ACOUSTICS IN THE MULTIPURPOSE HALLS OF THE NEW MAIN LIBRARY AND THE NEW MUNCH MUSEUM IN OSLO

J Olshausen Multiconsult as, Oslo, Norway
J H Rindel Multiconsult as, Oslo, Norway

1 INTRODUCTION

This paper will introduce you to two very different multipurpose halls planned in two new buildings in Oslo; The new main library (the Deichman library) drawn by Lund Hagem architects and the new museum for the Norwegian painter Edvard Munch drawn by estudio Herreros architects, both planned to be opened in 2019. The two buildings are located close together and will be significant contributions to a new cultural centre near the Oslo opera house (opened 2008). The capacity of the minor hall is about 200 seats, whereas the larger hall has about 277 to 380 seats, depending on the seating arrangement. The Odeon models used for the acoustic design of the halls will be presented and discussed. The calculation results and the geometry of the halls will be presented in context with the Norwegian standard NS 8178 “Acoustic criteria for rooms and spaces for music rehearsal and performance”.

2 LOCATION OF NEW CULTURAL BUILDINGS

Figure 1 shows the location of the new buildings in Oslo (Norway).

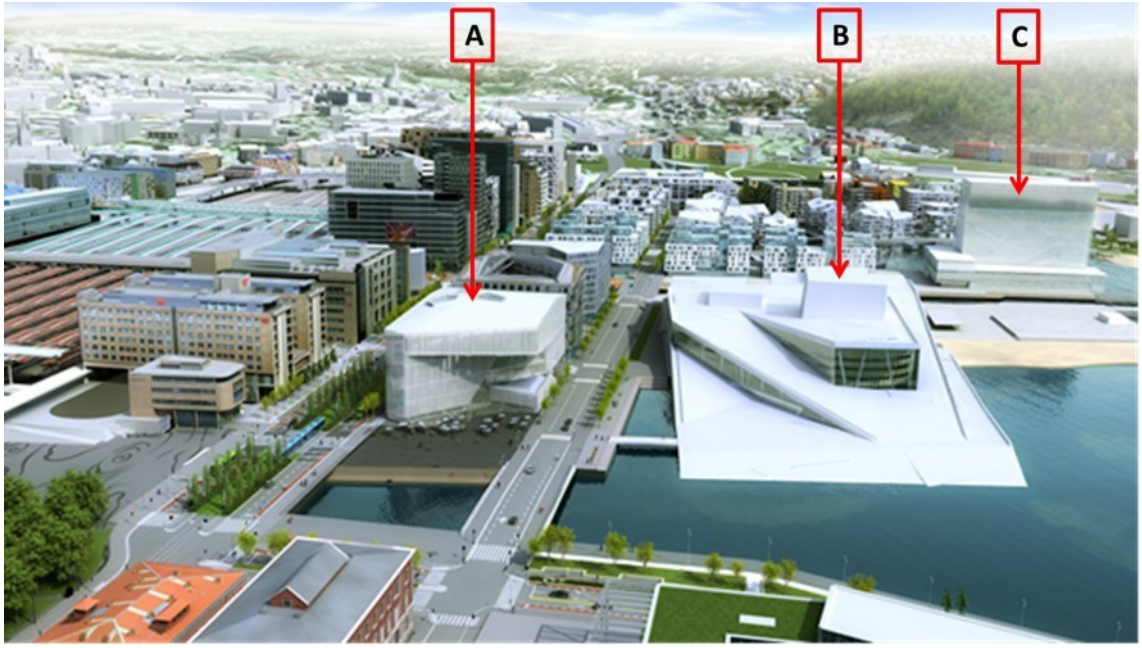

Figure 1 View towards the East of central Oslo, Norway. The location of the new library (A), the opera house (B) and the new Munch museum (C). (Illustration from estudio Herreros)

Within the buildings the multipurpose hall in the library will be located in the lower ground floor, while in the Munch museum the hall will be located on the first floor directly accessed from the lobby as shown in Figure 2.

Figure 2 The lobby in the new Munch museum with access to the multipurpose hall by the stairs. (Illustration from estudio Herreros)

3 ACOUSTIC DESIGN CRITERIA FOR THE HALLS

Music performance has a high priority in both of the new multi-purpose halls, amplified music in the hall of the library and acoustic music in the hall of the Munch museum. For several years the museum has hosted the annual chamber music festival, and this tradition should continue in the new building.

As a reference for the acoustic design, the Norwegian standard for music rooms NS 8178 [1] was applied. This specifies the preferred mid-frequency reverberation time depending on the type of music (amplified music, loud acoustic music and quiet acoustic music) as a function of room volume; See Figure 3. The reverberation time is for fully furnished rooms without audience. More information about this standard is available in ref. [2].

The reverberation times in Figure 3 is understood as the average in the mid-frequency octave bands 500 and 1000 Hz. Upper and lower limits of the reverberation time at other frequencies are specified in NS 8178 [1] for amplified music and acoustic music, the former demanding relatively short values in the bass region, especially at 125 Hz. For acoustic music the reverberation time may be longer in the bass region compared to the mid frequencies.

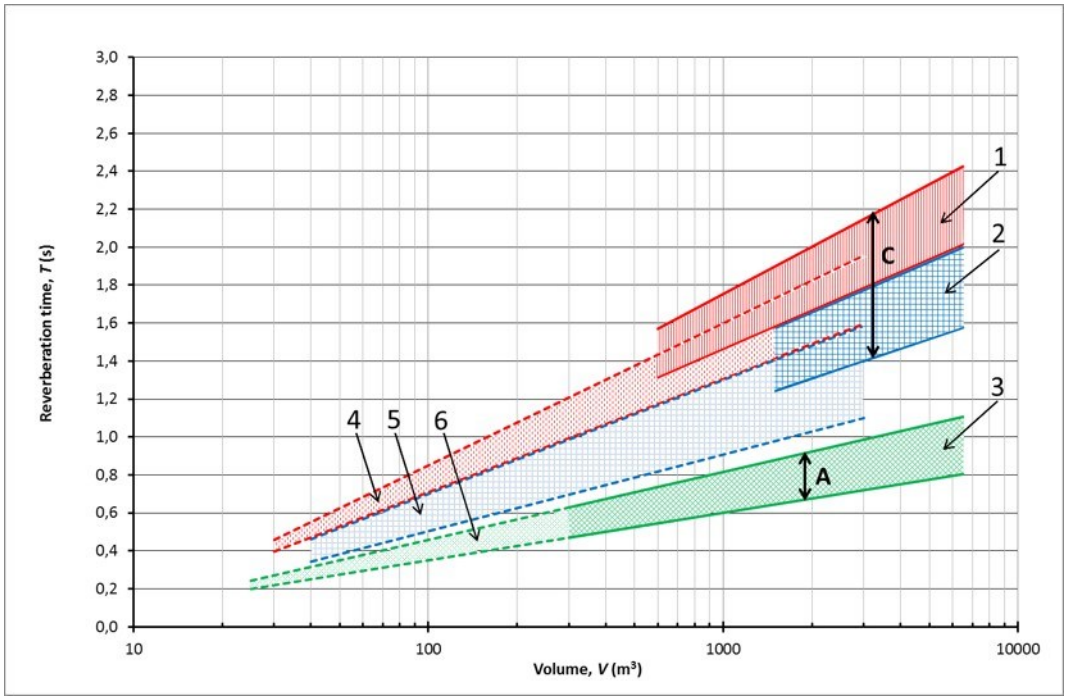

Figure 3 Reverberation time (mid frequencies) as function of volume after NS 8178 [1]. Regions with full lines are for performance spaces and regions with dotted lines are for rehearsal rooms. 1 and 4: Quiet music. 2 and 5: Loud music. 3 and 6: Amplified music. A: The hall in the library. C: The hall in the Munch museum.

The hall for amplified music (the Deichman library) has a volume around 1800 m^3 and the corresponding recommended reverberation time is 0.7 – 0.9 s. The hall for acoustic music in the Munch museum has a volume of around 3300 m^3 and the corresponding reverberation time for loud music is 1.4 – 1.8 s. For quiet music, the reverberation time could be longer than 1.8 s, up to about 2.2 s.

4 THE NEW DEICHMAN LIBRARY

4.1 Geometrical facts

Figure 4 and 5 shows the geometry of the hall and indicates its vital measures. The volume of the hall is approximately 1800 m^3, having a maximum height of 7.5 meter and seats for 200 people. The maximum width of the hall is 16.5 meters and the length of the hall is 15 meter.

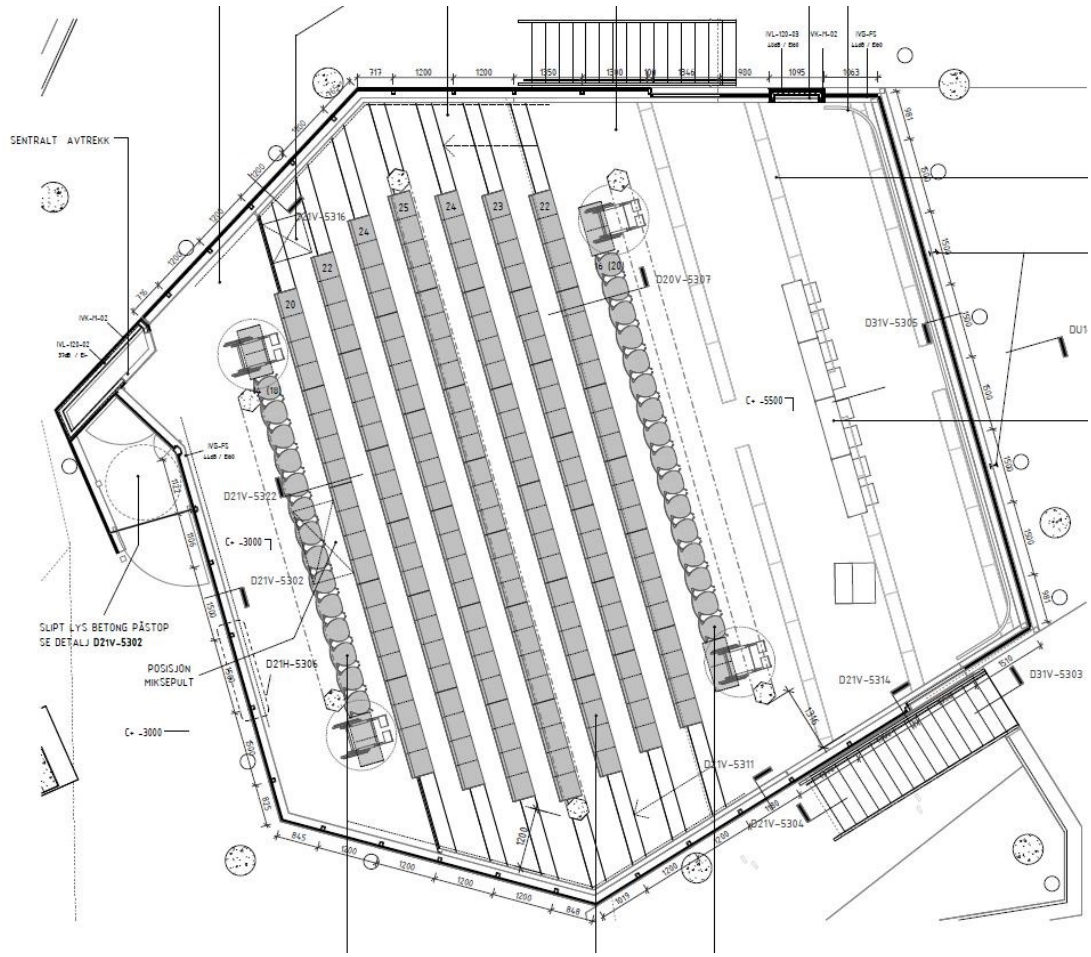

Figure 4 Floor plan of the hall in the new library (Courtesy of Lund Hagem architects)

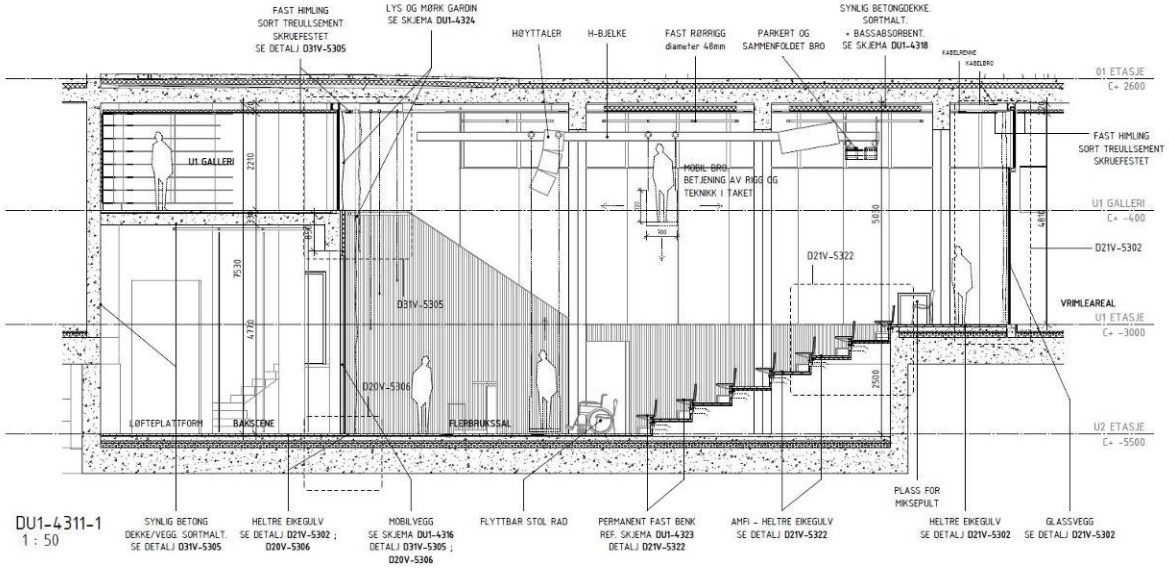

Figure 5 Sectional drawing of the hall in the new library (Courtesy of Lund Hagem architects)

4.2 Material facts

Table 1 presents a list of the materials that have an acoustical significance for the calculated reverberation times.

Table 1 Materials of acoustical significance and their absorption coefficients.

Materials	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
25 mm wood wool slabs + 45 mm mineral wool in the rim of the ceiling.	0,20	0,60	0,90	0,90	0,85	1,00
Gustaf panel system on the walls, 0 % perforation, 40 mm mineral wool + 30 mm air	0,11	0,04	0,03	0,03	0,04	0,05
Gustaf panel system on the walls, PG5 perforation, 40 mm mineral wool + 30 mm air	0,49	0,54	0,51	0,35	0,21	0,15
Bass absorbers in the ceiling: Ecophon Sombra A 20, gamma + Sombra X-bass 20 + 90 mm mineral wool, total construction height 200 mm	0,70	0,35	0,45	0,35	0,20	0,15
Medium upholstered chairs (4-6 cm) – absorption related to floor area with chairs. Surface area of chairs: 2,75 m^2 per m^2 floor	0,35	0,45	0,57	0,61	0,59	0,55
Fraster curtain, 5 mm wool, 200 mm cavity between curtain and glass	0,35	0,65	0,9	0,85	0,85	0,9

4.3 Odeon calculation models

The reverberation time for the hall has been calculated for four different amounts of curtains. Figures 6 - 9 illustrate these four different scenarios. Acoustic colours are applied in these figures, see ref. [3]. So, dark colours represent high absorption and light colours less absorption. Red colours mean absorption mainly at mid and high frequencies. Bluish colours mean absorption mainly at low frequencies.

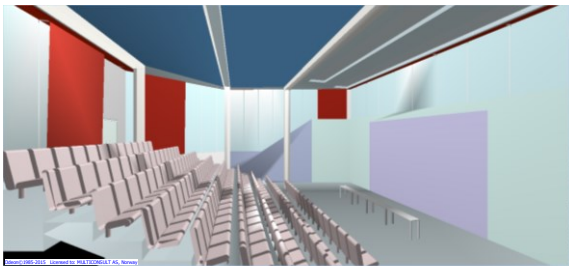

Figure 6 Model with a minimum of curtains. Approximately 25% of the glass walls covered with curtains.

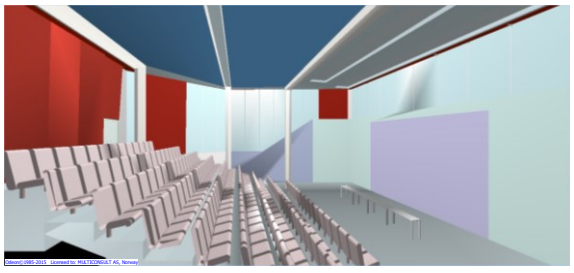

Figure 7 Model with the back wall covered with curtains.

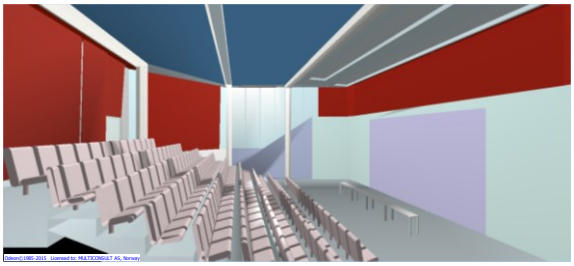

Figure 8 Model where 2/3'rds of the glass walls are covered with curtains.

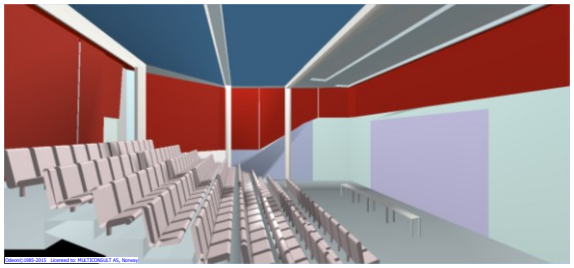

Figure 9 Model where all curtains are drawn.

4.4 Odeon calculation results

With the four different scenarios explained above, the reverberation time in the hall has been calculated and is found to vary as shown in Figure 10, from 0.7 sec. to 1.2 sec in the mid frequencies. For comparison is also shown the upper and lower limits at mid frequencies for amplified music in a volume of 1800 m^3.

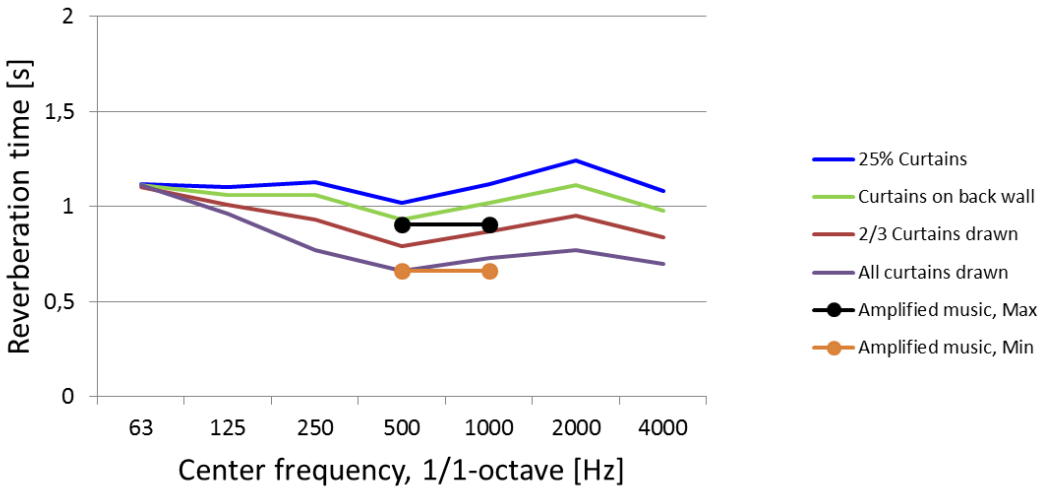

Figure 10 Calculated reverberation times for the four different scenarios compared to the recommend range for amplified music.

In Figure 11 the course of the reverberation time with 2/3 curtains drawn is compared to the recommended limits for performance of amplified music. The amount of absorption seems to be insufficient at low frequencies, especially at 125 Hz. This is an issue that will be dealt with in the final design.

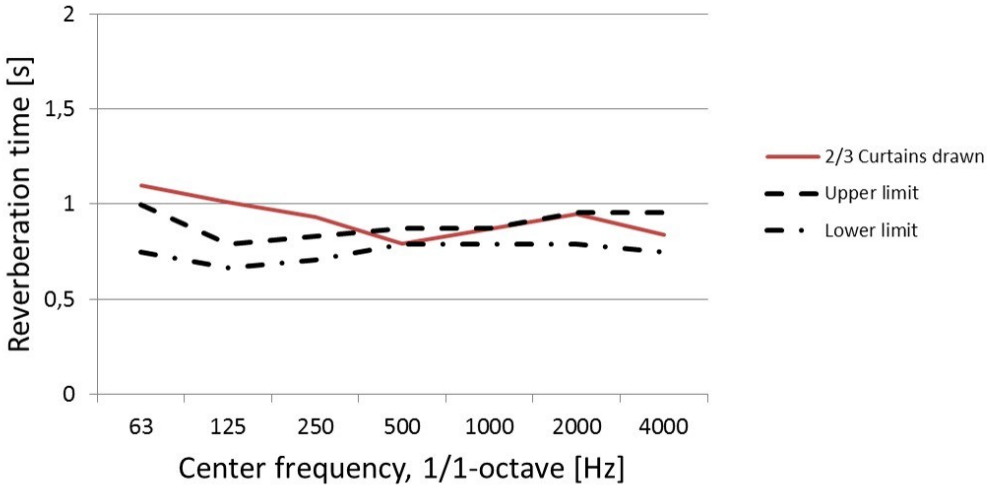

Figure 11 Calculated reverberation time as a function of frequency with 2/3 curtains drawn. The upper and lower limits are for performance of amplified music according to NS 8178.

The following conclusion can be drawn: The hall is too small (volume, height) and has too short reverberation time to work well for acoustic music, and the limited size of the stage will limit the hall to small ensembles applying sound reinforcing equipment. In other words the hall will be best suited for amplified music, even though more bass absorption would be feasible. The reverberation time will be suited for speech as well. The hall will be acoustically satisfying for other planned activities such as children theatre, debates and authors reading loud.

5 THE NEW MUNCH MUSEUM

5.1 Geometrical facts

Figure 12 shows a 3-D illustration of the hall taken from the architect's ifc model. Figure 13 and 14 show the geometry of the hall and indicate its vital measures. The volume of the hall is approximately 3300 m^3, having a maximum height of 9 meter and seats for 277 and 380 people depending on the halls setup: amphi setup or arena/flat-floor setup. The width of the hall is approximately 15 meters and the length of the hall is 26 meter.

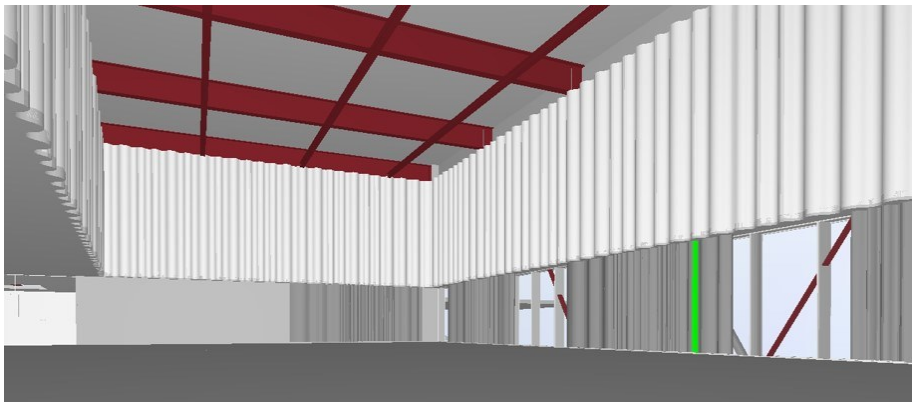

Figure 12 3-D model of empty hall illustrating the curved sound diffusing walls (Courtesy of estudio Herreros).

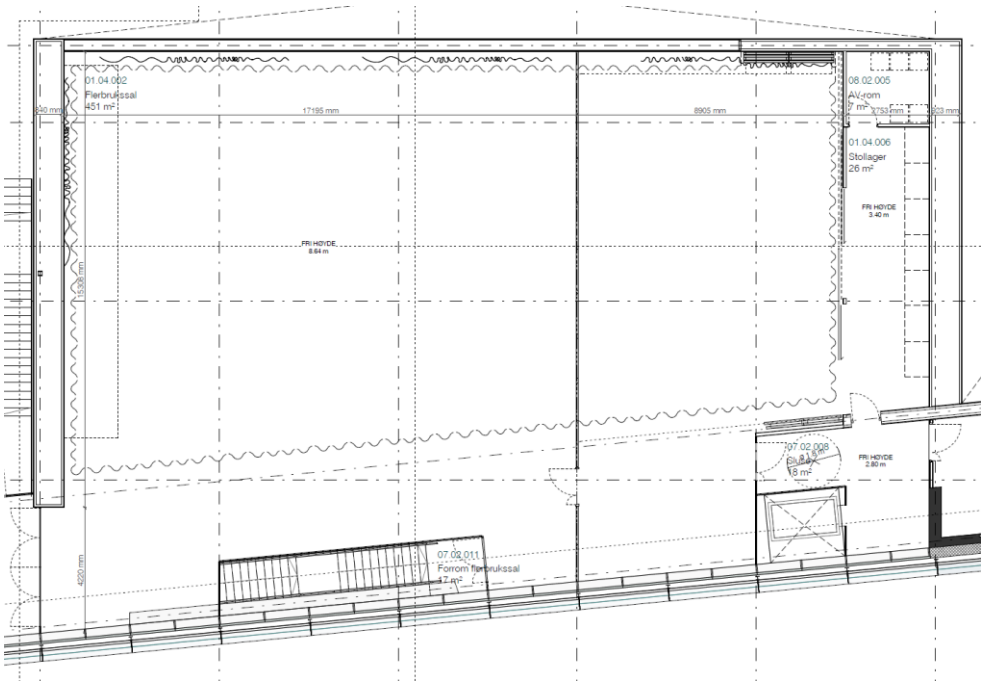

Figure 13 Floor plan of the hall in the Munch museum (Courtesy of estudio Herreros).

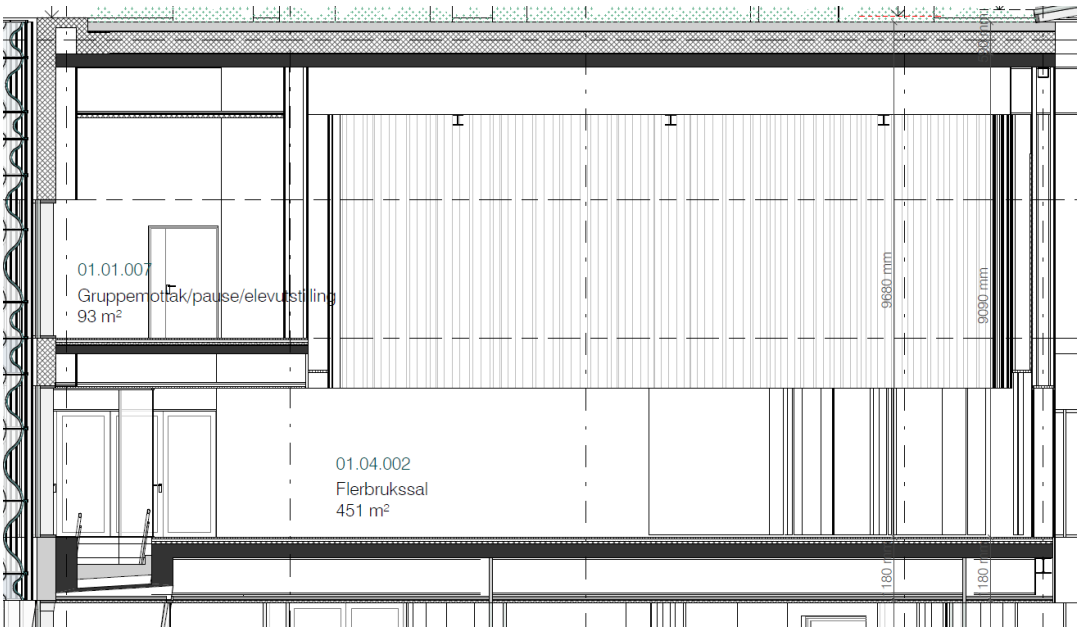

Figure 14 Sectional drawing of the hall in the Munch museum (Courtesy of estudio Herreros).

5.2 Material facts

Table 2 presents a list of the materials that have an acoustical significance for the calculated reverberation times.

Table 2 Materials of acoustical significance and their absorption coefficients.

Materials	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz
Diffusing/Curved walls, 0% perforation	0,25	0,15	0,10	0,09	0,08	0,07
Diffusing/Curved walls, perforated (back wall)	0,48	0,71	0,73	0,66	0,56	0,42
Audience on flat floor	0,35	0,45	0,57	0,61	0,59	0,55
Empty upholstered chairs in amphi	0,40	0,50	0,58	0,61	0,58	0,50
Amphi	0,15	0,11	0,10	0,07	0,06	0,07
Curtains, densely woven, 90 mm from wall	0,18	0,24	0,38	0,63	0,70	0,73

Figure 15 shows the sound diffusing/curved walls in more detail, having the same geometry as the perforated curved plates in front of the glass façade of the Munch museum (for sun shading).

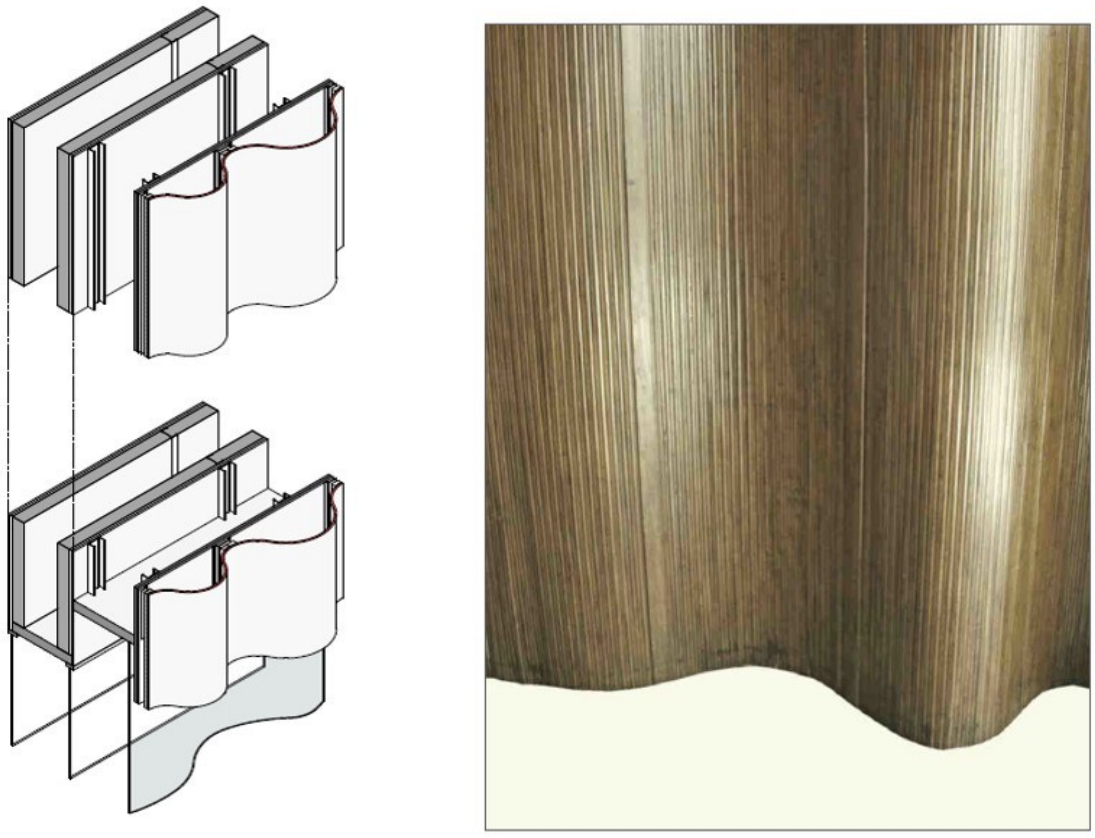

Figure 15 Sound diffusing/curved solid wood panels, 218-270 mm cavity (Courtesy of estudio Herreros).

5.3 Odeon calculation models

The reverberation time for the hall has been calculated for two different seating arrangements:

1. Amphi setup, 277 seats, 15+1 rows (900, 250 mm) 100 m^2 stage (h = 0), with or without sound absorbing curtains
2. Arena setup, 340/380 seats, flat floor, 24/50 m^2 stage (h = 500 mm), with or without sound absorbing curtains.

Figure 16 and 17 illustrate the two seating arrangements.

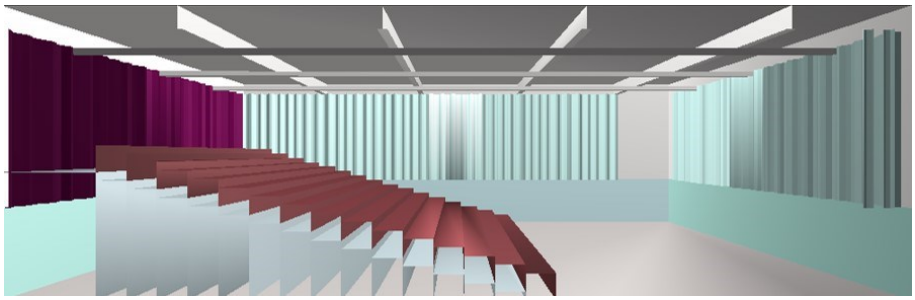

Figure 16 Amphi setup without curtains.

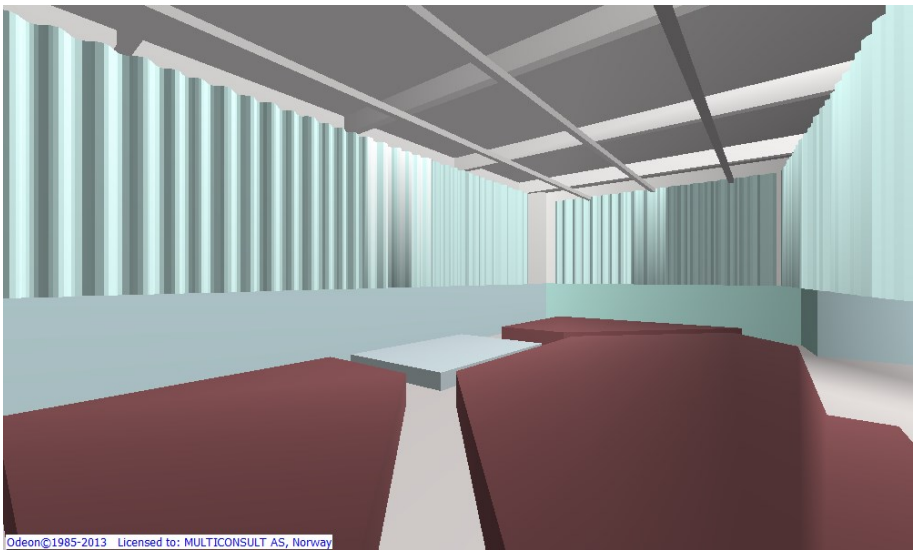

Figure 17 Arena setup with audience on flat floor (without curtains, 24 m^2 stage).

5.4 Odeon calculation results

Figure 18 shows the calculated reverberation times for the two audience arrangements, without and with sound absorbing curtains. For comparison, the upper and lower limits at mid frequencies for performance of acoustic music in a volume of 3300 m^3 are shown.

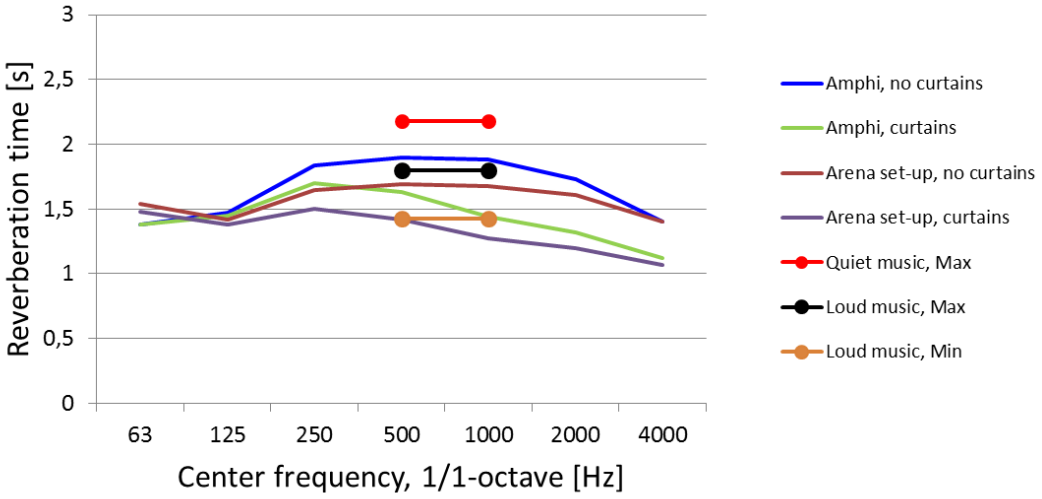

Figure 18 Calculated reverberation time for the amphi and arena setup without and with curtains compared to the recommend range for performance of acoustic music.

Due to the large seating surface for the arena setup this will be less reverberant than the amphi setup, but both setups are still considered suitable for acoustic music. Without curtains and in the arena setup the course of the reverberation time is closely following the recommended range for performance of acoustic music according to NS 8178, see Figure 19.

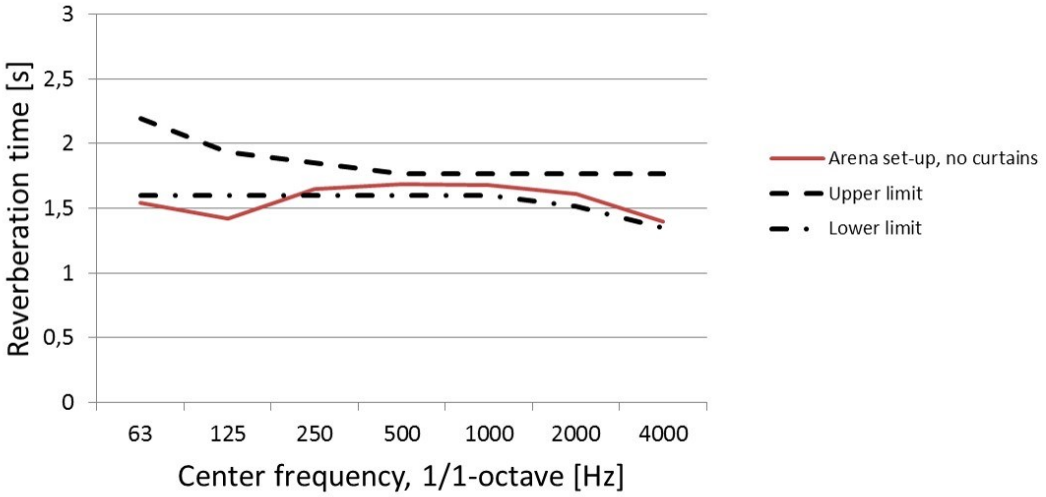

Figure 19 Calculated reverberation time as a function of frequency for the arena setup (flat floor, 50 m^2 stage) without sound absorbing curtains. The upper and lower limits are for performance of acoustic music according to NS 8178.

The sound strength G is calculated for the two audience setups as well, and is summarized in Table 3 together with reverberation times.

Table 3 Calculated sound strength and reverberation time (mid-frequency) for the two audience arrangements.

Alternative	Sound strength G [dB]	Reverberation time [s]	Suited for
Amphi without curtains	10	1,9	Quiet acoustic music
Amphi with curtains	9	1,5	Loud acoustic music
Arena setup without curtains	12	1,7	Loud (quiet) acoustic music
Arena setup with curtains	10	1,3	Loud acoustic music

6 SUMMARY

The multipurpose hall of the Deichman library and the multipurpose hall of the Munch museum will complement each other: The library hall being best suited for amplified music and speech while the Munch hall has sufficient volume and reverberation time to support acoustic music.

Important success factors for achieving satisfying room acoustics within these halls will be as follows:

- Fine tuning of the diffusing/curved walls in the multipurpose hall of the Munch museum optimising the bass absorption in particular (stiffness of curved plates, depth of cavity and amount of mineral wool in cavity).
- Choosing sound absorbing curtains of a high quality in the multipurpose hall of the library; read thick/heavy curtains with a generous cavity between the curtain and the glass walls, again in order to achieve sufficient bass absorption.

7 REFERENCES

1. NS 8178:2014, Acoustic criteria for rooms and spaces for music rehearsal and performance. Standards Norway, Oslo, 2014. (English and Norwegian editions). http://www.standard.no/en/.
2. J.H. Rindel: New Norwegian standard on the acoustics of rooms for music rehearsal and performance. Proceedings of Forum Acusticum 2014, Krakow, Poland, September 2014.
3. J.H. Rindel, C.L. Christensen: The use of colors, animations and auralizations in room acoustics. Proceedings of Internoise 2013, Innsbruck, Austria.