



BUILDING RESEARCH NOTE

B.R.N. 81

DATA BANK ON SOUND ABSORBING MATERIALS

Sound is a form of energy and is propagated with a finite speed in a medium. When sound impinges on a surface of a material, it gets partially absorbed, partially reflected and partially transmitted. It means the fraction absorbed, reflected, transmitted together equal the incident energy. In this research note sound absorption properties of the materials are discussed.

Sound Absorption

Sound absorption in an acoustical material takes place by the dissipation of sound energy by the action of thermal and viscous processes. The absorption characteristics are governed by their basic physical properties. In general, porous material with rigid backing absorb more at the middle and high frequencies than at low frequencies. The pores of the porous acoustical materials must be intercommunicating so that the sound waves can easily penetrate into the material and attenuation of sound energy takes place by multiple reflection inside the material.

Since the absorption coefficient of any material varies considerably with the angle of incidence of soundwaves, two types of measurements are normally carried out, one for normal incidence and other for random incidence. The normal incidence sound absorption coefficient is useful for comparing the absorptivity of different materials and can be measured with a small sample of the material. The other measurement is done in a special chamber known as reverberation chamber in which soundwave strike the test sample from many direction simultaneously and therefore large areas of the sample are required. Generally, the chamber coefficients are higher than normal incidence absorption coefficients.

The audience in room provides absorption amounting to about 0.46 units (sq. metres) per person and this is nearly constant over the important frequency range. Curtains also provide good absorption. On the other hand,

concrete and masonry act as reflectors and have absorption coefficient less than 0.05.

Absorption Coefficient

The most important factor by which the efficiency of an acoustical material is determined is called sound absorption coefficient which is denoted by α . The sound absorption coefficient of a material is defined as the fraction of the incident sound energy absorbed by it. It depends on the nature of the material, on the frequency of the sound and on the angle at which sound waves strike the surface of the material. Comparing the absorption coefficient of different materials, a scale based on the concept of Noise Reduction Coefficient (NRC) should be used. It is the average of the coefficients at four frequencies 250, 500, 1000, 2000 Hz.

There are two methods to determine the absorption coefficient

(i) Standing wave tube method and (ii) Reverberation Chamber Method.

(i) Standing wave Tube

Absorption coefficient is measured with the apparatus shown in Fig.1. The sound wave generated from Beat Frequency Oscillator at a desired frequency. The loudspeaker is fitted in one end of the tube. the soundwave reinforced in loudspeaker passes through the tube and fall on the sample normally. Some sound energy will be absorbed in the sample whereas some will be reflected back. The reflected wave and the incident wave form a system of standing waves inside the tube. Since the energy of the reflected wave depends on the absorption properties of the sample the maxima and minima of sound pressure along the tube measured by the probing tube attached with a microphone, give a measure of absorption properties. The probe tube is gradually moved away from the sample and readings corresponding to maxima ($P_{max.}$) and minima ($P_{min.}$)

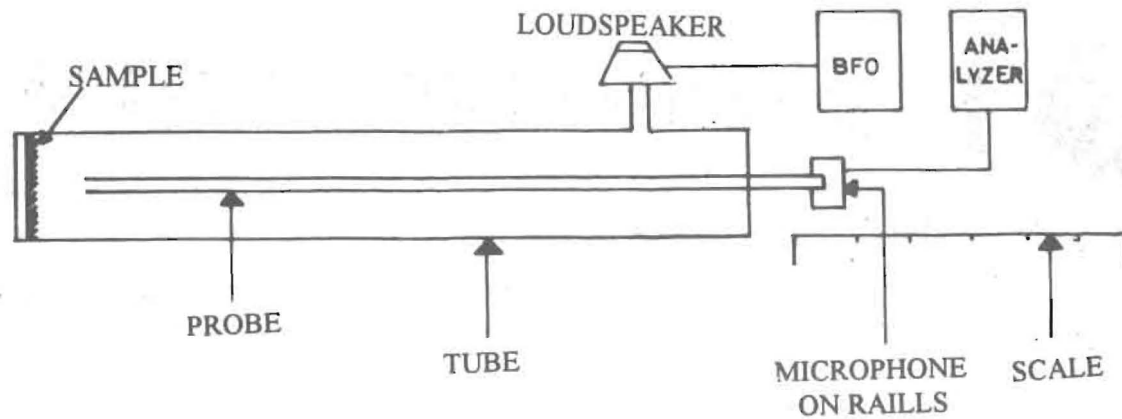


FIG. 1 The Standing wave apparatus for measurement of absorption coefficients of samples at normal incidence (Sectional View)

of the sound pressure noted. With the help of the sound analyser the absorption coefficient is thus given by the formula

$$\alpha = \frac{4}{n + 1/n + 2}$$

where α = absorption coefficient

$$n = \frac{P_{\min}}{P_{\max}}$$

This experiment is done for the frequencies 125, 250, 500, 1000, 2000, 4000 Hz. The tests are conducted at normal incidence of sound on the sample according to ASTM standards C-384 (1977). The values of the absorption coefficients for different acoustical materials

tested in CBRI are given in Table 1.

(ii) Reverberation Chamber Method

Absorption coefficient can also be measured in a Reverberation Chamber. Here reverberation time is to be measured when it is empty and again when the sample is laid out on the floor of the chamber as shown in Fig. 2. Reverberation time of the chamber, for a sound of a given frequency is the time required for the sound pressure level in the enclosure to decrease by 60 dB, after the source has been stopped. The change or difference in reverberation times give the measure of absorption coefficient of the material by the Sabine formula.

$$\alpha = \frac{.16V}{S} \left[\frac{1}{T_1} - \frac{1}{T_2} \right]$$

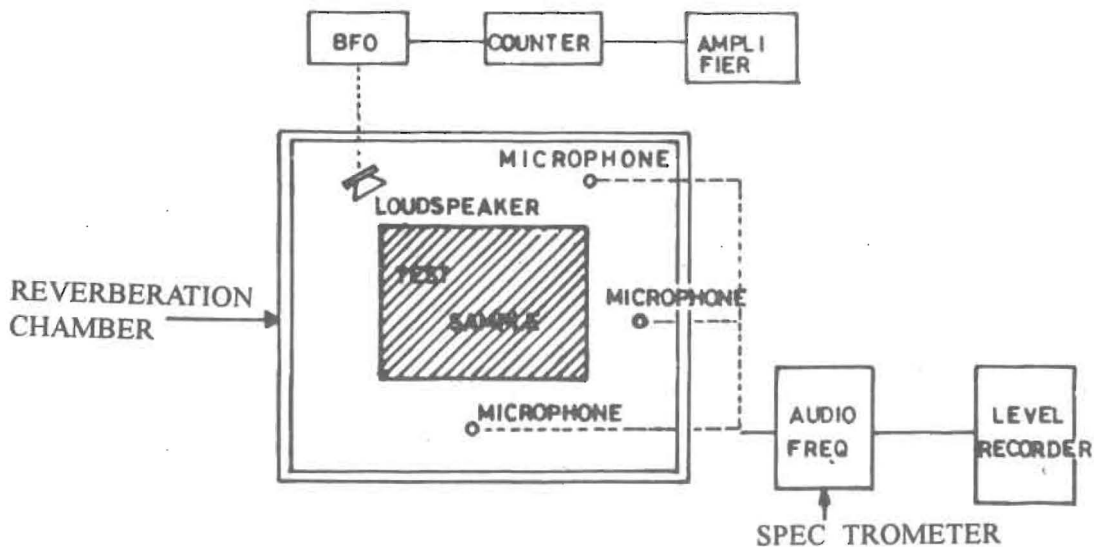


FIG. 2 The Experimental set up for measurements on absorption coefficients at random incidence using large samples (Floor plan of reverberation chamber)

Table 1: Standing Wave Tube Data for Absorption Coefficient of Materials with Rigid Backing

Sr.No.	Name of Material	Manufacturer	Thickness mm	Density Kg/m ³	Absorption Coefficients,						NRC
					Freq. Hz	125	250	500	1000	2000	
1.	Sitatex - Perforated 1600 (Standard)	M/s Plywood Products Sitapur (U.P.)	19	-	.12	.17	.21	.66	.67	.68	.43
2.	Sitatex - Perforated random (Standard)	-do-	19	-	.12	.18	.26	.45	.48	.62	.34
3.	Sitatex - Perforated 964 (Standard)	-do-	19	-	.08	.17	.28	.51	.54	.56	.37
4.	Sitatex - Perforated 1681 (Standard)	-do-	19	-	.09	.15	.33	.54	.74	.76	.44
5.	Sitatex - (Plain)	-do-	13	-	.13	.18	.21	.18	-	-	.18
6.	Sitapore	-do-	25	-	.05	.11	.28	.40	.60	.43	.35
7.	Sitatex - Perforated 1964 (White)	-do-	19	-	.07	.13	.23	.42	.66	.51	.36
8.	Sitatex - Perforated 1681 (White)	-do-	19	-	.09	.15	.30	.57	.71	.66	.43
9.	Sitatex - Perforated 1600 (Standard)	-do-	19	-	.08	.15	.28	.62	.70	.63	.44
10.	Sitatex - Perforated random (White)	-do-	19	-	.09	.12	.28	.50	.52	.58	.36
11.	Anil Board random (Standard)	M/s Anil Hardboard, Bombay	131	540	.09	.13	.15	.22	.33	.80	.21
12.	Fibrosil	M/s Indian Rockwool Co. Pvt. Ltd. Delhi-6	50	96	.07	.16	.33	.66	.84	.92	.50

Table Contd....

1	2	3	4	5	6	7	8	9	10	11	12
13.	Fibrosil Resin Bonded Slabs	M/s Indian Rockwool Co. Pvt. Ltd. Delhi-6	25	32	.06	.10	.20	.46	.81	.95	.39
14.	Lloyd Board	M/s Punj & Sons Pvt. Ltd. New Delhi-1	25	240	.06	.25	.40	.79	.82	.80	.57
15.	Fibreglass	-do-	25	80	.07	.11	.15	.33	.71	.92	.37
16.	Spintex	-do-	25	80	.09	.14	.22	.53	.88	.93	.45
17.	Fibreglass Crown Wool	-do-	25	32	.11	.14	.27	.35	.71	.90	.37
18.	Spintex	-do-	25	64	.18	.18	.52	.46	.86	.96	.55
19.	Vermiculite	M/s New Kern Products Corp. Bombay-14	25	-	.12	.19	.21	.23	.26	.27	.22
20.	Bartex	M/s Barnagore Jute Factory Ltd. Alam Bazar, Calcutta-35	25	-	.15	.21	.69	.97	.96	.71	.71
21.	Barmil Board	-do-	13	297	-	.03	.16	.33	.64	.58	.29
22.	Kurlon	M/s Karnataka Coir Products Bangalore	38	-	.03	.21	.39	.46	.70	.55	.44
23.	Coir Fibre Rice Straw Building Board	C.B.R.I., Roorkee	50	500	.09	.30	.38	.35	.40	.38	.36
24.	Coir Fibre Cement Particle Board	C.B.R.I., Roorkee	12	-	.08	.14	.15	.21	.26	.24	.19
25.	Wood Wool Board	C.B.R.I., Roorkee	30	450	.13	.18	.25	.46	.88	.55	.44
26.	Woodtex Insulation Board	M/s Wood India, 178 M.G. Road, Calcutta-7.	50	400	.20	.21	.58	.70	.60	.54	.52

Table Contd.....

1	2	3	4	5	6	7	8	9	10	11	12
27.	Wood Wool Insulation Board	M/s Pan Insulation, 149 New Gandhi Nagar, Ghaziabad.	35	350	.27	.36	.50	.74	.72	.38	.58
28.	Duratex (Woodwool Board)	M/s B.K. Insulation, 4/5 Netaji Subhash Marg, N.Delhi.	25	400	.24	.38	.58	.62	.70	.66	.57
29.	Wood Wool Insulation Board	M/s B.M. Mittal, Ex.Engr.C 1st Floor, C/3, Pushpa Bhawan M.B. Road, N. Delhi-62	15	600	.15	.21	.32	.38	.56	.52	.37
30.	Thermotex	M/s Vijay Udyog, F-54, Ind. Area, Buland Shahar Road, Ghaziabad.	25	375	.20	.25	.51	.60	.61	.58	.49
31.	Thermofridge Woodwool Insulation Board (Plaster of Paris 1mm on one side)	Asstt. Engineer, III, Civil Const. Wing, Air, C-3, Pushpa Bhawan, MB Road, New Delhi.	25	650	.16	.28	.32	.40	.35	.28	.34
32.	Insulation Board (Woodwool Board)	Mr. Ramesh Garg, Ex.Engr., PWD, 27(DA), 8th Floor MSO Building, New Delhi.	20	400	.21	.24	.38	.45	.76	.43	.46
33.	Composite Panels (Fibreglass + Perforated wood- Wool Board)	C.B.R.I., Roorkee	25+12	-	-	.38	.53	.70	.78	.83	.59
34.	Composite Panels (Bartex + Perforated wood- Wool Board)	C.B.R.I., Roorkee	25+12	-	-	.34	.47	.63	.78	.79	.56
35.	Composite Panels (Sunn + Perforated wood- Wool Board)	C.B.R.I., Roorkee	25+12	-	-	.21	.52	.58	.65	.73	.49

Table Contd....

1	2	3	4	5	6	7	8	9	10	11	12	
36.	Composite Panels (Bartex + Perforated Ply Sheet)	C.B.R.I., Roorkee	25+12	-	-	.12	.22	.60	.60	.40	.38	
37.	Composite Panels (Sunn + Perforated Ply Sheet)	C.B.R.I., Roorkee	25+12	-	-	.12	.30	.58	.50	.60	.37	
38.	Duorfoam	Rubrofibre Pvt. Ltd., Trichur-1, Chungom, Allappay (Kerala)	13	125		.07	.10	.26	.53	.56	.77	.37
39.	Gypsum Plaster Board	C.B.R.I., Roorkee	13	125		.10	.15	.18	.21	.30	.36	.21
40.	Phosphogypsum Anhydrite Plaster	C.B.R.I., Roorkee	13	-		.15	.16	.28	.30	.31	.35	.26
41.	Minwool Insulation Board	15-9-495 Mahboobganj Hyderabad	50	120		.33	.48	.58	.77	.86	.93	.67
42.	Minwool Insulation Board	15-9-495 Mahboobganj Hyderabad	50	150		-	.58	.63	.70	.86	.93	.69
43.	Kinifoam Board	Shroff Textile Ltd., Fort House DR.DN Road, Bombay.	-	-		.24	.28	.24	.38	.24	.36	.28
44.	Hyderabad Asbestos HACPAsbestos Cement Products REF 108	Res. Manager, Hyderabad Ltd., Sanat Nagar, Hyderabad.	60	650		.28	.29	.30	.36	.32	.38	.30
45.	Pheno-Therm Fenolic Foam	Bakelite Hylam Ltd., 9D Atma Ram House, 1 Tolstoy Marg, New Delhi.	50	36.5		.35	.40	.42	.48	.50	.55	.45

1	2	3	4	5	6	7	8	9	10	11	12
46.	Non-Woven Carpet	M/s Uniproducts (India) Ltd., 21 Community Centre, Friends Colony, New Delhi.	30	450	.09	.17	.18	.23	.24	.43	.21
47.	Non-Woven Carpet	M/s Uniproducts (India) Ltd., 21 Community Centre, Friends Colony, New Delhi.	70	230	.15	.26	.30	.35	.41	.55	.33
48.	Non-Woven Carpet	M/s Uniproducts (India) Ltd., 21 Community Centre, Friends Colony, New Delhi.	30	210	.12	.21	.30	.28	.32	.38	.28
49.	Non-Woven Carpet	M/s Uniproducts (India) Ltd., 21 Community Centre, Friends Colony, New Delhi.	50	187	.15	.25	.36	.28	.26	.36	.29
50.	Gypsum Composite Board	R.R.L., Jammu	12	1000	.10	.18	.30	.32	.28	.28	.30
51.	Anchor Ceiling Tiles Teakwood Particled Board Bonded with Phenol Formaldehyde Synthetic Resin	The Indian Plywood Manufacturing Co. Ltd., 25/3 Mall Road, Kanpur	12	820	.05	.11	.15	.20	.26	.31	.18
52.	Cerwool Blanket	Orient Cerwool Ltd. 1212, Chiranjib Tower 43, Nehru Place, New Delhi.	30	96		.33	.56	.60	.63	.77	.53
53.	Cerwool Blanket	Orient Cerwool Ltd. 1212, Chiranjib Tower 43, Nehru Place, New Delhi.	30	128		.28	.56	.64	.69	.86	.54

Table 2: Reverberation Chamber Data For Absorption Coefficients Of Materials With Rigid Backing

Sr.No.	Name of Material	Manufacturer	Thickness mm	Density Kg/m ³	Absorption Coefficients,						NRC
					Freq. Hz	125	250	500	1000	2000	
1.	Sitatex - Perforated 1600 (Standard)	M/s Plywood Products Sitapur (U.P.)	19	-	.05	.10	.52	.75	.80	.85	.54
2.	Sitatex - Perforated 1600 (Standard)	-do-	13	-	.02	.05	.30	.55	.56	.63	.36
3.	Sitatex - Perforated Random (Standard)	-do-	19	-	.05	.07	.56	.68	.80	.99	.53
4.	Sitatex - Perforated Random (Standard)	-do-	13	-	.05	.06	.34	.56	.67	.70	.40
5.	Sitatex - Standard	-do-	19	338	.05	.10	.61	.78	.91	.96	.60
6.	Sitatex - Standard	-do-	13	370	.04	.05	.36	.63	.78	.99	.46
7.	Sitatex - Perforated 1964 (Standard)	-do-	19	-	.04	.07	.53	.75	.98	.99	.59
8.	Sitatex - Perforated 1964 (Standard)	-do-	13	-	.05	.07	.24	.47	.88	.90	.41
9.	Sitatex - Perforated 1681 (Standard)	-do-	19	-	.06	.09	.51	.82	.84	.99	.57
10.	Sitatex - Perforated 1681 (Standard)	-do-	13	-	.02	.06	.22	.55	.75	.80	.38
11.	Sitatex - Perforated 1964 (White)	-do-	19	-	.04	.09	.51	.75	.91	.85	.57
12.	Sitatex - Perforated 1964 (White)	-do-	13	-	.05	.06	.23	.53	.65	.81	.37
13.	Sitatex White	-do-	19	384	.10	.18	.62	.78	.74	.69	.58
14.	Sitatex White	-do-	13	400	.05	.09	.40	.66	.82	.59	.49

Table Contd....

1	2	3	4	5	6	7					
15.	Sitacore	-do-	25	-	.05	.16	.41	.46	.70	.72	.43
16.	Sitatex - Perforated 1600 (White)	-do-	19	-	.06	.10	.45	.73	.74	.85	.50
17.	Sitatex - Perforated 1600 (White)	-do-	13	-	.02	.07	.27	.67	.72	.46	.43
18.	Sitatex - Perforated 1681 (White)	-do-	19	-	.06	.07	.52	.91	.91	.92	.60
19.	Sitatex - Perforated 1681 (White)	-do-	13	-	.02	.06	.17	.61	.72	.63	.39
20.	Sitatex - Perforated Random (White)	-do-	19	-	.06	.15	.63	.67	.76	.91	.55
21.	Sitatex - Perforated Random (White)	-do-	13	-	.02	.07	.34	.68	.72	.63	.45
22.	Scrimat Mat Fibreglass	M/s The Bombay Co. Pvt. Ltd. Wallace Street Bombay	50	80	.20	.62	.99	.93	.61	.42	.79
23.	Scrimat Mat Fibreglass	M/s The Bombay Co. Pvt. Ltd. Wallace Street Bombay	25	80	.06	.36	.99	.94	.49	.31	.70
24.	Scrimat Mat Fibreglass	M/s The Bombay Co. Pvt. Ltd. Wallace Street Bombay	50	80	.57	.80	.99	.99	.95	.99	.93
25.	Scrimat Mat Fibreglass	M/s The Bombay Co. Pvt. Ltd. Wallace Street Bombay	25	80	.29	.59	.85	.87	.84	.98	.79
26.	Uniformly Perforated Jolly Board	M/s Anil Hard Board Bombay	12.7	300	.06	.12	.55	.66	.67	.76	.50
27.	Randomly perforated Jolly board	M/s Anil Hard Board Bombay	12.7	300	.15	.18	.52	.58	.76	.58	.51

Table Contd....

1	2	3	4	5	6	7	8	9	10	11	12
28.	Bitumen Bonded Fibre Insulation Board	M/s Anil Hard Board Bombay	12	300	.25	.36	.40	.45	.51	.66	.43
29.	Anil Hard Boards	M/s Anil Hard Board Bombay	18	315	.40	.45	.42	.45	.42	.42	.43
30.	Anil Hard Boards	M/s Anil Hard Boards Ltd. 8733 Desbandhu Gupta Marg 2nd floor Paharganj New Delhi	18	451	.28	.34	.39	.45	.42	.35	.40
31.	Anil Hard Boards	-do-	18	406	-	.35	.36	.37	.35	.36	.36
32.	Fibrosil	M/s Indian Rockwool Co. Ltd. Delhi-6	50	-	.40	.55	.90	.99	.99	.92	.88
33.	Fibrosil	-do-	25	-	.36	.53	.74	.93	.93	.92	.78
34.	Fibrosil	-do-	25	98	.06	.07	.13	.24	.54	.80	.25
35.	Fibrosil	-do-	50	-	.07	.16	.33	.66	.84	.92	.52
36.	Lloydwood Board	M/s Punj & Sons (Pvt.) Ltd. New Delhi	25	98	.14	.26	.99	.99	.85	.93	.77
37.	Spintex (Resin bonded)	M/s Punj & Sons Pvt. Ltd. New Delhi	50	40	.18	.69	.84	.90	.82	.73	.81
38.	Spintex (Resin Bonded)	-do-	50	65	.36	.80	.96	.96	.94	.73	.91
39.	Spintex (Resin Bonded)	-do-	50	65	.36	.75	.88	.90	.86	.73	.85
40.	Spintex (Resin Bonded)	-do-	25	49	.13	.32	.82	.95	.96	.94	.76
41.	Spintex (Resin Bonded)	-do-	25	49	.16	.41	.84	.96	.96	.92	.79
											25mm air gap
42.	Spintex (Resin Bonded)	-do-	50	49	.23	.58	.85	.96	.98	.94	.84

1	2	3	4	5	6	7						
43.	Spintex (Resin Bonded)	-do-	50	49	.28	.66	.98	.97	.95	.94	.89	25mm air gap
44.	Pulpwood Insulation Board	M/s Saharanpur Straw Board Factory, Saharanpur	19	-	.20	.61	.99	.68	.40	.38	.67	
45.	Pulpwood Insulation Board	M/s Saharanpur Straw Board Factory, Saharanpur	13	-	.08	.42	.71	.49	.38	.26	.50	
46.	Fibreglass Crown RBwool-100(RB-1)	M/s Fibreglass Pilkington Ltd. Bombay	25	16	.18	.23	.54	.75	.85	.88	.59	
47.	-do- 150(RB-2)	-do-	25	24	.24	.30	.59	.78	.92	.98	.65	
48.	-do- 200 (RB-3)	-do-	25	32	.17	.23	.63	.71	.92	.92	.64	
49.	-do- 100 (RB-1)	-do-	25	16	.16	.28	.62	.83	.84	.78	.64	25mm air gap
50.	Fibreglass Crown RB Wool-150(RB-2)	M/s Fibreglass Pilkington Ltd. Bombay	25	24	.26	.36	.67	.87	.91	.90	.70	-do-
51.	-do- 150 (RB-3)	-do-	25	32	.23	.36	.86	.91	.91	.98	.76	-do-
52.	Fibreglass Crown RB Wool-100 (RB-1)	M/s Fibreglass Pilkington Ltd. Bombay	50	16	.25	.52	.79	.84	.91	.98	.76	
53.	-do- 150 (RB-2)	-do-	50	24	.35	.59	.96	.98	.98	.98	.88	
54.	-do- 200 (RB-3)	-do-	50	32	.31	.61	.97	.98	.98	.98	.98	
55.	-do- 100 (RB-1)	-do-	50	16	.31	.55	.86	.87	.91	.98	.79	25mm air gap
56.	-do- 150 (RB-2)	-do-	50	24	.31	.65	.98	.98	.87	.98	.87	-do-
57.	-do- 200 (RB-3)	-do-	50	32	.31	.67	.98	.98	.94	.98	.89	-do-
58.	Sound Deadening Quilt	-do-	25	-	.09	.29	.50	.71	.88	.89	.59	
59.	Fibreglass Rigid Board	-do-	25	-	.16	.25	.65	.78	.89	.90	.64	

11

Table-3 Consolidated Data Of Acoustical Material

N.R.C.	Thickness, mm	Name of the material	Manufacturer
.90 to .98	50	Spintex (Resin bonded)	M/s Punj & Sons (Pvt.) Ltd., New Delhi - 110001
	50	Fibreglass Crown 200 (RB-3)	M/s Fibreglass Pilkington Ltd. Bombay
.80 to .89	50	Fibrosil	M/s Indian Rockwool Co. Ltd. Delhi-6
	50	Spintex	M/s Punj & Sons (Pvt.) Ltd. N. Delhi
	50	Fibreglass Crown 150 (RB-2)	M/s Fibreglass Pilkington Ltd. Bombay
.70 to .79	25	Bartex	M/s Barnagore Jute Factory, Alambazar, Calcutta
	50	Serim mat fibreglass	M/s The Bombay Co. Pvt. Ltd. Wallace Street, Bombay
	25	Fibrosil	M/s Indian Rockwool Co. Ltd. Delhi-6
	25	Spintex	M/s Punj & Sons (Pvt.) Ltd. N. Delhi
	50	Fibreglass Crown 100 (RB)	M/s Fibreglass Pilkington Ltd. Bombay
.60 to .69	19	Sitatex Standard	M/s Plywood Products Sitapur (U.P)
	19	Sitatex Perferated 168 (White)	-do-
	25	Fibreglass Crown RB-2, RB-3	M/s Fibreglass Pilkington Ltd. Bombay
	25	Fibreglass Rigid Board	-do-
	50	Minwool Insulation Board	15-9-495 Mahaboobganj Hyderabad
.50 to .59	19	Sitatex Perforated 1600 Standard	M/s Plywood Products Sitapur (U.P.)
	19	Sitatex perforated standard random	-do-
	19	Sitatex perforated 964 standard	-do-
	19	Sitatex perforated White	-do-
	13	Uniformly/Randomly perforated Jolly Board	M/s Anil Hard Board Bombay
	25	Fibreglass Crown 100 (RB-1)	M/s Fibreglass Pilkington Ltd., Bombay
	50	Woodtex	Wood India, 178M.G.Road, Calcutta-7
	35	Woodwool Insulation Board	M/s Pan Insulation, 149 New Ghandhinagar Ghaziabad
	25	Duratex (Woodwool Board)	M/s B.K. Industries 4/5 Netaji Subhas Marg N. Delhi
.40 to .49	13	Sitatex standard	M/s Plywood Products Sitapur, (U.P.)
	13	Sitatex perforated 964 Sitatex White Sitatex perforated random white	-do- -do- -do-
	18	Anil Hard Board	M/s Anil Hard Board Bombay
	25	Thermotex	M/s Vijay Udyog F54 Industrial Area Bulandshahar Road Ghaziabad

where

- a → absorption coefficient of the material.
- V → Volume of the chamber, m³
- S → Surface area, m²
- T₁ → Empty reverberation time.
- T₂ → Reverberation Time in presence of

sample of the material.

Large samples are used and the sound is incident randomly. These values are more reliable and useful for acoustical designers and architects. The tests are conducted on the sample according to ASTM Standards

C 423-81. The values of the absorption coefficients for different acoustical materials tested in CBRI are given in Table 2.

Conclusion

In addition to the bulk of information regarding the sound absorption of materials, consolidated data of NRC values of various thicknesses of materials with their manufacturers is shown in Table 3. These data will be very much useful to the Architects, Acoustical designers and Contractors.

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