Variable Acoustics without Compromise: Concert Halls for both Symphonic and Pop Music

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VARIABLE ACOUSTICS WITHOUT COMPROMISE: CONCERT HALLS FOR BOTH SYMPHONIC MUSIC AND POPMUSIC

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ABSTRACT

There is a need for concert halls that can host different kinds of music, ranging from classical symphonic music to pop concerts. Due to competition with acoustically well designed single purpose halls, the acoustical quality for both symphonic music and pop music should be very high.

In the Netherlands an existing concert hall in Groningen was refurbished in a way that the acoustics for symphonic music were improved and variable elements were added that now can turn the hall into a pop venue as well. In Arnhem a new concert hall for both symphonic music and pop music was created with smart solutions to change the acoustic properties of the walls. In Amsterdam the acoustics of the Concertgebouw was improved for amplified events. This paper describes the main design characteristics and acoustics results for these halls. The measurements results as well as the subjective experience is very good in these halls, for both types of use.

1. INTRODUCTION

Lots of smaller cities want to offer their residents an extensive and divers cultural program, including symphonic music and pop concerts. But most of these smaller cities do not have the possibilities nor the means to build or exploit several single purpose halls for different kind of events. A multi-purpose hall appears to be the answer, the magic solution to host all kind of activities, although the acoustic requirements for these events would vary tremendously. When looking at extremities in the spectrum of possible use, symphonic music versus pop music, it is no wonder that ”the multi-purpose average between the two” can never satisfy any of these.

The correct approach would be to define the requirements for each purpose and then create one hall that can fulfill both requirements by means of changing the hall, so neither of the extremes in use should be compromised by the other. This need for quality is related to the competition by other excellent venues, in the Netherlands the Concertgebouw Amsterdam and De Doelen Rotterdam for classical music and Ziggo Dome and Heineken Music hall (now: AfasLive) for popmusic. This sets the minimum standard for other venues.

2. ACOUSTICAL REQUIREMENTS

To evaluate the possibility to realize such acoustically different functions in a single space a clear understanding of the acoustical requirements is essential. We will focus on a few important geometrical/acoustical issues

2.1 Symphonic Music

Symphonic music requires a certain mixing of sound. Especially for certain instruments, like violins, the early reflections attribute to the sound quality. The late sound, the reverberance, creates a certain warmth. Of course the need for this also relates to the repertoire, that was written in the past to be performed in the halls that were then existing, and with a certain speed of harmonic changes. So a symphony hall requires reflective surfaces, especially to realize lateral reflections. The ceiling need to be high and diffusive, so these reflections come in late and the sound is dominated by the horizontal sound field.
To have a sufficient loudness, but not too much, a rather precise amount of absorption will be needed. Optimum Strength for symphonic music is about + 5dB. This defines the amount of absorption (about 1600 m^2.). This absorption is reached in a hall with about 1800 audience. In that case all surfaces need to be reflective. The volume needs to be sufficient, typically in a range of 15000 to 22.000 m^3, to reach a reverberation time of about 1,9-2,2 seconds.
Concert halls can have other requirements regarding lines of sight that theatres. A good vision on the stage is not absolutely necessary. Especially the 19th century concert halls, also the famous three: Concertgebouw Amsterdam, Wiener Musikverein and Boston Symphony hall, have a flat floor and a high stage. Nevertheless there are many (mainly post 2ndworldwar) concert halls with moderate or even steep increase of the audience floor to accommodate improved lines of sight. In terms of acoustics there is a draw back in this: there is no rear wall reflection and envelopment is significantly less than in concert halls with a flat floor. So it is a good starting point for a hall for symphonic music to have an (almost) flat floor.
So the good symphony hall is basically characterized by an absorbing audience on an (almost) flat floor, a high ceiling and reflective surfaces.

2.2 Popmusic

For popmusic the sound is generated over the loudspeaker system, excess mixing of sound is generally not appreciated for its reduced intelligibility. Especially the base sound should have a temporal clarity, the rhythm should not be blurred.

There is difference between acoustical requirements between smaller and larger halls. In larger halls the delay times of reflections are larger with increased risk for echo-like phenomena. So for larger pop music halls it is important to suppress late reflections from surfaces. A short reverberation time is not a goal in itself, but follows from the effective suppression of disturbing reflections [1].For halls in a range of 15000 to 20.000 m^3, suppressing most of the late reflections would lead a reverberation time of around 1,0 s. (see [2]).

The loudness of pop music (or other types of popular music like house music) at low frequencies is significant and has increased in the last 20 years due to improved equipment. To get the clear bass sound, absorption needs to cover the real low frequencies equally well. ZiggoDome and Heineken Music Hall have sound absorbing constructions with a thickness of 30 cm [3].

The position of the absorption is also relevant. Line arrays and vertical subbass arrays have high directivity, so especially the wall surfaces directly above the audience are the most risky surfaces in terms of adverse reflections. These surfaces are the best and most effective surfaces to apply absorption.

So, with the amplification system directed to walls for mid- and high frequencies, the ceiling might remain reflective, resulting in longer reverberation times target of 1,2 to 1,3 s for halls of 15,000-20.000 m^3.

Pop music venues have a large flat floor for standing people. In several cases there are also seated areas (such as in Ziggo dome, Ahoy Arena, the Zeniths in France) but in front of the stage is always for standing audience.

2.3 Similarities and Differences

The main and rather important similarity in the requirements is the (almost) flat floor. A symphonic hall that has a flat floor and is able to remove the seats from the floor, can receive a standing audience for amplified music. Acoustically halls pop music are more closer to theatres, but in theatres good lines of sight are needed and generaly fixed seats are made in a slopped audience arrangement. So geometrically the symphonic hall is much closer to the pop music venue.

Of course there a few more non-acoustic issues to solve. For example, in many performance halls with fixed seating the air supply system is with a displacement system with air inlets under the seats or in the chair legs. A different air supply system need to be chosen, for example a displacement system from the side walls or a mixing system. Other practical issues are for example hall capacity, exit width, toilet capacity, type of audience and materials used, etc.

The main difference between the acoustical requirements is the function of the walls: reflective for the symphonic music and absorptive for the pop music. So something is needed here to change this. Especially critical is the rear wall, since the line arrays are directed to that. Also important, but slightly less critical are the audience side walls and the stage rear wall regarding reflections from the monitor loudspeakers and the backfiring of the line arrays.

The ceiling is not so critical for venues of about 2000 audience with a high ceiling, as required for symphonic music. This is mainly because the sound system is not directed in that direction. Even when increasing the reverberation time, the reflective ceiling has little influence on the direct/reverberant sound ratio at the audience.

3. CONCERT HALLSFOR BOTH SYMPHONIC MUSIC AND POPMUSIC

We will discuss a few examples of concert halls in the next chapters, that are both being used for symphonic music and pop music. The best example is a newly built concert hall, the Parkzaal of Musis in Arnhem, Netherlands. The second is a renovation of an existing hall in Groningen, Netherlands. Both are examples where the combination was designed without compromise. The third example is the Concertgebouw Amsterdam where an important improvement was made in order to facilitate amplified events.

4. MUSIS ARNHEM

Musis in Arnhem has a 19th century society-concert hall that was enlarged in the past to accommodate symphonic music. The complex was extended with a new hall, the Parkzaal. From the start, this was to be a hall that should be able to accommodate both symphonic music and amplified music. The hall should accommodate 1000 audience. The volume requirement was 10.000 m^3. For acoustical reasons (see section 2.1) for symphonic music, the contest design that we proposed had a volume of 15.500 m^3. The concept was a shoebox type of hall, with almost flat floor and a high ceiling.

Figure 1. MusisParkzaal Arnhem, opening concert.

In the concert situation the floor height at the rear of the hall is equal to the stage, with a linear slope towards stage, 1m under stage level. In case of standing audience the floor at the rear is lowered, while hinged at the front, to obtain a flat floor, see fig. 2. In the sluice the steps move along with the floor and the door is separated in 2 parts.

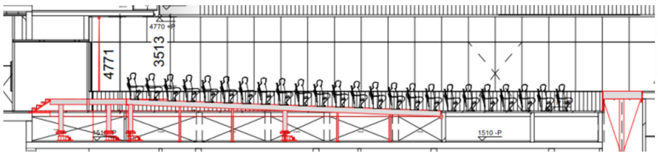

Figure 2. MusisParkzaal, section of hinged floor

The seats are coupled in blocks of 2-4 seats and on wheels for easy removal from the hall, over a stage elevator platform to the storage space under the hall.

The volume of the hall is based on the required loudness for symphonic music. But the amount of audience is rather low for a hall of 15.500 m^3. A concept was made with narrow stalls and a U-shaped balcony without overhang. The geometry for symphonic music was optimized with 1:10 scale model research. The rather extreme budget restriction asked for a simple and effective method for variable absorption. The horizontal balcony was essential to implement a moveable panel system for variable sound absorption.

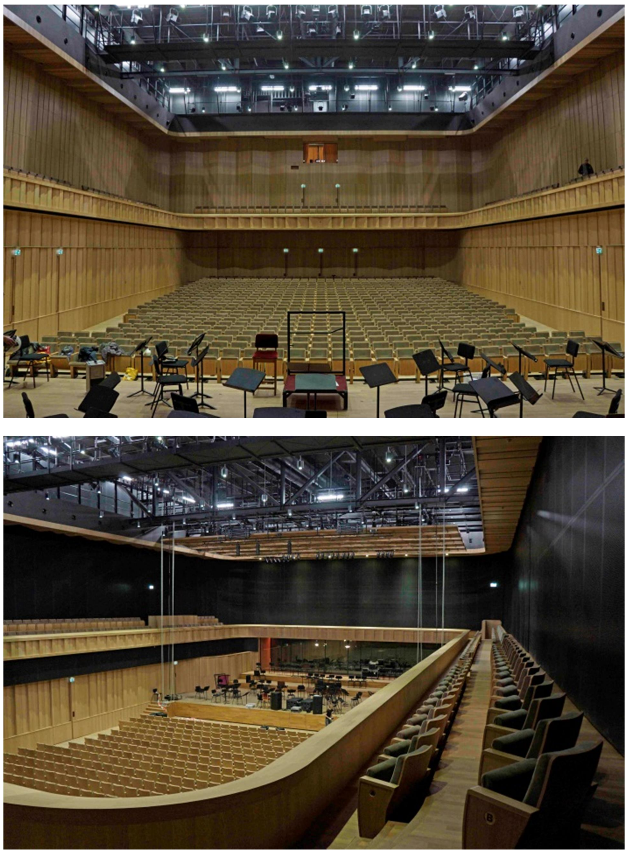

Figure 3. Musis Parkzaal Arnhem, configurations for Upper: symphonic music; lower: amplified music (light on technical gallery is usually off)

This is a conventional system on rails, normally used as flexible mobile wall to separate meeting rooms. In this case the frames were covered with a 30% perforated wooden panel and filled with layered absorptive material and positioned at 30 cm from the rear walls, providing broad band sound absorption. The absorptive panel wall is shown in fig. 3. The variable absorption not only changes the acoustics, it has also a significant effect on the esthetics of the hall. Due to the separate system for absorption, the design of the walls for symphonic music is not influenced by the variable absorption. The panels can be moved from/to storage rooms at the rear of the hall, behind large doors. All the walls at balcony level, including the large window behind the stage, can be covered with this system. At stalls level only the top part of the walls is covered. The remaining visible rear wall with the entrance doors has a zick-zack shape, to prevent disturbing reflections back to the stage.

The walls at the level of the technical gallery are partly absorptive (fixed absorption). The ceiling is diffuse reflective.

The measured RT is presented in fig. 4

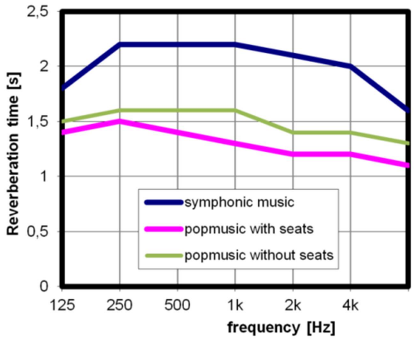

Figure 4. Reverberation times in the Parkzaal, without audience, for different settings.

The sound quality for pop music is just as good as for classical music: very good, without disturbing reflections. It can be concluded that a hall was realized with excellent acoustics for both symphonic music and amplified music, without compromise.

5. OOSTERPOORT GRONINGEN

The Oosterpoort Groningen has a concert hall for 1150 audience , with a volume of about 13.000 m^3. The first part of the hall is a flat floor with flexible seating. The rest of the hall is sloped with fixed seating. The hall is rather wide and the orchestra was lacking effective early reflections. An overhanging balcony on stage created large differences on stage. The walls of the hall are of concrete with a regular pattern of diffusive blocks of cast concrete, creating diffusive sound. The Oosterpoort is also used for amplified music, it houses an important yearly popmusic event, Noorderslagfestival. There was a need to improve the acoustics for both symphonic music and amplified concerts. During the renovation the seating was renewed and the stage was changed. The overhanging balcony was removed and a wooden construction was made to provide the orchestra reflections from the rear and the sides.

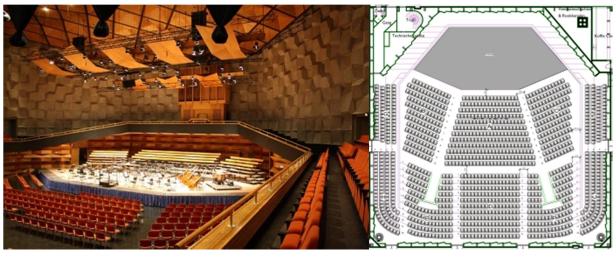

Figure 5. Oosterpoort Groningen, before renovation. Right; floor plan

As for the acoustics for amplified events, two methods were used to integrate variable broad band absorption in the hall.

The first method was rotating panels of considerable thickness (15 cm) to create sufficient low frequency absorption. This method was applied for the stage walls and the lower side walls of the flat floor area.

Figure 6. Oosterpoort Groningen: rotating elements at the side walls of the flat floor area, with reflective and absorptive sides.

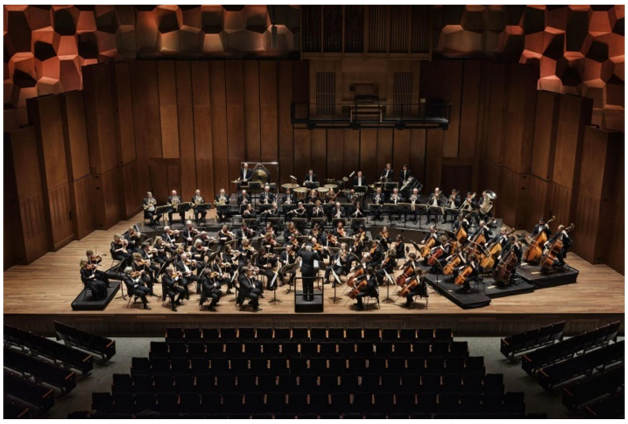

Figure 7. Oosterpoort Groningen: New Stage environment with rotating elements at the rear wall. Also at the side walls of the stage these rotating elements are intended, but not yet implemented.

The second method was to apply thick but flexible sound absorptive mats. A multilayer mat based on sheep wool was selected with a total thickness about 10 cm, covered in acoustically open fabric. Figure 8 shows absorption data measured in our reverberation chamber. By placing a porous material on an air gap the low frequency absorption is increased, but this air gap need to be closed, otherwise the sound waves will go around and equalize the pressure difference. When the mats are applied in an open setting, the mid- and high frequency absorption increases but the low frequency absorption decreases.

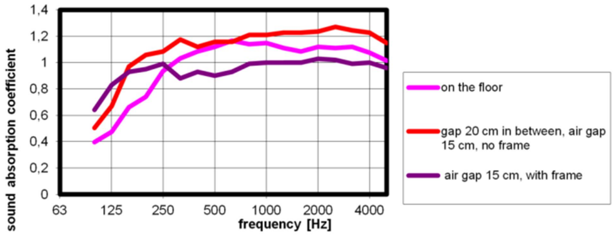

Figure 8. Measured sound absorption of 10 cm sheep wool mats, applied in the Oosterpoort.

The ceiling of the Oosterpoort is hung up to a steel truss construction and there are openings between the ceiling and the wall. This made it possible to create a roll-up system for the mats above the ceiling and lower the mats along the walls. Also the large overhanging control room in the rear can be covered, the mats are pulled towards the wall. The underside of the mats are at about 2 m above floor level, so reflections of the walls above audience still occur. The strongly diffusive concrete walls sufficiently reduce possible nasty echoes.

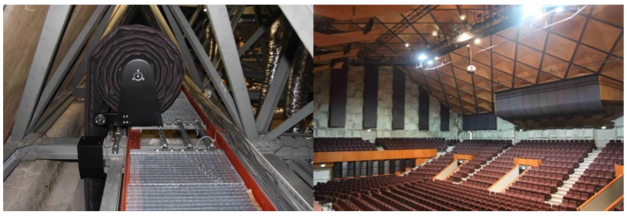

Figure 9. Oosterpoort Groningen: left: Roll-up system for the sheep wool mats, Right: Mats rolled out in the hall.

Due to financial reasons only half of the intended mats are mounted. In future also mats can be added at the spaces in between. The calculated RT is given below.

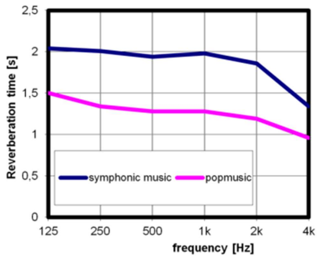

Figure 10. Oosterpoort Groningen: Calculated RT in the symphonic and popmusic configurations with audience (as realized).

In the popmusic configuration a flat frequency response is maintained with sufficient reduction at the low frequencies, despite the “open” way of suspending them. The audience response to both improvements for symphonic music and popmusic are very positive.

6. CONCERTGEBOUW AMSTERDAM

The Amsterdam Concertgebouw is famous for its acoustics for symphonic music. Nevertheless, the hall is also used for other types of music, with amplification. Already since the fifties there are jazz concerts and nowadays mainly in the summer period, amplified concerts take place. The flat floor and seats on wheels make it possible to have all sorts of events in the hall. However, the acoustical quality of the hall is not optimal for amplified events. Simulations were performed to investigate how the acoustic could be improved.

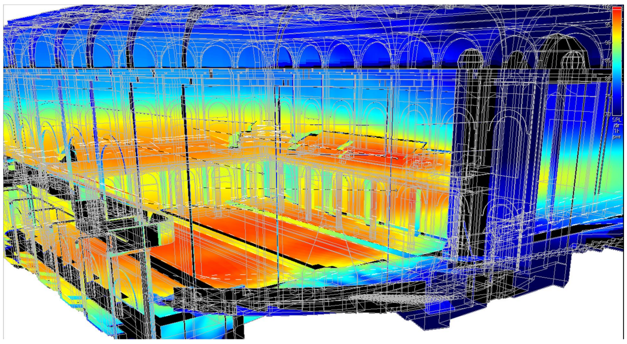

Figure 11. Concertgebouw Amsterdam: Color mapping of the sound level on audience and walls with a 16 cabinet line array system.

With high directivity of the sound system the sound energy can be directed as much as possible on the sound absorbing audience (fig 11). However there is a limit in this. The walls below the rear and side balconies receive significant sound power, that will reflected into the hall. When using the sound system, a disturbing echo-like reflection from the rear wall can be observed (fig 12), that should be removed.

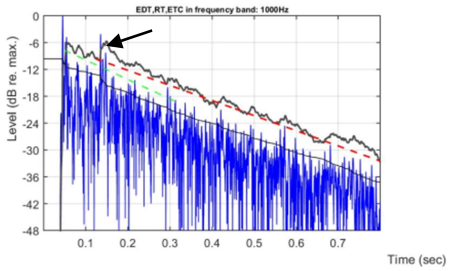

Figure 12. Concertgebouw Amsterdam: measured impulse response from the line array to an audience position in the middle of the hall without absorptive rear wall. Strong rear wall reflection indicated with arrow

After the simulations, a test setup was made with sound absorbing coverings of different parts of the hall, impulse response measurements were made and a music test with hearing test panel were performed. (fig 13). The improvements were significant. The first and most important surface to be covered is the rear audience wall below balcony.

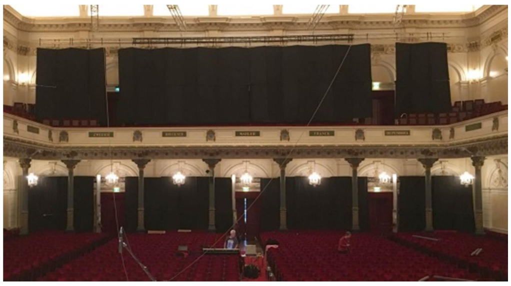

Figure 13. Concertgebouw Amsterdam: test setup with curtains below and above rear balcony.

This concept was implemented by the Concertgebouw. Baffles described in section 5 were used, with a photo print of the rear wall of the hall (fig. 14). The baffles are hung on a fly bar system that was built into the balcony under the stepped floor.

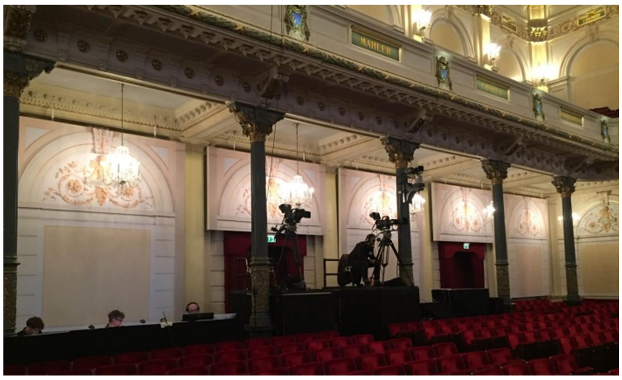

Figure 14. Concertgebouw Amsterdam: View of the sound absorption on the rear wall (with photo print).

The baffles can be removed by lowering and folding them on wagons that are rolled to the storage space.

Even though the effect on reverberance is rather small, the baffles are on a strategic position and the acoustical quality of the hall for amplified concerts has significantly improved.

7. CONCLUSION

The hall in Arnhem and the other two examples in this paper show that with a clever design, it is possible to combine a concert hall for symphonic music with a hall for pop music, without compromise in terms of acoustics.

8. REFERENCES

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