ACOUSTICS IN NEW CONCERT HALLS IN HAMBURG AND DRESDEN

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1 ABSTRACT

This year two concert halls have opened in Germany, in January Hamburg's Elb-Philharmonic Hall and in Dresden the concert hall inside the existing Kulturpalast. Both projects started 7 to 9 years ago. The author has been responsible in Hamburg for the Sound systems, whilst in Dresden he has been the acoustic adviser for the client.
The presentation will report about the history and development of both projects and about the cooperation with the other involved room acoustic consultants.
For both halls the acoustic parameters are explained and measurement results (partially based on author's own data acquisition) are demonstrated. Additionally for both halls the required Speech Alarm system is explained, not just installed in the halls but also in the lobbies and other halls around them. Finally some subjective impressions and acoustic appraisals are given.

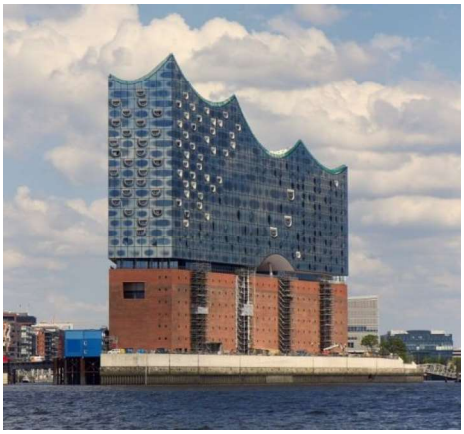
2 BACKGROUND

The construction of concert halls is not a daily job, but this happened in parallel in two German cities over the past 7 to 9 years. In Hamburg a unique building in the harbor area had been selected to be the base and the platform for a concert house building more or less on top of it. After an architectural competition the world-renowned architectural office Herzog & de Meuron from Basel, Switzerland had been awarded the contract as a winner of the competition in 2006. The construction began in 2007 and after some problems and delays and the increase of the required budget to almost 800 Mill. EUR the building on top of the old quay storehouse was finished in 2016. From the beginning Herzog & de Meuron worked with the Acoustic office Nagata Ass., in person with Dr. Yasuhisa Toyota for the room acoustic design. The local office Taubert & Ruhe supported the Building Acoustic design and our office planned all significant sound systems, specifically of high importance in context of emergency announcement / voice alarm system based on the German standard DIN VDE 0833-4. So we had to collaborate with the other acousticians and could observe the creation of this wonderful culture temple.
In the 60ties of the last century a so-called "Kulturpalast" was erected in Dresden and we as students from the Technical University Dresden observed the design work of our teacher Prof. Walter Reichardt and made measurements in this original hall. It was a multi-purpose hall for almost 2.000 visitors and all the years the Philharmonic Orchestra complained about the missing concert hall acoustics. So in 2008, two years later as in Hamburg an architectural competition was started to convert the multi-purpose hall of the palace into a concert hall. 2009 the Berlin office gmp Generalplanungsgesellschaft mbH did win the competition and our office supported the winning design from the acoustic point of view. A vineyard shape had been selected. Our office was too small to act as the Acoustician in the following design steps and the company Peutz bv (Dr. Vercammen and Margriet Lautenbach MA) was selected for the detailed room and building acoustic design work. For stage mechanics, stage lighting and electro-acoustics the Munich office Daberto & Colleagues had been awarded. ADA Acoustic Design worked all over the 7 years for the client as the acoustic adviser of the project and participated in all important design steps.
Both projects shall be explained now mainly from the acoustic point of view.

3 ELB-PHILHARMONIC HALL HAMBURG

3.1 Architectural design

The old quay storehouse was gutted completely and only the heritage-protected outer walls remained. Inside these walls and finally on top of the old storehouse the new concert building was erected, refer to figure 1 and 2.



Figs.1and 2: Outside views
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The section through the building published by the architects shows the positions of the two larger halls, the lobby and so-called plaza, see fig. 3.

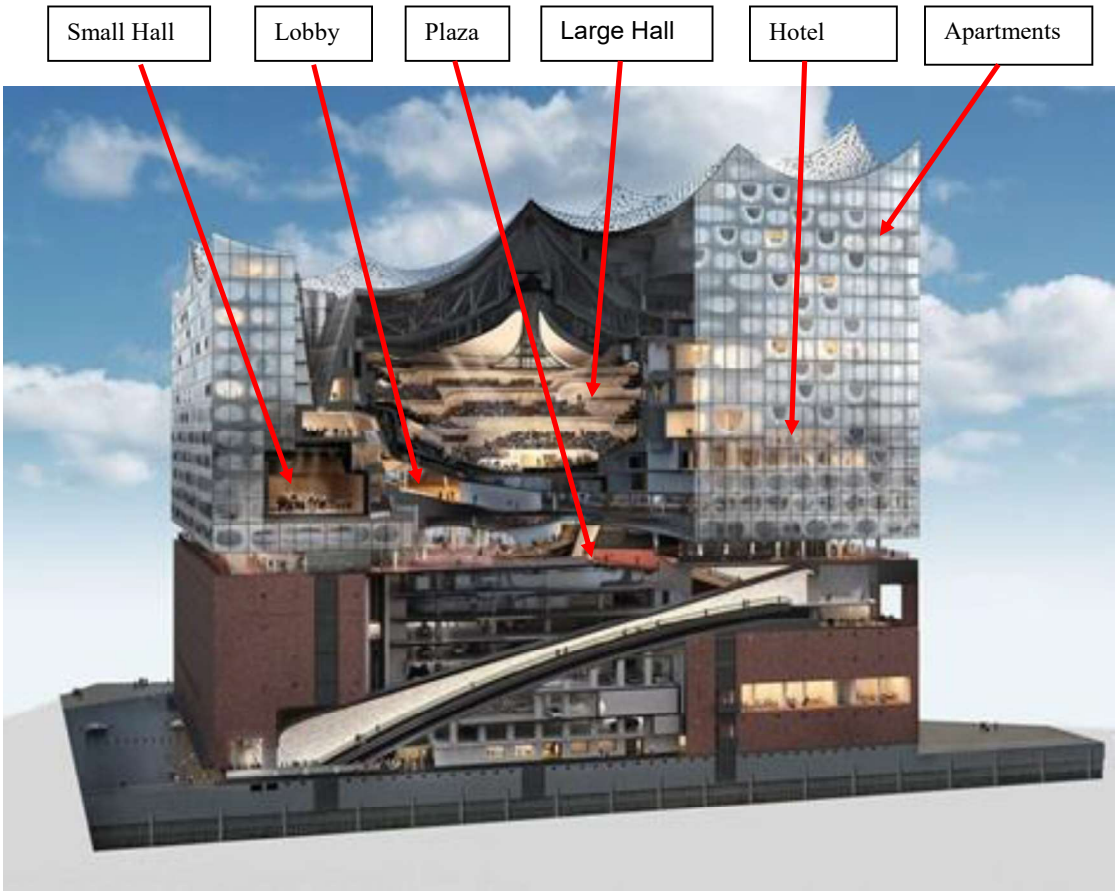
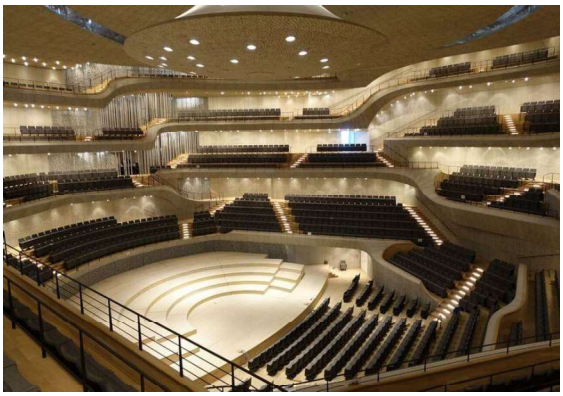


Fig. 3: Section through the building

The building contains not only a concert hall, but also smaller halls, a Hotel with 244 rooms and 45 apartments. Additionally there are parking floors in the basement area for altogether 520 parking spots.
Both larger halls are box-in-box constructions for perfect impact sound isolation.

3.2 Large Hall

The large hall has a volume of 23.000m^3 and hosts 2.100 visitors. So the volume/seat index is around 11m^3/seat. The maximal distance to the conductor is only 30m. A substantial reflector (15m diameter) has been installed above the stage (270m^2).



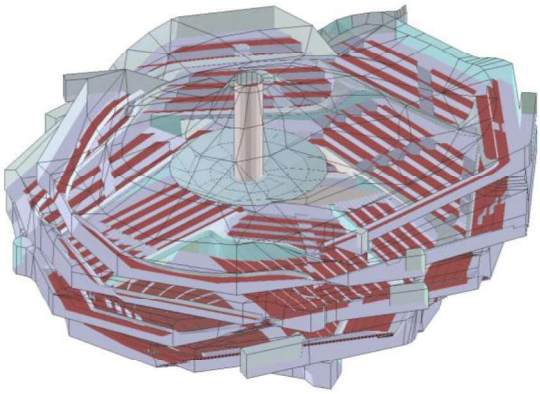


Fig. 4: View and model of the large hall
® nagata ass.

In 2004 Nagata Ass. was named by Herzog & de Meuron to support them in Room Acoustic Design and in the following years the acoustic design work was started, after 2007 first by using own simulation tools. In a second step 1/10 scale models had been used to check echoes or disturbing reflections and to calculate the expected reverberation time .

Fig. 5: 1/10 scale model of the large hall
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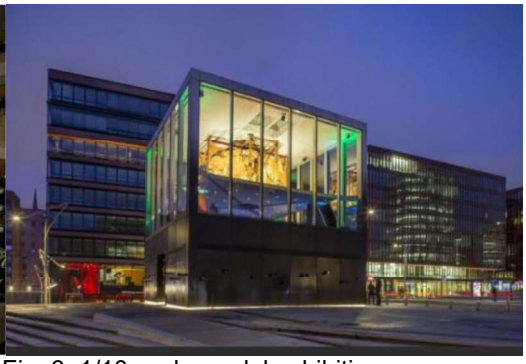


Fig. 6: 1/10 scale model exhibition

After the measurements in the scale model this model was presented to the public during the entire construction period.

The surface of the large hall ("white skin") consists of very heavy multilayer gypsum boards (around 120kg/m^2), finely milled to varying depths between 1 to 10cm. This is called 'micro-shaping' by Nagata Ass. , see fig. 7.

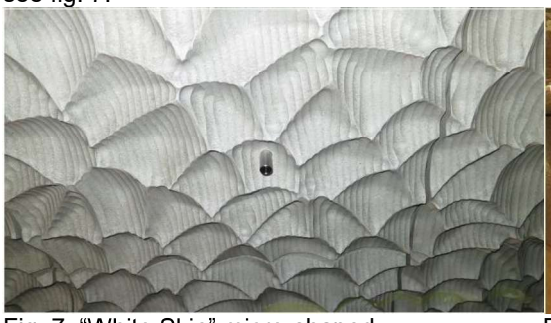


Fig. 7: "White Skin" micro-shaped

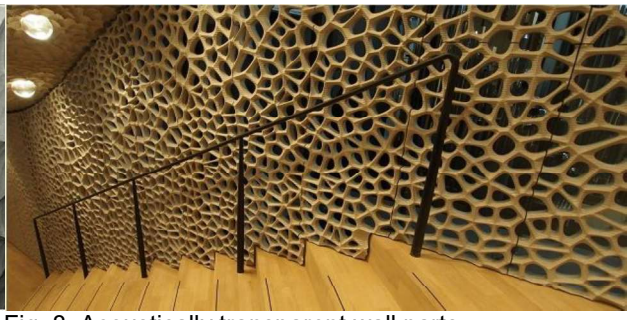


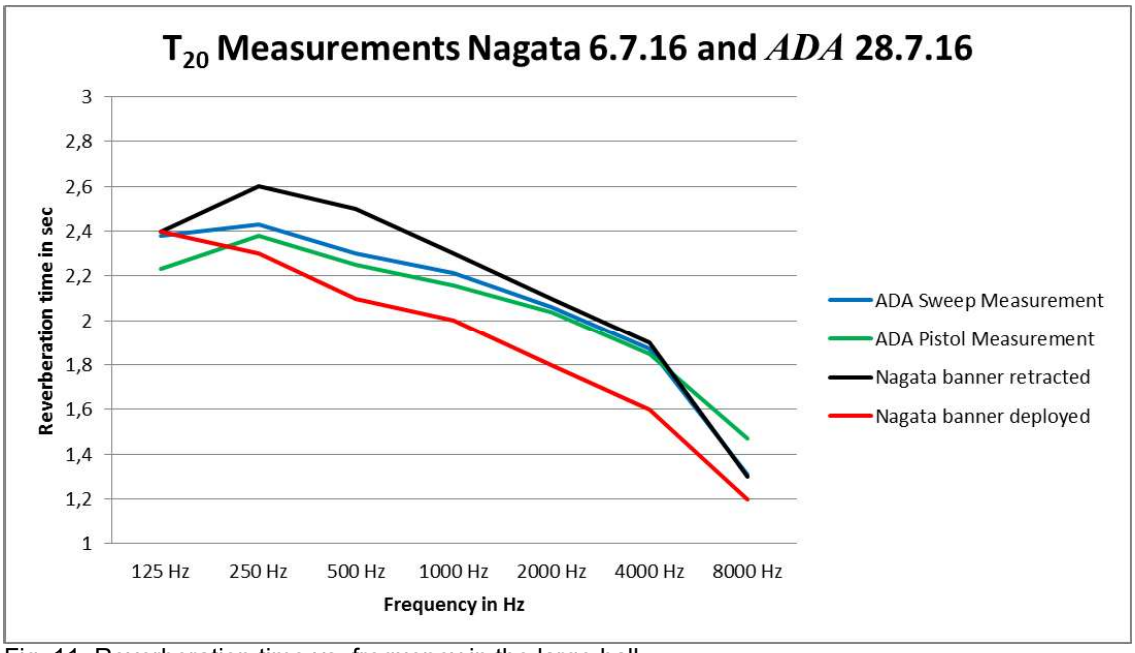
Fig. 8: Acoustically transparent wall parts

In front of the organ (Johannes Klais Orgelbau, 69 stops, 4.765 pipes) and behind the orchestra on stage the wall parts are acoustically transparent, see fig. 8.
For other performances like jazz or rock and pop performances 81 absorbing banners can be installed automatically in front of the wall. The banners are not lowered, but rise up from the parquet floor. This way the reverberation is reduced significantly, refer to fig. 9.

In fig. 10 the huge reflector is shown with a weight of around 100t (steel construction, white skin, stage machinery, line arrays and 4 stops of the organ)) and a diameter of 15m.

Fig. 9: Banners in front of wall

Fig. 10: Reflector on top of the hall



Fig, 11: Reverberation time vs. frequency in the large hall

Further Data published by Nagata Ass.:

Acoustic quantity	Grosser Saal	Kleiner Saal (Concert Confiig.)
Reverberation Time, T30, in seconds Unoccupied Occupied	 2.4 2.3	 1.7 1.4
Sound strength, G, in decibels	5.4	11.0
Early decay time(EDT), in seconds	2.3	2.0
Clarity, C80, in decibels	0.3	-0.8
Centre time, TS, in milliseconds	135	143

Note) Frequency averaging 500 Hz to 1000 Hz, measured in unoccupied

3.3 Small hall

The small hall (see fig.12) has a volume of around 4.000m^3 and is designed for 550 visitors. The volume/seat index is therefore 7.3m^3/seat, what is recommended for a chamber music hall of this size.

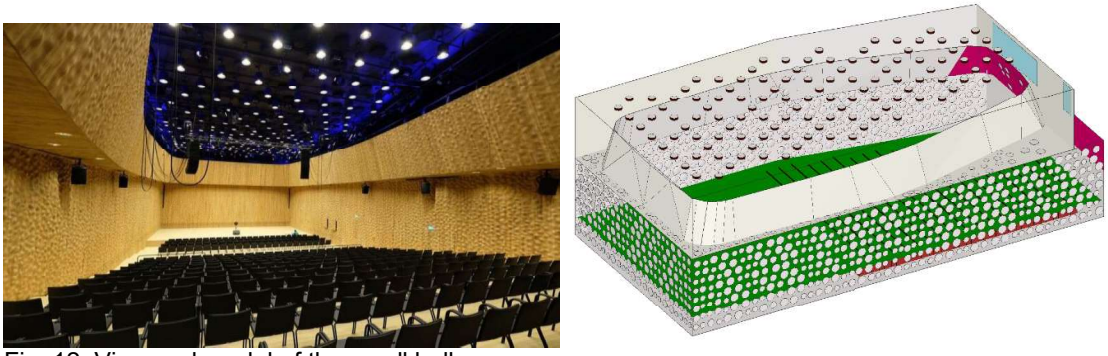


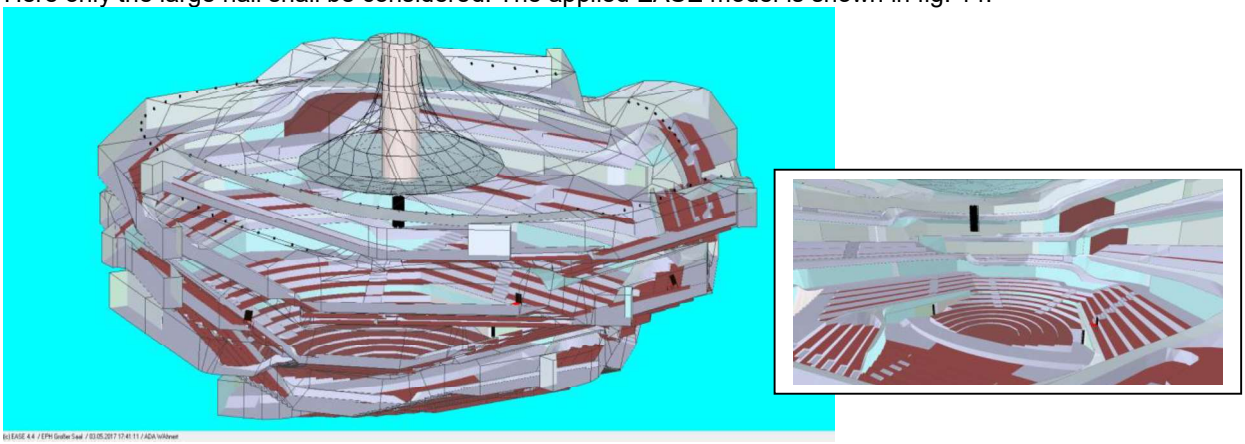
Fig. 12: View and model of the small hall
® nagata ass.

Fig. 13: Micro-Shaping with structured wood elements of different depths

Nagata Ass. writes later: In the "Kleiner Saal", we fabricated the walls of laminated wood with cut-out patterns that achieve the desired uneven surface treatment.
For basic acoustic data see table above.

3.4 Public Address System (PAS) also for emergency calls

Here only the large hall shall be considered. The applied EASE model is shown in fig. 14:



Fig, 14: EASE4.4 model of the large hall used for PAS optimization

The PAS system consists of 6 Meyer Sound Systems CAL64 lowered from the reflector and 2 CAL32 arrays on the stage edges to cover mainly the front parts of the stalls.
The results for Total SPL and STI are shown in fig. 15.

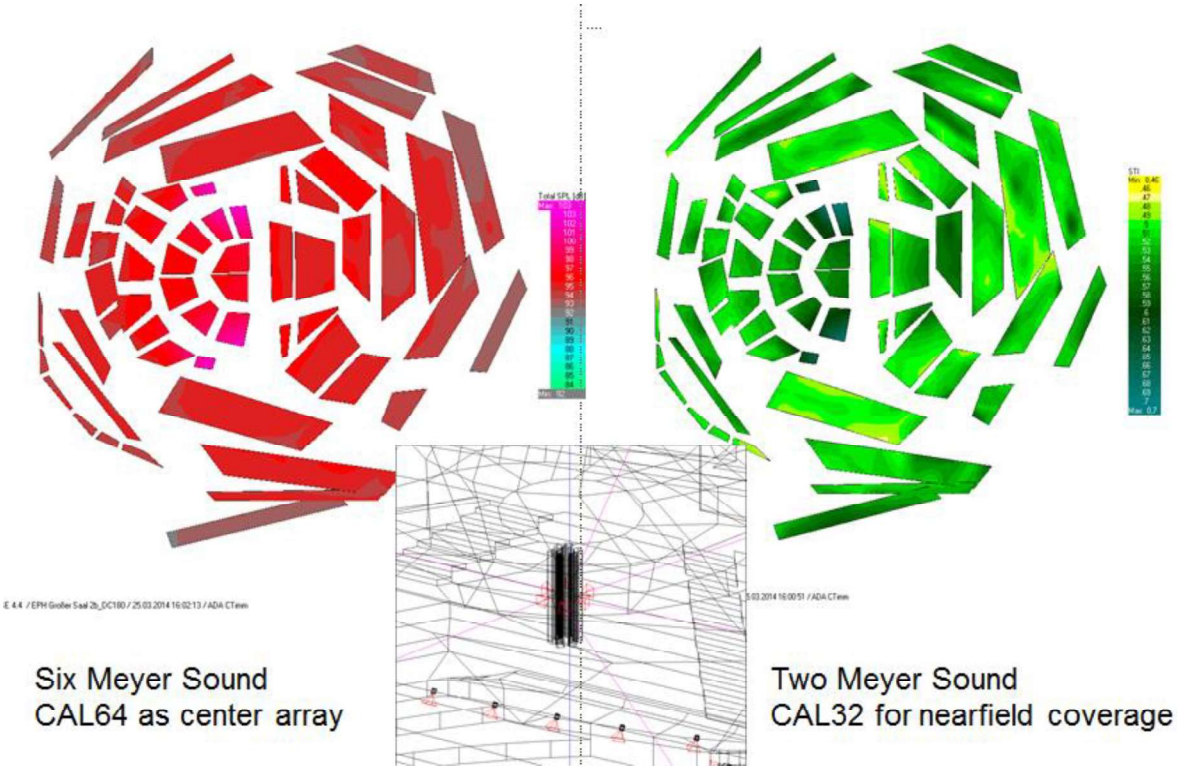


Fig. 15: TSPL and STI mapping in the large hall

Similar investigations have been done in the other halls and in the complicated lobby area, see fig. 16.

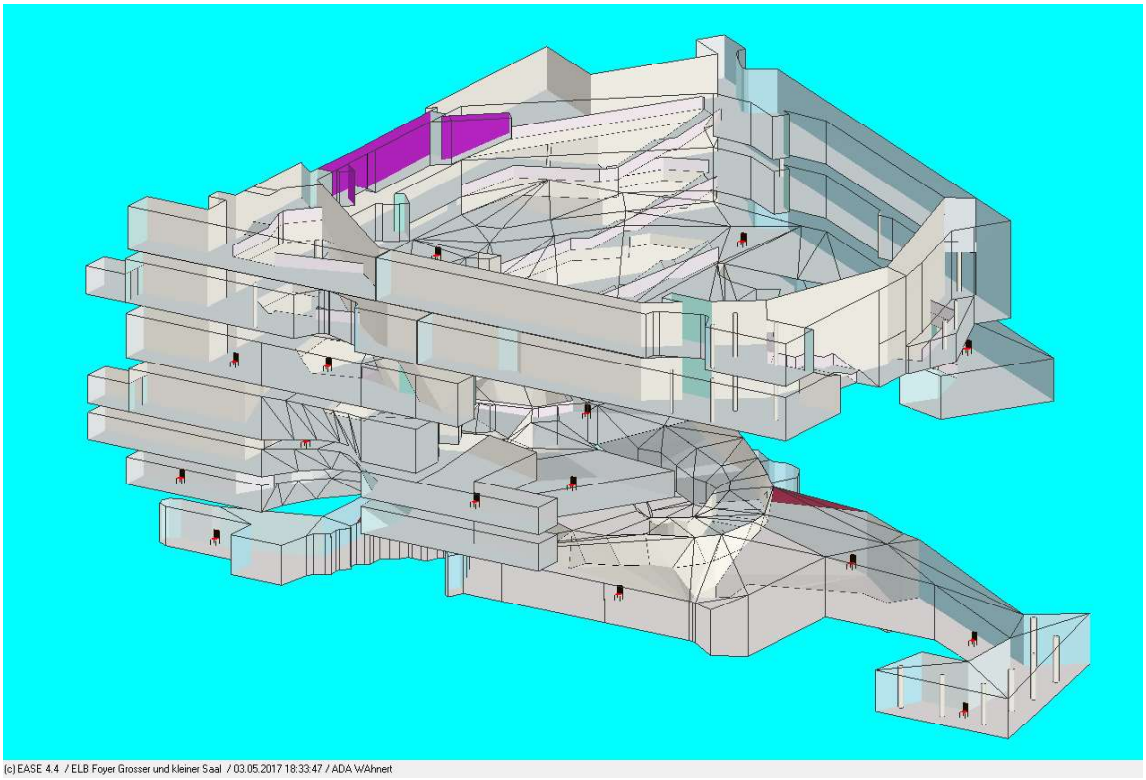


Fig. 16: Staircase or lobby computer model for Speech intelligibility investigation

4 KULTURPALAST DRESDEN

4.1 Architectural Design

The building was opened in 1969 with a large multipurpose hall inside, see figs. 17 and 18.

Fig. 17: View to stage

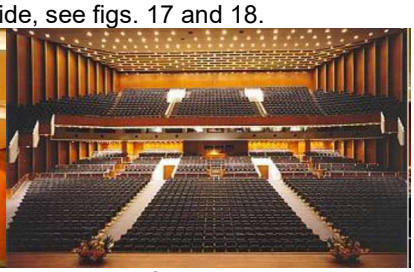


Fig. 18: View from the stage

In 2008 an architectural competition was started to design a classical concert hall inside the building by removing the multipurpose hall, but not touching the outside shape of the building which was put under monument protection in 2008 as well. In 2009 Berlin based “gmp architects” in collaboration with ADA Acoustic Design have been awarded the first price among 26 design proposals of national and international architects, fig. 19 and 20.

Fig. 19: SketchUp model of the new hall

Fig. 20: Rendered view of the competition design

4.2 Acoustic design of the hall

The acoustic design work was contributed by the company Peutz bv based in the Netherlands. First a model was built to make basics investigations. The used CATT model was transformed to the EASE platform by ADA-AMC to check the design proposals, see Figs. 21 and 22.

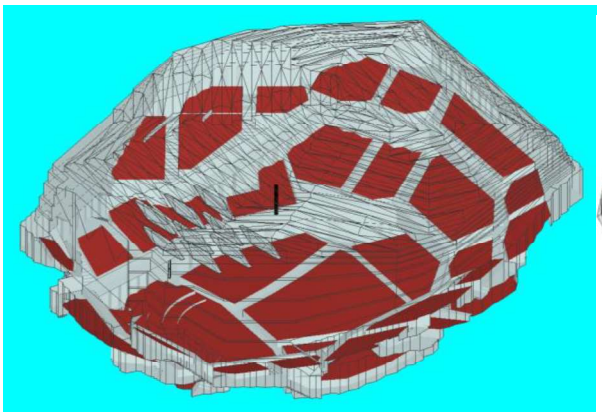


Fig. 21: First model in EASE4.4

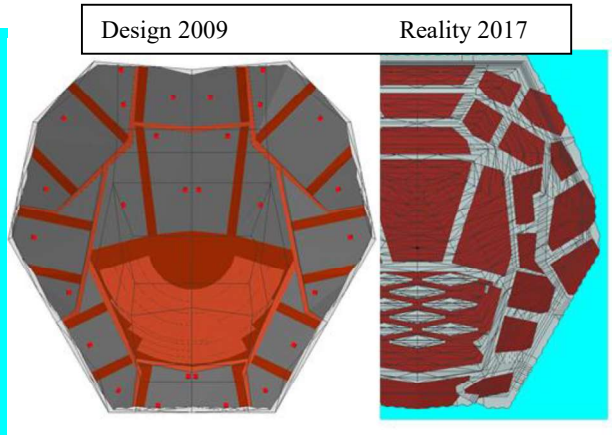


Fig. 22: Model 2017 compared with competition design

In a first step the target values for the new hall were determined, such as the reverberation time (table 1), the clarity value C80 (for 500…2000Hz range between -1…-2dB) and the Strength G with +5dB.

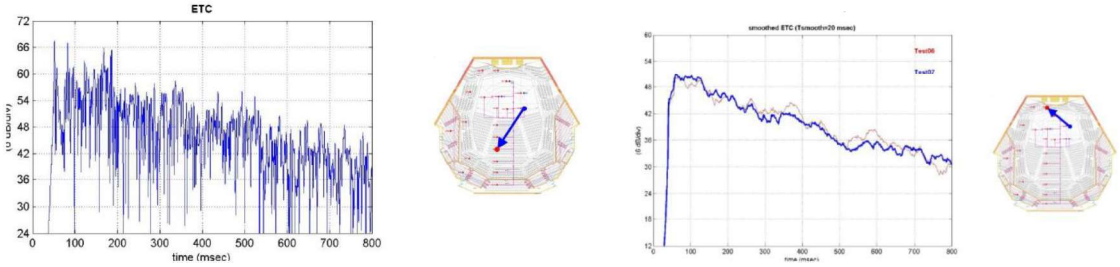
Reverberation time in sec	125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz	Average value 125-250 Hz
unoccupied	2,6	2,5	2,4	2,4	2,2	2,1	2,4
occupied	2,4	2,3	2,2	2,2	2,0	1,9	2,2

table 1

After the first phase of computer simulation a 1/10 model was built and measurements were undertaken, see next figures.

Figs. 23 and 24: Model views

The next two figures show the examples of the realized measurements. They have been used to determine results for the reverberation, freedom of disturbing echoes or needed scattering surfaces.

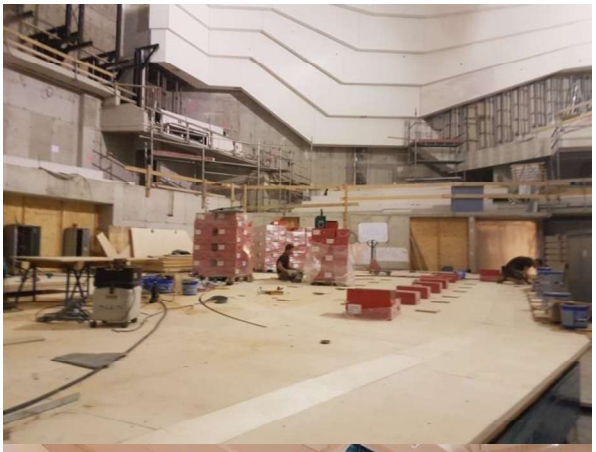


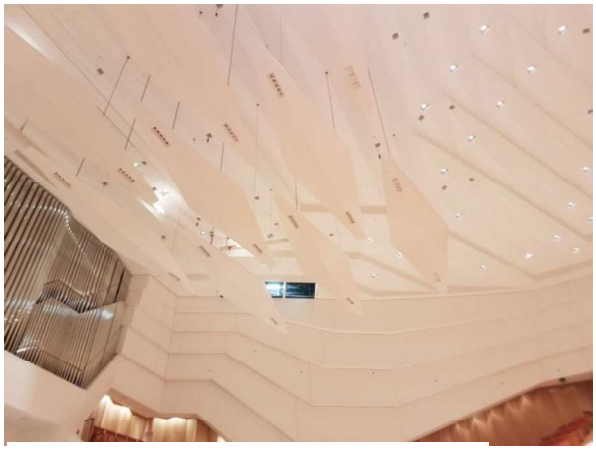
Figs. 25 and 26: Energy-Time curves vs. time

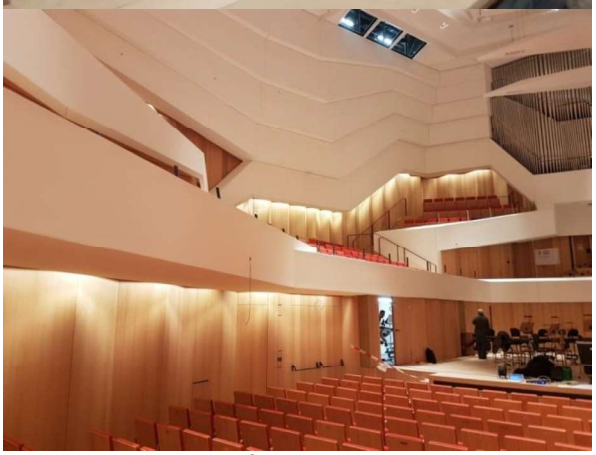
Seat measurements have been done at Peutz as well (figs. 27 and 28). An extensive investigation was performed to further define the construction of the upholstery of seats and backrest. The wood panel below the seat is now perforated but the panel of the backrest is unperforated as a result of these optimizations.

Figs. 27 and 28: Measurements of 16 chairs in the laboratory

The next figures show details of the fitting out of the hall, especially illustrating the different cladding.







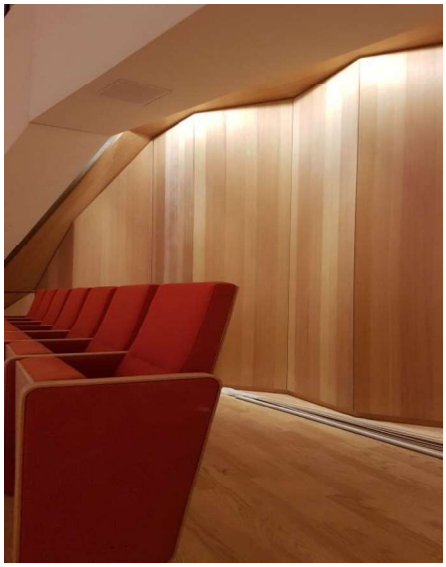


Fig. 29: Fit-out work of the hall
Fig. 30: View of the ceiling structure and the reflectors
Fig. 31: Balcony rail structure
Fig, 32: Zigzag sidewall design in the stalls

Peutz made the official final measurements (Fig. 34) in the unoccupied hall and the simulated occupied one. For the audience simulation fabric blankets were used (Fig. 33)

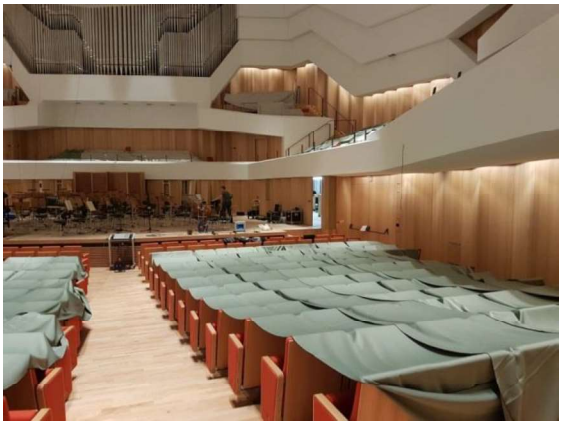


Fig. 33: Fabric blankets for audience simulation

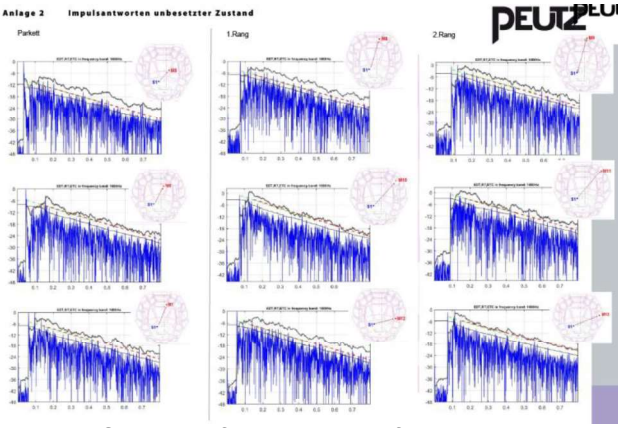
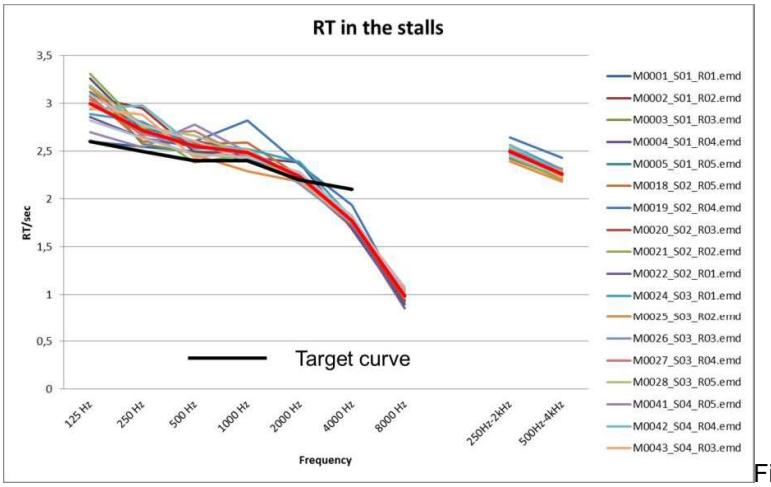


Fig. 34: Samples of the numerous final measurements

The final results for the reverberation time measurements done by Peutz bv and by ADA is shown in Fig. 35. It is visible that during the measurements the expected values at 4 kHz could not be achieved. But at that time the fit-out work was not completely finished and dust from the construction had a certain impact.



Fig, 35: RT vs. frequency

4.3 Sound system for announcements and emergency calls

The sound system is similar to the system in the large hall in Hamburg. In Dresden 4 Renkus-Heinz arrays IC32 were installed as a cluster and two IC16 on both sides of the stage. Additionally small front fill boxes for the first rows are present, not shown in fig. 36. In figure 37 the direct sound distribution is shown only in half of the hall (symmetric results are to be expected) and in fig. 38 the achieved STI values.

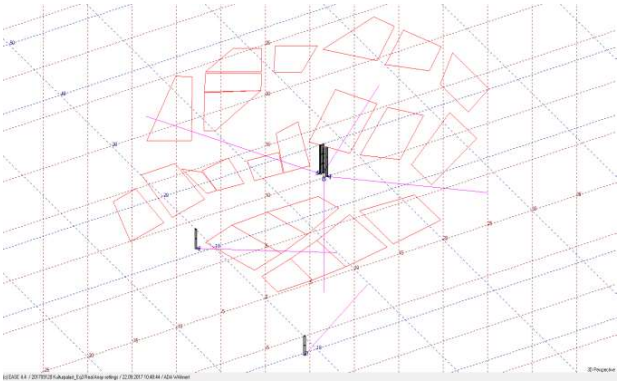


Fig. 36: Speaker layout

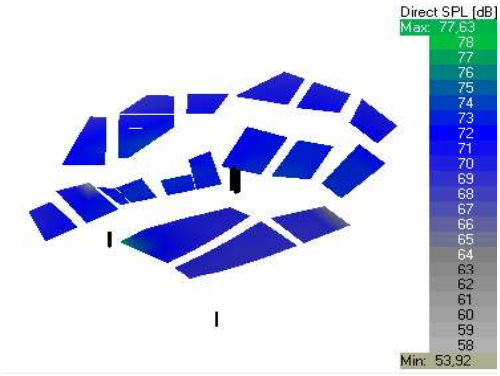


Fig. 37: Direct sound mapping

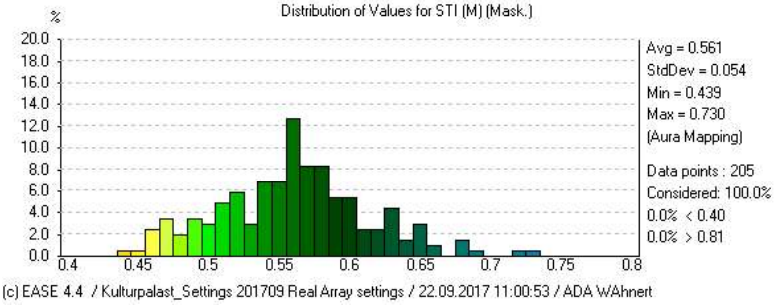


Fig. 38: STI Distribution in the hall

5 REFERENCES

A Press report of the Elb-Philharmonie Hamburg (in German) 2017
B https://www.elbphilharmonie.de/en/elbphilharmonie
C https://www.kulturpalast-dresden.de/