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Indian Standard

CODE Of PRACI1CB FOR ACOUSTICAL DESIGN OF AUDITORIUMS AND CONFERENCE HALLS

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

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Indian Standard

CODE OF PRACTICE FOR ACOUSTICAL DESIGN OF AUDITORIUMS AND CONFERENCE HALLS

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CONTENTS

PAGE

0. FOREWORD 4
1. SCOPE 5
2. TERMINOLOGY 5
3. ACOUSTICAL REQUIREMENTS 7
   3.1 Halls Used for Speech and/or Drama 7
   3.2 Halls for Music 7
   3.3 General Purpose Halls Used for Both Speech and Music 7
   3.4 Cinemas (Sound Picture Halls) 7
   3.5 Open-Air Auditoriums and Conference Halls ... 8
4. GENERAL PRINCIPLES OF DESIGN 8
   4.1 Site Selection and Planning 8
   4.2 Size and Shape 8
5. SEATS 11
6. REVERBERATION TIME 12
7. DISTRIBUTION OF ACOUSTIC MATERIAL 14
8. SOUND ABSORBING MATERIALS 14
9. SOUND AMPLIFICATION SYSTEM 15
10. ADDITIONAL REQUIREMENTS FOR OPEN-AIR AUDITORIUMS AND CONFERENCE HALLS 15
   10.1 Open-Air Auditoriums 15
   10.2 Conference Halls 15

APPENDIX A SUMMARY OF COMMON ACOUSTICAL DEFECTS IN AUDITORIUMS & CONFERENCE HALLS AND RECOMMENDED REMEDIES FOR THE SAME 17

APPENDIX B ABSORPTION COEFFICIENTS FOR BUILDING MATERIALS AND FURNISHINGS 18

APPENDIX C ABSORPTION COEFFICIENTS OF INDIGENOUS ACOUSTICAL MATERIALS 19

Indian Standard
CODE OF PRACTICE FOR ACOUSTICAL DESIGN OF AUDITORIUMS AND CONFERENCE HALLS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 26 October 1963, after the draft finalized by the Functional Requirements in Buildings Sectional Committee had been approved by the Building Division Council.

0.2 A series of codes are being prepared by the Functional Requirements in Buildings Sectional Committee to cover the functional aspects of buildings, such as heat and sound insulation, acoustics, ventilation, daylighting and orientation. Code covering sound insulation of non-industrial buildings (IS : 1950-1962) has already been published and others are in course of formulation. This code is intended to cover the basic principles of acoustical design of auditoriums, cinemas, theatres and conference halls for general guidance of the architects and builders. It is, however, suggested that in all major and complicated cases expert acoustical advice should be sought at the planning stage itself in order to obviate excessive expenditure on corrective measures later on.

0.3 A summary of common acoustical defects usually noticed in auditoriums and conference halls as also recommendations for remedying the same are given in Appendix A for guidance.

0.4 The Sectional Committee responsible for the preparation of this standard has taken into consideration the views of architects, acoustical experts and builders and has related the standard to the current practice followed in the country in this field. Due consideration has also been given to the practices and standards followed in different countries of the world.

0.5 Metric system has been adopted in India and all the dimensions and quantities appearing in this standard have been given in this system.

0.6 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.

0.7 This standard is intended chiefly to cover the technical provisions relating to the acoustical design of auditoriums and conference halls, and it does not cover all the necessary provisions of a contract.

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1. SCOPE

1.1 This standard covers acoustical requirements and design of various types of auditoriums and conference halls.

1.1.1 This code does not give recommendations for ancillary facilities, such as lighting, air-conditioning, fire fighting, toilets, number and size of emergency exists, etc, to be provided in auditoriums and conference halls. These shall be provided in accordance with relevant Indian Standards, wherever available, and local regulations, if any.

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Absorption Coefficient — Ratio of sound energy absorbed to the incident sound energy on a material.

2.2 Absorption Unit — This is expressed in sabins (*see* **2.24**).

2.3 Absorption of a Surface — Product of the area of a surface multiplied by its absorption coefficient.

2.4 Acoustical Treatment — Any treatment of surfaces of an enclosure or introduction therein of sound absorbing devices with the specific purpose of controlling the reverberation time of an enclosure.

2.5 Aisles — The gangways left within and around the seating area for walking into or out of a group of seats.

2.6 Auditorium — An enclosure, covered or open, where people can assemble for watching a performance given on the stage.

2.7 Back Stage Wall — The wall at the back of the stage facing the audience. The back stage wall may also be called Cyclorama when it is given a special shape for providing the ultimate background for scenic effects.

2.8 Balcony Floor — Extra floor constructed over part of the house for seating additional audience which may or may not project beyond the rear wall.

2.9 Balcony Soffit — The area of under surface of the balcony within the hall.

2.10 Cinema — An auditorium where the performance is in the form of pictures projected on a screen with or without the accompaniment of scenic atmosphere.

2.11 Conference Hall — A hall intended for use by participants (sometimes with non-participating audience) in a discussion or deliberation on a topic in the form of speech or conversation made by one person at a time seated anywhere in the hall.

2.12 Crush Hall — The first entrance hall (sometimes provided in addition to the foyer) outside the main hall for purposes such as buying tickets, waiting, etc.

2.13 Echo — A distinct and clearly discernible reflected sound received at a point within the enclosure when any sound emanates from any part of that enclosure. A quick succession of such echoes is called flutter or flutter echo.

2.14 Foyer — Hall in front of the entrance in which the audience may wait before actually entering the house.

2.15 Lounge — Sitting room or place for relaxation.

2.16 Lobby — Passage or small ante-room, into which one or more rooms open.

2.17 Proscenium — The total opening between the stage and the house through which the audience witness a performance on the stage.

2.18 Proscenium Overhang — The front area of the proscenium that is still visible to the audience when the curtain is lowered. It includes the curtain and the arch or the frame work that holds it.

2.19 Public Address System (PA System) — The complete chain of sound equipment (comprising essentially of microphones, amplifiers and loud-speakers) required to reinforce the sound emanating from a source in order to provide adequate loudness for comfortable hearing by the audience.

2.20 Raking of Seats — The gradual rise in the level of seats in successive rows, away from the stage, so as to ensure unobstructed view of the stage performance to the audience.

2.21 Rear Wall — The wall facing the stage at the end of the hall.

2.22 Reverberation — Persistance of sound in an enclosure (partially or completely enclosed) after the source of sound has stopped.

2.23 Reverberation Time — The time taken by the reverberant sound to decay to one-millionth of the sound intensity level existing at the time the source of the sound is stopped.

2.24 Sabin (m^2) — Unit of sound absorption in metric system. This is equal to sound absorption of one square metre of ' open window '.

2.25 Sound Insulation of Building Components — The reduction in the level of sound when it passes through a building component like wall, floor, roof, door, window, etc.

2.26 Stage Apron — Portion of stage which extends beyond the proscenium into the house.

2.27 Staggering of Seats — An arrangement of seats in a manner whereby seats are displaced (relative to each row) by half-seat pitch in every successive row.

NOTE — Such staggering ensures a clear view from each row with relatively less raking than is necessary if seats are exactly one behind the other in successive rows.

2.28 Theatre — An auditorium where the performance is essentially given by ' live ' characters with or without the accompaniment of sound.

3. ACOUSTICAL REQUIREMENTS

3.1 Halls Used for Speech and/or Drama — The clarity of speech is most important in this case. Optimum clarity depends on:

a) correct reverberation time,

b) absence of echo,

c) correct loudness level at all parts of the hall, and

d) low background noise.

3.2 Halls for Music — Adequate reverberation is important to lend proper blending and fullness of music. The reverberation time is required to be higher than for halls meant for speech only.

3.3 General Purpose Halls Used for Both Speech and Music — The reverberation time should be in-between that provided for in **3.1** and **3.2**.

3.4 Cinemas (Sound Picture Halls) — In view of the fact that a certain amount of reverberation is already present in the recorded sound, the reverberation time required in this case is lower than that required for **3.3**.

3.5 Open-Air Auditoriums and Conference Halls — While the general acoustical requirements are similar to those specified for halls (*see* **3.1**), additional requirements which arise are dealt with in **10**.

4. GENERAL PRINCIPLES OF DESIGN

4.1 Site Selection and Planning — The choice of site for an auditorium is governed by several factors which may be mutually conflicting, but a compromise has to be struck between the various considerations involved. The problem of noise is an important consideration. A noise survey of the site should be made in advance so that noisy locations are avoided where possible, as otherwise elaborate and expensive construction may be required to provide requisite sound insulation. In fact, the quietest possible condition should be provided so that intelligibility of speech does not suffer and even soft passages of music are heard. It is particularly necessary to keep the level of extraneous noise low by proper orientation and site selection in cases where no air-conditioning is provided and doors and windows are normally kept open during the performance. When air-conditioning is provided special care should be taken to attenuate the plant noise and the grill noise. For this purpose plant should be suitably isolated and ducts as well as the plenum should be so designed that noise gets adequately reduced so as to be within the permissible limits.

4.1.1 Depending on the ambient noise level of the site, orientation, layout and structural design should be arranged to provide necessary noise reduction, so that the background noise level of not more than 40 to 45 dB (as measured on 'A' scale of sound level meter) is achieved within the hall.

NOTE — Decibel (dB) is a unit of sound intensity level and expresses the ratio of a given sound level to the minimum perceptible level (quantitatively 0·000 2 dynes/cm^2) on a logarithmic scale.

4.2 Size and Shape

4.2.1 The size should be fixed in relation to the number of audience required to be seated. The floor area of the hall including gangways (excluding the stage) should be calculated on the basis of 0·6 to 0·9 m^2 per person. The height of the hall is determined by such considerations as ventilation, presence (or absence) of balcony and the type of performance.

4.2.1.1 The average height may vary from 6 m for small halls to 7·5 m for large halls. Ceiling may be flat but it is preferable to provide a slight increase in the height near the centre of hall. The volume per person required to be provided should normally range between 3·5 to 5·5 m^3. Suitable volumes for different types of auditoriums are given below but it is recommended that higher values be adopted only in special cases:

	Cubic Metres per Person
a) Public lecture halls	3·5 to 4·5
b) Cinemas or theatres	4·0 ,, 5·0
c) Musical halls or concert halls	4·0 ,, 5·5

In the case of (c), the upper limit is suitable for musical performances while the lower limit may be chosen in the case of small general purpose auditoriums.

4.2.2 Floor plans of various shapes are used, but the one which is considered to give satisfactory results without introducing complications in the acoustical treatment of the hall is the fan-shaped plan. The proscenium may bear any suitable ratio with the height of the hall to suit stage requirements and considerations of visibility. The side walls should be arranged to have an angle of not more than 100 degrees with the curtain line. In the case of talking pictures synchronisation of sound with lip movement is most essential. Also, in the case of theatres a person with normal vision should be able to discern facial expressions of the performers. In order to satisfy these conditions, it is recommended that the distance of the farthest seat from the curtain line should not normally exceed 23 metres.

4.2.3 *Stage* — The size of the stage depends upon the type of performance the hall is to cater for. It would be large for theatres, while it would be comparatively small for cinema halls which again depends on the size of the screen.

4.2.4 *Rear Wall* — The auditorium rear wall(s) should be either flat or convex in shape. This should not be concave in shape, but where it cannot be avoided, the acoustical design shall indicate either the surface to be splayed or convex corrugations given in order to avoid any tendency for the sound to focus into the hall.

4.2.5 *Side Wall* —Where the side walls are non-parallel as in the case of a fan-shaped hall, the walls may remain reflective and may be architecturally finished in any manner required, if sound absorbing material is not required from other considerations. Where the side walls are parallel they may be left untreated to a length of about 7·5 m from the proscenium end. In addition, any of the surfaces, likely to cause a delayed echo or flutter echo should be appropriately treated with a sound absorbing material. Difference between the direct path and the path reflected from side walls shall not exceed 15 m.

4.2.6 *Roof and Ceiling* — The requirements pertaining to a roof are mainly governed by architectural, engineering or economic considerations. In large halls a false ceiling is usually provided below the trusses. The portion of the false ceiling near the proscenium is constructed of reflective material (usually plaster of Paris) and is suitably inclined to help reflections from the stage to reach the rear seats of the hall. The remaining portion of this ceiling is constructed to take acoustical treatment. Concave shaped ceilings (in the form of dome or barrel) should be avoided. The rear portion of the ceiling may be treated with sound absorbing material partly for control of reverberation and partly to prevent build-up of audience noise.

4.2.6.1 *Noise from aircrafts* — If the auditorium is so located that aircraft noise causes a serious disturbance (that is when noise level created inside the hall is more than 50 dB) special precautions should be taken to make the ceiling soundproof. A suitable soundproof false ceiling should be provided below the roof under such circumstances.

4.2.6.2 *Rain noise* — Wherever this problem arises due to frequent and heavy showers the same method should be followed as suggested for noise from aircrafts (*see* **4.2.6.1**).

4.2.7 *Floor* — For good visibility as also for good listening conditions, the successive rows of seats have to be raised over the preceding ones with the result that the floor level rises towards the rear. The elevation is based on the principle that each listener shall be elevated with respect to the person immediately in front of him so that the listener's head is about 12 cm above the path of sound which would pass over the head of the person in front of him. It is possible to reduce this to 8 cm, if the seats are staggered (*see* **2.27**). As an empirical rule the angle of elevation of the inclined floor in an auditorium should not be less than 8 degrees.

NOTE — Where more accurate values are considered necessary, the slope of the floor may be calculated by the following formula:

$$h_n = h_{n-1} + h - \frac{r (H - h_{n-1})}{S + (n - 1) r}$$

where

H = height of sound source above normal head level;

r = back to back distance between rows of seats;

h = ' head clearance ' in relation to the sound source, the difference in height between one row of people and the next;

$S = \left(\frac{rH}{h} + r \right)$ = horizontal distance from the source to the last row which does not require elevation; and

h_1, h_2, ... and h_n are elevations of the first, second..... and nth rows behind the row which is at a distance S from the source.

4.2.8 *Balcony* — Where a balcony is provided, its projection into the hall should not be more than twice the free height of the opening of the balcony recess.

4.2.9 *Line of Sight* — The elevation of the balcony seats should be such that line of sight is not inclined more than 30 degrees to the horizontal.

4.2.10 *Foyers, Crush Halls, Attached Rooms* — All the enclosed spaces, such as foyers, lounges, flanking verandahs, etc, adjacent to the auditorium should be isolated from the main hall by suitable (well fitting) doors so that the acoustics of the hall are not influenced by these rooms; heavy curtains may be used to aid absorption of external noise from foyers, verandahs, etc.

4.2.10.1 The foyer area, number and size of entrances also depend on the size and seating capacity of the auditorium. At least 20 percent of the seating area of the hall is recommended for foyer.

4.2.10.2 For lobby and lounge, areas at least corresponding to 10 percent of the seating area in the hall are recommended.

4.2.10.3 Further, these spaces should be acoustically treated so that the noises originating there do not cause any disturbance in the main hall. Incidentally, this will also reduce air-borne noises coming from outside.

4.2.11 *Doors and Windows* — Where the external noise level is high, properly fitted doors and windows should be provided. Their rebates should preferably be lined with draught strip rubber or felt.

In the case of existing doors and windows where leakage of sound is observed, it would be necessary to improve the fitting of the shutters and, at the same time, provide draught strip rubber or felt on the rebates.

5. SEATS

5.1 The seats should be arranged in concentric arcs of circles drawn with the centre located as much behind the centre of the curtain line as its (curtain line) distance from the auditorium rear wall.

5.2 The angle subtended with the horizontal at the front-most observer by the highest object should not exceed 30 degrees. On this basis, the distance of the front row works to about 3·6 m for drama and it should be 4·5 m or more for cinema purposes. Minimum distance of front seats should be determined by the highest point required to be seen on the stage which is usually raised by about 75 cm or more.

5.3 The width of a seat should be between 45 cm and 56 cm.

5.4 The back to back distance of chairs in successive rows of seats shall be at least 85 cm. If extra comfort is required, higher spacing may be provided which shall vary between 85 cm and 106 cm.

5.5 Seats should be staggered sideways in relation to those in front so that a listener in any row is not looking directly over the head of the person in front of him.

5.6 Upholstered seats shall be provided, wherever possible, so that the acoustic charcteristics of the hall are not appreciably affected by fluctuating audience occupancy. This is particularly important for halls where the audience provides the major part of the required sound absorption.

6. REVERBERATION TIME

6.1 The optimum reverberation time for a hall of particular volume may be chosen from the curves given in Fig. 1 depending on the function of the hall. These values are for a frequency of 500 cycles.

6.2 The number of absorption units required to give the desired reverberation time may be calculated according to Sabine's formula which is as follows:

$$A = \frac{0{\cdot}16\ V}{T}$$

where

$A = \Sigma\alpha_n\, S_n$ = total sound absorption,

V = volume in m^3,

T = reverberation time in seconds,

α_n = absorption coefficient of the corresponding surface(s), and

S_n = individual area in m^2 corresponding to each value of α_n.

6.3 In order to estimate the quantity of absorption A_1 required, it is necessary to calculate the quantity of existing absorption A_2 provided by various surfaces, furnishings and two-thirds of the audience. This may be deducted from the total absorption A indicated by the formula given below:

$$A_1 = A - A_2$$

6.4 The reverberation time varies at different frequencies. For the purpose of this code, it is enough to consider only one frequency as indicated in Fig. 1.

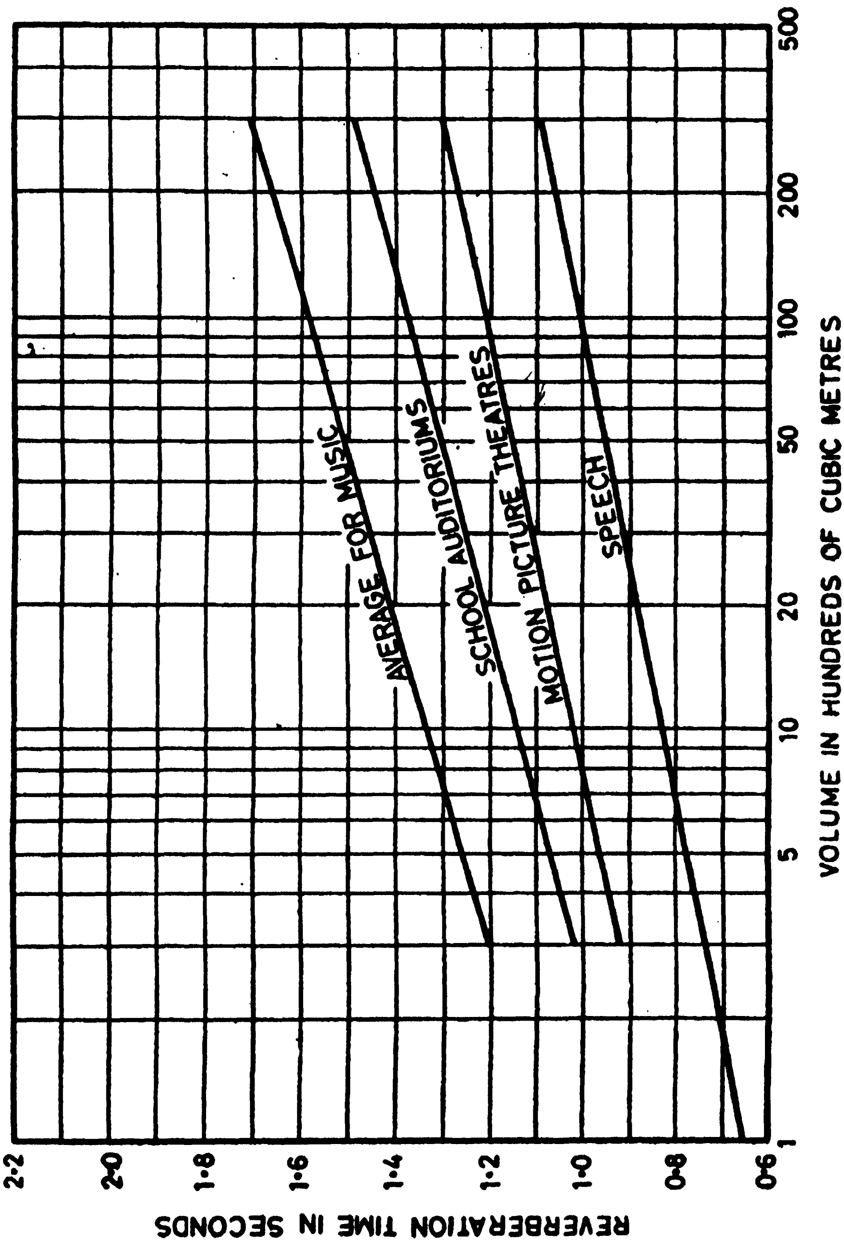

FIG. 1 OPTIMUM REVERBERATION TIME AT 500 CYCLES FOR DIFFERENT TYPES OF ROOMS AS A FUNCTION OF ROOM VOLUME

7. DISTRIBUTION OF ACOUSTIC MATERIAL

7.1 Reflecting surfaces shall be so designed as to aid distribution of sound. Those areas which cause objectionable sound reflection and need to be treated with sound absorbents should be earmarked for treatment with sound absorbing material. These areas are (a) the rear wall, (b) the balcony parapet, (c) any areas which may reflect sound back to the stage, (d) concave areas which have a tendency to focus sound in certain places, and (e) such other areas as will contribute to indirect sound arriving at any point in the hall later than 50 milliseconds after the direct sound. The rest of the sound absorbing material required to be introduced in the room should be distributed over the various remaining surfaces.

8. SOUND ABSORBING MATERIALS

8.1 The materials generally used may be broadly classified into the following categories:

a) Acoustic plaster (a plaster which includes granulated insulation material with cement);
b) Compressed cane or wood fibreboard, unperforated and perforated;
c) Wood particle board;
d) Compressed wood wool;
e) Mineral/glass wool quilts and mats;
f) Mineral/compressed glass wool tiles;
g) Composite units of perforated hardboard backed by perforated fibreboard;
h) Composite units of perforated board (hardboard, asbestos board or metal sheet) backed by mineral or glass wool quilt or slab; and
j) Special absorbers constructed of hardboard, teak ply, etc, backed by air.

8.2 In an average hall, most of the absorption is provided by the audience. This is relatively more in the high frequency range than in the middle or in the low frequency range. It, therefore, becomes desirable to introduce special low frequency absorbers (such as wooden panelling used as wainscot or otherwise) on ceilings and walls which will provide the requisite amount of absorption so as to achieve optimum reverberation time over as wide a frequency range as possible. The amount of the absorptive materials required should be calculated on the basis of the absorption values at one or more frequencies in each of the low, middle and high frequency regions namely 125, 500 and 2 000 c/s. The absorption coefficients for various materials are given in Appendices B and C.

9. SOUND AMPLIFICATION SYSTEM

9.1 A loudness of speech level of about 60 to 70 dB is required for comfortable listening and good intelligibility provided the ambient noise level is within the acceptable values given in **4.1.1**. This level can be obtained in an acoustically well designed hall provided the volume does not exceed 1 400 m^3 and the maximum distance from the speaker to listener is of the order of 23 m. Where background noise is high or the hall is large, a sound amplification system becomes necessary.

10. ADDITIONAL REQUIREMENTS FOR OPEN-AIR AUDITORIUMS AND CONFERENCE HALLS

10.1 Open-Air Auditoriums — While the general considerations given in **4.1** and **4.1.1** would apply to open-air auditoriums also, particular care should be taken in the case of open-air auditoriums as these are not enclosed. Prevailing noise conditions should not exceed 45 dB on 'A' scale. Wind velocities naturally experienced at site should not exceed 16 km/h.

10.1.1 Back stage wall should be made reflective and broken into convex shaped surfaces. Overall shape should be flat in plan; however, if it is desired to be concave, it should be broken into convex surfaces which in either case should be of at least 90 to 180 cm width.

10.1.2 Depth of stage should be arranged to suit individual requirements; where it exceeds 6 m, it is necessary to treat back stage wall acoustically. A ceiling reflector should be provided for directing the sound to the rear seats. This reflector may be a hard reflecting surface slanting at a suitable angle towards the audience and fixed over the main sound originating area of the stage.

10.1.3 If direction of wind generally remains the same, the auditorium should be so located that wind direction is towards the audience from the stage.

10.1.4 Even if reflectors are provided as recommended in **10.1.2**, sound amplification should be resorted to in case the number of audience exceeds 600 or back ground noise is more than 45 to 50 dB. The loudspeaker system should be so designed that it is capable of providing an average level up to 80 dB over the entire listening area.

10.2 Conference Halls — Basic difference between conference halls and auditoriums, like theatres and cinema halls, lies in the possibility of sound originating, in the former case from any part of the hall. In a conference hall a table or cluster of tables is generally placed in the centre of the hall, and persons who are listeners as well as speakers sit around the table. Conference halls may have any shape to suit architectural or any other special requirements. In designing conference halls particular consideration should, therefore, be given to the following requirements.

10.2.1 Acoustics of the halls should be so designed as to ensure proper conditions for listening, assuming that a person may speak or listen from anywhere in the hall.

10.2.2 Optimum reverberation time should be chosen from Fig. 1 (speech). It may be noted that too long a reverberation time muffles and confuses the speech intelligibility while too short a time prevents build-up of proper level for good listening.

10.2.3 Use of sound amplification system should be avoided as far as possible. But where necessitated, because of size or other requirements, low level loudspeakers or head phones should be provided for individual or a group of seats.

10.2.4 Absorbent material should be distributed evenly over the wall surfaces of the hall.

10.2.5 Ceiling should not be domed and should not be higher than 6 metres. Acoustical treatment on the ceiling should be confined to peripheral regions only. In the case of larger halls with considerable heights, more area of ceiling would need to be treated.

APPENDIX A

(*Clause* 0.3)

SUMMARY OF COMMON ACOUSTICAL DEFECTS IN AUDITORIUMS AND CONFERENCE HALLS AND RECOMMENDED REMEDIES FOR THE SAME

SL No.	DEFECT	CAUSES	RECOMMENDATION FOR	
			New Design	Existing Buildings
(1)	(2)	(3)	(4)	(5)
1	Excessive reverberation	Insufficient absorption	Add absorbents	
2	Echoes	Unsuitable shape	Avoid unsuitable shapes	—
		Remote reflecting surfaces	Make offending surface highly absorbent	
3	Sound foci	Concave reflecting interior surfaces	Avoid curvilinear interiors	Alter shape or use absorbents on focussing areas
4	Dead spots	Irregular distribution of sound	Provide even diffusion of sound	Introduce suitable diffusers
5	Insufficient sound volume	Lack of reflections close to source of sound	Dispose hard reflecting surfaces about the source of sound	
		Excessive absorption	Adjust absorption to give optimum reverberation	
6	Colouring of sound quality	Selective absorption	Use combination of absorbents to obtain uniform absorption coefficient over the required frequency range	
		Uncontrolled resonance	Use wood panel absorbents which resonate over a wide frequency range and fix these on battens provided at irregular intervals. Adopt rigid construction with studs, etc	
7	High background noise	Poor sound insulation, badly fitting doors and windows or noisy air-conditioning system	Select construction with requisite sound insulation; provide proper fitting doors and windows with requisite sound insulation. Reduce noise from air-conditioning equipment by isolating the machine and/or treatment of plant room, etc	

APPENDIX B

(*Clause* 8.2)

ABSORPTION COEFFICIENTS FOR BUILDING MATERIALS AND FURNISHINGS

Sl No.	Material	Absorption Coefficient at 125 c/s	500 c/s	2 000 c/s
	Hangings and Floorings			
1	Carpet, lined	0·10	0·25	0·40
2	Carpets, unlined	0·08	0·15	0·25
3	Cotton fabric, 475 g/m² draped to half its area	0·07	0·49	0·66
4	Draperies, velours 610 g/m²	0·05	0·35	0·38
5	Draperies, as above draped to half their area	0·14	0·55	0·70
6	Stage curtain	0·19	0·20	0·23
7	Linoleum or concrete floor	0·02	0·03	0·04
8	Floor, wood on solid	0·12	0·09	0·09
9	Floor, wood boards on timber frame	0·25	0·13	0·15
	Masonry and Building Material			
10	Brick wall 40 cm thick	0·02	0·03	0·05
11	Plaster in wall	0·03	0·02	0·04
12	Ceiling, 50 mm plaster of Paris suspended from trusses	0·08	0·05	0·04
13	Plyboard on 75 mm air space	0·30	0·10	0·05
14	Wood veneer 10 mm thick on 50 × 75 mm wood studs at 40 cm centre to centre	0·11	0·12	0·10
15	Glass against solid surface	0·03	0·03	0·02
16	Marble	0·01	0·01	0·01
	Audience, Chairs, etc			
17	Audience seated in fully upholstered seats (per person)	0·18	0·46	0·51
18	Chair, upholstered seat with spring	—	0·16	0·071
19	Seats (unoccupied) fully upholstered (per seat)	0·16	0·40	0·44

APPENDIX C

(*Clause* 8.2)

ABSORPTION COEFFICIENTS OF INDIGENOUS ACOUSTICAL MATERIALS

Sl No.	Material	Thickness	Density	Absorption Coefficient at			
				125	500	2 000	4 000
		mm	g/cm³	c/s	c/s	c/s	c/s
1	Fibrous (acoustic) plaster	20	0·1	—	0·30	0·50	—
2	Compressed fibre board:						
	a) Unperforated	12	—	0·24	0·3	0·2	0·24
	b) Perforated uniformly over part depth (rigid backing)	12·7	0·3	0·06	0·55	0·67	0·76
	c) Perforated randomly over part depth (rigid backing)	12·7	0·3	0·15	0·52	0·76	0·58
3	Compressed wood particle board						
	a) Perforated (rigid backing)	12·7	0·37	0·04	0·36	0·78	0·99
	b) Perforated (rigid backing)	19·1	0·34	0·05	0·61	0·91	0·96
	c) Perforated and painted (rigid backing)	12·7	0·40	0·05	0·40	0·82	0·59
	d) Perforated and painted (rigid backing)	19·1	0·38	0·10	0·62	0·74	0·69
4	a) Wood wool board	25	0·4	—	0·20	0·60	—
	b) Wood wool board (50 mm from wall)	25	0·4	—	0·35	0·35	—
5	Mineral glass wool quilts and mats	25	0·06	0·09	0·17	0·50	—
6	Bonded & compressed mineral/glass wool tiles	50	0·04	0·12	0·26	0·44	0·8
7	Composite units of perforated hardboard backed by perforated fibre oard	25	0·4	0·25	0·5	0·65	—
8	a) Mineral/glass wool with scrim mat (rigid backing)	25	0·08	0·29	0·85	0·84	0·98
	b) Mineral/glass wool with scrim mat (rigid backing)	50	0·08	0·57	0·99	0·95	0·90
	c) Mineral/glass wool with scrim mat faced with perforated (10% open area) hardboard (rigid backing)	25	0·08	0·06	0·99	0·49	0·31
	d) Mineral/glass wool with scrim mat faced with perforated (10% open area) hardboard (rigid backing)	50	0·08	0·20	0·90	0·61	0·42

SL No.	MATERIAL	THICKNESS mm	DENSITY g/cm³	ABSORPTION COEFFICIENT AT 125 c/s	500 c/s	2 000 c/s	4 000 c/s
9	Miscellaneous:						
	a) Strawboard	13	0·24	—	0·30	0·35	—
	b) Strawboard spaced 50 mm from wall	13	0·24	—	0·35	0·30	—
	c) Composite panel 5 mm perforated plywood 50 mm mineral wool and 22 mm cement asbestos (suspended from trusses)	—	—	0·36	0·95	0·67	—
	d) Composite panel 5 mm perforated plywood 50 mm mineral wool and 22 mm hardboard (suspended from trusses)	—	—	0·47	0·20	0·09	—

NOTE — The absorption coefficients of materials given in items 2(b), 2(c), 3(a) to 3(d) and 8(a) to 8(d) are based on tests made at the Central Building Research Institute, Roorkee.

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