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Acoustics and Sustainability:

How should acoustics adapt to meet future demands?

What is the Sound Transmission Loss of an Open Window?

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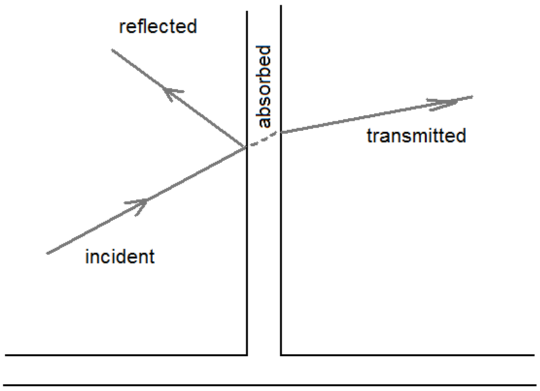
ABSTRACT

Theory will tell us that it is 0, but measurements by the Australian Standard AS1191-2002 give different results! What is the sound absorption of an open window? Theory will tell us that it is unity, but measurements by the Australian Standard AS ISO 354-2006 give different results! This paper is about two "silly" measurements, but I think it uncovers deficiencies in our standards and measurement techniques, and in our application of the theoretical properties of sound in enclosures and sound transmission.

ROOM ACOUSTICS



For the conservation of energy;

$$i = r + a + t \tag{1}$$

The sound pressure (SPL) level in a room is defined as;

$$\begin{aligned} L_{p(r)} &= L_w + 10 \log (4/ R_c) \\ &= L_w + 10 \log (4(1-\propto)/S\propto) \end{aligned} \tag{2}$$

Where, L_w – source power
R_c – room constant
S – room surface area
α - average surface absorption
$= L_w + 10 \log (4(1-\propto)/S\propto)$

Equation (2) tells us that the SPL is a function of the sound power present and the surface absorption; so what affect does the transmitted energy have? Is the transmitted energy included in the "absorption"? Not when the absorption is measured with AS ISO 354-2006 [3], where the sample is attached to the solid wall or floor of the testing chamber; the testing chamber is assumed to have very little transmission loss.

Whereas the R value is determined by the difference between the incident sound power and the received sound power, it therefore <u>does</u> include the reflected and absorbed energies.

TEST FACILITY

The Mechanical Engineering Acoustic Chambers at The University of Adelaide consist of:-

Source Room

Dimensions: 6.085 m × 5.175 m × 3.355 m (1.81:1.54:1)

Volume: 105.6 m^3

Surface Area: 135.5 m^2 (including opening)

Constructed of concrete and mounted on springs, and isolated from the receiver room. The chamber contains a rotating diffuser that was operating during the tests. This added a total reflecting surface area of 17.67 m^2 to the chamber.

Receiver Room

Dimensions: 6.840 m × 5.565 m × 4.720 m

Volume: 179.7 m^3

Surface Area: 193.2 m^2

Constructed of concrete and mounted on springs, and isolated from the source room. The chamber contained stationary diffusers (surface area 11.52 m^2) and a rotating diffuser with an additional surface area of 36.01 m^2, amounting to a total area of reflecting surfaces in the room of 47.53 m^2.

The two rooms are separated by 353 mm.

Test Opening

For small tests, see Figure 1, we use:-

1005 mm x 1510 mm, where the remaining 8.5 m^2 is a multi-layer lead panel

Surface Area: 1.52 m^2

Figure 1 : Small test opening

TRANSMISSION LOSS OF AN OPEN WINDOW

When measured in accordance with AS 1191-2002 [1] the 1.5 m^2 Open Window has R values ranging from 1 to 8, see Figure 2. The calculated [2] R_w value is 2. Not zero as theory would predict.

FREQ	R	σ
63	3.4	1.1
80	8.8	0.7
100	7.5	0.2
125	2.9	0.3
160	4.5	0.1
200	3.6	0.1
250	2.4	0.2
315	2.0	0.1
400	1.0	0.1
500	1.9	0.1
630	1.5	0.1
800	1.2	0.0
1000	1.3	0.0
1250	1.5	0.1
1600	1.4	0.0
2000	1.4	0.1
2500	1.6	0.1
3150	1.5	0.1
4000	1.4	0.0
5000	1.2	0.1

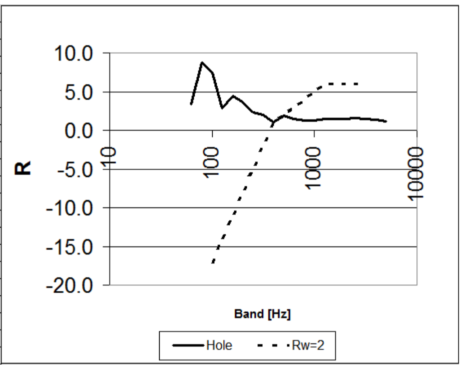


Figure 2 : Sound transmission loss results for the Open Window of Figure 1.

Comments

The low frequency performance at 80 and 100 Hz is influenced by the lower limits of our rooms, but with a 120 second averaging time we would expect the energy to flow through the hole in all frequencies.

While we know we have an upper limit to the R values we can determine at any test facility, primarily due to flanking, do we know have to specify a lower limit?

SOUND ABSORPTION OF AN OPEN WINDOW

Using the same facilities and procedure [3] the following absorptions were obtained for the 1.5 m^2 opening. The absorption measurements were made in the Receiver Room. Because we use a double walled lead infill to reduce the 10 m^2 opening for smaller tests the following absorption is for 8.5 m^2 of lead and the 1.5 m^2 opening.

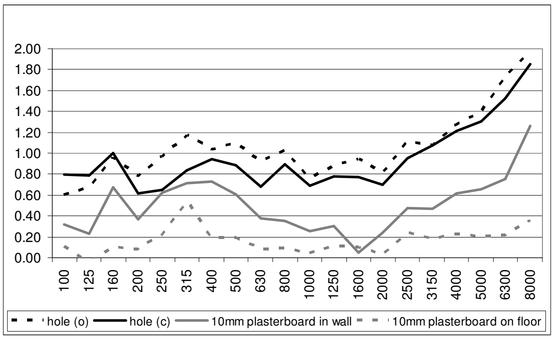


Figure 3 : Sound absorption of the Open Window; hole (o) Refers to the Source Room door as open and (c) as closed, and a 1.5m^2 10mm plasterboard sheet tested on the floor *as per*[3] and on the test opening.

Comments

There is a significant difference between measuring the absorption of the 10mm plasterboard panel when measured to [3] on the floor and when it is mounted in the test opening. I believe the latter mounting is more representative of the actual use of a wall panel. Opening the door on our Source Room changes the test from a panel on a fixed volume (the Source Room) to an infinite volume; an open space.

Why are some values greater than 1? I don't believe it is a question of accuracy or measurement error, I think it is a result of removing the (1-α) term from the use of the room constant R for the calculation of T_{60}

$$R = \frac{S\bar{\alpha}}{1-\bar{\alpha}}$$

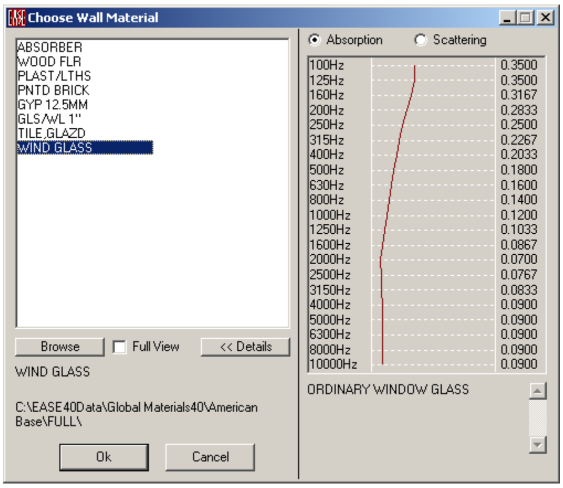
AS ISO 354-2006 [2] has six mounting options for the determination of sound absorption:-

a. mounted or placed directly against a room surface, wall or floor,
b. glued directly to a hard surface with an acoustic panel adhesive,
c. none
d. none
e. mounted with an airspace behind it,
f. none
g. test specimen, such as a curtain, drapery, window shade or window blind, is hung parallel to the room surface,
h. none
i. for spray- or trowel-applied materials, such as plaster. The material shall be applied to a suitable substrate.
j. for baffles

I think there should be another mounting option for wall and floor panels, and ceiling systems; where the mounting reflects the actual installation in a building system. For example; a partition which is used as a wall on the exterior of a building would be mounted in the test chamber with open space on the opposite side.

It is interesting that several sources specify sound absorption which could not have been determined by [3], *eg* EASE® window glass has the absorption shown in Figure 4.

I contend that our standards [1 & 3] should be modified so that whenever a panel is tested for sound transmission [1] it could also be tested in-situe for sound absorption [3].



ABSORBER
WOOD FLR
PLAST/LTHS
PNTD BRICK
GYP 12.5MM
GLS/WL 1"
TILE,GLAZD
WIND GLASS

☐ Full View

WIND GLASS

C:\EASE40Data\Global Materials40\American Base\FULL\

● Absorption ○ Scattering

100Hz	0.3500
125Hz	0.3500
160Hz	0.3167
200Hz	0.2833
250Hz	0.2500
315Hz	0.2267
400Hz	0.2033
500Hz	0.1800
630Hz	0.1600
800Hz	0.1400
1000Hz	0.1200
1250Hz	0.1033
1600Hz	0.0867
2000Hz	0.0700
2500Hz	0.0767
3150Hz	0.0833
4000Hz	0.0900
5000Hz	0.0900
6300Hz	0.0900
8000Hz	0.0900
10000Hz	0.0900

ORDINARY WINDOW GLASS

Figure 4 : Sound absorption of a glass window, from EASE®.

CONCLUSIONS

By doing a series of "silly" measurements of transmission loss and sound absorption I think that I have uncovered more [4] shortcomings in the "standards" we use to determine the acoustic properties of materials.

REFERENCES

[1] *AS 1191-2002* : Acoustics – Methods for laboratory measurement of airborne sound insulation of building elements
[2] *AS/NZS ISO 717.1 – 2004* : Acoustics – Rating of sound insulation in buildings and of building elements
[3] *AS ISO 354-2006* : Acoustics - Measurement of sound absorption in a reverberation room
[4] Critique of ISO 354; Byron Martin – AAS/NZ Acoustics Conference 2006