Amsterdam Music Hall – Design of and validation measurements in a great pop music hall

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Introduction

This paper deals with the design of and validation measurements in an extraordinary hall: the Amsterdam "Heineken" Music Hall.

Figure 1: view of the interior of the Amsterdam Music Hall

Design Goal

The design goal was a modern multi-functional venue for the main purpose of high-quality pop concerts, i.e. use of PA-systems, for an audience of up to 5500 persons.

In contrast to the free field a classical concert hall adds to the direct sound multiple reflections, the totality of which forms the reverberation pattern.

In the sound field of an usual concert hall there is a relative low direct to reverb ratio and a high sound level caused by many and strong (best lateral and diffuse) reflections 0.1 – 0.3 sec. after the direct sound.

However, reverberation and reflective surfaces are not very suitable for PA but unwanted effects as mirror images by direct reflections from the speakers used modifying the timbre by the comb-filter effects and spectrum of the reverberation time.

Consequences for the Design

Consequence for the design was the desired acoustic properties to differ from normal concert halls. First the number of listeners in the audience should be minimum 3000 to 6000, which is 3 to 4 times higher than in usual auditoria. To allow the audience dancing, a large floor area was asked. Together with a minimum height a large volume results, whereas the reverberation time should be as short as possible stay below 1.6 sec. at a low reverberation level. Regarding the timbre an homogenous energy distribution (63Hz … 8kHz) is desirable as well as a flat reverberation time spectrum even in low frequency bands.

To ask is further a minimum of resonance in the Eigen-frequencies.

Moreover, special properties are needed: all surfaces hit by direct sound and side-lobes of arrays should be absorptive to minimize the danger of reflections and echoes. At no point in the audience audible or even disturbing echoes should be perceptible. The audience surfaces had to be designed to be simply to cover with sound.

Design Philosophy

Starting point was the setup of a simple audience surface with balconies. An design of radical suppression of reverberation and echoes was chosen; because of the long distances suppression of the first reflections is essential. But, the less the reverberation, the better echoes are audible – hence contains this approach a certain amount of risk; nevertheless, to make walls and ceiling less absorbing was regarded even more risky. This low-reverberation-level approach leads to the effect that much information is in direct sound and total reverberation and to a high direct to reverb ratio, if much sound is absorbed directly at the walls. The coverage of the audience with sound is not problematic in this situation, special high-directivity systems, which have not always a good sound quality, are therefore not necessary.

Applied measures and detail solutions

The measures and solutions to fulfill the requirements mentioned above are special coating materials on the walls, special absorbing wall constructions behind the coating, special absorbing ceiling constructions, and a diffusive pattern of absorption construction elements.

As visible coating of the walls a perforated metal sheet was chosen, allowing most of the sound to reach the absorption constructions behind and giving an optically stable limit to the room. Behind these metal plate three different kinds of highly broad-band absorbing material element constructions of dimension 0.9m x 1.3m, see figure 2, were placed in an alternating pattern. The resulting phase differences lead to low and mid frequency diffusion.

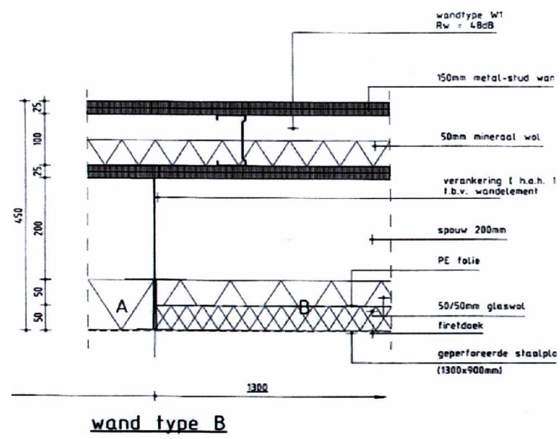


Figure 2: highly broadband absorbing wall element construction [1]

Validation measurements

Measurements to reveal the efficiency of the designed measures have been applied:

- absorption properties in reverberation chamber (ISO 354);
- reverberation time in practice with pistol shots and pink noise bursts (ISO 3382);
- impulse responses with omni-directional source and MLSSA (ISO 3382);
- decrease of sound level with distance with omni-directional source and class 1 SLM.

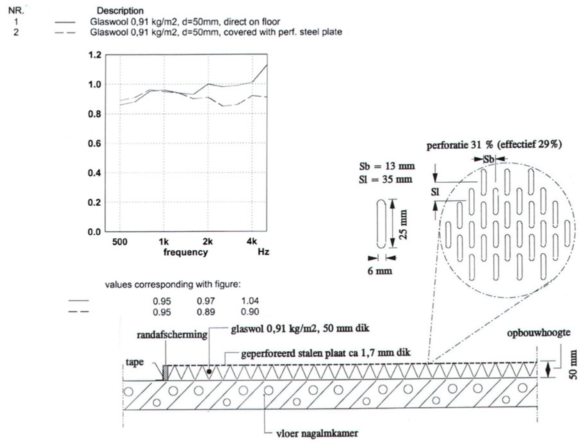
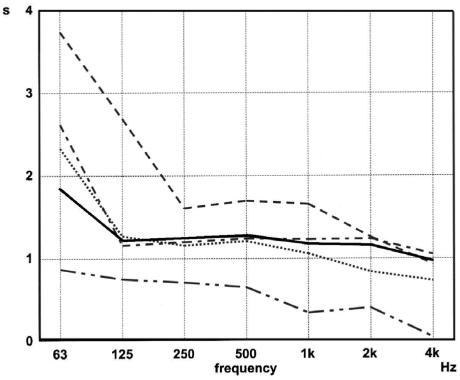


Figure 3: measurements in reverberation chamber of the influence of the perforated metal wall covering on absorption

Before building the wall constructions the influence of the perforated metal plates on the absorption were investigated by absorption measurements in the reverberation chamber conform to ISO354. Only in frequencies above 1.5 kHz a difference is visible.



values corresponding with figure:

	63	125	250	500	1k	2k	4k
averaged RT (14 pistol shots)	1.85	1.22	1.25	1.27	1.18	1.16	0.97 s
averaged RT (18 noise bursts)	2.62	1.16	1.20	1.24	1.23	1.24	1.05 s
EDT average (22 IR)	2.33	1.27	1.16	1.21	1.06	0.84	0.73 s
EDT max. (22 IR)	3.74	2.69	1.61	1.70	1.66	1.26	0.93 s
EDT min. (22 IR)	0.87	0.75	0.71	0.65	0.34	0.40	0.04 s

Figure 4: averaged RT and EDT in unoccupied hall

The reverberation time of the worst case (RT, see figure 4), the completed unoccupied hall, was measured with pistol shots and pink noise bursts. The averaged value stays below 1.3 sec. in the octave bands between 125 Hz to 4 kHz, which is extremely low for an hall of a volume of 48000 m³. This shows the efficiency of the applied absorption measures. Impulse responses were measured using an omni-directional source and MLSSA at 2 source and 12 receiver positions, Figure 5 shows as typical result the broad-band ETC of the response at half the length of the hall.

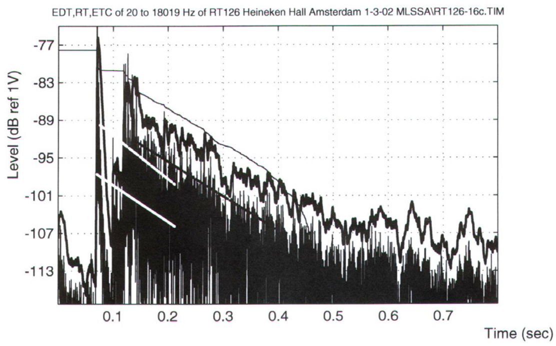


Figure 5: typical ETC, measured at half the length of the hall

Additionally the decrease of sound level with increasing distance from the source was measured using an omni-directional tube source and a class 1 SLM. The result can be seen in Figure 6 and has the value of –5.5 dB/2R, which is quite near to free-field conditions. The measured values of AL_{CONS} [2] stay below 10% with an average of 7.6%. The strength factor G was measured for 1 kHz and averaged:

$$\overline{G}(f=1kHz)=\overline{L_{p,measured}}(d>10\,m)-L_{p,free\_field}(d=10\,m)=-6.2\ dB \quad (1)$$

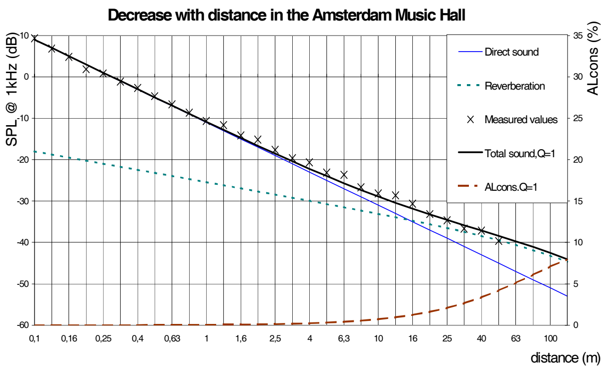


Figure 6: decrease with distance in the hall

Conclusions

The hall was completed in 2001. Since then it turned out to be very successful and widely appreciated for Pop-events.[3] The measurements of absorbing materials and the completed hall show the design goals to be fulfilled very satisfying:

- reverberation time is very low for a room of 48000 m³;
- the measured decay patterns are mostly homogenous;
- echoes result only from metal surfaces above 1.5 kHz;
- measured values of AL_{CONS} indicate very good speech intelligibility.

With special thanks have to be mentioned D. de Leeuw for his help with the measurements and M. Luykx for the fruitful discussions.

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