THE NEW CONCERT HALL IN STAVANGER

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1 NYTT KONSERTHUS I STAVANGER

The new Stavanger Konserthus will contain two halls, one concert hall and one multipurpose hall, and will be the home of the Stavanger Symfonieorkester. The design was initiated during an architectural competition in 2003, design work started in May 2007 after the selection of the full design team. Building works are planned to start during the fall of 2008, after the closure of Stavanger 2008, Capital Culture of Europe.

The paper will describe the acoustic features of the 1500-seat concert hall, the multipurpose hall (900 seats or 1900 standing capacity) and the noise isolation challenges of the building.

2 CONCERT HALL

The design of the Concert Hall in Nytt Konserthus i Stavanger proposes an intimate concert hall layout inscribed inside a larger acoustic volume, required for the performance of the major symphonic musical works.

2.1 History of Design Development

From the onset of the project, the client and the users favoured a shoebox-type concert hall. A 1500-seat, three-balcony shoebox was described in the rather detailed architectural and acoustic programme for the international architectural competition. The question of whether the room should have a variable ceiling or reverberation chambers as another means for variable volume was left open and to the discretion of the architects during the competition. The winning design of Medplan Arkitekter from Oslo left the question open, showing that both solutions could be accommodated within the proposed architectural design. After the end of the architectural competition, but still prior to the selection of the acoustical consultant, a decision was taken against reverberation chambers and for a moveable ceiling.

The importance for variable volume in the concert hall lies in the size of both the city of Stavanger and its orchestra. Stavanger Symphony Orchestra (SSO) is a medium-sized symphony orchestra with a total of 75 musicians. They specialize in baroque music (with Fabio Biondi as specific music director for this type of programmes), as well as in contemporary music and the main symphonic repertoire (with principal conductor Steven Sloane). The city’s population is about 150’000, and that of the region is 250’000 – surrounded by mountains that makes getting to the concert hall difficult for audience members from outside of the region. As a consequence, the concert hall needs to cater well both for more intimate concerts (baroque and classical) and for the main symphonic repertoire, including large-scale musical works like the symphonies of Gustav Mahler.

2.2 Current Design

The architectural competition design proposed a hall width of 26m which, while appropriate for a large-scale concert hall we considered excessive for an intimate concert hall.

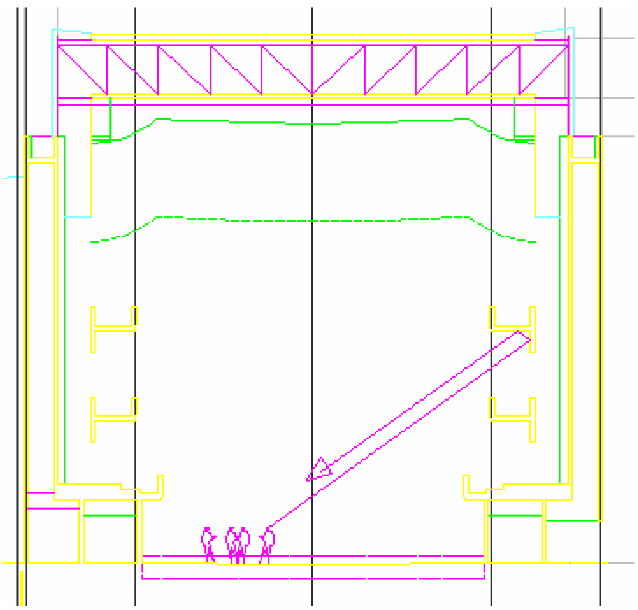
Two design changes were implemented in collaboration with the architects, which we believe will strongly enhance the visual and acoustic intimacy of the hall as well as the general acoustic quality:

- The size of the main parterre was reduced, inscribing a smaller parterre (in both length and width) inside a bigger first balcony. From the first balcony upwards, the hall “opens up” to full width and length. In addition it was possible to minimize balcony overhangs for the rear balconies.
- The side balconies are hung “off” the wall, creating an additional acoustic volume behind the free-hanging balconies while reducing the width between the balcony fronts and getting the audience members on the side balconies closer to the centreline of the room. Downstands; located under the balcony soffits, are integrated into the design in order to create strong lateral reflections to all audience members, both in the parterre and on the balconies, as well as strong reflections back to the musicians. The height of each side balcony was defined in order to ensure the efficiency of these corner reflections.

The movable ceiling was maintained, with additional underhung reflectors above the stage and the first rows of audience seating.

The final dimensions of the concert hall are the following:

- width of the hall, parterre: 19m (slightly reverse fan)
- width of the hall, to downstands (i.e. to end of corridor behind side balcony seats): 22m
- width of hall, to structural walls: 25.5m
- length of hall, stage edge to last row parterre: 20m
- length of hall, stage edge to rear wall: 30m
- length of hall, max: 46m
- height of hall, variable ceiling in lowest position: ~ 17m
- height of hall, variable ceiling in lowest position: ~22.5m
- volume of hall, with low ceiling: ~ 17’000m³, 11m³/person
- volume of hall, with high ceiling: ~ 22’000m³, 15m³/person



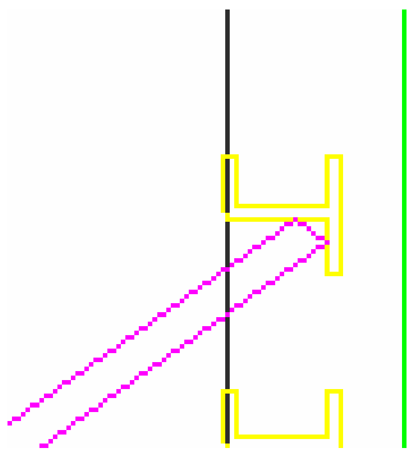


Figure 1: *short section of the Concert Hall, showing the reduced, more intimate parterre and the stepping out of the hall at first balcony level, as well as the free-hanging balconies and the movable ceiling (lowest position dotted line, highest position full line). The right image shows in more detail the downstands, and how the combined action of downstand and balcony soffit creates lateral reflections back to the main floor parterre. The shape of the downstand in plan will be variable so that further towards the back of the room the downstands will create improved reflections to the rear balconies as well.*

From a purely acoustic point of view, we believe that the combination of the intimate inner space (with multiple reflective surfaces close to the performers and audience members) and the larger outer volume allows the optimisation of both clarity (definition of the sound) and reverberation (the presence of the room). In addition, the location of the reverberant volume both high in the room (under the movable ceiling) and at the sides of the room (behind the side balconies) guarantees that audience members will be truly enveloped by the room sound.

2.3 Variable acoustics

In addition to the movable ceiling, the design includes a set of acoustic reflectors above the stage and the first rows of audience seating that are adjustable in height, and a full set of acoustic curtains, both in the inner volume and in the additional volume behind the side balconies. Variable acoustics curtains are equally included around the stage.

2.4 Computer simulations

In order to verify the validity of the acoustic design, and especially to test the effect of the free-hanging balconies, a computer simulation study was undertaken.

As a first estimate, calculations based on statistical models were performed. These simple calculations make it possible to validate the concert hall volume and to get a better understanding of how this volume will behave acoustically. The following volumes were determined for the concert hall:

- Inner volume (inscribed within the shape of the downstands and with flexible ceiling at its lowest position) : 15'500 m³
- Upper additional volume (added when flexible ceiling at its highest position): 4'950 m³
- Lateral additional volumes (located behind lateral balconies): 1'718 m³

Based on these volume estimations, Sabine reverberation time calculations were performed. The results are very positive, confirming that the basic design (total volume and surface areas) of the Concert Hall meets the reverberation time goals set by the acoustic brief (2.1 seconds):

- Lowest ceiling position: volume of 17'218 m³, RT of 1.79 s
- Highest ceiling position: volume of 22'168 m³, RT of 2.20 s

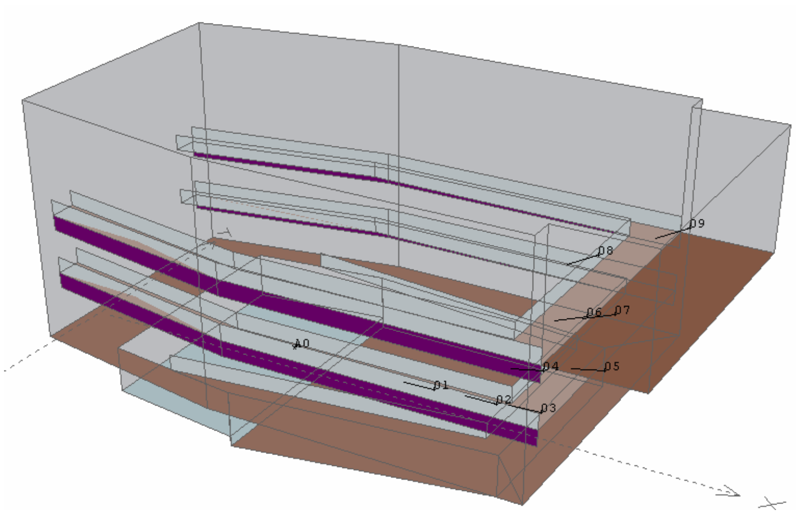


***Figure 2**: simplified CATT Acoustics model of the Stavanger Concert Hall.*

A simplified 3D computer model was created and analysed using CATT Acoustics. The model was deliberately simple, consisting of about 100 surfaces including downstands, in order to avoid "ray loss", especially in the particular case of Stavanger concert hall, where very high order reflections in the lateral additional volumes tend to be artificially lost when the surfaces they encounter are too small.

Six different configurations were tested, including configurations with and without downstands, configurations with free-hanging (floating) balconies, a configuration with the balconies pushed outwards to the side walls, and one configuration with the side walls pushed in to meet the balconies.

The results of the simulations for the different configurations sometimes showed surprisingly little variations, indicating that the standard acoustical parameters often used in the analysis of computer models (like RT, EDT, C80 and G) are not necessarily sufficient or appropriate to describe subtle but important variations in room design – though we know from experience that all the different configurations would lead to rooms that sound significantly different! Nevertheless, and especially when studying more detailed parameters, we believe that the results from the computer simulations confirm the design decisions. Differences in the acoustic results for the simulations of the different configurations included the following:

- all configurations without the downstands have significantly lower values of both C80 and lateral energy fraction
- removing the lateral additional volumes (i.e. pushing the side wall against the side balconies) reduces reverberation time. What is interesting to note is that the removal of the additional lateral volumes reduces reverberation time, but does not reduce reverberation level. We believe that the presence of the lateral volumes will lead to a more open and more airy room sound, with less interference between the source and the room sounds, i.e. better combining clarity and reverberation.
- removing the lateral additional volumes by pushing the balconies out towards the side wall (i.e. maintaining the total volume, with a more classical balcony design directly fixed to the side walls) slightly increases reverberation time, but decreases lateral energy fraction, C80 as well as G, especially with respect to early sound.

The computer model was used to confirm on-stage conditions and appropriate reflection coverage for all audience locations. Results are generally very positive and confirm that the main design decisions will lead to a hall with a strong and enveloping sound.

In order to verify the results of the computer simulations, and for a final check of all elements of the acoustic design, measurements of an acoustic scale model at scale 1:25 will be performed later this year.

2.5 Conclusions

We believe that the proposed layout for the Stavanger Concert Hall perfectly corresponds to the needs, both from the performers and the audience perspective. A relatively large part of the programming of the hall will involve regular-sized or even moderately-sized symphony orchestra, for which the intimacy and the proximity of the audience members to the performers on stage is equally important as the late reverberation of the hall. Chamber orchestra and chamber music – for which proximity and intimacy are even more important – are an important part of the programming of the hall as well. At the same time, even the largest orchestral works must remain possible under excellent acoustic conditions, with an appropriately large stage size and the required large acoustic volume for appropriate loudness and reverberation. In addition, we believe that the concept of the free-hanging balconies with additional acoustic volume behind them are both promising from and acoustic and from an architectural point of view, contributing to create a highly interesting architectural design.

3 FLEXIBLE HALL

3.1 Background

In the building program the multipurpose hall is described as:
”The Multipurpose hall should be a very flexible space planned for electronically reinforced event: cabaret, musicals, jazz-concerts, pop-concerts etc. The hall should also function as a ”black-box” theatre and lyric theatre”

Through discussions with the users the following prioritized list of uses has been decided:
- All sorts of reinforced music
- Musical/Music theatre
- Dance
- Banquets etc.
- Brass band concerts
- Acoustic (non amplified) music
-

Based on this list, the hall is designed as a space with variable staging and layout as well as highly variable acoustics.

3.2 Description of the hall

The hall is basically a shoebox, with one back balcony and 3 side balconies, where the upper is mainly for technical use. The layout has some resemblance with the Vanaja Hall in Hämeenlinna in Finland. The back part of the parterre fixed, the front is moveable telescopic seating elements, so that the hall can have a large flat floor.

The normal stage is 13 m deep and 20 m wide, with a 6.5 m deep side stage on one side, a 3 m deep side stage on the other side and a 11 m deep back stage. It is envisioned that the hall can have standing audience in the whole hall (including the main stage), with the concert stage being located in the back-stage area. The hall has an orchestral pit of approx. 63 m2 with possibility to extend the pit under the stage to a maximum size of approx. 138 m2. This implies that a typical Mozart orchestra or a typical musical orchestra can fit in the basic pit (without overhang), whereas larger orchestras will have to be partly seated under the stage.

The ceiling of the hall is more or less flat throughout the space, meaning equal height in both the audience area and on stage. This also implies that it is possible to create a proscenium stage and “stage tower”, with a stage opening of about 7 m. Along the sides and back part of the hall there is a technical space for AV-equipment and theatre mechanics.

The hall has extensive surfaces of variable absorption, done with curtains. There are both transverse curtains behind all lighting bridges, curtains along the walls of the technical room as well as curtains in front of the side wall on upper levels. Furthermore the proscenium curtain and stage curtains will work as variable absorption. Bass frequency control for amplified sound is integrated into the design of the architectural and acoustic finishes of the hall; additional variable absorption specifically for bass frequencies is still under study.

3.3 Computer models

The acoustics of the hall is mainly designed using computer models, and essentially three different configurations have been tested:
- Normal ”audience risers ” with normal side wall under the first balcony
- Flat floor with medium-sized normal stage
- Flat floor with stage in the back-stage area.

These configurations have all been simulated for four different acoustic conditions. All simulations were done for a hall without audience:

A: No curtains
B: Proscenium curtain
C: Proscenium curtain and curtain in front of the technical room and transverse curtains
D: All curtains exposed
In all simulations there are a certain amount of curtains in the stage to control the stage-house.

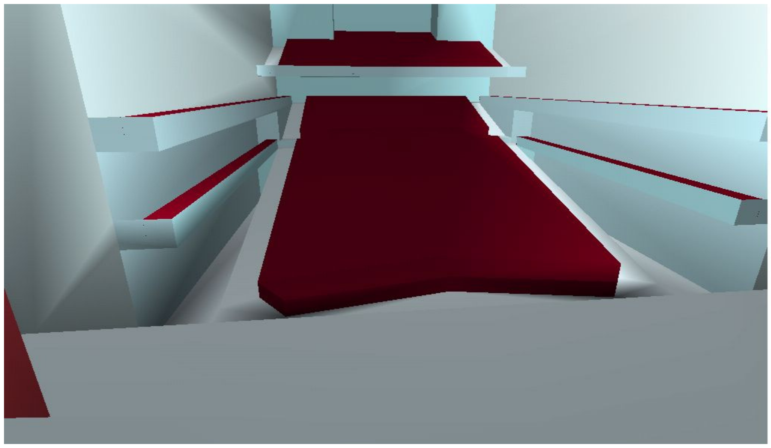


***Figure 3**: View of the hall, normal seating*

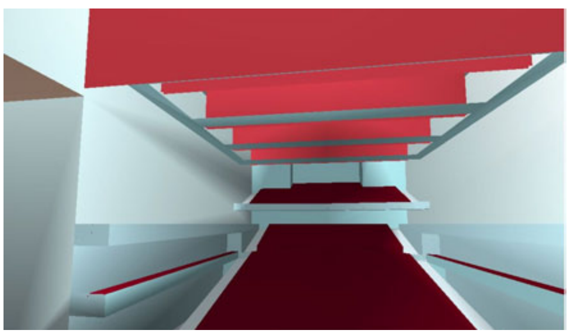


***Figure 4**: Transverse curtains left)*

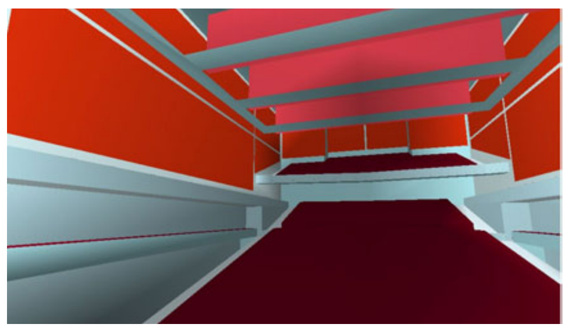


***Figure 5**: View of hall with all curtains exposed.*

The computer simulations essentially showed that the acoustic goals set in the program can be achieved. The hall will have a maximum reverberation-time of 2 s without extra absorption, which is more than the program calls for. In other words it will be necessary to install fixed absorption, in particular at bass frequencies. In particular the simulations clearly showed that without absorption in the stage house, dual decay could be a problem. Also it is clear that without added absorption, the difference between a situation with normal seating and with flat floor will be quite large.

The lateral efficiency of the hall in general is predicted to be sufficient, however as there are no real stage enclosure, lateral reflections in the front part of the parterre can be a problem.

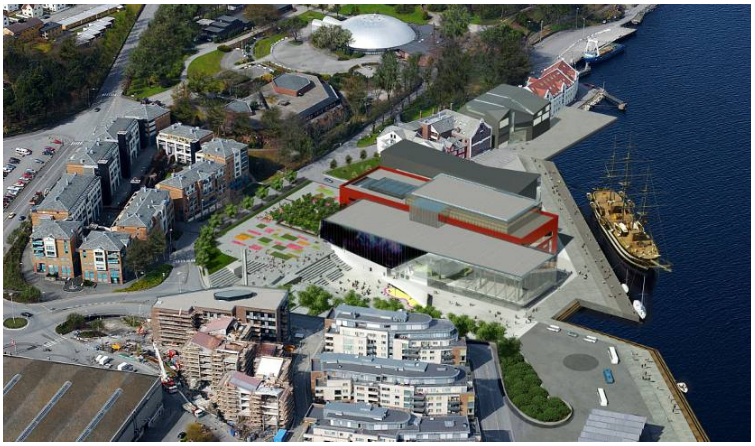
3.4 Conclusions

As always, packing multiple, acoustically more or less contradictory usages into a hall, which is thought of as the "small hall", is not easy. We believe that with the current layout we have found a good and workable compromise between acoustic requirements, ease of use requirements and economic boundaries.

4 BUILDING ACOUSTICS AND EXTERNAL NOISE

4.1 Situation

The concert hall is placed at the waterfront in Stavanger city. Even if the container activity is being moved out of the city there will still be a lot of ships visiting Stavanger.



The visualisation by "Placebo effects" shows the concert hall with a sailing ship along the quay. The picture is a bird's view seen from the south. (Sinus's office is located in the grey building by the sea near the upper right corner in the picture)

***Figure 6**: Bird's eye perspective of the building. Architect: Medplan. Visualisation: Placebo Effects.*

4.2 Noise sources

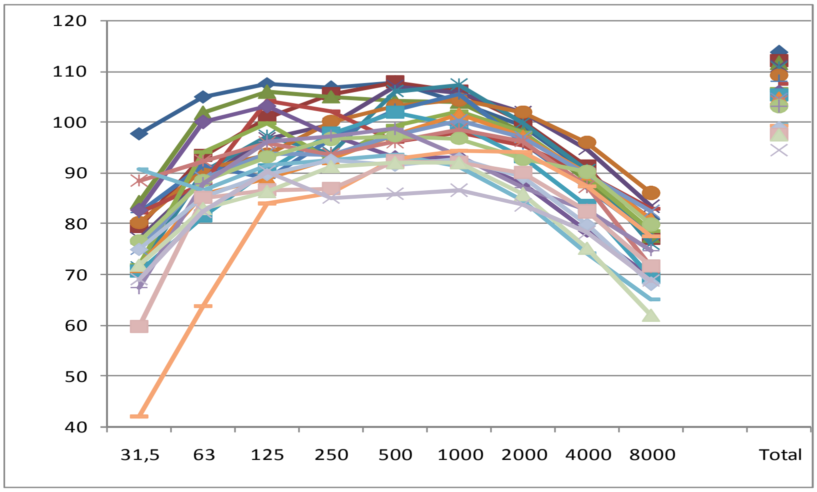
Even if sailboats still happen to visit Stavanger, this will not be the normal type of ship that one can expect to be placed close to the concert hall. A picture taken from Sinus's office, i.e. towards the concert hall area from the north, shows the normal visitors in the future: These are Offshore supply boats and cruise ships. Continuous noise is generated by service engines and ventilation. Intermittent noise sources are horns as the ships are leaving the quayside.

Continuous noise from cruise ships is normally much lower than the noise from offshore supply boats, despite the fact that cruise ships are much bigger.

While cruise ships seldom create sound power levels above 100 dBA, this is often the case for offshore supply boats.

***Figure 7**: Real life seen from Sinus's office: Noise sources and no "placebo effects" . . . .*

Sound power levels above 112 dBA have been measured, and the frequency spectrums are often dominated by energy at low frequencies. Typical frequency spectrums for a sample of the more noisy boats visiting Stavanger are given in the figure below:



Horns can have quite extreme sound power levels. Sound power levels in the range of 140 – 160 dBA have been estimated from a few measurements. (The major uncertainty is distance to source during sound level measurements).

Now and then helicopters are used in the harbour during larger exhibitions and conferences like for instance ONS (Offshore Northern Seas).

Figure 8*: Sound power levels of typical noisy boats. Values in dB(A).*

Other sources like for instance normal traffic noise, is significantly lower than for instance the noisiest boats.

4.3 Noise requirements and solutions

The most critical space in the concert house is the concert hall with a noise requirement of 15 dBA. The multipurpose hall has a noise requirement of 25 dBA. There is also an informal playing area on an elevated "saucer" in the glass foyer, with no defined noise limit. Still, we would like the noise level to be as low as feasible, preferably below 25 – 30 dBA "in most situations".

In order to solve the potential noise problem with such sources and requirements, administrative, technical and practical choices and solutions need to be looked into.
It is for instance considered nearly impossible to reduce the noise from ship horns sufficiently. However, cruise ships normally leave at hours when there are no critical activities in the building. If there should be such activity, it will be possible to request that the leaving ship omits use of horns at departure. In many situations horns are not strictly required (but it is of course a big manifestation or "show off"). The most noisy offshore supply boats are normally placed in other areas of the city due to potential conflict with people living in flats and houses in this particular area.

The remaining noise challenge is taken care of by sound insulation. Double concrete structures are planned around the concert hall. However the roof has been changed in order to have an open access and view to and from the technical loft. Therefore a lightweight suspended ceiling with a large cavity will be installed instead of a concrete loft floor.

The multipurpose hall will have well insulated walls and ceiling partly integrated in the internal acoustic treatment. The foyer will be built with a double glass façade with a significant air gap between the two layers of glass façade.

4.4 Conclusion

It is not feasible to provide sufficient sound situation for the most extreme noises that may occur occasionally in the harbour of Stavanger. Still we believe that the halls, the foyer and the rehearsal rooms will be sufficiently protected against the external noise sources that can be expected during concerts.