PROCEEDINGS of the
23rd International Congress on Acoustics

9 to 13 September 2019 in Aachen, Germany

Acoustic regulations and design of the multipurpose hall and exhibition halls of the new Munch museum in Oslo

Jannicke OLSHAUSEN

Multiconsult Norge AS, Norway

ABSTRACT

This paper presents some acoustic challenges dealt with in connection with the building and construction of the new Munch museum in Oslo. The museum for the Norwegian painter Edvard Munch drawn by estudio Herreros architects plans to open in 2020. The paper will discuss room acoustical challenges that comes up with the multipurpose hall and high ceiling exhibition halls for monumental works by Edvard Munch. The paper presents calculation results (carried out in Odeon) in context with the Norwegian standard NS 8178 "Acoustic criteria for rooms and spaces for music rehearsal and performance" (1) for the multipurpose hall. The calculation results of the exhibition halls are compared with the Norwegian acoustic regulations (2) to reverberations times in museums.

Keywords: Multipurpose hall, Museum acoustics, Norwegian acoustic regulation

1. INTRODUCTION

The engineering phase of the new museum for the Norwegian painter Edvard Munch started in 2010 and is now in its finishing stage. The museum has 13 floors and is located close to the Oslo opera house (opened 2008). Apart from exhibition areas, the museum accommodates an exhibition shop, café and cinema in the large lobby area, a restaurant on the top floor, a library, and education facilities for school classes and areas for the staff including specialized rooms for conservation. The museum aims to be one of the most respected museums in the world and wants to contribute to the interest of art.

The capacity of the multipurpose hall is about 277 to 380 seats, depending on the seating arrangement: telescopic seating setup or arena/flat-floor setup. The volume of the hall is approximately 3300 m^3, having a maximum height of 9 m. The width of the hall is approximately 15 m and the length of the hall is 26 m.

The two exhibition halls for Munch's monumental works have 7 m of ceiling heights, while the other nine exhibition halls have approximately 4 m of ceiling heights. The floor area varies between 300 and 800 m^2.

2. LOCATION OF THE MUNCH MUSEUM

The building with label C in Figure 1 shows the location of the new Munch museum.

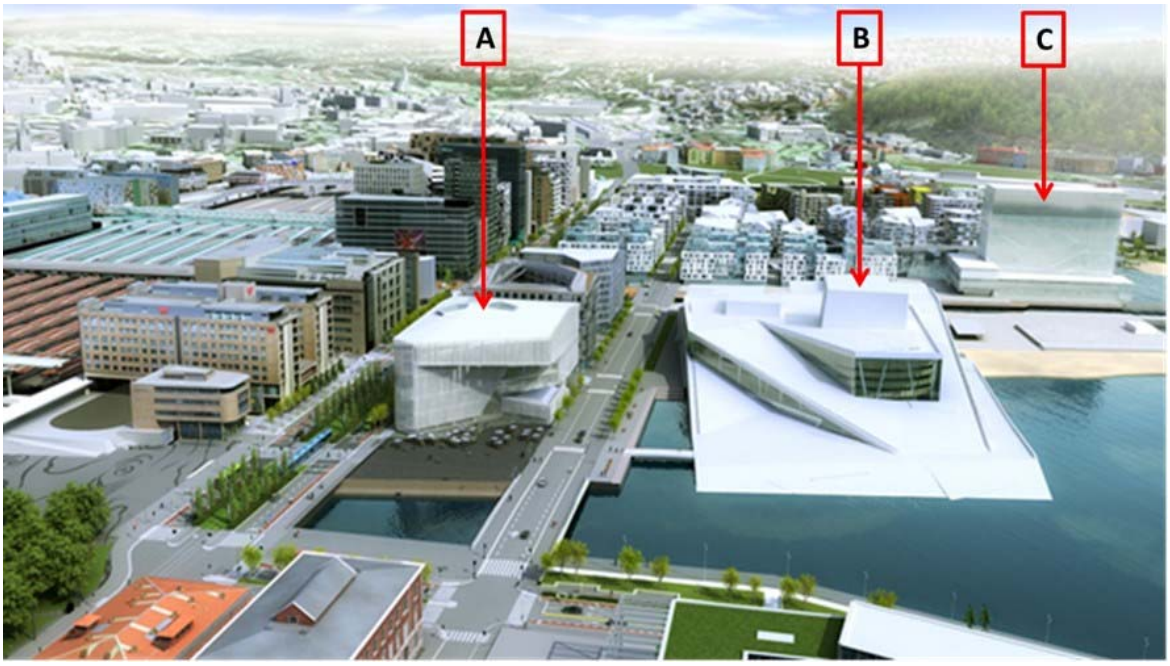

Figure 1 - View towards the East of central Oslo, Norway. The location of the new library (A), the opera house (B) and the new Munch museum (C). (Illustration courtesy of estudio Herreros)

Within the building, the multipurpose 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 courtesy of estudio Herreros)

As when it comes to the exhibition halls, they are located on floor 2, 3, 5, 6, 7, 8 and 9.

3. THE MULTIPURPOSE HALL

3.1 Acoustic Design Criteria for the Hall

Music performance has a high priority in the multipurpose hall. For several years the museum has hosted the annual chamber music festival, and this tradition should continue in the new building.

The acoustic design of the hall is based on the Norwegian standard for music rooms NS 8178 (1). The standard states the preferred mid-frequency reverberation time as a function of room volume depending on the type of music (amplified music, loud acoustic music and quiet acoustic music), see Figure 3. The recommended reverberation time is for fully furnished rooms without audience. More information about this standard is available in ref. (3).

The reverberation time 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.

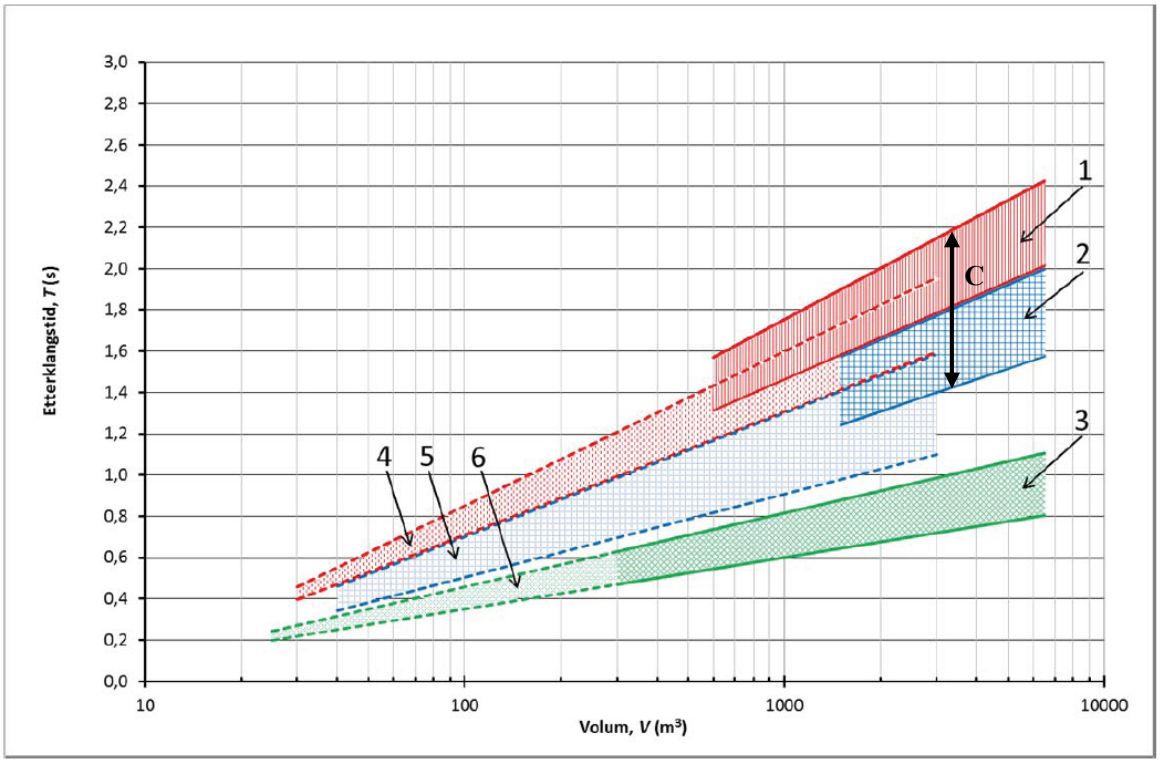

Figure 3 - Reverberation time (mid frequencies) as a function of volume after NS 8178 (1).
Regions with full lines are for performance spaces and regions with dotted lines are for rehearsal rooms.
1 and 4: Quiet music. 2 and 5: Loud music. 3 and 6: Amplified music.
C: The hall in Munch museum.

3.2 Geometry of the hall

Figure 4 shows a 3-D illustration taken from the architect's ifc model.

Figure 4 - 3-D model of the multipurpose hall illustrating a mixture of the two set-ups for audience seating: telescopic seating setup or arena/flat-floor setup (Courtesy of estudio Herreros)

3.3 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
Diffusing/Curved walls, 0% perforation	0,23	0,16	0,12	0,12	0,12	0,14
Diffusing/Curved walls, perforated	0,41	0,84	0,67	0,64	0,50	0,37
Audience on flat floor	0,35	0,45	0,57	0,61	0,59	0,55
Empty upholstered chairs	0,40	0,50	0,58	0,61	0,58	0,50
Telescopic seating	0,15	0,11	0,10	0,07	0,06	0,07
Curtains, 90 mm from wall	0,18	0,24	0,38	0,63	0,70	0,73

Figure 5 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 5 - Sound diffusing/curved solid wood panels, 218-270 mm cavity
(Courtesy of estudio Herreros).
Picture of the lab model at the bottom for measuring the sound absorption coefficients

3.4 Odeon calculation results

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

1. Telescopic seating 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 seats, flat floor, 50 m^2 stage (h = 500 mm), with or without sound absorbing curtains.

Figure 6 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 as recommended in NS 8178 (1) is shown (the three straight lines).

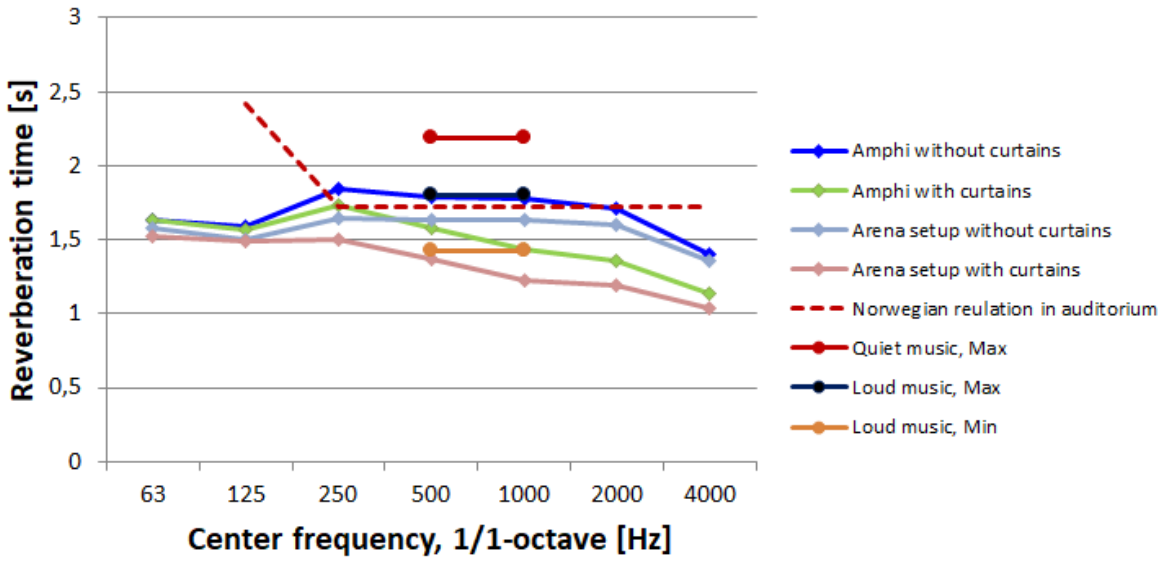

Figure 6 - Calculated reverberation time for the telescopic seating and arena setup without and with curtains compared to the recommend range for performance of acoustic music.

Due to the large seating surface for the arena set-up, this will be less reverberant than the telescopic seating setup, but both setups are still considered suitable for acoustical 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 (1), see Figure 7.

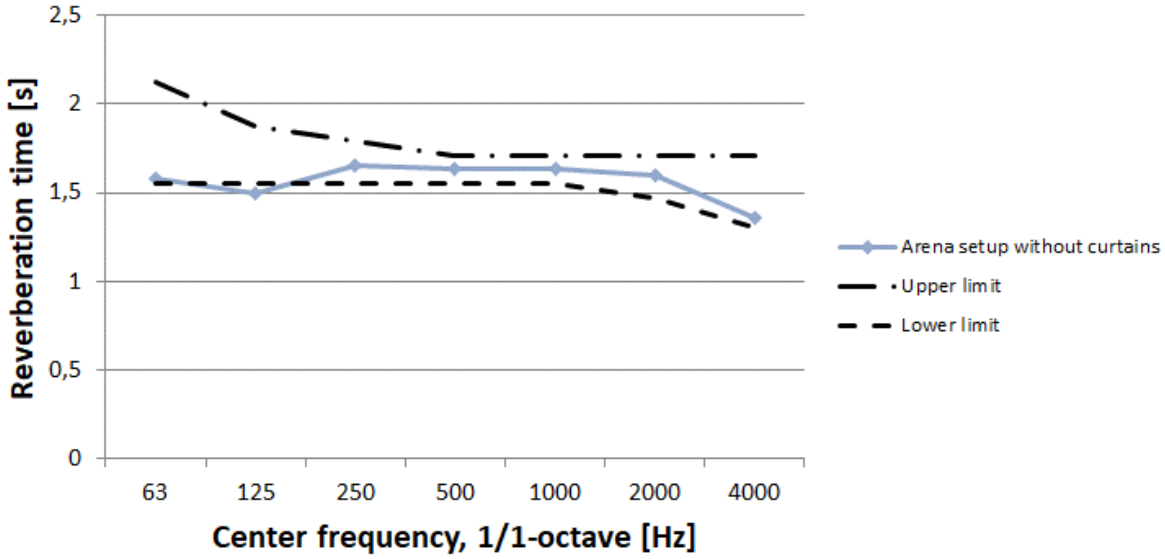

Figure 7 - Calculated reverberation time as a function of frequency for the arena setup (flat floor, 50 m^2 stage) without sound absorbing curtains. The upper and lower limits shown are for performance of acoustic music according to NS 8178 (1).

Table 2 summarize the calculated sound strength G together with calculated mid-frequency reverberation times, and for each set of calculated parameters, the hall's ideal function is specified.

Table 2 – Calculated sound strength and reverberation time (mid-frequency) for the two audience arrangements

Alternative	Sound strength G [dB]	Reverberation time [s]	Suited for
Telescopic seating without curtains	10	1,8	Quiet acoustic music, min.
Telescopic seating with curtains	9	1,5	Loud acoustic music, min.
Arena setup without curtains	12	1,7	Loud acoustic music, max.
Arena setup with curtains	10	1,3	Loud acoustic music, min.

4. THE EXHIBITION HALLS

4.1 Acoustic Design Criteria for the exhibition halls

Norwegian regulations (2) are strict when it comes to reverberation times in museums. The strict requirements came in 2012 in order to reach the desired level of sound quality for hearing disabled audience. The intention was good, but for the new Munch Museum it has given the acoustician some challenges when it comes to finding enough available surfaces for sound absorbing materials. The walls will mainly be covered by paintings and the remaining wall surfaces should easily be repainted, changing the background color from one exhibition to the next.

In Norway the reverberation time (in s) should not exceed 0,2 multiplied by the ceiling heights (in m), which in the case for the Munch museum leaves us with requirements of maximum 0,8 s and 1,4 s in respectively 4 m and 7 m tall exhibition halls.

4.2 Geometrical Facts

In total there will be nine halls of 4 m height in the museum, and two of 7-8 m height. The width of the hall is approximately 17 m and the length of the halls varies between 20 and 30 m. Figure 8 shows the 3-D calculation model from Odeon for a typical exhibition set up of mobile walls.

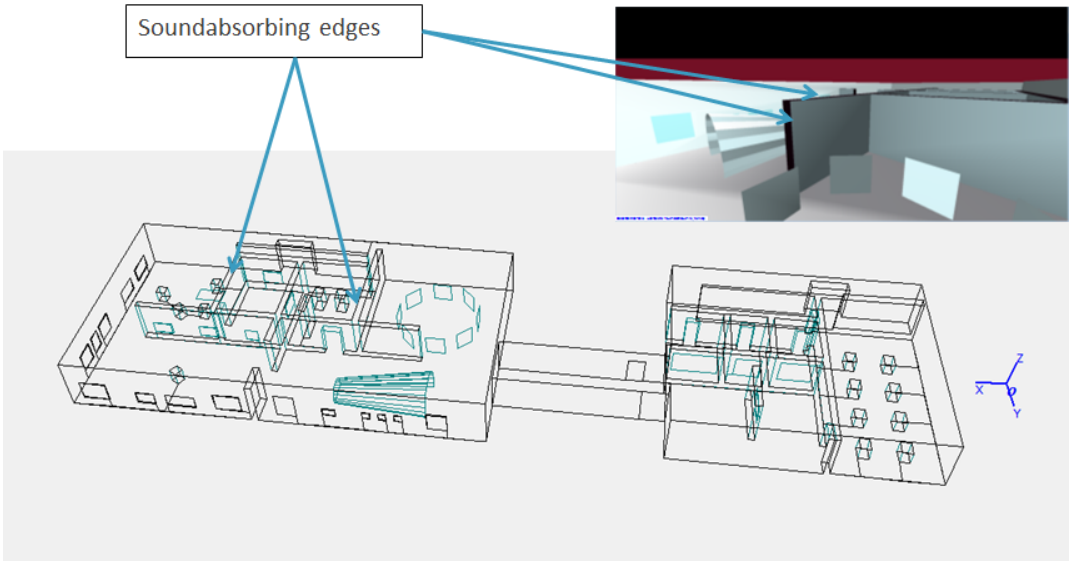

Figure 8 – Odeon calculation model of the two exhibition halls on floor 8 with a typical set up of mobile walls.

As indicated in Figure 8, the mobile walls of 50 mm thickness are covered by sound absorbing material in order to contribute to the sound absorption of the halls. The more mobile walls the less reverberant the halls will be, as shown in Figure 9 presenting calculated reverberation curves for different set ups.

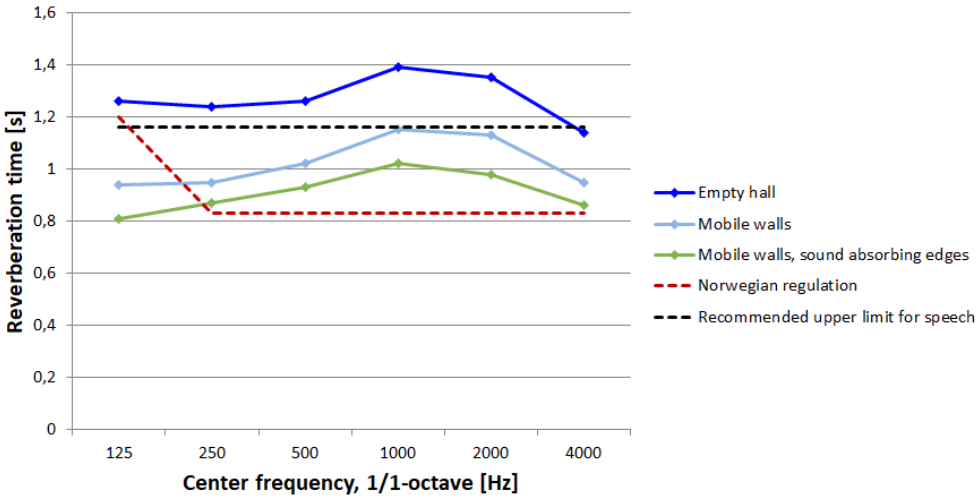

Figure 9 – Calculated reverberation times for different set ups of the exhibition halls compared to recommended reverberation time in Norwegian regulations (2) and recommended reverberation time for speech (4).

Figure 9 shows that the recommended reverberation times are exceeded for empty halls, and different compensating actions will therefore be needed as listed below:

- All mobile walls will be built with sound absorbing edges
- The loudspeaker system is designed with a high speech transmission index: STI ≥ 0,6
- The audience will be guided to the hall through highly absorbing sluices
- Visitors are offered personal audio guides or headsets for private cell phones
- All guided tours will have electro acoustical facilities
- For empty halls, the maximum recommended numbers of visitors are equal to the acoustical capacity of the hall.

The acoustical capacity (5) of the halls were calculated using the method described in (6). The calculated acoustic capacity for the halls of 4 m height was approximately 110 visitors, and approximately 80 visitors in the halls of 7-8 m height. The representative of the museum is informed about the hall's acoustic capacity. If more visitors are present than the acoustic capacity it might still be satisfactory, if the percentage of visitors talking at the same time is low.

5. FINAL REMARKS

The rather spacious multipurpose hall of the Munch Museum will make it possible to pass on the museum's tradition of having acoustical music performances. A conference set up will require the use of electro acoustical facilities.

The exhibition halls of Munch will have longer reverberation times than recommended due to the lack of available surfaces for sound absorbing material, but with restrictions to the number of visitors in each hall and with the use of electro acoustical facilities, satisfying conditions for speech will be ensured.

REFERENCES

1. Standard Norge, NS 8178, Acoustic criteria for rooms and spaces for music rehearsal and performance. Norway, Oslo, 2014. (English and Norwegian editions). http://www.standard.no/en/
2. Standard Norge, NS 8175 Lydforhold i bygninger. Lydklasser for ulike bygningstyper, 2012.
3. Rindel, J.H. New Norwegian standard on the acoustics of rooms for music rehearsal and performance. Proceedings of Forum Acusticum 2014, Krakow, Poland, September 2014.
4. Sintef Byggforsk, "527.300 Romakustikk", 1998
5. Rindel, J.H. Acoustical capacity as a means of noise control in eating establishments. Proceedings of BNAM 2012, Odense, Denmark, 18-20 June 2012
6. Rindel, J.H, Christensen, C.L, Gade, A.C. Dynamic sound source for simulating the Lombard effect in room acoustic modeling software. Proceedings of Internoise 2012, New York, USA, August 2012.