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MUSIC IN GLASS - THE AGA HALL, AMSTERDAM

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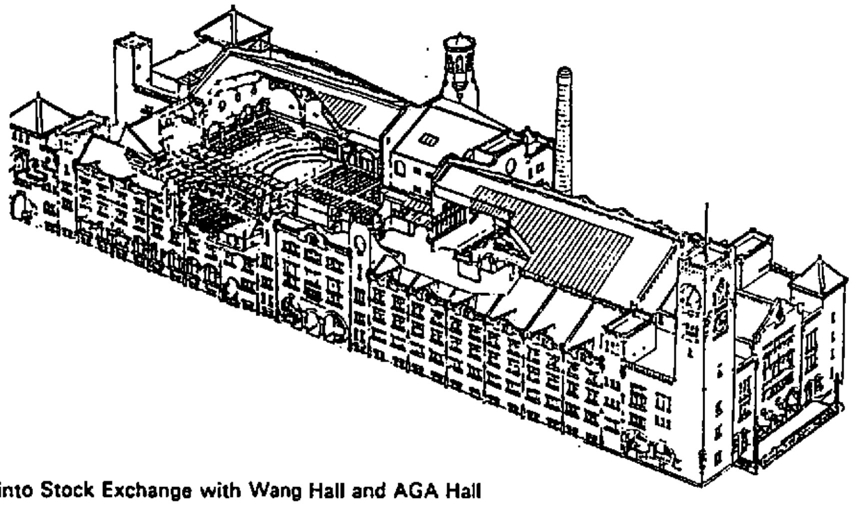
1. INTRODUCTION

AGA hall is one of the two halls in use by the "Nederlands Philharmonisch orkest" (symphonic orchestra) and the "Nederlands kamerorkest" (chamber orchestra), situated in the architecturally famous stock exchange of Hendrik Petrus Berlage, built in the beginning of this century.
The hall is named to its sponsor AGA as is the adjacent 800 seat concert hall, the Wang hall.
Both halls are primarily built as rehearsal halls, but as it happens more often, they proved to be good concert halls too, the 11000 m³ Wang Hall for classical symphonic music (a bit small, but still usable for the romantic repertoire) and the 2000 m³ glass AGA hall for chamber music.
The design concept for the insertion of a glass music hall as a separate box in the former grain hall of Berlages stock exchange was based on the following considerations:

- sound insulation to the adjacent Wang Hall (fig. 1); necessary improvement from R'_w = 53 to 75-80 dB to allow for simultaneous use (fig. 2);
- sound insulation to adjacent offices. These are only separated by a door to the grain hall;
- insulation to outside noise (traffic on Damrak, aircraft noise);
- climatic conditions; the grain hall has a thermally bad roof.



View into Stock Exchange with Wang Hall and AGA Hall

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Its main volume is given by acoustical considerations. Our experience is that for a orchestra up to 40-50 musicians, 2000 m^3 is a minimum size.
Architecturally this was considered to be the maximum within the given size of the grain hall. To preserve the architectural monument sufficiently, a transparent and therefore glass concept was required.

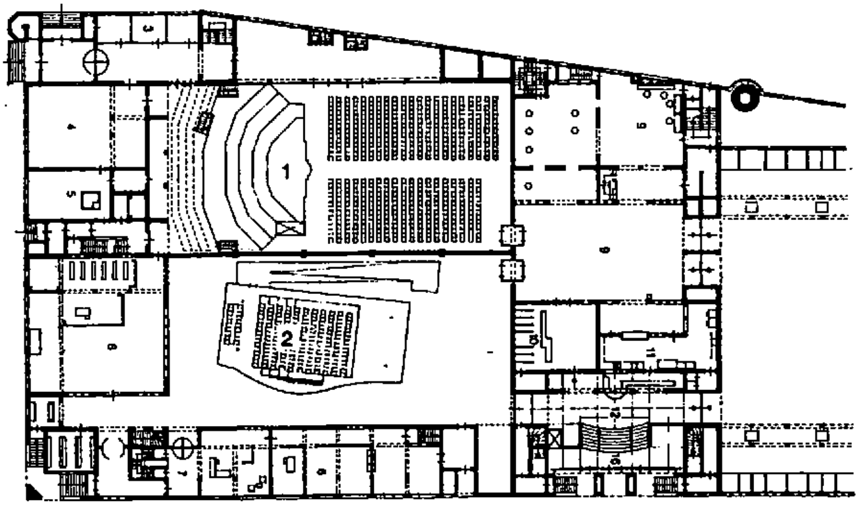

Fig. 1 Plan View 1. Wang Hall 2. AGA Hall

To attain an "insertion loss" of approximately 25 dB, 8 mm prestressed and stabilised toughened glass panels, mutually sealed by silicon rubber were chosen; the foundation of the AGA hall is separated from the building by founding it on its own piles to keep flanking transmission within the necessary limits.

The architect of the AGA hall, Pieter Zaanen and the constructor, Mick Eekhout, came to a concept of a space frame roof construction supported by steel columns, the glass facade hanging down from the roof. Special here is the use of glass as a structural element, stabilised and stiffened by cross bars and tensile wires (fig. 3 and 4).

Ventilation comes from over pressure under the (computer) floor, which has a large number of small grilles. Exhaust is through silencers in the roof. To reduce the heat of lighting, all lighting elements are hung outside the hall; one of the advantages of a glass roof.

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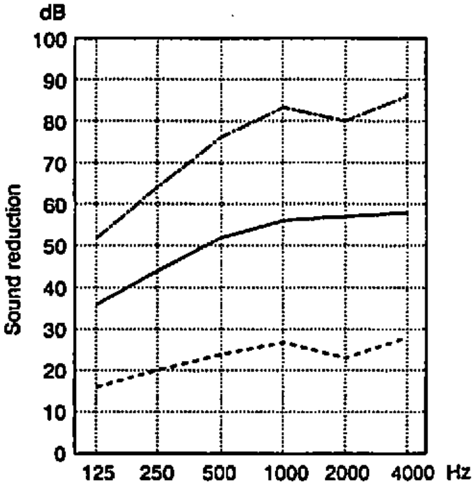
Fig. 2 Sound reductions

—— Wall between Wang hall and grain hall

- - - - "insertion loss" AGA hall

-·-·- Total insulation between Wang hall and AGA hall



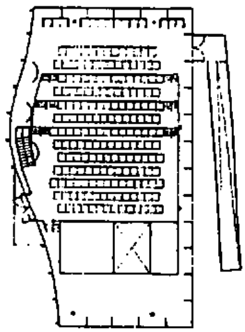
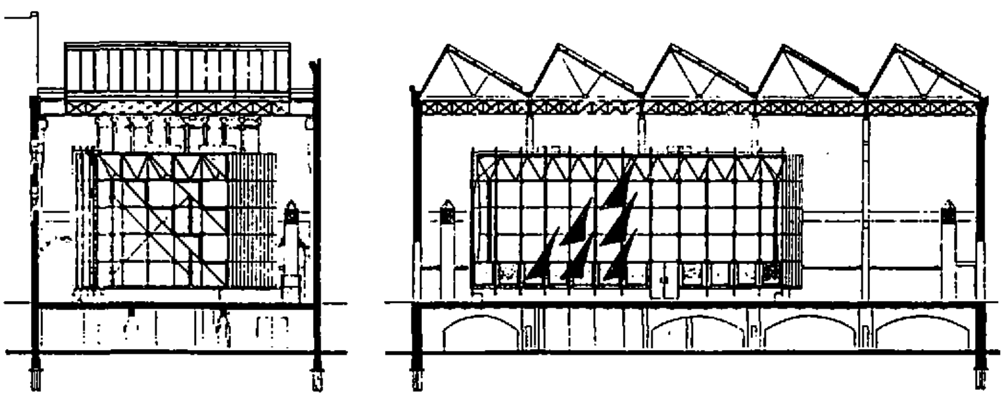
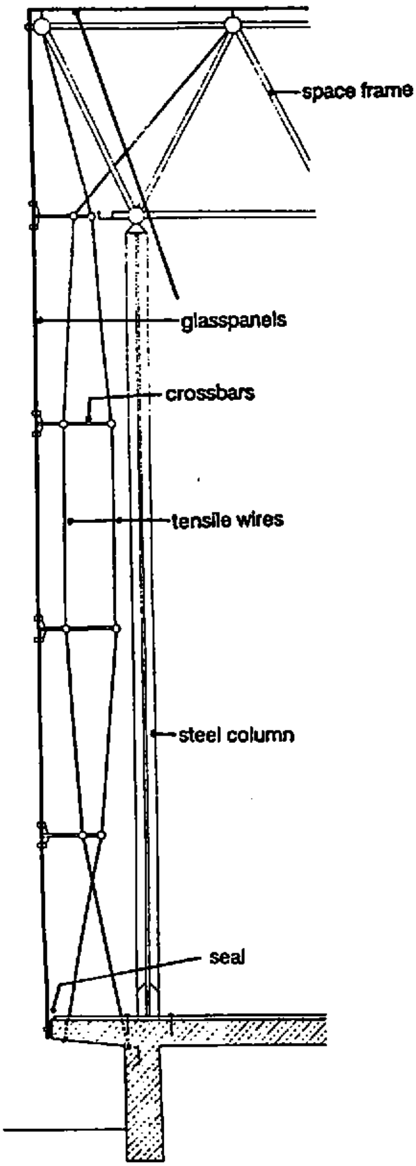


Fig. 3A Plan AGA hall

Fig. 3B Side views AGA hall





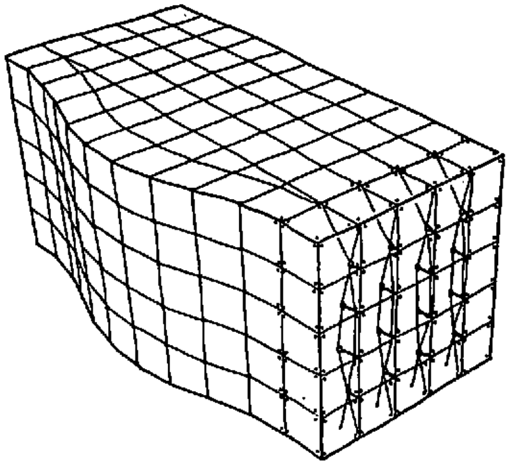
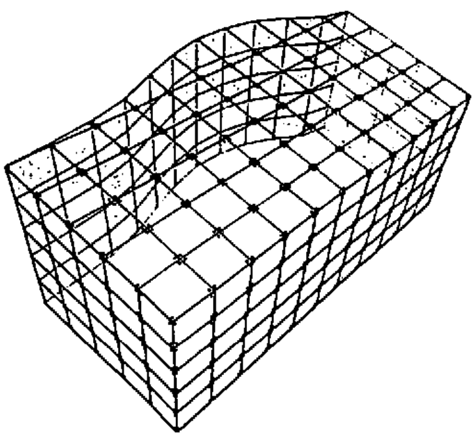


Fig. 4 Structural Design and Details



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2. ACOUSTICAL DESIGN CONSIDERATIONS

In itself a 2000 m^3 rehearsal and chamber music hall is not an exceptional case, in the case that proper room dimensions are chosen (approximately 20 x 10 x 10 m^3).
In general the following considerations apply:

Reverberation time
The following values for reverberation times were supposed to be appropriate:
T_{60} (rehearsal situation): 1.0-1.2 seconds
T_{60} (concert situation) : 1.2-1.4 seconds

The 200 chairs and public in the concert situation are replaced by the lesser absorption of a 15-50 people chamber orchestra in the rehearsal situation, a kind of variable acoustics is in fact necessary. It was chosen not to do this and to accept a slightly longer reverberation time for the rehearsal situation (1.2-1.3 seconds) and a slightly shorter reverberation time for the concert situation (1.0-1.1 seconds).

In fig. 5 the total absorption of the seating is given:
a) 200 chairs empty;
b) 200 chairs with people;
c) 200 chairs in 20 stacks covered in heavy (triple velours) "bags".

Fig. 5 Sound absorption in M2 Sabine

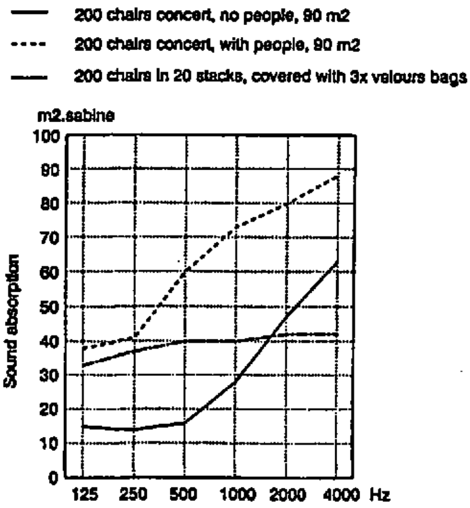
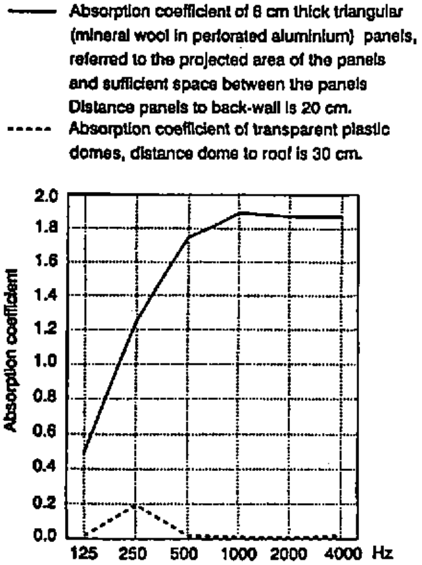


Fig. 6 Absorption coefficients



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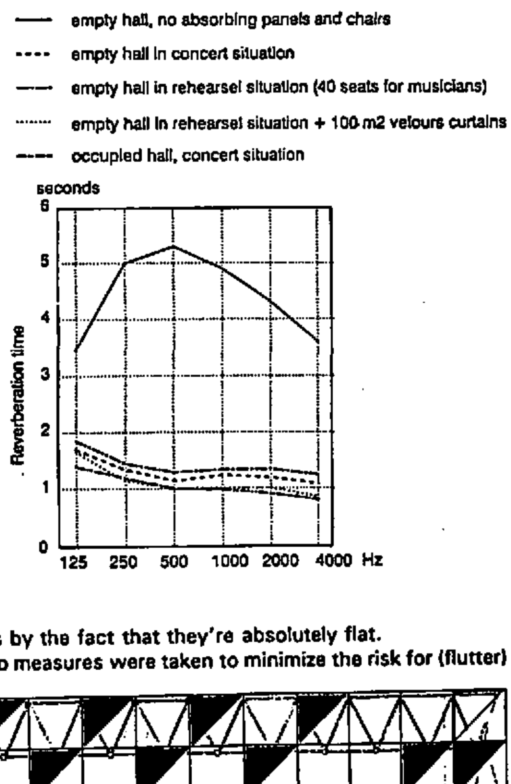
The effect of taking the seats out is limited by leaving the stacked, covered chairs in the hall during rehearsals.

To attain these required reverberation times it was necessary to add absorption materials, that would not *interfere* with the transparency of the walls and ceiling. It took some time to convince the architect that transparent broadband absorption does not exist, so triangular mineral wool (in perforated aluminium) elements approximately 20 cm in front of the glass were chosen as an option where minimal area gives maximal absorption. Because of edge effects and the distance to the glass an effective absorption coefficient of over 1.5 was attained (fig. 6). After all, these elements gave the desired architectural effect of giving the room its size (without the elements one wouldn't see where the walls are). Fig. 7 shows the RT in different situations from the completely "hard" situation to the concert, respectively rehearsal situation. From the measurements in the completely "hard" situation an absorption coefficient of approximately 0.04-0.06 could be calculated for the glass roof and wall structures, one would expect some lower values.

Fig. 7 Reverberation times AGA hall



Diffusion

Glass panels differ to more common materials by the fact that they're absolutely flat.

This lack of natural diffusion made us worry, so measures were taken to minimize the risk for (flutter) echoes and the like.

The bent wall was designed to prevent flutter echoes between the long walls. In front of the concave part of it convex sails of glass/polyester with a mineral wool backside are hung, to prevent focusing effects.

The straight walls get their diffusion from the absorbing triangles, spread quite regularly over the surfaces (fig. 8).

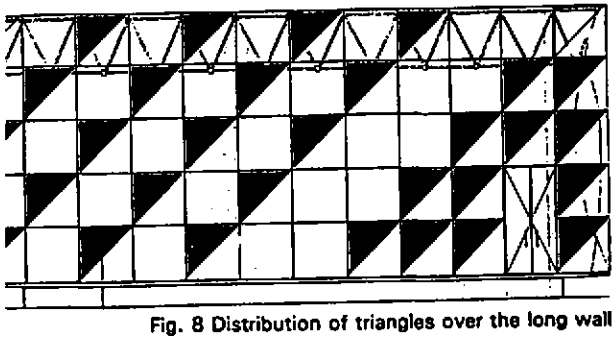


Fig. 8 Distribution of triangles over the long wall

Of course the question of "symmetry" arises in this hall. As far as this can be calculated acoustical symmetry exists almost for the side wall reflections. The diverging shape and low absorption of the curved wall should give almost equal reflection intensity as the straight wall with the absorbing/diffusing triangles.

Since in the rehearsal situation the floor is quite empty, it was found necessary to make the roof also strongly diffusing. This was realized by transparent (inflammable) plastic domes, hung at approximately 30 cm under the roof over approximately 35% of the total surface. These domes also contribute to the total absorption mainly in the 250 Hz band as Helmholtz resonators (fig. 6).

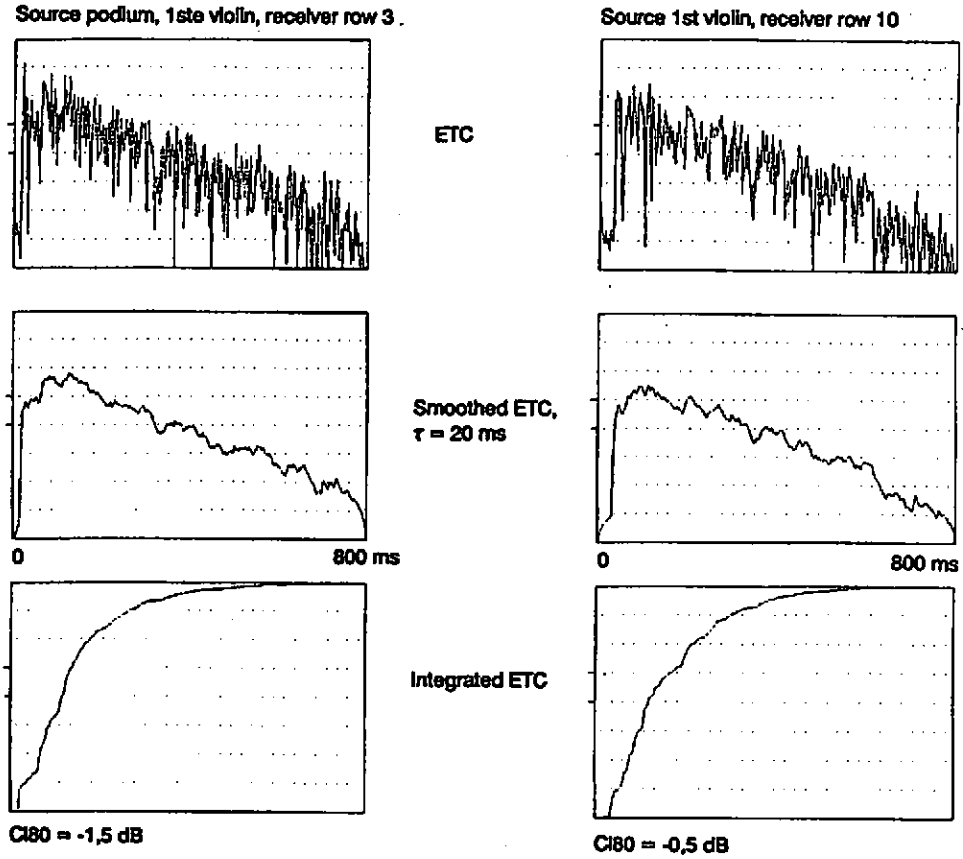


Fig. 9 ETC respons AGA hall, 1000 Hz octave

3. EVALUATION

The primary design goals (reverberation time, sound level distribution, lack of echoes) were met. Some measured ETC's are given in fig. 9.
Clarity values are around 0 dB, which is quite low for a hall of this size and reverberation time. This seems to go together with what some conductors call a "big" sound. Conductors and musicians appreciate the acoustics of the hall very much, as well for rehearsing as for chamber music.
Many people praise its "transparent" sound (what you see is what you hear). Although its reverberation time is not particularly long for a rehearsal hall, musicians note that the hall is maybe playing too easy, much sound for little work. Maybe the glass is more reflective in the very high frequencies (> 4000 Hz) - where we usually don't measure - which could make the sound subjectively louder by stronger harmonics.
The problem that arises from this, is that the concert situation (e.q. in the 20.000 m^3 Concertgebouw) is very different, one has to give more energy there than in the rehearsal situation.
For this reason an experiment was made to attenuate the high frequencies further by adding some heavy curtain. Subjective loudness seems to decrease significantly at a RT of about 0.95 seconds (fig. 6) which is considered to be advantageous in the case of a relatively big orchestra.
For rehearsals of the full orchestra (50-60 musicians) this extra absorption will be used in the future. For the normal rehearsals and concerts no acoustical changes are foreseen. The "clear" and "full" character of the sound for these situations is well appreciated.