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THE DR. ANTON PHILIPS HALL IN THE HAGUE

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INTRODUCTION

After the The Hague "Residentie orkest" (orchestra of the residence, the Dutch government resides in The Hague) lost their medium sized, but suitable hall about 20 years ago by a fire, the municipality op The Hague decided that the congress hall in the just completed Dutch congress center, would be used as the city's concert hall.
Despite several attempts over a period of appr. 10 years to improve the acoustics of this hall for symphonic music, it became clear that the situation was hopeless and finally the orchestra decided to build its own 1900 seats hall, a single purpose hall for symphonic music.
The fundraising process took several years and was successful, as can be read from the hall's name.

The implications of this history are clear:

- The budget was low(est). Dfl. 12.000.000 was available when the hall was actually designed. The extra money that came available by fundraising during the construction phase (another Dfl. 11.000.000) was mainly used for improvements of technical installations, some beautifications etc..
- The reason to build the hall was good acoustics.
  Therefore the risk of a failure had to be "excluded"; an orchestra cannot afford to try a second time.

We followed the orchestra on a few tours, discussing different acoustic environments. This lead to rather well defined acoustical criteria for the new hall. (See also paper by P. Heringa on concert-hall acoustics, ref. 2).
Taking the budget into account it became soon clear, that the traditional shoe-box shape had to be chosen. This paper describes a few features of the design of this "modern" shoe-box, built of the simplest materials.

MAIN DIMENSIONS

From the first discussion with the orchestra it became clear that the hall had to be well suited for the late romantic repertoire, which means that a volume around 20.000 m^3 is necessary, based on a room constant of -26 to -27 dB for the preferred loudness of the hall and a reverberation time of appr. 2.2 seconds.

A width of 23.5 meters was chosen after many and intense discussions with the architects.
Width is always a compromise between the acoustical preference for narrow halls for a good direct to reverberant ratio, giving good clarity and providing strong early, lateral sound and architectural preference for wide halls to achieve small distances between public and orchestra for good sight.

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For a minimal decrease of sound level to the back side of the hall a high ceiling is necessary. The necessary ground area to accommodate orchestra and public as well as a maximal allowable distance between the back wall and the orchestra of appr. 35 meters led to a height of appr. 18 meters (width/height ratio 1,31) and a length of appr. 47 meters, to give a total volume of 19.200 m^3.
The orchestra is placed in a large volume (appr. 6000 m^3 from front of stage to front wall).

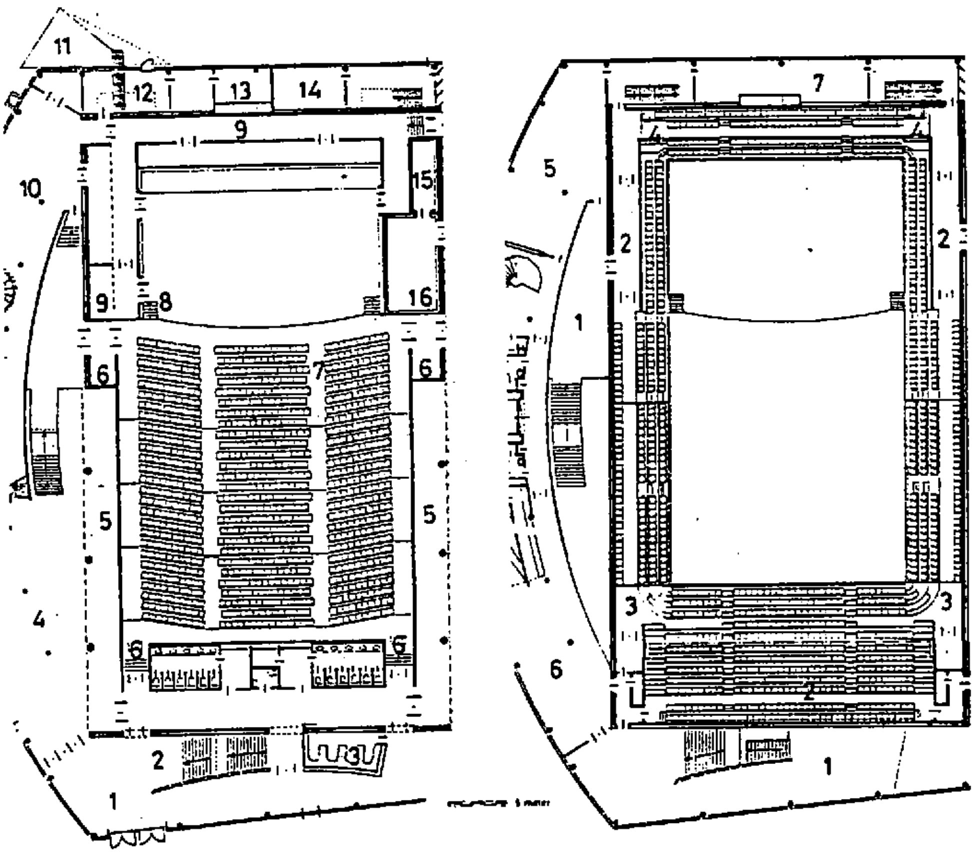

figure 1 Ground floor plan 1st floor plan

The center of the orchestra is appr. 10 meters before the front wall and a moderate amount of absorption, ca 230 chairs, is present in the orchestra volume.

The stage area is very large (20 x 13,5 meters) surrounded by diffusing walls of 3 m. This area is not fully occupied by the orchestra. The orchestra should of course be seated as close to getter as possible, but some distance to the surrounding walls (creating "volume") is an important factor of this design, creating a well blended, not too loud reverberant field.
To keep the acoustical volume for the orchestra maximal no overhead reflector is used. Early reflected sound for support and ensemble conditions have to be supplied by the (diffusing) walls around the orchestra.

See figures 1-3 for plans and sections of the hall.

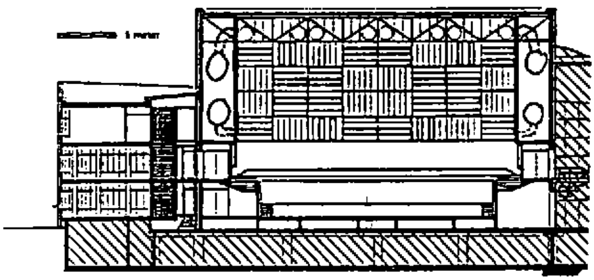

figure 2 Cross section (stage)

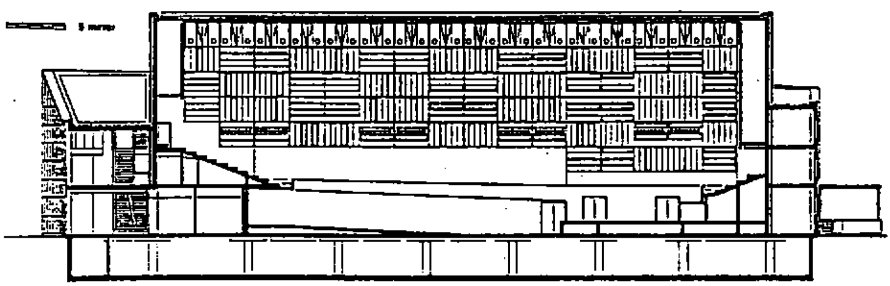

figure 3 Longitudinal section

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BUILDING CONCEPT, MATERIALS, REVERBERATION TIMES

The "classical" shape was built in modern materials. The exterior construction is a concrete box (wall thickness 35 cm) with a single roof of 10 cm concrete over a steel structure that is part of the halls interior and ceiling diffusion.

Inner walls are of 1.5 mm steel with heavy (10 kg/m^2) bituminous damping material to prevent resonance, leaving air spaces of circa 3 meters for ventilation ducts etc..
The choice for steel, apart from the fact that steel is a relatively cheap material, was based on the experience we had with this material in IRCAM (Paris) and the fact that the sound absorption of a well damped thin plate of a certain weight is well predictable.
Especially the (lack of) absorption in the low frequencies is important for the bass sound in the hall.
Since the total area of the metal inner walls is appr. 1700 m^2 great care had to be taken to prevent absorption by slits etc.
See fig. 4 for a detail of this wall construction.

In the old classic halls usually plaster ceilings and a wood over airspace floor give some absorption in the low frequencies.
In this case the floor is a parquet glued on concrete (except for the podium which is wood over an airspace) and the ceiling is of painted concrete, so the walls had to give the right low frequency absorption by choosing an adequate surface weight of appr. 20 kg/m^2.
With an airspace of 2-3 meters behind the metal walls the mass-spring resonance is far too low to be of importance, so the absorption is fully mass controlled.

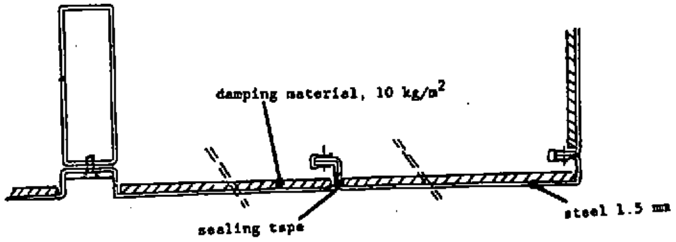


figure 4 Detail steel inner walls
The wall exists of 1,5 mm steel, glued to a damping material of 10 kg/m^2.
Slits between panels sealed with foam tape, thickness appr. 0,5 mm

Laboratory measurements indicated sufficiently low absorption coefficients of 5-10% in the low frequencies to 1-4% in the middle and high frequencies. These figures were confirmed in the real hall as far as this is possible with any accuracy.
The main absorption area, as in every concert hall, is in the seating area. For an accurate prediction of the reverberation times some research was carried out (ref. 2) concerning the influence of the place of the absorption area, see fig. 5. In a hall like this with a relatively constant reverberant sound intensity over the seating area these effects are relatively small. The chairs, specially designed for this hall were measured in the laboratory with and without surrounding shields to measure, respectively eliminate, edge effects.

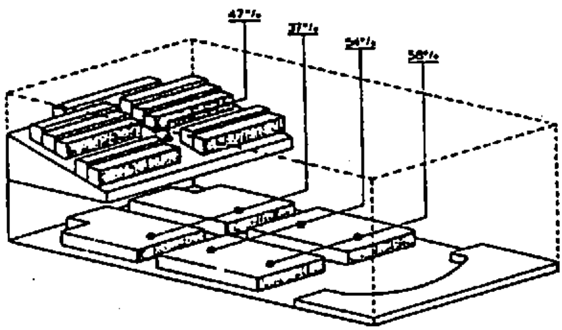


Fig. 5. The absorption of the audience in a lecture room in dependence of the place.

In fig. 6 a few results of these measurements are given, compared with the average absorption coefficients as found in the real hall.
It turns out, that, taking the edge effects as derived from the laboratory situation into account for the real seating areas the laboratory figures give a good prediction, well within 10% over the frequency range.

The extra absorption of the audience turned out to be smaller in the hall (fig. 7) than in the laboratory situation, probably due to the fact that the surrounding shields in the laboratory had the same height as in the case of the chairs only, so the elimination of the edge effects was not sufficient.
To get more accurate data the effect of the increased effective height with audience should possibly be compensated by higher shields in the laboratory situation.

The measured reverberation times in the hall without chairs, with chairs, and with (nearly) full audience and orchestra are given in fig. 8.

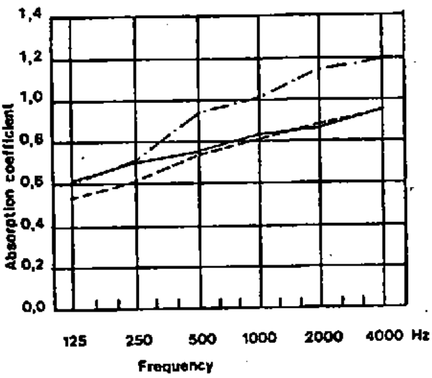


figure 6 absorption coefficients seating area, unoccupied
..... 10 chairs, lab, in corner, shielded
-.-.- the same but, unshielded
——— measured in real hall

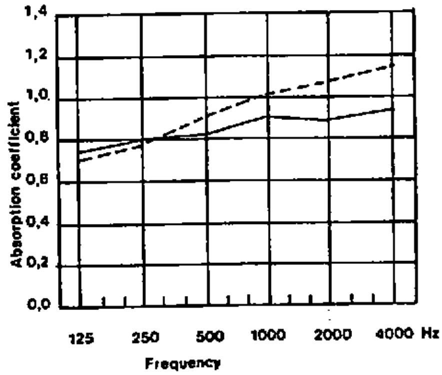


figure 7 absorption coefficients seating area occupied
.... in lab, in corner, shielded
——— measured in real hall

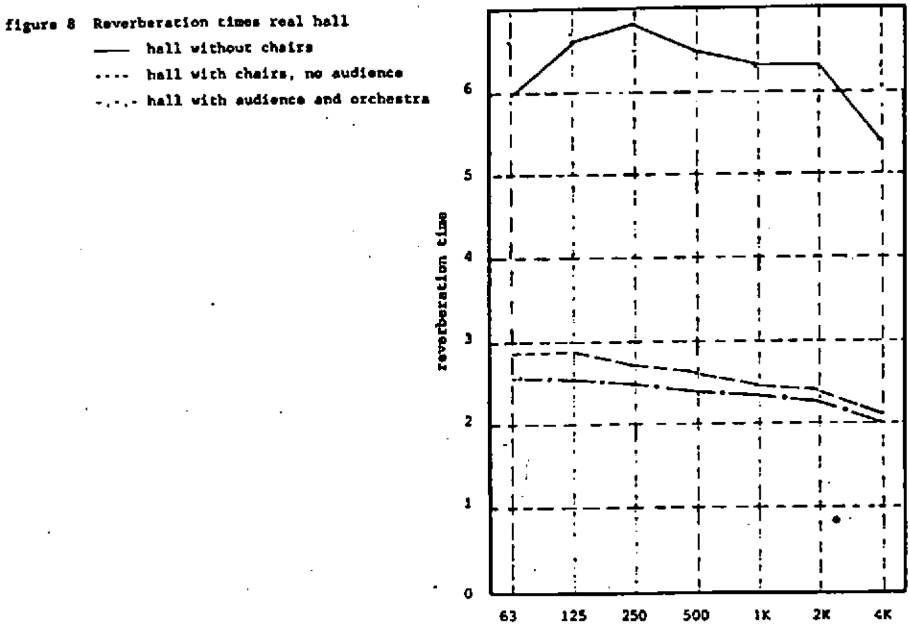
REFLECTION PATTERNS. DIFFUSION

A scale model (1:16), was built to study the reflection patterns, using TDS technique.
One of the aims of this work was to find the right amount of suppression of the back wall echo and (even worse) a back wall-front wall echo.
A study of the old famous halls etc. learned that all of these halls feature absorption an the back-wall (Vienna, Boston) or strong diffusion on back and front wall (Concertgebouw). The model study with different balcony shapes and wall diffusion gave the designing information to attain the right, relatively small, "size" of echo, just to hear the length of the hall, a part of the orchestra's feedback.

Criteria had to be derived from the model measurements to give the architects criteria for the diffusing properties of the walls.

By increasing the diffusing properties of the walls by adding horizontal and vertical bars, measuring the time-energy curves, clarity etc. (see fig. 9), it turned out that the response of the hall in the studied frequency range, did not change significantly above a certain amount of diffusion. This amount of diffusion seemed to be smaller than in many modern halls.

figure 8 Reverberation times real hall



The criteria for diffusion of walls and roof that were given to the architects are of a statistical nature, based on the chance that a wave of a certain width, related to its wavelength, will be reflected specular or diffused.
In our way of solving the problem for the walls, only depth variation of the walls, giving phase jumps by reflection, are present. See fig. 10. Above a certain phase jump within the width of the wave, in dependence of the angle of incidence, diffraction is supposed to occur.
Such an approach makes a comparison of the amount of diffusion between completely different shaped walls and ceilings (including our steel structure roof) possible.
When we compared the amount of necessary diffusion in the model with the amount of diffusion in the classic halls, it appeared that the figures were similar, certainly within a factor 2, which seems very accurate in the case of quantification of diffusion (one of the remaining vague subjects in room-acoustics).
Whether more diffusion has adverse effects is not yet quite clear to us, although our feeling is, that not too much diffusion, helps to give the sound a certain "character".

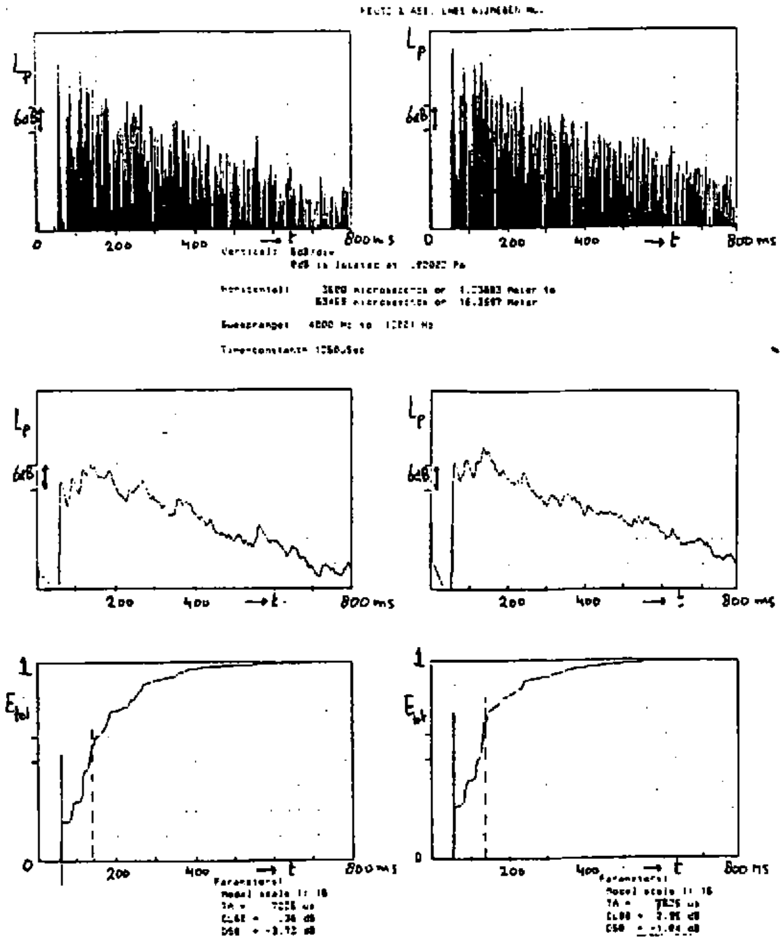


figure 9 Pulse response of hall (model) with smooth walls (left) and walls with horizontal bars over the full length. (right)
top : energy time curve ETC (pulse response),
middle: smoothed ETC, time constant 20 ms,
bottom: integrated pulse response; linear scale

Note increased clarity due to increased wall diffusion

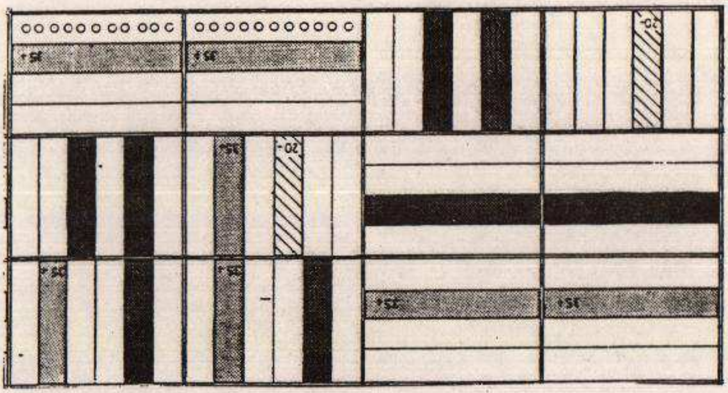


figure 10 part of side wall
Diffusion is altained by variation in depth. Three depths are applied: 20,35 and 45 cm

BACKGROUND NOISE

One of the most important properties of a good hall is the absence of unwanted sound.
A norm of 20 dB(A) (NR15) was set for the admissible noise from installations, outside noise etc. to give the hall a maximum dynamic range.
Special care was taken to prevent low frequency noise, a factor that can influence the quality of the bass reproduction considerably in the pianissimi. For the octave bands 250 Hz and lower NR5-NR10 was aimed for.
Using a ventilation system consisting of nozzles for air supply and special quiet PL-lighting the norms were met. With the ventilation in the concert-mode (40.000 m^3/h) the measured noise level is appr. NR 8 (500 Hz and higher) and below NR 5 (250 Hz and lower), which can be considered as "inaudible".

CONCLUDING REMARKS

Building a concert hall for symphonic music along "classical" lines turns out to be a grateful job.
The for this type of hall so characteristic clear, warm, and spacious sound was well appreciated by the orchestra, its audience and the critics.
Accuracy in the approach, to keep full control over all relevant acoustical factors was, also in this case of a modern shoe box, an important factor in the design and building stages to fulfill the high expectations.

References:

V.M.A. Peutz — The design of the acoustics of auditoria and concert halls
Proceedings ICA 12, Vancouver p.108

P.H. Heringa et al — Concert hall acoustics
Proceedings Acoustics '88, Cambridge

The first rehearsal in the new hall, september 1987