CENTRAL BUILDING RESEARCH INSTITUTE, ROORKEE-247667 (INDIA)

BUILDING RESEARCH NOTE

B.R.N. 87

ACOUSTICAL DESIGN OF PARTITIONS FOR OPEN PLAN SPACES

1. Introduction

The problem of creating good aural conditions in open plan spaces of offices and schools is now well recognized. Portable acoustical screens can play a very useful part, but sometimes they are incorrectly designed and placed at positions which render them ineffective. Besides reducing the transmission of noise from one location to the other in such open spaces, these screens can be utilized for other functions such as visual barriers, display panels, territory enclosures, sound absorbers. To make such screens acoustically most effective acoustically different space variable and screen properties should be taken into consideration while designing the partitions. In office, intruding noises and speech sounds from neighbours in the same space cause annoyance. Intrusive speech articulation index therefore becomes the most important parameter to the studied for better speech privacy and listening conditions. As most of the offices have been found to be highly reverberant they spoil speech clarity. Screens of absorbing type can be employed to serve

Table 1
Relation between Intruding Articulation Index (I.A.I.) and Subjective Impression.

I. A. I.	Speech privacy condition	Communication condition
.05 to .11	Excellent	Nil
.12 to .14	Good	V. Poor
.15 to .16	Acceptable	Poor
.17 to .18	Poor	Fair
.19 to .20	V. Poor	Good
.20 & above	Nil	V. Good

Acceptable value of IAI = 0.16

dual purposes i.e. improving their screening effect and controlling the reverberation time of the space.

2. Speech Communication *vs* Privacy

An ideal office environment would permit speech privacy, i.e. any occupant would be able to talk easily with a visitor or talk on telephone without distracting other occupants.

Intelligibility of speech is a function of signal-to-noise ratio. The lower the value of IAI, the better is the speech privacy of that space. However a very good condition of speech privacy corresponds to sufficiently bad or poor condition of speech communication. Thus, the two things, i.e. speech privacy and speech communication are not complementary to each other. A compromise is therefore sought between the two. The Articulation Index ranges in value from zero, for no communication/perfect privacy, to unity, for perfect communication/zero privacy (see Table-1). The values mentioned in this table refer to the observations made in an open space when no screen is used as an acoustical device. IAI values of 0.16 and 0.12 have been found to be acceptable in open type of offices and schools respectively.

3. Role of Screen in an Open Space

Screens are normally used in an open plan space to segregate the working space into different groups. Thus it acts as a territory enclosure and visual barrier as well. It not only acts as a means to accommodate more people in a given space but also improves the overall working efficiency of the people. As regards the acoustical role, a portable acoustical screen is beneficial in many other ways. It provides some degree of local sound absorption on the source side, reduces noise at the receiving point and also promotes sound absorption reducing the reverberant sound in the space.

Sound pressure level at the receiving point behind the screen is composed of three components viz. sound diffracted around screen edges, sound transmitted through the screen and sound reflected from the room boundaries (Fig. 1). Of these three, diffracted and transmitted components depend chiefly on the design of the screen structure and its material, whereas the reflected component depends upon the acoustical properties of room surfaces. Since much of the noise reaching the remote side of the partition is composed of diffracted and

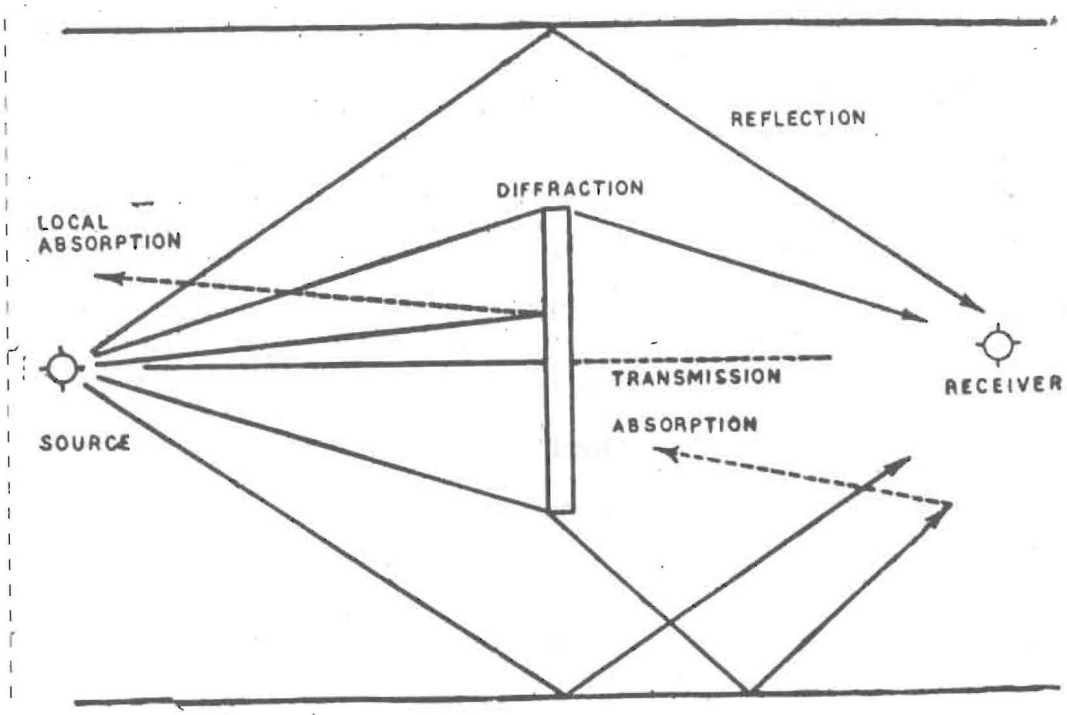

Fig. 1 Behaviour of a Partial Screen between Two Rooms.

transmitted components, these screens can effectively be used in controlling the overall acoustics of an open space. Using absorbing type of screens, it is simultaneously possible to reduce the reverberation time of the space also. As most of the open type of offices have been observed to have high reverberation, these types of screens serve better as they not only cut down noise reaching the other side of the screen but also reduce the reverberation time.

4. Background Noise

Background noise in a space is the overall noise level comprising of externally generated noise as well as those generated within the space. It plays an important role in designing a partial partition for open type of space. A high level of background noise in an open space spoils speech communication whereas a very low level of background noise spoils speech privacy of the space. An optimisation is therefore sought between the two extreme levels so that the acceptable value of IAI is attained. It has been observed that most of the spaces like offices have high background noise, resulting in an unhealthy environment and discomfort is complained to by the occupants in these spaces. Levels above 60 dB are responsible for poor acoustics in these spaces. Noise levels of 60 dB have been found to be acceptable under normal conditions in an office space. Similarly, in teaching spaces levels below 60 dB provide comfortable teaching atmosphere.

5. Effect of Reverberation Time

Reverberation time of a given space is the most important factor to be considered while proposing a design of partial partition in an open space. A high reverberation time destroys the quality of sound and there is an overlapping of words spoken within such spaces. A space should neither be highly reverberant nor dead, i.e. with a very low reverberation time. An optimum reverberation time is therefore sought which depends mainly on the volume of the space under consideration.

Table 2
Noise Reduction of Partitions

S.No.	Description	Height (metres)	Noise Reduction (dB)
1.	Bamboo chicks partition across full width of the room.	2.0	4
2.	Plywood screens, 1.25 cm thick	2.0	5
3.	Timber Partitions, 4 cm thick	2.0	6
4.	Thick timber partition across full width of the room.	Full height	10
5.	ARISBR class division unit	2.0	6
6.	ARISBR science storage unit	2.0	8
7.	Masonry wall, 10 cm thick across full width of the room.	2.5	8
8.	Masonry wall, across full width of the room	Full height	18
9.	Partition of perforated acoustical boards.	1.8	6
10.	Partition made of fibreglass packed between two tapestry cloth.	1.8	7
11.	Gypsum board, 6 mm thick across full width	1.8	8
	Minimum Acceptable value of Noise Reduction = 5 dB		

* Further increase in the partition height does not improve the performance much. If it is not possible to provide chalk boards on the partition, the partition height can be increased to 2.4 m to achieve the desired noise levels.

6. Noise Reduction by the Screens

The basic function of a screen is to reduce the noise passing through it. Noise reduction by a partition is based on the transmission loss of the material of the partition. While choosing a screen, it must be seen how much noise reduction is achieved by it. It has been found that wherever the screen was placed it reduced the sound by atleast 5 dB. Noise reduction also depends upon the height of the partition. The greater the height of the screen higher will be the noise reduction. Two metre high partition has been found to be quite effective in segregating two teaching spaces. Chalk boards should be provided on these screens so that teachers remain near the screens. * In offices, however, the screen's height can be reduced. As absorbing type of partitions act as functional sound absorbers in an open space, their lower height (1.8m) has been found equally

VALUES USED FOR TEST WORK

1. Nature of Sound field (Reverberation time T second)
   $T_1 = 0.5$, $T_2 = 1.0$
2. Screen, Source distance D (Metres)
   $D_1 = 0.5$, $D_2 = 6.5$
3. Height of the screen
   $H_1 = 1.52$, H_2 = full height
4. Screen Composition C
   C_1 = Light, C_2 = Heavy

NOTE : Light Partition here is Wooden 1.25 cm Thick Plywood etc.

Heavy Partition is of 11.3 cm Brick wall

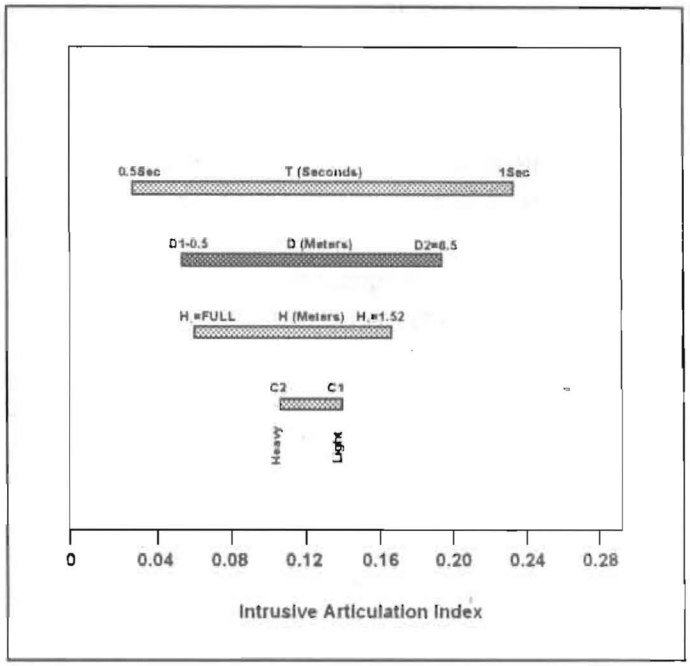

Fig. 2 Importance of Different Variables in Use of Partial Partition between Two Class Rooms.

Table 3
Decline of Reverberation Time (R.T.) due to Absorbing Type of Partial Partitions and the Absorption Coefficient of partial Partitions

Empty chamber R.T. (Sec.)	with acoustical perforated boards covering 6 m^2 area.			With fibreglass blanket within two layers of tapestry, covering 4.8 m^2 area.		
	R.T. (sec.)	Total absorption m^2	Abs. coeff.	R.T. (Sec.)	Total absorption m^2	Abs. Coeff.
7.0	3.3	5.34	0.89	3.4	5.09	1.06
4.2	2.7	4.44	0.74	2.8	3.98	0.83
3.4	2.4	4.14	0.69	2.45	3.84	0.80
2.9	2.0	5.22	0.87	2.1	4.41	0.92
2.5	1.8	5.55	0.87	1.8	5.18	1.08
2.0	1.55	4.80	0.80	1.6	4.22	0.88

effective. Noise reductions achieved by some of the screens have been shown in (Table-2).

7. Dependence of Different Parameters on Instrusive Speech Articulation Index

Listening and communication conditions within an open space depend on many factors, such as, height of the screen, reverberation time of the space, distance between speaker and the listener and the composition of the screen. The relative importance of these factors, when compared with the intrusive speech articulation index, indicates how much a factor is responsible in controlling the intrustive speech Articulation Index. In Fig. 2 these factors are plotted against intrustive speech Articulation Index when a hard reflective types of partitions is used within an open type of school. It is clear from this figure that reverberation time of the space is the most important factor in designing a partial movable screen for an open type of school or space. The next important factor is the distance D between the speaker and the listener. Similarly, the height of the screen plays an equally important part in reducing the noise traveling to the other side of the partition. In a class room where the volume of the space is not very large, the composition of screen does not matter much, and so, any screen having atleast a noise reduction of 5 dB is sufficient to serve the purpose.

8. Acoustical Screen for Open Plan Offices

It is clear from the foregoing discussions that the reducing efficiency of partial partitions depends, among other things, on the reverberation time of the open space. As most of such spaces have reverberation time much above the optimum, hard reflecting types of screens have been found less efficient. Absorbing type of acoustic screens create better conditions in such reverberant rooms. These screens function not merely as noise reducing devices, but also functional sound absorbers, reducing considerably the reverberation time of the room. Thus partitions of absorbing type are more useful in such conditions. In addition to providing the desired value of speech privacy, the sound absorbing material like fibre glass packed between two sheets of tapestry cloth of partition, reduces the reverberation time quite effectively. The noise reduction inside the room, when an absorbing screen is introduced, is shown in Table 3. It can be seen from Table 3 that the absorption coefficients of materials on the screens do not consistently diminish with decline in an empty room reverberation time.

While testing these partitions in an acoustic chamber, it is observed that besides rendering drop in reverberation time, the absorbing screens do cause reduction in intrusive Articulation Index values, thereby suggesting improvement in the screening efficiency of these partitions. These values have been reported in Table 4. The variation of IAI values in the screens are used, show their relative efficiency in improving the acoustics of the hall. The above study forms a good background for acoustically designing 'Call Centres' where a number of persons are required to maintain speech privacy and intelligibility in large open plan space.

Definitions of the Technical Terms Used

1. **Intrusive Speech Articulation Index**
   The ability to recognise the speech components spoken by a speaker from the remote side of the partition.
2. **Reverberation**
   Persistence of sound in a room.
3. **Functional Sound Absorbers**
   Sound absorbing material when used in the form of a shaped unit is known as functional sound absorber. The absorption is increased mainly due to diffraction effect of the sound.

Table 4
Variation of Intruding Articulation Index (IAI) in the Screened Areas of the Partitions in the Acoustic Test Chamber

R.T. (Sec) of the room with partition	Plywood Hard partition Height 2 m. Width 3 m.	Absorbing type partition	
		Of perforated board H = 2 m, W = 3 m	Of fibreglass tapestry H = 1.7 m, W = 3.0,
1.2	0.15 — 0.16	0.075 — 0.09	0.075 — 0.085
2.3	0.19 — 0.22	0.095 — 0.145	0.10 — 0.12
3.4	0.21 — 0.25	0.11 — 0.14	0.13 — 0.16
7.0	0.22 — 0.27	0.16 — 0.19	0.22 — 0.27

Prepared by : R.K. Srivastava & R.L. Dhabal
Revised : April 2004
First Printed : January 1977 (as BD 123)

Published by : Central Building Research Institute Roorkee - 247 667
E-mail : director@cbrimail.com
Website : www.cbri.org

Edited by : Dr Atul Kumar Agarwal & Shri Dinesh, Scientists, Printed at: Paramount Offset Printers 7, Avas Vikas, Roorkee Ph. 261778, 264117