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DIFFUSIVITY – ITS SIGNIFICANCE TO SEAT ABSORPTION IN CONCERT HALLS – AN ODEON 8.5 SIMULATION STUDY

Different rooms have different diffusivity. Therefore, one and the same absorbing surface, e.g. concert hall seats, will in general have different effective absorption coefficients. We have to deal with three different sets of absorptions coefficients when predicting acoustics, namely the input coefficients in the prediction algorithm, the lab-test coefficients, and the in-situ coefficients.

A sound absorbing object does not have absolute absorption coefficients. **There exists only relative absorption coefficients**, related to the measuring conditions, whether in different laboratories, or in different halls as measured in-situ. This paper suggests a method to predict the relation between absorption coefficients. In concert hall planning this method can be used to take diffuse field differences between laboratory and a concert hall into account.

Uncertainty in absorption data from lab

The first uncertainty is that effective absorption does not approach a constant value as diffusivity increases. Rather, it seems to fluctuate between 100% and 114% for surface diffusion coefficients from 0.40 and upwards.

The second uncertainty lies within the fact that the effective absorption is sensitive to diffusivity. Specifically, the absorption increases from 45% to 65% as diffusion increases from 0.10 to 0.20 and from 65% to 100% as diffusion increases from 0.20 to 0.40. If diffusion exceeds 0.40, the effective absorption exceeds the theoretical value. This means that the effect of seats measured in the average laboratory will be underestimated if they were installed in a performance space with surface diffusion in the range 0.40—0.90, and overestimated if surface diffusion was less than 0.40. For example, with surface diffusion less than 0.20, the effective absorption will be less than 65% of the average laboratory value. ISO 354 does not specify diffusivity below 500Hz, so in the crucial 125 octave, it can be just about any value.

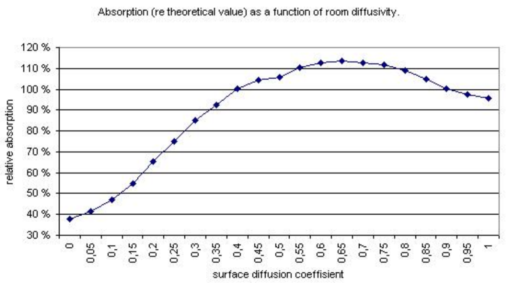

Figure 1: Absorption vs laboratory diffuseness

Uncertainty in predicting diffusivity

Also, there are uncertainties associated with predicting the actual surface diffusion of an existing hall or a planned hall based on geometrical properties alone. The same goes for the task of aiming to design and build a surface with surface diffusion 0.40, since reaching only 0.30 diffusion results in 15% less effective absorption.

Seats installed in rectangular halls with large plane wall surfaces in the upper volume have less absorption effect than if installed in a nonrectangular space where reverberant sound is directed more into the seating area than in the case of the rectangular halls. Beranek's seating absorption data are separated into these two categories of halls. *Figure 2* shows one example of how the predicted RT's in different octave bands may depend on upper wall surface scattering in one case of a 1200 seat rectangular hall with volume of approx. 15.000 cubic meter. The higher octave bands are more sensitive to increased surface scattering, as can be expected: More scattering on vertical surfaces will redirect more sound down into the audience area, and audience areas are effective high frequency absorbers. On the other hand, to make a 5% difference—a Just Noticeable Difference JND– the scattering needs to increase from the reference value of 0.15 to the rather high scattering value of 0.70.

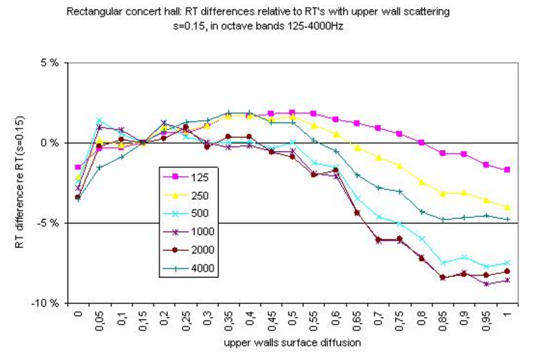

Figure 2: RT (in JNDs) vs concert hall diffuseness

The results in *Figure 2* may indicate that the uncertainty related to surface diffusion of the upper walls in a rectangular concert hall can be rather small in some cases. However, the overall degree of diffuseness in a concert hall also depends on the surfaces of the ceiling, the floor and the lower part of the walls, in addition to the course geometry of the hall (parallel walls, non-parallel walls, height and width ratios, balconies, etc.), together with the fact that the main absorption (seating area) is concentrated on the floor surfaces rather then well distributed. Therefore, it is far from certain that the seat absorption has the same effect in the concert hall as in the laboratory where they were tested, as we pursue in the following:

From laboratory to hall

Figure 3 shows the effective absorption of the 1200 seats when installed in the 15.000 cubic meter concert hall. Each octave band percentage is the ratio of the seat absorption coefficient obtained by using the concert hall as a reverberation room, to the seat absorption coefficient obtained in the laboratory. Surface diffusion coefficient of the upper walls surrounding the hall is 0.15. The diagram illustrates that the laboratory tests overestimates the seat absorption in this case. When the seats are "installed" in the concert hall, the effective absorption at 125Hz is only 84% of the value from the laboratory test. One explanation for this is that the overall diffuseness at low frequencies in the rectangular concert hall is less than in the laboratory, allowing sound to linger longer in the upper volume rather than being exposed to the sound-absorption seating areas at floor level. At 125Hz the RT was 2.4 s, seat a was 0.68 in lab and 0.57 in-situ, while the ODEON input a was 0.60.

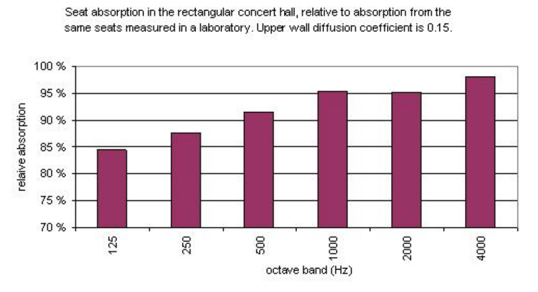

Figure 3: Seat absorption in concert hall relative to absorption from same seats measured in laboratory

In concert hall planning, the absorption effectiveness (*Figure 3*) and the diffuseness sensitivity (*Figure 2*) should be predicted. Lab test facility should provide verified diffusivity (*Figure 1*) down to the 63Hz octave.

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