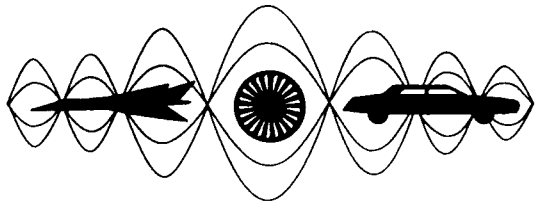

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ACOUSTICAL PLANNING OF A BUILDING CONTAINING BOTH APARTMENTS AND A THEATRE

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In Stockholm an old electric power station built in the 1920s is being converted into a combined theatre and apartment building. The four storey theatre contains 400 seats and it is flanked with apartments inside the power station on one side and in a new building connected to the old one on the other side. The foyer of the theatre and a restaurant are situated on the ground floor directly below some of the apartments. This poses a number of problems.

Before and during the design of the building an extensive acoustical investigation was made in order to fulfil the tough acoustical demands. It is hard to avoid disturbances from neighbours in a common apartment building and in this case the sound levels of the disturbances are quite different. The activities in the theatre must not cause disturbances in the apartments even though there are performances late at night.

Some of the considerations that had to be taken are presented and also some solutions that were used.

BACKGROUND

An old electric power station situated among apartment houses in one of the most noble parts of Stockholm was taken out of service in 1992. The station consists of a large machine-hall, 30 x 13 x 12 m, build together with an office building in four stories.

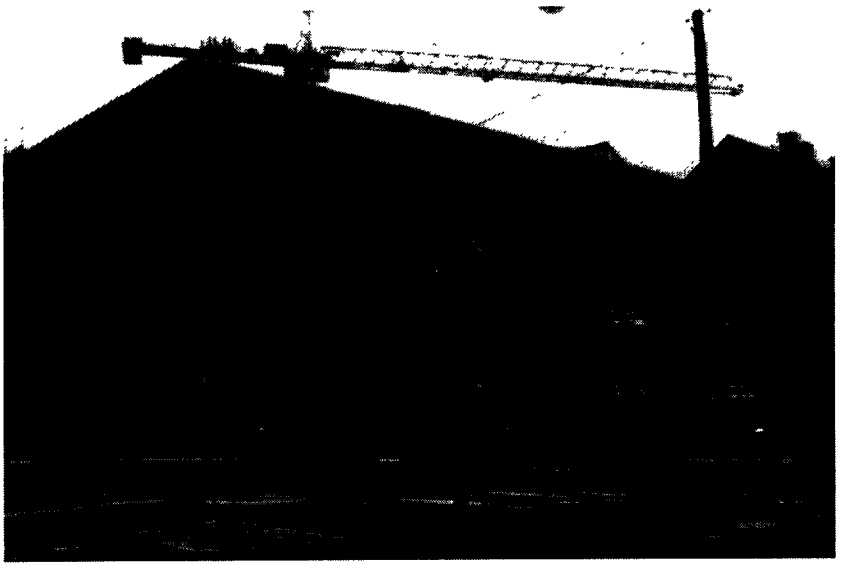

Figure 1.
The south facade of the old building.

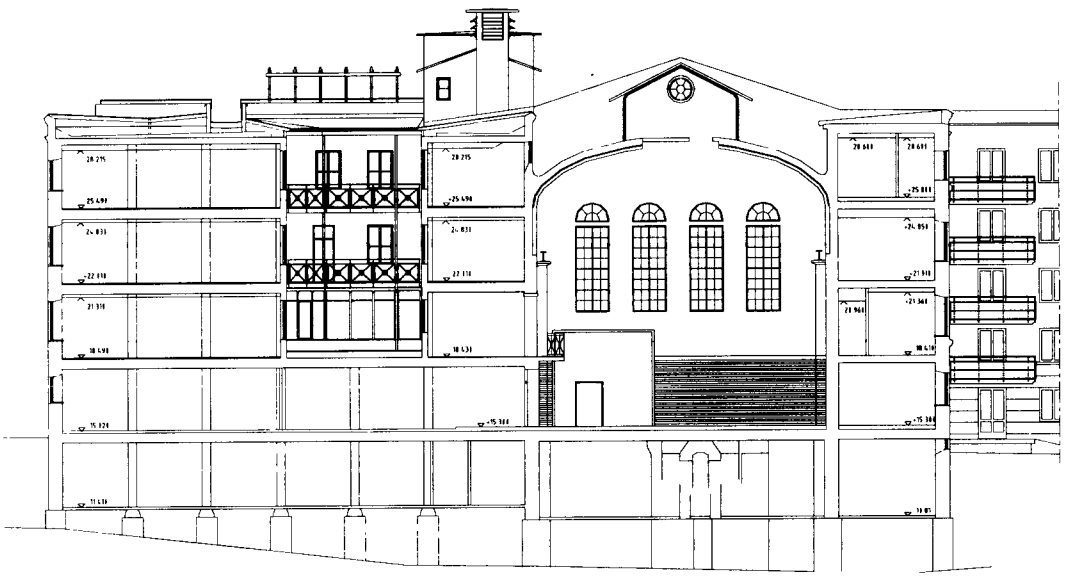

Figure 2.
Section through the old and a part of the new building.

The Royal Swedish Theatre was early interested to have the machine-hall as a scene for modern theatre for among others performances of rock musicals. The maximum sound levels during a rock musical can be as high as 115 dB within the octave bands 125 - 4000 Hz. These sound levels will of course give problems for the rest of the building as well as surrounding

buildings. In a theatre there are always a lot of construction activities going on. This can also create noise problems due to structure borne sound.

The intention for the office building was to have apartments with high standard, mostly for elderly people.

GOALS

In order to obtain a high acoustical standard in the apartments and in the theatre some goals was defined early in the project.

Maximum sound levels in apartment rooms due to music in the theatre.

Hours	Maximum sound levels, dB(A), Fast response
09.00 - 19.00	30
19.00 - 22.00	25
22.00 - 09.00	20

Maximum sound levels in apartment rooms due to construction activities in the theatre

Hours	Maximum sound levels, dB(A), Fast response
09.00 - 17.00	45
17.00 - 22.00	35
22.00 - 09.00	25

The goal for maximum sound levels in the theatre is 30 dB(A) and 40 dB(C) due to noise from the ventilation system and 25 dB(A) due to traffic noise.

MEASUREMENTS

The sound insulation between the machine-hall and the office building was measured before any building work had started. The sound level differences in octave bands were:

Octave band	31,5	63	125	250	500	1000	2000	4000 Hz
Sound level difference	35	45	50	55	60	60	60	70 dB

DISCUSSION

Without any measures, the sound levels in the apartment rooms will be about 55 dB(A) with rock music in the theatre. In order to fulfil the goals, the sound level difference between the theatre and the apartments had to be at least 35 dB(A) higher or in octave bands:

Increased sound level differences in octave bands between the theatre and the apartment rooms

Hours	31,5	63	125	250	500	1000	2000	4000	Hz
09.00 - 19.00	25	20	25	25	25	30	30	20	dB
19.00 - 22.00	30	25	30	30	30	35	35	25	dB
22.00 - 09.00	35	30	35	35	35	40	40	30	dB

The new building situated next to the theatre is build with a gap between the two building. Therefore, there will be no problems with transmission of structure borne sound from the theatre. However, considerations had to be taken to noise from large fan rooms and ventilation fans for the theatre since they are situated on the roof of the building close to the apartment building.

MEASURES TO IMPROVE THE SOUND INSULATION

In order to fulfil the sound level goals the following measures were taken:

- A sound absorbent ceiling was fitted in the theatre hall to reduce the sound levels and of course to improve the room acoustics. The sound absorbent ceilings of mineralwool reduces the reverberation time to 1,0 - 1,5 seconds.

- All rooms in the apartment building was designed with sound insulating ceilings. The construction consists of gypsum board and mineral wool. This was done to reduce the noise from the foyer and the restaurant on the ground floor of the apartment building.

- All rooms were also designed with sound insulating floors for the same reason as above. The construction consists of a parquet floor on top of heavy gypsum boards with foam rubber underneath.

- Most important of all measures is the noise-gap between the theatre hall and the apartments. The entire building was sawed in two separate parts with a gap of approximately

70 mm. In order to prevent the two parts of the building to be reconnected rubber pads was placed in the gap.

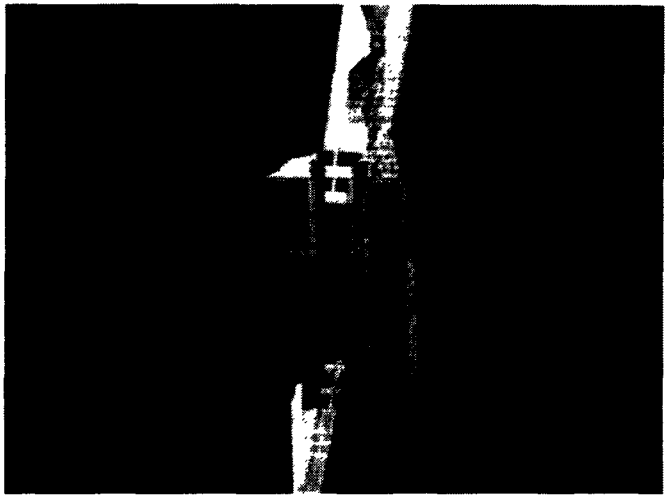

Figure 3.
Rubber pads were fitted between the two parts of the building after it was sawed in two parts.

- All installations, like water pipes and ventilation ducts, that passed the gap had to be mounted with resilient mountings in order not to transmit sound across the gap.

RESULTS

When this paper was written the theatre building was still under construction. The new building next to the theatre was ready but only a few preliminary measurements had been done. Measurement results will be presented at the conference.