order of 80 to 90 db (measured at a distance of about 3 m), the building should be located at a minimum distance of about 30 m from the road; but a distance of 45 m or more, where possible, should be aimed at for greater relief from noise. When the windows are at right angles to the direction of the above type of noise, this distance should be arranged to be about 15 to 25 m. In case another building, boundary wall or trees and plantations intervene between the road traffic and the house/flat or school, certain further noise reduction is achieved and in such cases the above distances may be reduced suitably.

5.3 Sound insulation for air-borne noise or overall sound insulation required between individual rooms or apartments of a building unit shall be as given in Table VI. These values may, however, be suitably increased where required.

TABLE VI SOUND INSULATION BETWEEN INDIVIDUAL ROOMS

SL No.	SITUATION	INSULATION IN db
i)	Between the living room in one house or flat and the living room and bedrooms in another	50
ii)	Elsewhere between houses or flats	40
iii)	Between one room and another in the same house or flat	30
iv)	Between teaching rooms in a school	40
v)	Between one room and another room in an office	30
vi)	Between one ward and another in a hospital:	
	Normal	40
	Extra quiet	45

NOTE 1 — Where communicating doors are provided, all doors should be so designed as to provide recommended insulation between the rooms.

NOTE 2 — There are cases when a set of houses or flats have to be built for the people who work at night and sleep during the day. It is desirable to consider the design of at least one such room in each of the houses or flats which will provide an insulation of about 45 db in that room.

5.4 Sound Insulation of Impact Noise — The floor of a room immediately above the bedroom or living room shall have impact insulation as indicated in **5.4.1** and **5.4.2**.

5.4.1 *Concrete Floors* — In the case of houses and flats, these floors shall be insulated so as to reduce the average loudness of impact sound by about 15 db above that provided by a bare concrete floor of normal thickness. In the case of schools the floor of the room immediately above the teaching room shall have an insulation of about 10 db above the normal floor insulation.

5.4.2 *Timber Floors* — In the case of houses and flats, these floors shall be insulated so as to reduce the average loudness of impact sound by about 20 db as compared with the normal floor construction of a wooden board joist floor with lath and plaster ceiling. In the case of schools, the floor of the room immediately above the teaching room shall have an insulation of about 15 db above the insulation of normal floor construction indicated above.

5.5 Sound Insulation for Noise Emanating from Mechanical Equipment — Mechanical equipment which emanate sound such as water-closets, pumps, motors, lifts, etc, shall be adequately insulated.

6. MEANS OF ACHIEVING NOISE REDUCTION AND SOUND INSULATION

6.1 Noise Reduction

6.1.1 *By Suitable Location, Orientation in Layout and Plan* — The most obvious method is to locate the residential buildings in a quiet area away from the noisy surroundings like the industrial areas, railway tracks, tramway lines, aerodromes, roads carrying heavy traffic, etc. They shall be adequately set-off from the road and oriented in such a way that doors and windows do not face the source of noise. In case this is found not possible, double doors and windows shall be provided to prevent leakage of sound. Where possible, the windows and ventilators may be eliminated by providing artificial illumination and mechanical ventilation.

6.1.2 *By Suitable Arrangement of Rooms within Residential Buildings* — The bed-rooms which are required to be quieter than the rest of the rooms are best located in the portion farthest from the noise source. Noise reduction is further attained by separating the bed-rooms from other rooms where noisy conditions can be permitted or tolerated. Mechanical equipment required for various services shall not be located above or close to the bedrooms or other rooms required to provide quiet condition.

6.1.3 *By Suppressing Noise at the Source Itself* — Certain types of noise, for example, the operation of mechanical equipment in the building, shall be suitably isolated or enclosed in sound-insulated enclosures so that noise emanating from it is reduced to the minimum.

6.1.4 *By Suppressing or Reducing Noise after its Entry into the Room* — The noises, where required could be further suppressed on entry into a room if some sound absorbent material is installed therein. Provision of special material may not be warranted in the case of residential buildings; however, the existence of furnishing material in living and bed rooms help to reduce noise.

6.1.5 *By Reducing the Noise Transmitted Through the Structure* — Reduction of air-borne noise through opening, the most common and major cause of penetration of noise into a room, requires that the structure should be made air-tight. The smallest crack or opening would vitiate the effect of insulation provided otherwise. Ventilating ducts, where installed, should be specially designed to minimize transmission of noise. In order to prevent the transmission of noise through vibration of structure as a whole, designs utilizing materials which transmit sound less easily than others may be used; the construction of the wall itself is important in obtaining the desired degree of sound insulation. Discontinuous or non-homogeneous structures may also be used to reduce the transmission of noise. The transmission of air-borne noise may be most effectively prevented by employing rigid and massive walls which do not have any openings for ventilation ducts, pipes, etc.

Reduction of 'impact noise requires the use of discontinuous or non-homogeneous materials in the construction of the structure.

6.2 Sound Insulation

6.2.1 *Sound Insulation Values of Non-porous Rigid Partitions* — The sound insulation of non-porous, homogeneous rigid constructions, such as well plastered solid brick masonry walls, varies as the logarithm of the weight per unit area and would thus increase with the thickness of wall. There is, however, a limit beyond which it requires an excessive increase in thickness to produce only a small increase in sound insulation (*see* Table VII). The relation between the weight of a rigid partition and its sound insulation is approximately such that every time the weight is doubled, there is an increase in sound insulation of about 4 to 5 db. Sound insulation values in relation to weight per square metre of wall are given in Table VII.

TABLE VII SOUND INSULATION VALUES ACCORDING TO WEIGHT OF MATERIAL PER SQUARE METRE

WEIGHT PER SQUARE METRE OF WALL AREA kg	TRANSMISSION LOSS IN db (SOUND INSULATION VALUE AVERAGE FOR 128 AND 2 048 c/s)
5	22·8
25	33·2
50	37·6
100	42·0
150	44·7
200	46·4
250	47·9
300	49·1
350	50·0
400	50·9
450	51·6
500	52·3
550	52·9
600	53·6

6.2.2 *Sound Insulation of Porous Materials*

6.2.2.1 *Porous rigid materials* — The relation between weight per square metre and the sound insulation value given in Table VII does not apply in the case of porous rigid materials, such as porous concrete masonry, cinder concrete, etc, because of their sound absorptive properties which provide about 10 percent higher insulation than the non-porous variety of the same weight. In order to secure the best insulation from such porous materials, it is recommended that the porous partition should be plastered at least on one side and if possible on both the sides.

6.2.2.2 *Non-rigid or flexible porous materials* — These are materials such as felt, mineral wool, quilt, etc, and they by themselves provide low sound insulation as compared to rigid materials and therefore they are not generally used for the purpose of noise reduction and isolation. However, a composite construction employing a combination of rigid materials and porous absorbers may be adopted where weight is an important factor. Such a construction produces better insulation per unit weight of the partition.

6.2.3 *Hollow and Composite Wall Construction*

6.2.3.1 *Heavy weight construction* — Neither the non-porous rigid materials nor the porous materials alone provide the desired insulation in a reasonable thickness. For example, about 100 cm thick wall (1 950 kg/m^2) or about 85 cm thick rock wool (80 kg/m^3 density) would be required to secure an insulation of about 60 db. A double wall construction with an intervening air space of 10 cm is however, more effective than a single partition of the same weight*. The use of porous rigid materials like cinder blocks also results in less pronounced vibrations than with the use of non-porous rigid materials in addition to the advantage of sound absorption provided by the hollow space.

6.2.3.2 *Light weight construction* — For light weight construction a variety of materials such as metal lath and plaster, fibreboards, plywood, plasterboards, etc, fixed on studs may be employed. For equal weight these provide greater insulation than solid masonry. Tests conducted on such partitions have shown that sound is mainly transmitted through the studs and very little through air space. Structural cross-connections or ties between the two partitions should

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*For example, solid 10 cm (195 kg/m^2) and 20 cm (390 kg/m^2) brick walls have a sound insulation of 45 and 50 db respectively, in mid-audio-frequency range, whereas two separate 10 cm (390 kg/m^2) walls with an air space of 10 cm provide an insulation of 90 db at the same frequencies, that is a substantial increase of about 40 db over that of a solid wall of equal weight.

therefore be avoided, but where they cannot be avoided only the minimum number required should be used. These ties where provided should be made of wire or, even more preferably, of a suitable flexible material. Construction with staggered studs (*see* Fig. 2) which makes the two partitions independent, is recommended.

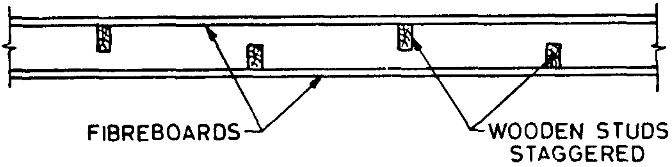


FIG. 2 TYPICAL SECTIONAL PLAN OF A SOUND PROOF PARTITION

6.2.3.3 *Filling of hollow spaces in partition* — The filling of hollow space with acoustic materials like rock wool or glass-wool which absorbs sound more effectively than air, does not always produce satisfactory results as the filler may form a bridge across the two partitions and thereby considerably reduce the insulation. Air space is generally better than a filling material unless the acoustic material is in the form of a quilt or an insulation board, suspended or fixed to one side only of a staggered stud partition with no rigid or even semi-rigid connection to the other side. This arrangement effects considerable increase in the insulation value. In the case of hollow light weight partitions, which may not be structurally separated, the acoustic filler helps to increase the insulation only slightly and therefore may not be worth the additional expenditure involved on the filler.

6.2.3.4 *Composite wall* — Composite walls of laminated construction may be designed to obtain any sound insulation desired; the maximum value is obtained when all the layers of alternate porous and rigid materials are separated by an air space in which case the value approaches approximately the sum of the values of individual units. Such a construction, however, occupies more space and needs great care in installation in order to obtain the anticipated efficiency. Use of such composite walls may be required in special cases where high sound insulation is necessary.

6.2.4 *Extent of Insulation Required* — As a general rule in practice reduction of noise requires to be carried to a level of about 10 to 15 db below the prevailing inherent noise level in the surroundings. For example, if ambient noise level in a certain room is, say, 60 db it is satisfactory if adequate sound insulation is provided so that no outside noise reaches inside the room above 45 to 50 db.

6.2.4.1 The desired sound insulation may be achieved in any one or more of the following three ways:

a) By adopting a continuous construction by using homogeneous materials where the extent of sound insulation is controlled by the weight per square metre. Where the requirements are not relatively stringent and are of the order of 50 db, solid construction of 20 cm to 30 cm bricks is considered suitable.

b) By adopting semi-discontinuous construction where air cavities are employed with cross-connections between the two partitions, the cross-connections being kept as few as possible and made preferably of a flexible material. For example, two 10 cm thick brick wall will provide 90 db, provided adequate discontinuity is maintained between the floor and the wall and the ceiling.

c) By adopting a fully discontinuous construction where complete discontinuity in the structure is introduced by means of an air cavity or an elastic acoustic material. This method would meet the requirements of the highest insulation required within reasonable weight per square metre.

6.2.5 *Overall Insulation* — In providing sound insulation in any room the question of overall sound insulation should be considered. Some areas, like sound-proof doors, windows, etc, may provide insulation lower than that of the other surfaces and thus would adversely effect the overall insulation. All the areas should, therefore, be designed and constructed to provide sound insulation approximating to the desired overall value.

6.2.6 *Classification of Partitions* — The result of tests made on the transmission of speech through partitions of known insulation value together with the rating of their relative efficiency is indicated in Table VIII. In each case conditions with ambient noise level of 30 db have been assumed on the listening side.

6.2.7 *Examples of Sound Reduction Values* — Values of sound reduction for typical types of (a) continuous construction, (b) semi-discontinuous constructions, and (c) discontinuous construction are given in **A-1**. Sound reduction values obtainable with various types of windows are given in **A-2**.

6.2.8 *Insulation or Isolation of Impact Sounds* — The transmission of such sounds as in the case of air-borne sounds may be effectively stopped or minimized by interposing a resilient material for obtaining discontinuity along the path of the vibrations. Both the semi-discontinuous and the fully discontinuous methods are applicable for isolation of such sounds.

TABLE VIII CLASSIFICATION OF SOUND INSULATING PROPERTIES OF PARTITIONS ACCORDING TO THEIR AVERAGE TRANSMISSION LOSS

(*Clause* 6.2.6)

SL No.	TRANSMISSION LOSS OF WALL db	HEARING CONDITION	RATING
i)	30 or less	Normal speech can be heard through the wall	Poor
ii)	40	Loud speech can be understood fairly well but normal speech cannot be understood	Fair
iii)	45	Loud speech can be heard but is not easily intelligible. Normal speech can be heard only faintly, if at all	Good
iv)	50	Loud speech can be faintly heard but is not understood. Normal speech is inaudible	Very good (recommended for dividing walls or partitions)
v)	60 and above	Very loud sounds, such as loud singing and brass musical instrument or a radio at full volume can be heard faintly	Excellent (recommended for band rooms, music practice rooms, radio and sound studios)

6.2.9 *Sound Insulation of Floors and Ceilings* — Both air-borne and structure-borne sounds may be transmitted through floors and ceilings. In most of the cases where the ceilings and floor construction is of solid type like cement concrete these have sufficient weight and rigidity to provide adequate insulation for air-borne sounds, but offer poor insulation for structure-borne or impact sounds. Insulation against impact sounds may be done in the following three ways:

a) *By using a resilient surface material on floors* — This helps to damp the impact noises, but has no appreciable effect on air-borne sounds. Linoleum, insulation board, cork, asphalt mastic and carpet are some of the materials usually employed; the softer the material used, greater is the insulation effected. An insulation of 5 to 10 db over a bare concrete floor is obtained with such material.

b) *By providing a floating floor construction*

1) *Concrete floors* — This is an additional floor constructed and isolated or floated from the existing concrete floor by means of a resilient material, and therefore, does not let the impacts and consequent vibration to be transmitted to the room below. It also provides useful improvement in the

insulation of air-borne sounds. A typical construction is shown in Fig. 3. The cement concrete used may be of about 5 cm thickness which is poured over a resilient material like quilted mineral or glass-wool. It is important that a waterproof paper be used in between, and both the quilt and paper lapped so as to prevent concrete from getting through.

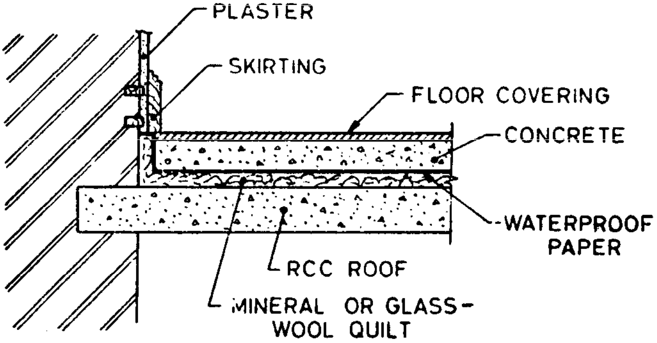


Fig. 3 Concrete Floor Floating Construction

2) *Wooden floors* — In the case of floors constructed of wooden joists the problem of sound insulation becomes more difficult particularly in the presence of heavy mechanical impact sounds. Sketches in Fig. 4 show methods of insulating such floors employing mineral or glass-wool quilt for isolation purposes. Resilient mountings may be used to obtain even more satisfactory results.

A further improvement in the insulation of such floors is achieved by employing a 'pugging' or a 'deadening' material in the air space between the wooden joists (*see* Fig. 4 and 5). Either sound absorbent type materials like mineral wool or other materials like sand or ashes, may be used; the latter are more effective because of the fact that the efficiency of the 'pugging' depends on the weight of the material used. In order to obtain useful improvement, at least 100 kg/m^2 of sand 'pugging' is usually employed. Mineral wool pugging (at least 15 kg/m^2) is used mainly in conjunction with thin walls of 10 cm thickness or less.

c) *By using a suspended ceiling with air space* — This helps to improve the insulation of both air-borne and structure-borne sounds by attenuating and isolating them from the room below. Typical constructions for wooden floors are shown in

(*Continued on page* 20)

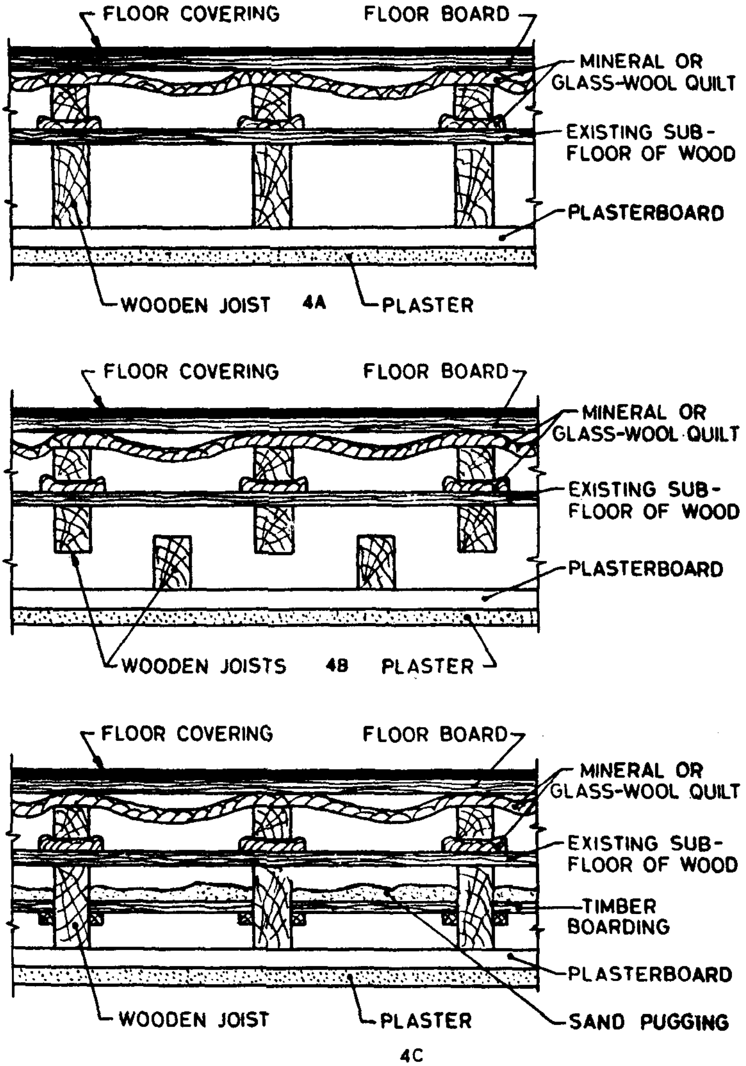
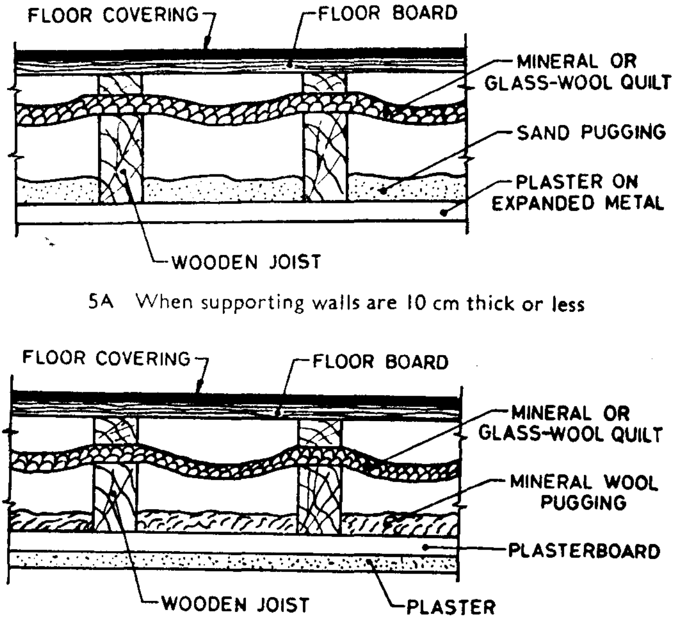


FIG. 4 EXISTING TIMBER FLOORS, FLOATING CONSTRUCTION

Fig. 6A, 6B, and 6C, which provides increasing degree of insulation. For solid floors, metal hangers or acoustic clips may be used to support the ceiling below, as shown in Fig. 6D. The extent of improvement effected depends on the weight of the ceiling as well as on the structural rigidity with which it is connected to the solid or wooden floor. Thus the highest insulation could be achieved by using a heavy ceiling which is arranged to be independent of the floor by supporting it on resilient mountings.

In cases of very heavy impacts which are difficult to eliminate altogether, both the methods (b) and (c) may be adopted.

Sound insulation values of typical floors and ceilings covered above are given in **A-3** and **A-4**.



5A When supporting walls are 10 cm thick or less

5B When supporting walls are 20 cm thick or more

FIG. 5 NEW TIMBER FLOORS, FLOATING CONSTRUCTION WITH PUGGING

6.2.10 *Skirting* — The type of skirting fixed will affect the insulation of the floor a great deal. The larger the contact area it provides between floor and the walls, the lower would be the insulation. A

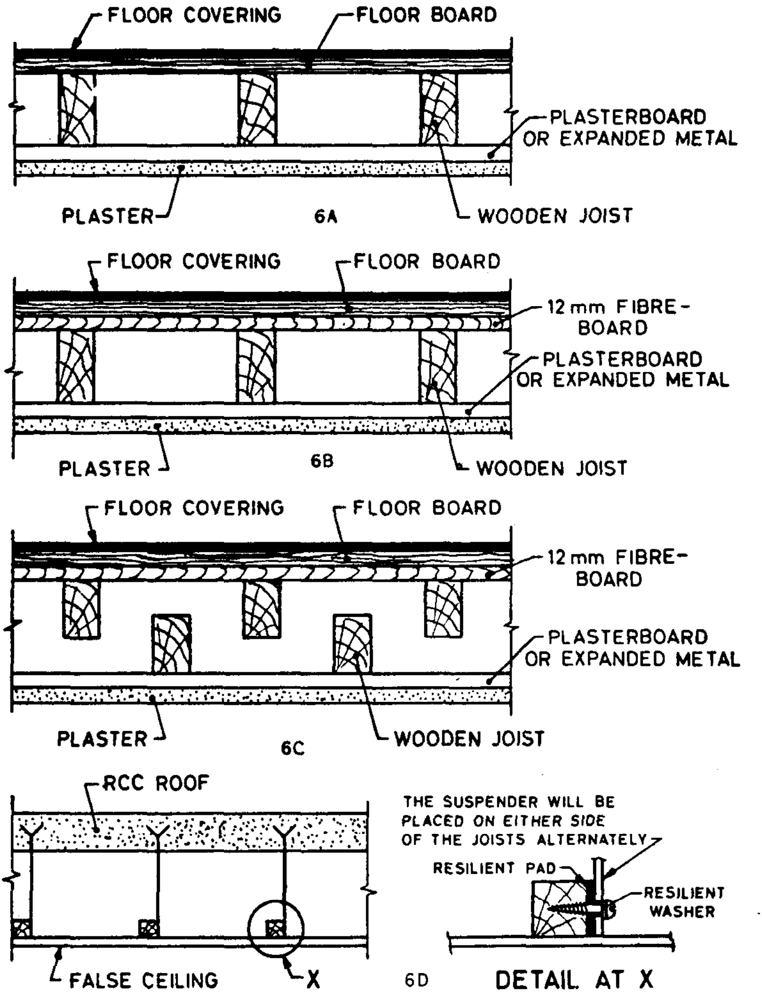


Fig. 6 Timber Floors, Floating Construction, with Suspended Ceiling

typical method of fixing skirtings is shown in Fig. 3. These use air gap or a resilient material between the skirting and the floor or the lower edge is chamfered to reduce the contact area. Again, most of the inner portion of the skirting is scooped out to minimize contact with the walls.

APPENDIX A

(*Clauses* 6.2.7 *and* 6.2.9)

A-1. EXAMPLES OF SOUND REDUCTION VALUES

SL No.	MATERIAL OR TYPE OF CONSTRUCTION	AVERAGE SOUND REDUCTION db
	Continuous Constructions	
1	12·5-mm fibreboard	20
2	7·5 kg/m² sheet glass	25
3	10-mm plasterboard	25
4	6·5-mm plate glass	30
5	20-mm plasterboard, plastered 16 mm each side	35
6	7·5-cm clinker concrete block, plastered	40
7	10-cm brickwork or concrete, plastered	45
8	20-cm brickwork, plastered	50
9	40-cm brickwork, plastered	55
	Semi-Discontinuous Constructions	
1	Boarding on timber joists, with plasterboard ceiling with skim-coat plaster	30-35
2	Boarding on timber joists, with metal lath and plaster ceiling	35-40
3	As 1, plus pugging on trays at 50 kg/m², the pugging to be air-tight (e.g. sand, mortar)	40-45
4	As 2, plus floating floor boarding on battens on resilient quilt	55
5	As 3, but with floor replaced by boarding on cross battens on resilient quilt laid over joists	55
6	Timber stud partition with metal lath and plaster both sides	35
7	Double partition of 7·5 cm hollow clay blocks, plastered externally, 5-cm cavity, with strip metal ties	40-45
8	As 7, but with wire ties	50-55
9	Cupboards used as partitions	25-35

SL No.	MATERIAL OR TYPE OF CONSTRUCTION	AVERAGE SOUND REDUCTION db
	Discontinuous Constructions	
1	Two leaves of 6-cm clinker concrete, plastered and separated by a 5-cm air space associated with suspended ceiling and floating floors:	
	measured across the walls	50 to 60
	measured through the floor	65 to 75
2	As 1, but with a third leaf or 5-cm clinker concrete between the two discontinuous shells; each air-space 5 cm, measured across the walls or through the floor	65 to 75
3	As 1, but with walls of 10-cm brick, plastered:	
	measured across the walls	60 to 70
	measured through the floor	65 to 75
	The values given for these three items are for walls without wall ties. Wire ties effect a slight reduction (about 5 db) and strip metal ties a considerable reduction in these values.	

NOTE — Variations in sound insulation due to the use of different plasters do not appear to be significant.

A-2. SOUND INSULATION VALUES OF TYPICAL WINDOWS

DESCRIPTION OF WINDOW	AVERAGE SOUND REDUCTION db
Open, in average furnished domestic room or in class rooms occupied by pupils	5
Open, but with openings reduced to about 0·46 m^2	10
Closed, single 7·5 kg/m^2 glass	25
Closed, double 7·5 kg/m^2 glass, 25 mm apart	35
Closed, double 7·5 kg/m^2 glass, 15 cm apart	45
Closed, single 6·5-mm plate glass	30
Double, with baffled ventilation openings	30 to 35
Closed, double 6·5-mm plate glass, 15 cm apart	55
Closed, double 6·5-mm plate glass, 15 cm apart and reveals lined with absorbent material	60 to 65

A-3. SOUND INSULATION OF TYPICAL FLOORS OTHER THAN TIMBER FLOORS

Sl No.	Treatment	Improvement Over Bare Concrete Floors db
	Resilient Surface Material on Concrete	
1	Bare concrete	0
2	Linoleum	5
3	Wood blocks or thin carpet or rubber	5 to 10
4	Carpet or underfelt	10
	Floating Floor	
	a) *5-cm Dense Concrete Screed on:*	
5	Clinkers 5 cm	5 to 10
6	Granulated cork 2·5 cm	10 to 15
7	Slag wool quilt, 2·5 cm nominal thickness (density 190 kg/m^3)	15 to 20
8	Glass silk quilt, 2·5 cm nominal thickness (density 80 kg/m^3)	20
9	Glass silk quilt, two nominal 2·5 cm layers	25
	b) *Boarding on Battens on:*	
10	Clips, unlined	5 to 10
11	Asbestos or felt pads, 12·5 mm	5 to 10
12	Fibreboard pads, 12·5 mm	10
13	Felt pads, 2·5 cm or rubber pads, 12·5 mm	10 to 15
14	Slag wool quilt, 2·5 cm nominal thickness	10 to 20
15	Glass silk quilt, 2·5 cm nominal thickness or rubber pads, 2·5 cm	15 to 20
	Suspended Ceilings (subject to notes under **A-4**)	
16	10-mm (single coat) or 12·5-mm (two coats) plaster on 12·5-mm fibreboard on 50 × 50 mm battens in clips	5 to 10
17	5-mm (single coat) or 12·5-mm (two coats) plaster on 10-mm plasterboard, on battens in felt-lined clips	10 to 15

A-4. SOUND INSULATION OF TIMBER FLOORS

SL No.	TREATMENT	IMPROVEMENT OVER FLOOR DESCRIBED IN ITEM 1 BELOW db
1	Boarding on joists with ceiling of lath and plaster, or plaster on plaster board	0
2	As 1, plus carpet or underfelt	5 to 10
3	As 1, plus floating floor of boarding on battens on fibreboard	5
4	As 1, plus floating floor of boarding on battens on resilient quilt	10 to 15
5	As 1, plus pugging of sand or ashes 50 kg/m^2 or glass silk or slag wool 10 kg/m^2	5 to 10
6	As 1, plus pugging of sand or ashes 100 kg/m^2	10
7	As 1, but with floor replaced by boarding on cross battens on resilient quilt (not nailed)	5 to 10
8	As 7, plus pugging of sand 50 kg/m^2	20
9	Boarding on joists with separate joists for ceiling	5
10	Carpet on underfelt with boarding on joists for ceiling as above	10 to 15
11	Boarding on joists, pugging of sand or ashes 10 kg/m^2 with ceilings as above	15
12	Floating floor, boarding on battens on resilient quilt on sub-boarding, with joists and ceiling as above	15 to 20

NOTE 1 — Suspended ceiling alone will not be effective or give the value shown unless precautions are also taken to prevent transmission of impact noise by indirect paths, for example, by the use of a floating floor or by insulating the structural floor from the walls of the room below, or by using fully discontinuous construction.

NOTE 2 — The values of the treatments given in **A-3** and **A-4** may in appropriate cases be added; for example, the value of pugging may be added to the value of a floating floor, giving a total noise reduction of 20 db.

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Alterations

(*Page* 18, *Fig*. 3) — Substitute the following for the existing figure:

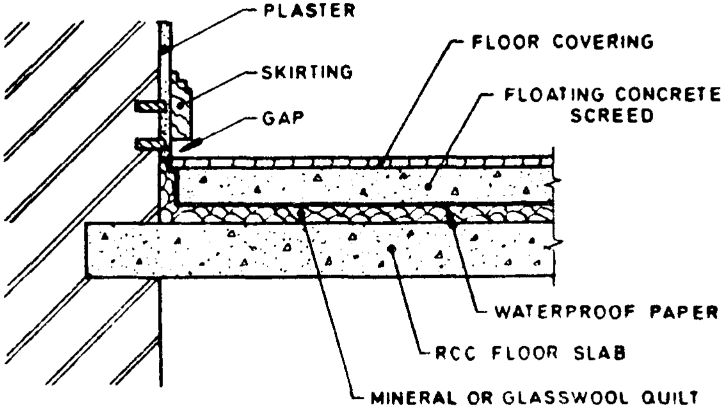
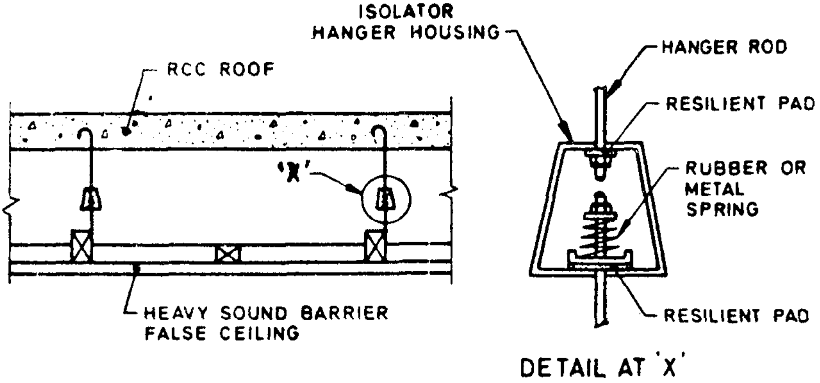


FIG. 3 CONCRETE FLOATING FLOOR CONSTRUCTION

(*Page* 21, *Fig*. 6D) — Substitute the figure on page 2 of this amendment for the existing figure.



6D

FIG. 6 TIMBER AND SOLID FLOORS, FLOATING CONSTRUCTION, WITH SUSPENDED CEILING

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