Room acoustic aspects of some recently opened pop venues

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Summary

In 2014 Peutz could enjoy the opening of four new pop venues in the Netherlands and Turkey. Although very different in size and shape, ranging from 550 up to a 5.800 capacity hall, they all share a common design concept for the room acoustic aspects.

In this paper the general room acoustic concept for pop venues is described. Following the goal for a maximum reflection strength for the late reflections, this criteria can be transformed to an approximate requirement for the reverberation time. For the four pop venues it is described how the room acoustic criteria are realized and the approximation formulas evaluated.

PACS no. 43.55.Fw

Introduction

In 2014 Peutz enjoyed the opening of four new pop venues: Hedon in Zwolle, Doornroosje in Nijmegen, Grenswerk in Venlo and Volkswagen Arena in Istanbul. The capacity of these halls ranges between 550 listeners up to 5.800 listeners.

Hedon is a project that was partly a renovation. The other three halls are completely new buildings

The common aspects of the acoustic design of these halls are the high sound insulation to adjacent rooms and to dwellings nearby, a flat reverberation spectrum combined with a short reverberation time, and a sufficient low background noise from installations.

The sound insulation of the projects will be described in the paper "Popvenues in living areas" by the same autheurs.

The paragraphs 4 to 7 give a description of the new pop venues, including the measurement results of the room acoustic aspects. But before turning to the acoustic results of the pop venues, the underlying goals and means are described. The room acoustic requirements follow from earlier investigation as described in [1]. This theory is checked and extended for smaller halls.

Room acoustic requirements for pop venues

To accommodate a maximum control over the reproduced music via the control table and loudspeaker system, a minimum influence of the hall is usually preferred for amplified pop music.

A high direct to reverb ratio is the first condition which has to be accomplished for good definition of the amplified music. The direct sound comes from the loudspeakers and a low reverberation level due to the numerous reflections from walls, ceiling and floor is required. For large venues it becomes even more important to suppress the reflection strength. In order to prevent echoes to occur, the strength of the late reflections (50 ms or more) needs to be reduced by about 10 dB relative to the direct sound. When the geometrical decrease with distance is taken into account, this demand for a minus 10 dB per reflection might seem a bit exaggerated. But if we take a closer look at possible reflection paths, it becomes quite clear that for instance the different reflection paths via the rear wall will not differ a lot in delay time. At the receiver position the sound level of the reflections has to be added in order to estimate the echoic effect. The larger the hall, the smaller the delay difference from reflections over the rear wall and the smaller the sound level difference between the direct sound and the reflections.

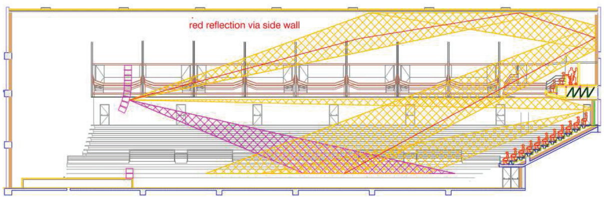


Figure 1. Longitudinal section of the Volkswagon Arena, with the direct sound (pink) and first / second order reflection paths from the PA with more or less the same delay time relative to the direct sound.

For large halls, where the delay path of the reflections relative to the direct sound easily exceeds the 50 ms (17 m) it is therefore to be preferred to decrease the strength of reflections with 10 dB, which is achieved by absorption of 90% on all walls and ceiling. The rear stage wall is also important in this case, to prevent the reflection from the stage monitoring system to be echoic.
This 90% absorption on all walls and ceiling can be worked around to a requirement in reverberation time related to the volume [1]. For the most common ratios of height, length and width, the approximation formula for the desired RT becomes:

$$T_{60} = 0.038V^{0.33}\left(s\right) \qquad (1)$$

For smaller halls it will not be necessary to cover all walls with a 90% absorption material. Although echoic reflections (from the rear wall for example) have to be avoided in these smaller halls, the earlier reflections will add a feeling of "presence" and enlivenment.
For the large halls, the absorptive walls and ceiling produce a feeling like being outside, as if on a festival terrain. But if the smaller halls become too absorptive, they will be perceived like an anechoic room.
In order to sufficiently reduce echoic reflections in smaller pop venues an absorptive coverage of 100% of the ceiling area and 50% of the wall area is usually sufficient, provided that there are no concave surfaces being present. This amount of absorption can also be turned into a reverberation time approximation requirement for the smaller pop venues:

$$T_{60} = 0.055V^{0.33}\left(s\right) \qquad (2)$$

Both formulas will be evaluated for the 4 halls that opened in 2014.

At least as much important as the actual reverberation time, is a flat reverberation spectrum from at least 63 up to 4000 Hz. Special attention has to be paid to absorbing efficiency at low frequencies: the 63 and 125 octave band. If the reverberation level at low frequencies is high, a soup of sound 'swallows' all higher frequencies and kills the definition. In order to achieve a clear and perceivable bass rhythm in balance with the mid and higher frequencies, the reverberation time in the 63 and 125 Hz may not exceed the average RT by more than 10%.

Although the background noise level for pop venues is not as important as for non-amplified music or speech, it is necessary to set a requirement. For smaller pop venues a semi-acoustical concert may be part of the programming calendar, and a maximum of 30 to 35 dB(A) is a useful requirement. For the larger venues a semi-acoustical concert will be out of the question and a 40 dB(A) maximum background noise will do.

Means to achieve the design goals

Already a long time ago Peutz developed a multi-layered absorption material to gain a broader absorption spectrum then based on the thickness of the material alone. By combining different densities of mineral wool with a heavy foil, a combination of porous and resonator absorption properties are combined in one material. The weight, thickness and/or cavity define the resonance frequency, which therefore can be adjusted for the specific situations. Such a broadband absorber makes it unnecessary, at least for the smaller halls, to incorporate base traps. Such a broadband absorber is applied in the Heineken Music hall and as baffles in the Amsterdam Arena.

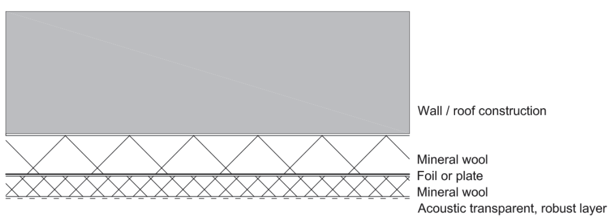


Figure 2. Example of a broad band absorption material.

For larger halls, where fixed tribunes are present, extra low frequency absorption is necessary located at these tribunes. By means of slits in the tribunes, the cavity behind/below the steps can function as a Helmholtz absorber in order to provide extra low frequency absorption.

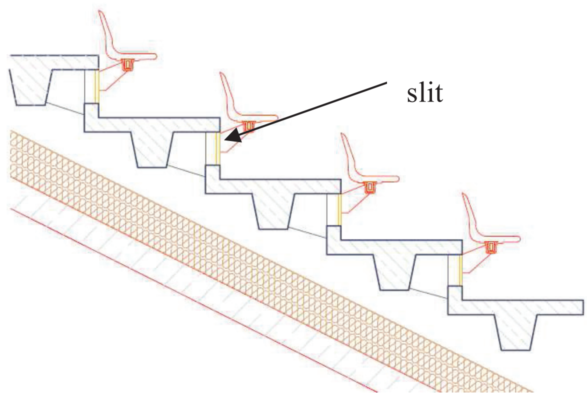


Figure 3. Example of the tribune as a Helmholtz absorber.

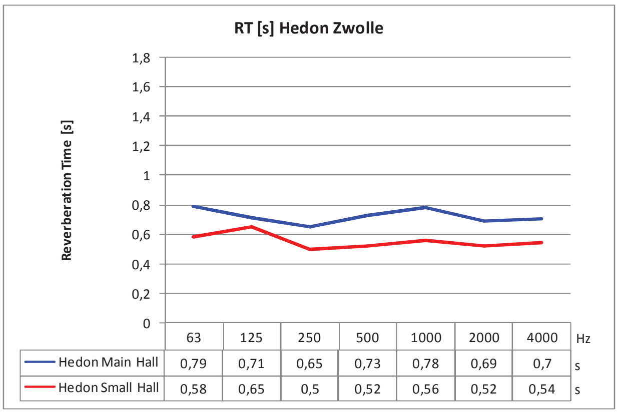
In order to achieve al sufficient low background noise from installations, the concept of air supply with relative low air velocities help to find efficient technical solutions. The required sound insulation usually demands large silencers at the entrance and exit of the air ducts, which will largely accommodate for the necessary reduction of the ventilator noise.

Hedon Zwolle

Opening: February 2014
Main Hall: Capacity 850, Volume 3.250 m^3
Small Hall: Capacity 200, Volume 675 m^3

The existing main hall and some of the surrounding rooms were taken as the heart for the new building in which the main hall doubled in size by reusing three walls and the roof. The design concept for the room acoustics is a 100% coverage of the ceiling and 50% coverage of the walls with broad band absorption. The curved balcony fronts are made absorptive as well.

Measured reverberation times:



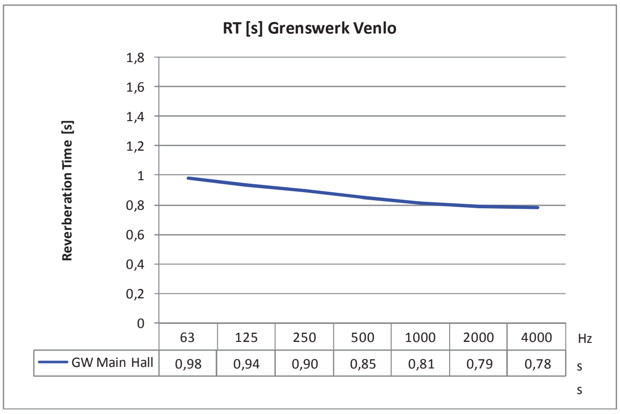
Background noise from installations (for different positions):
Main Hall: 30 – 35 dB(A)
Small Hall: 29 dB(A)

Grenswerk Venlo

Opening: October 2014
Main Hall: Capacity 550, Volume 3.300 m^3

The new hall is situated in the centre of the old city and part of a larger project with new dwellings. The ceiling of the main hall is shaped like a double saddle roof which follows the outline of the building design (and the roof line of the dwellings). The 100% ceiling coverage of broad band absorption gives already a very large absorption surface. The concrete walls (the inner walls of the box-in-box construction) have a rough top layer, which made it possible to reduce the wall broadband absorption to a coverage of about 25%.

Calculated reverberation time:



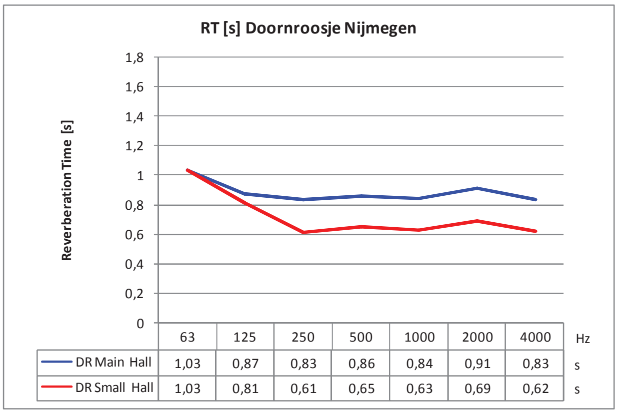
Background Noise from installations:
Main Hall: 36 dB(A)

Doornroosje Nijmegen

Opening: October 2014
Main Hall: Capacity 1.100, Volume 5.050 m^3
Small Hall: Capacity 400, Volume 2.000 m^3

Doornroosje is build in the city centre of Nijmegen, close to the central station, with dwellings on its roof. The room acoustic concept consists of a 100% ceiling and 50% wall coverage with broad band absorption.

Measured reverberation times:



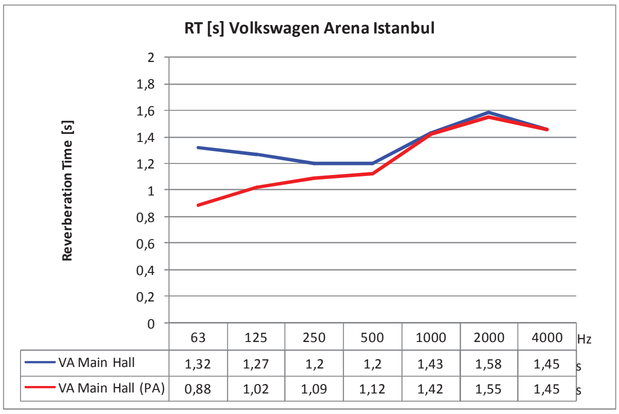
Background Noise from installations:
Main Hall: -- dB(A)
Small Hall: -- dB(A)

Volkswagen Arena Istanbul

Opening: June 2014
Main Hall: Capacity 5.800, Volume 56.000 m^3

The Volkswagen Arena is build in the new financial centre of Istanbul (Maslak Area) as a part of a shopping mall with offices. The room acoustic concept consist of a 100% coverage of the walls and ceiling with different compositions of broadband absorption. The fixed tribunes have Helmholtz resonator slits, with mineral wool in the cavity. The efficiency of these Helmholtz resonators is good to be seen in the short RT at low frequencies when measured with the high directive PA system.
During the final building stage, the through painted black wood wool, which was used as a top layer for the broad band absorption, was out of stock. A large part of the wood wool was therefore painted at the site, which accounts for the somewhat longer reverberation time at the higher frequencies. An alternative is under construction.

Measured reverberation times:



Background Noise from installations on different positions and 2 conditions (heating and cooling):
Main Hall: 34 - 40 dB(A)

Measured impulse response with an omnidirectional source on stage, receiver half way the arena floor:

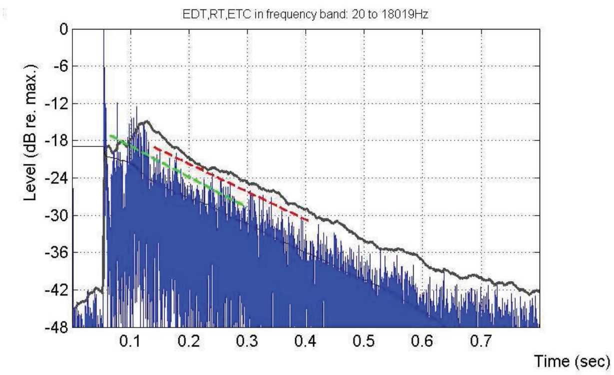


Figure 4. Broad band impulse response at the Volkswagen Arena, all reflections are below -10 dB relative to the direct sound.

Conclusions

We are very pleased that for all the four new pop venues described in this article the room acoustic criteria we defined at the start of the project have been realized. The acoustics have been very well received, which might lead us to conclude that these acoustic criteria worked out well.

Figures 5a and b show the described venues, along with a few other pop venues well known for their acoustics [1,2], alongside the graphs of the approximation formulas for the reverberation time criteria (1) and (2).

The smaller venues relate good with approximation formula (2), and the larger venues relate good with approximation formula (1). These approximation formula's can therefore be used to set a first goal for the room acoustic criteria.

From the data it can't be stated where the boundary is between "smaller" and "larger" pop venues. In practice: there are not many pop venues with a listener capacity between 1.500 and 5.000, which probably has its roots in programming and exploitation. But when the height, width or stage depth are of a seize that several first order reflections with a delay of 50 ms have to be expected, it seems obvious to incline to the stronger reduction of these reflections in order to realize a clear amplified sound.

References

[1] M.Lautenbach, P. Heringa, M. Vercammen: Acoustics for large scale indoor pop events, ISRA 2007.

[2] K.H. Lorenz-Kierakowitz, R. Metkemeijer, Y. Dekeyrel: Amsterdam Music Hall – Design of and validation measurements in a great pop music hall, DAGA 2004.

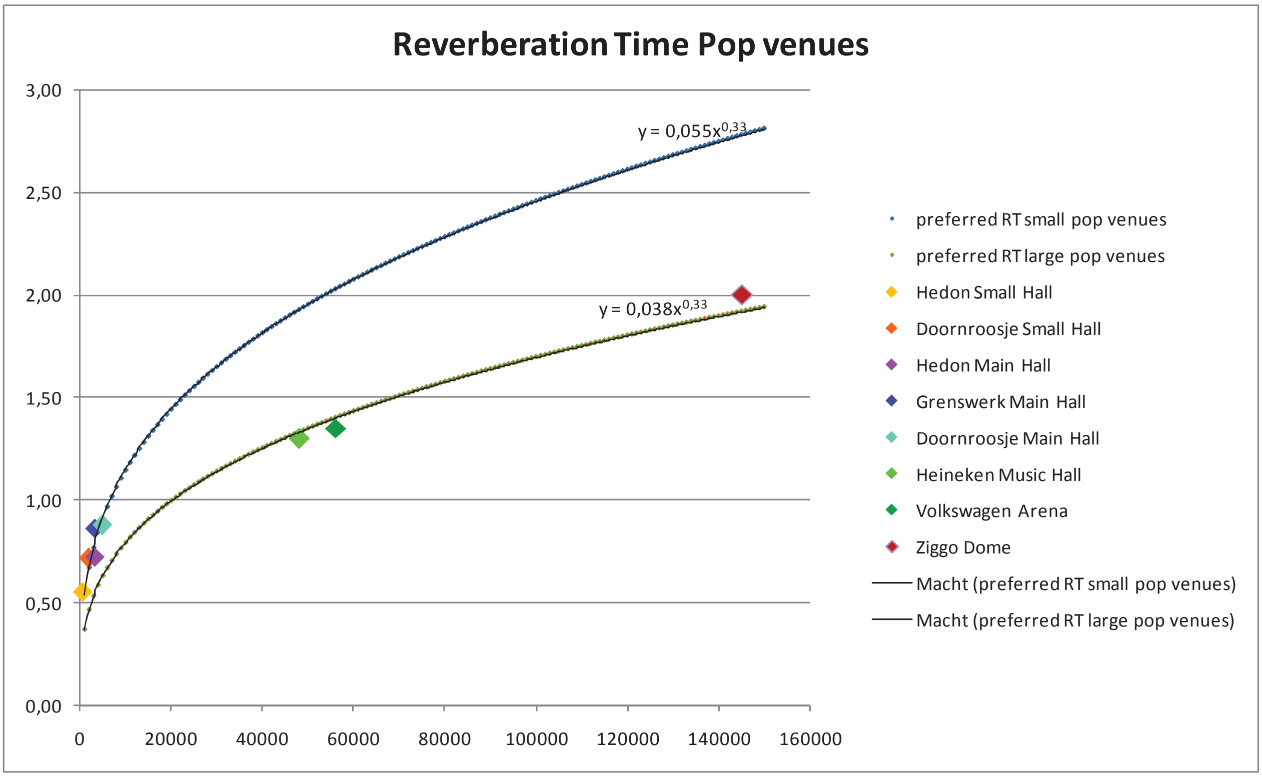


Figure 5 a. Average reverberation times (63 – 4000 kHz) of the 4 halls and a few well known other halls, with approximation formulas (1,2)

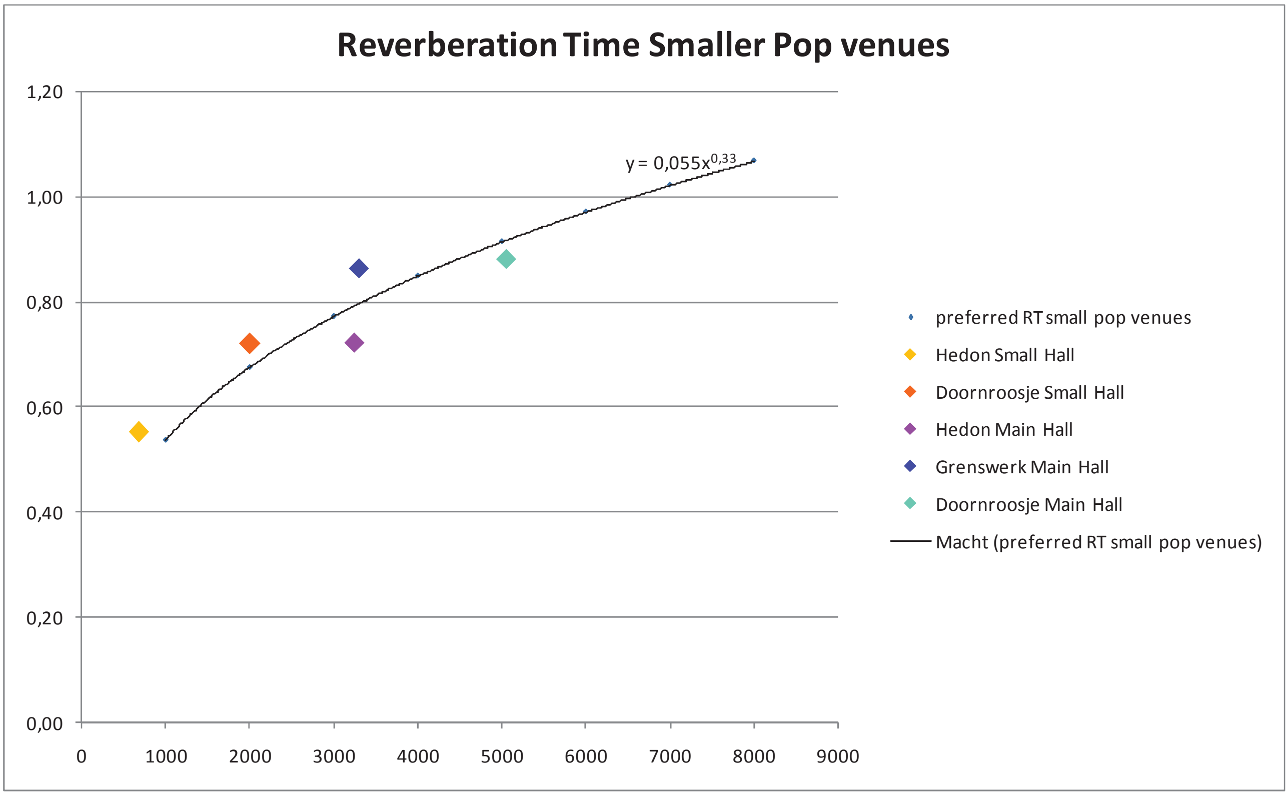


Figure 5 b. Average reverberation times of the 5 smaller halls, with approximation formula (2)