KILDEN – DESIGN FOR A CONTEMPORARY SHOEBOX CONCERT HALL IN KRISTIANSAND

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The Kilden Performing Arts Centre will provide a concert hall, theatre and other facilities for Kristiansand and the Agder region. The building is due for completion in 2010 and will provide a home for the Kristiansand Symphony Orchestra, as well as receiving orchestras from Norway and abroad. This paper describes the acoustic design in the context of the strong architectural concepts and the particular requirements of the resident orchestra. One challenge in the design was to produce a hall which provides an intimate acoustic for smaller orchestras, but is also able to take larger touring orchestras, staged events and amplified events. The architectural design included extensive use of strongly profiled concrete, prompting studies into sound diffusion; where diffusion becomes disruptive.

1 INTRODUCTION

The Kilden Performing Arts Centre will be located on a peninsular in the harbour of Kristiansand. The Centre includes a concert hall, theatre, multi-purpose hall and other facilities for the city of Kristiansand and the Agder region. The Kristiansand Symphony Orchestra (KSO) and Agder Theatre will move to the new venue, which will also receive visiting orchestras and productions from northern Europe.

The building design was selected by open competition and is the first major building by Finnish architects ALA. The concert hall is a 1200 seat shoebox, as required by the brief, with two narrow balconies wrapping round the hall.

2 THE BRIEF

The brief was for a hall with an acoustic optimal for the performance of symphonic music. Some semi-staged performances will also be included, requiring an orchestra pit and wing space, and there will be amplified music concerts. The KSO has its origins in a military band, so the 60 to 70 players include a high proportion of brass and woodwind (32 players). The concert platform is to be 12m deep, with the facility to increase it to 15m for larger orchestras or staged events.

Table 1 lists the numerical requirements of the brief, together with other design targets proposed.

Parameter (Occupied)	Value
Brief Requirements	
Reverberation time, T_{30}	2.0s – 2.2s
Low frequency (125Hz) T_{30}	2.4s – 2.5s
Early Decay Time, EDT	1.7s – 2.0s
T_{30} rehearsal condition	≤ 2.3s
T_{30}, variable absorption extended	1.4s – 1.5s
Low frequency T_{30}, variable absorption extended	≤ 2.1s
Design Targets	
Clarity, C_{80}	-2dB to +1dB
Vocal clarity, D_{50}	0.45 to 0.6
Loudness, G	5dB - 6dB (range < 7dB)
Lateral Energy Fraction, LEF	0.18 to 0.35

Table 1 Acoustic criteria given in the brief and design targets for other parameters, values apply for mid frequency (500Hz-1kHz) and 90% occupied, except where stated

3 COMPETITION DESIGN

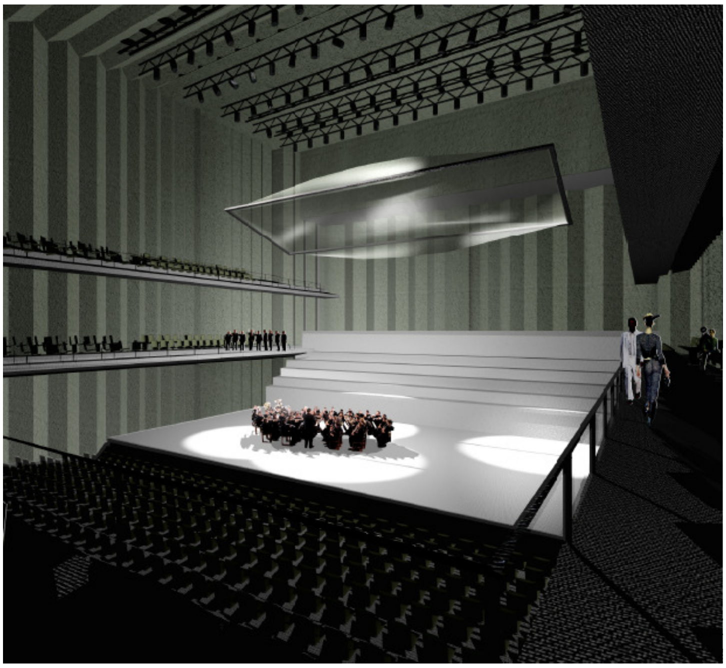

Figure 1 Image of the competition design

The concept of the competition design was of a very solid and strong enclosure of dark concrete. The first and second balconies were set away from the side walls so that sound absorbing banners can be dropped behind. The upper walls and ceiling were heavily folded into zig-zags. This was a key architectural element echoing the distinctive exterior.

The dark folded concrete forming the upper walls and ceiling had three disadvantageous. The first is a psychological reaction where performers (and to some extent the audience) may perceive the concrete as cold and harsh and react accordingly.

The dominating folded pattern was considered undesirable acoustically as it could lead to a 'banding' of principal sound reflections and energy distribution across the audience, giving wide differences in the perceived spaciousness and musical clarity. The profile varied, so as not to give any anomaly due to the regularity, but it did not provide any sound diffusion at the smaller scale and was likely to result in a harsh sound.

Lastly, the large amount of concrete results in heavy constructions, absorbing very little low frequency energy. Whilst a bass rise was targeted, some lighter weight elements were preferred to balance the frequency response.

An early design step was to change the stalls and performance area into a timber bowl within the larger concrete enclosure. The first balcony then looks over the timber bowl. Advantage was taken of the change in material to make the stalls level and performance area acoustically as well as visually intimate, narrowing the effective stalls width to 18m to provide good early lateral energy.

The concrete was a significant characteristic in the competition design, so it was important to keep this material and profile in some form. Design development produced first a series of fans of varying dimensions and then a matrix of pyramid forms varying in depth between 150mm and 600mm and up to 1200mm for the rear wall. The wall profile is discussed further in Section 4 and illustrated in Figure 2.

In contrast the ceiling is now lighter (50kg/m^2), being made of multiple layers of board. It is relatively flat in profile but modulated slightly by downstand beams, enclosures for bass absorbers and slots for lighting and stage equipment.

4 MUSICAL CLARITY PREDICTIONS AND IMPROVEMENT

Initial computer modelling revealed that musical and vocal clarity were not as high as desired in the centre of the rear balcony and the front of the rear balcony from a source at the front of the platform. One reason was because the side seating was obstructing reflections from the side walls. The seating was rearranged and the height of the balcony fronts reduced significantly.

Other options were also investigated to direct more early sound towards the rear balcony to improve the clarity. The addition of reflectors above the side balconies and the removal of one row of orchestral reflectors (which were otherwise screening some of the ceiling) were found to be the most effective within the architectural concept.

Reflectors above the side balcony improved the predictions of sound energy arriving in the rear balcony and significantly improved the clarity in the side balconies. The reflectors are to be 2m wide glass elements suspended horizontally from the ceiling. In many traditional concert halls, a higher audience or technical balcony or an architectural shelf serves the same purpose.

The side wall geometry and the degree that it scatters the sound were studied in the computer model. It was concluded that walls which scatter the sound over a wide frequency range were providing fewer strong sound reflections than if the wall profile had been simpler.

By reducing the mid-frequency scattering of the side walls towards the rear of the hall, the clarity at the back of the hall was improved. In the design proposals, the pyramid forms in the walls were reduced in dimension and complexity to reduce the scattering of sound in the shaded areas. Small scale grooves in the timber walls were formed to control high frequency glare at stalls level.

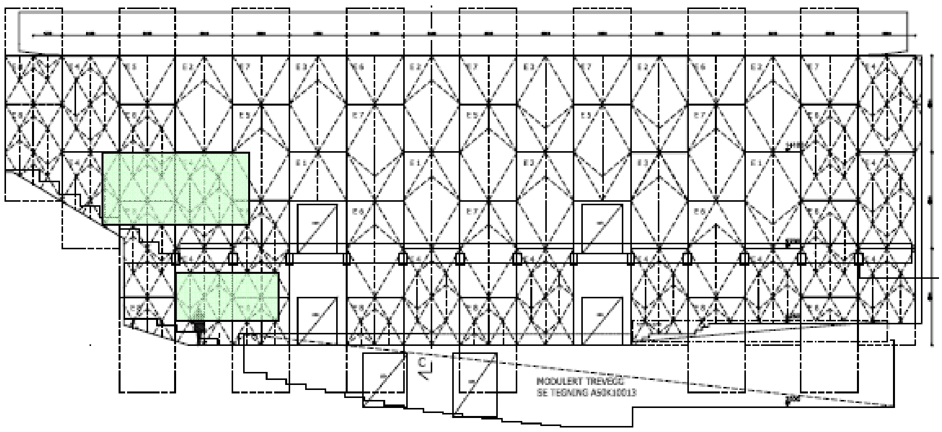

Figure 2 Areas of side walls where diffusion of the walls was limited

At the top of the wall the diffusion from the concrete elements uses larger dimensions (150 - 600mm depth). Near the audience on the balconies the elements reduce so that there is more variation in the 50 - 100mm range. On the rear wall, the depth increases to between 600mm and 1200mm from the wall.

In the Odeon model the scattering of the side walls was primarily modelled using scattering coefficients. To ensure that such a geometric design will not create any accidental focusing or channelling of the sound, the detailed shape of the wall was built in a control computer model. This consisted of a sound absorbing rectangular model box (representing the hall) built first with a plain flat wall and then with all the facets of the detailed geometry. Results of the two models were compared to ensure that the space remained diffuse.

5 PLATFORM LAYOUT AND DESIGN

A flexible layout for orchestra risers had to be found which would accommodate the KSO wind and percussion and be adaptable for other orchestras. The resulting design consists of 2 main risers across the rear of the platform, with smaller moveable risers to provide steps in front and in between. The brass and percussion have to be raised relatively high to ensure that they play over the musicians in front, to limit the exposure of players to high sound levels.

The design of the platform surround and the orchestral reflector are based on the orchestra usually being on a 12m deep platform. The choir will have additional removable risers positioned behind the orchestral risers. This is beneficial in keeping a tight format and good ensemble between the choir and orchestra.

The orchestral reflector array covers the entire platform up to the front row of the stalls. The height is generally 10m above the platform, rising gently at the front. The array of panels reflects some sound down to the performers and lets some of the sound energy through to the upper volume of the hall. The individual panels are 2.2m wide by 1.7m deep and are gently curved from front to back. Gaps of 0.9m are left between the rows of panels to allow lighting bars to be lowered between the panels. The curvature on the panels ensures that the sound reflection pattern is uninterrupted.

Panels in the rear corners of the array are reduced in size to fit onto the platform and enable them to be lowered to floor level. The panels will be connected together in rows and lifted as one. During the commissioning of the hall, the angle of the panels may be changed to optimise their performance, but afterwards they will be fixed.

All sound reflecting surfaces around the platform potentially support the musicians. The Odeon model was used to investigate sound reflections from surfaces around the platform. Looking at the pattern of sound reflections between selected performers, the results showed a high density of early sound reflections in all positions on the platform.

The outer rows of orchestral reflectors, above the side balcony, are particularly useful in providing sound reflections across the width of the platform, in combination with the side walls. Similarly the rear row provides vital communication between the choir balcony and the orchestra.

Many useful sound reflections come from the soffit of the side balcony which runs to the end wall above the platform. These combine with reflections from the overhead reflectors or the side walls to provide a good early sound response. A soffit under the balcony front wraps around all 3 sides of the platform. The soffit is only 300mm deep, so only reflects sound specularly at high frequencies, but the reflections are ‘early’, arriving soon after the direct sound. This is an essential component of providing support to musicians of their own sound.

The surface finish of the timber surround is grooved, as is the stalls timber lining, to provide high frequency diffusion. The panels forming the platform surround are reversible, providing sound absorption on the rear, and are 40kg/m^2 to limit low frequency sound absorption.

6 VARIABLE SOUND ABSORPTION

Variable absorption is provided by conventional banners all round the hall, which drop from a bulkhead at the side of the ceiling down to the first balcony, passing behind the upper balcony. The banners are supplemented by hatches in the ceiling, providing low frequency absorption.

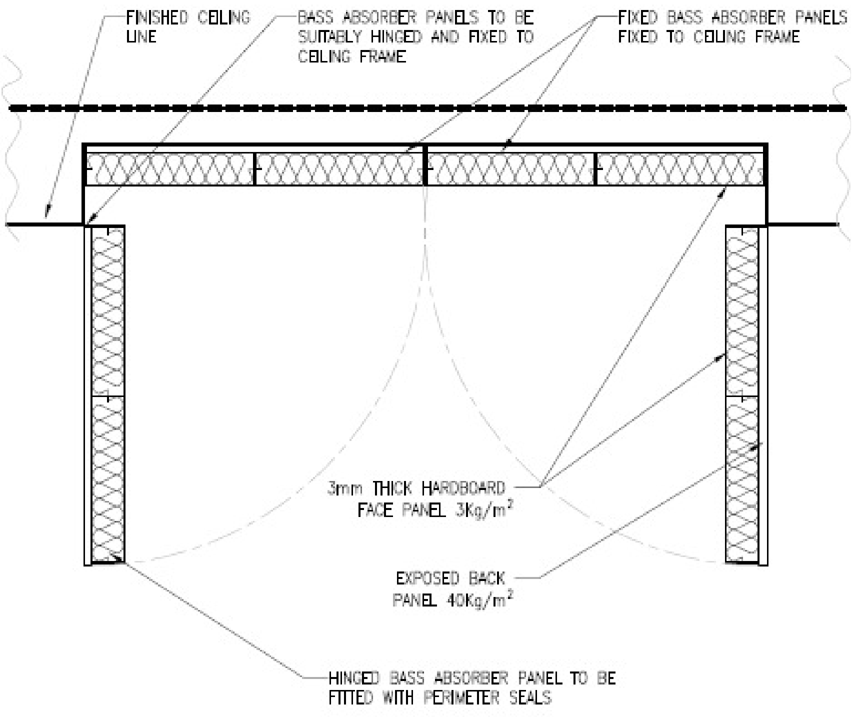

Figure 3 Hatches forming bass absorbers

The construction of the bass absorbers is 3mm hardboard over 150mm mineral wool (density 33kg/m^3) on both the hatch doors and the revealed opening. The hatch doors are $\geq$ 40kg/m^2, to reflect sound when closed and sealed shut.

The bass absorber hatches provide extra control in reverberance at low frequency, reducing the predicted T_{30} at 125Hz from 2.3s (with only the banners) to the target of < 2.1s. This is very beneficial in the design of the sound system for the hall.

As an additional indicator of the advantage of the low frequency absorption, the musical clarity at 125Hz was studied. C_{80} values > 0dB are predicted for over 70% of the seats.

An auralisation of male speech was listened to with the banners in place and with the low frequency absorption added. With the banners the speech was highly intelligible, but not quite natural. Adding the low frequency absorption made the sound much more natural.

7 SUMMARY OF THE CURRENT DESIGN

Figure 4 is an image of the current auditorium design. Figure 5 shows plans and sections.

Figure 4 Image of the auditorium design

Figure 5 Auditorium plans and long section

The rectilinear form of the auditorium remains. Up to the first balcony the room is clad in grooved timber 35kg/m^2 to 50kg/m^2 in weight. Above this are concrete walls (minimum 300mm thick) modelled in pyramid shapes continuously varying in dimension. The ceiling is a multi layer board, broken by structural beams and hatches for the bass absorbers. Banners drop down to the first balcony from a bulkhead around the ceiling. Above the side balconies are horizontal glass panels which reflect sound to the rear and side balconies. The orchestral reflector is 5 rows of 6 panels, curved front to back, at an average height of 10m with the first two rows lifted slightly higher.

Parameter	**Current Design**
No. of seats (N)	1202
Volume/ total absorbing area (V/St) , m	14.6
Volume/seat (V/N), m^3	11.7
Stalls width, m	18
Overall width, m	23
Maximum height (front stalls), m	18.9
Average height (mid stalls), m	17.7
Length, m	42.2
Furthest seat to platform, m	30
Platform area, m^2	190.8
Platform downstage width, m	18
Platform upstage width, m	13.4
Platform depth (orchestral concert) , m	12
Platform fan angle, º	10
Platform surround height, m	3
Reflector % platform coverage, %	75
Reflector max operating height, m	14
Reflector min operating height, m	8
Stalls rake angle, º	5 front, 11 rear
Seat-seat width, mm	530
Row-row spacing, mm	900
Balcony front height, mm	850
Platform front to 1st rear balcony, m	22

Table 2 Geometric indicators for the current design

The project is due to start on site in autumn 2008, for completion in 2011.