CONSIDERATION OF REFLECTION COEFFICIENT AS A FUNCTION OF FREQUENCY FOR WEDGES OF DIFFERENT MATERIALS

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Abstract: The wedges made of foamed poly-urethane-ether could withstand large de- formations without any damage. They would show a considerable extension before breaking, but a very low stiffness made additional support of the wedge tips necessary for horizontal mounting.

1.INTRODUCTION

The wedges made of foamed poly-urethane-ether could withstand large de- formations without any damage. They would show a considerable extension before breaking, but a very low stiffness made additional support of the wedge tips necessary for horizontal mounting.

Figures. 1 and 2 show the reflection coefficient as a function of frequency for the different materials. On the basis of these investigations four different manufacturers were invited to give in tenders for the supply and mounting of wedges in the two planned anechoic chambers, as the opinion was that the price should also be taken into account in the total considerations.

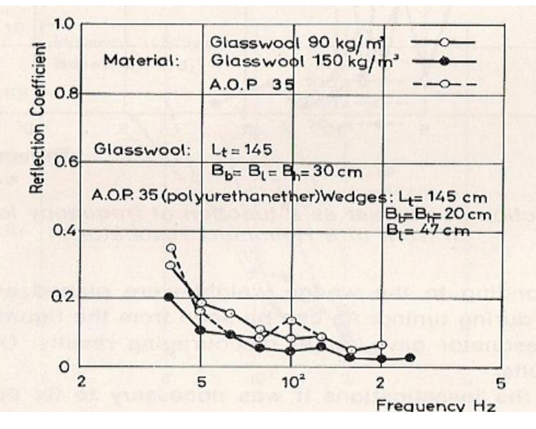

Figure1 *The reflection coefficient as a function of frequency for wedges of different materials*

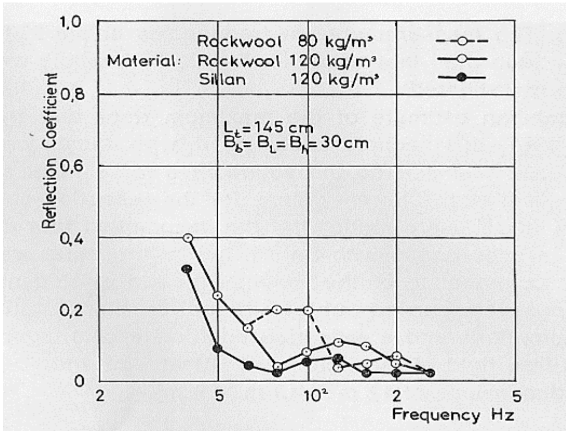

Figure2. *The reflection coefficient as a function of frequency for wedges of different materials.*

After a thorough testing of wedges from the two lowest quotations, Sillan wedges of specific density 120 kg/m', manufactured by GrOnzweig und Hart-mann, Ludwigshafen (Germany) were chosen as the best alternative.

Figure 3 shows the reflection coefficient as a function of frequency for the wedges chosen.

The measurements at frequencies above 250 Hz are carried out in a smaller tube than that shown in Fig. 3. Both whole wedges and parts of wedges were investigated.

In order to obtain an estimate of the maximum departure from a free field to be expected in an anechoic room lined with these wedges, a digital computer was used to calculate the sound field for a point source in rooms of different size and with different values for the reflection coefficients of the walls. The calculations were made with the assumption that the sound waves were reflected in accordance with Snell's law at the outer walls of the room and that phase coincidence of the reflected sound existed at the measuring point.

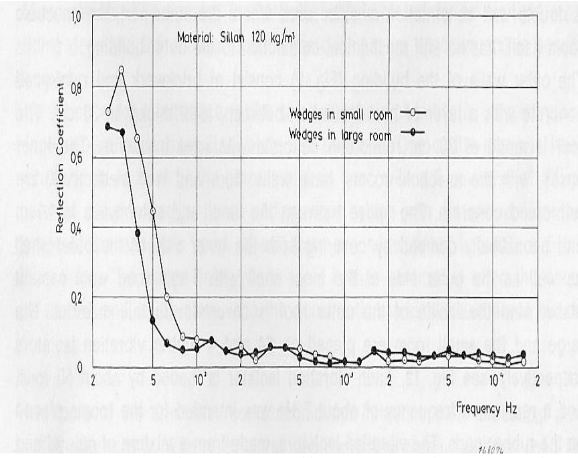

Figure3. *The reflection coefficient as a function of frequency for wedges used in the anechoic rooms*

Calculations were carried out for different positions of the sound source. With these assumptions and a reflection coefficient of 0.1 one should have a departure from free field of maximum ± 1 dB at 2 m and ± 3 dB at 11 m in a room of free dimensions of 12 m X 10 m X 9 m.

3.Sound insulation

As the anechoic rooms were also intended for a number of psycho-acoustical measurements, it was desirable to have a background noise level of about 10 dB below the threshold of hearing at frequencies above 200 Hz, whereas for frequencies below 200 Hz a level lower than 10 dB re 2 X 10-5 N/m' was required.

For extraordinary outdoor sound levels, such as those caused by jet aircraft at low altitudes, slightly higher background levels would be acceptable.

It would, however, be an advantage if normal acoustical measurements were not appreciably disturbed even in these cases.

These requirements necessitate a wall construction, which has a transmission loss of about 80 dB at 200 Hz, as a background level of 60-70 dB re 2 X 10-5 N/m2 must be expected outdoors during working hours. In order to achieve this, a double wall construction must be used where the inner part, the anechoic room itself, has no stiff mechanical connection to the outer building.

The outer walls of the building consist of brickwork and reinforced concrete with a layer of heat insulation between, total thickness 30 cm. The roof is made of 20 ern reinforced concrete with heat insulation. The inner boxes, with the anechoic rooms, have walls, floor and roof made af 40 ern reinforced concrete. The space between the inner and outer walls is 1.1 m and acoustically damped by covering both the inner side of the outer shell as well as the outer side of the inner shell with 5 cm wood wool cement slabs. Also the inside of the outer roof is covered with this material.

The large and the small room are placed on 24 and 4 rubber vibration isolators respectively, see Fig. 4 .

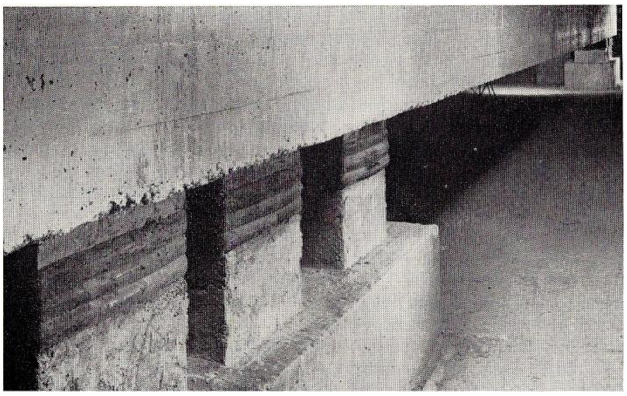

Figure 4. *Vibration isolators for the large anechoic room.*

Each vibration isolator is loaded by about 50 tons, and a resonance frequency of about 7 Hz was intended for the rooms placed on the rubber pads. The vibration isolators, made from a mixture of natural and artificial rubber (hardness 50° shore) are protected by a layer of neoprene and placed so that they can be inspected and replaced if necessary.

4.Doors

The doors are important parts of the construction with regard to lining and sound insulation. For the large anechoic room the entrance, which is 2.5 m X 2.7 m, is closed by two door sections travelling on rails and made up from three layers of steel (10 + 5 + 5 m) with concrete in between and covered with wedges. When the doors are closed the wedge lining of the room is thus continuous. For practical reasons there is also a hinged door covered with mineral wool, which can replace one of the door sections for less critical measurements. The opening in the outer wall is closed by an air tight steel sliding door and the

corridor outside the door has no windows and is heavily damped.
The 2.2 m X 1.6 m entrance to the small anechoic chamber is closed by two hinged doors made from steel plate and concrete. One of the doors is lined with wedges. In front of the other, which is lined with a 5 cm layer of Sillan, there is a light, wedge lined, sliding door which can be slided into the corner of the anechoic room where there are no wedges, but only a 5 cm Sillan lining. The wedge lining of the room is thus continuous when the doors are closed, and at the same time the construction is simple and saves space.

5.Floors
The floors of the anechoic rooms should not influence their acoustical properties appreciably. Wire netting was decided upon, which has been used for many anechoic rooms with satisfactory results. The mesh size was chosen to be 50 mm using 2 mm diameter steel string for the large room and 3.5 mm for the small room. The smaller wire thickness in the large room makes it necessary for people to use large overshoes with wide rubber sales when walking around in the room, in order to protect the strings and to distribute the weight over a larger area.
In the smaller anechoic room, which is used partly by the students, the influence of a thicker wire has been accepted, in order to avoid the use of extra shoes. The wires are fixed to adjustable tension grips situated on the outside of the inner concrete box. Each wire is pre-stressed by 200 kg, so that the deflection with a person (75 kg) situated at the center of the floor is about 1 cm.
The maximum load for each netting is 1,000 kg, however it must be distributed in such a way that the load per meter of the periphery of the load does not exceed 100 kg.
The wire nettings are electrically isolated from the building. This is done in order to reduce the risk of electric shocks from measuring instruments and to make it possible to fix the potential of the floor at any desired level independent of that of the surroundings.
The nettings are placed at the same level as the floors of the outside rooms and the central planes of the anechoic rooms, where most of the measurements will be taken, are situated about 1.5 m above the nettings. Parts of the rooms which are below the nettings can be reached through removable gratings in front of the doors.
A fine mesh perion netting is placed below the steel nettings, in order to catch small items accidentally dropped.

6.Lighting
As the linings of the rooms are highly insulating with respect to heat, the lighting must give a minimum of heat radiation. At the same time it is necessary to have quite a high light intensity in order to be able to work with small microphones, hearing aids etc. As the wall lining is also very light absorbing and as no reflectors can be tolerated around the lamps, which must also be placed as far away as possible from the measuring area, the lighting installation must have the highest possible conversion efficiency.
The main illumination comes from 200 W mercury vapour lamps, 12 in the large room and 2 in the small room. As these lamps ignite slowly and are probably not completely noiseless, there are also a set of ordinary 200 W incandescent lamps which may be used separately, 8 in the large room and 2 in the small room. It is a relatively simple matter to remove the lamps if this should be necessary for acoustical reasons.

7.Ventilation
The ventilation system is dimensioned with a view to obtaining a suitable rate of change of air in the rooms, and at the Same time to avoid any appreciable increase of background noise level with the system operating. In both rooms the ventilation system consists of a row of air inlets along the bottom of the walls of the room and outlets along the top of the opposite wall. The fans are placed in the basement outside the anechoic rooms, and on its way into the rooms the air passes through two long, heavily damped concrete ducts, which are connected by flexible tubes. The exhaust air is similarly taken through two concrete ducts connected by flexible tubes to the fans with outlets into open air.
For the large anechoic room the ducts are 16 m and 10 m long with internal cross-section 70 cm X 80 cm. The thickness of the concrete wall is 10 cm. The acoustical attenuation is obtained by lining one of the inner walls with 50 cm mineral wool, which is divided into sections by thin metal plates to avoid sound transmission through the material along the ducts.
The ducts for the small anechoic room are 7 m and 5 m long, and their concrete walls are 10 cm

thick. The internal dimensions are 45 cm X 60 cm and the sound absorbing lining consists of a 20 cm layer of mineral wool along one wall, divided into sections as that for the large room.
The inlet and outlet nozzles in the anechoic rooms are made of sheet metal and to avoid sound radiation from possible vibrations in the nozzles, these are covered externally with a 5 cm layer of mineral wool. The inlets and outlets in the large room have the dimensions 6 cm X 100 cm and in the small room 6 cm X 40 cm.
Also the ducts leading to the open air inlets and outlets are heavily damped so that noise from the fans will not disturb measurements in rooms situated on the same side of the buildings as these openings.
The air can be changed 4 to 5 times an hour in the large room and 12 to 17 times per hour in the small room. The air speed at the inlets and outlets into the rooms is about
2.9 m/sec. Starting and stopping of the ventilation machinery and control of the air temperature is conducted by control knobs outside the doors for each room. It is not, however, possible to obtain a lower air temperature than that of the outside air as there is no refrigeration system. A refrigeration system was discussed during the planning stages, but due to the particular insulating properties of the wedges, which made calculations difficult it was decided to leave space for a refrigeration unit but to delay the procurement and installation until the room had been used for some time. Experience from 1966-67 does not indicate any need for refrigeration of the air.

8. Conclusion

The measurements carried out show that both anechoic rooms can be used even for very exacting measurements, the data for the large room probably representing something near the limit of what one can achieve today.
From the background noise measurements it is seen that it has been possible to attenuate the noise from the ventilation system to such a degree that the ventilators may be used even during psycho-acoustical tests.
The insulation against noise in the vicinity of the buildings is extremely good, in as much as even with sound pressure levels of the order of 110 dB re 2 X 10-5 N/m' the sound pressure inside the room just reaches the threshold of hearing. It is therefore possible to carry out a large number of normal acoustical measurements in these rooms even under extreme outside condi- tions.

Bibliography

[1]. Rivin, A. N.: An Anechoic Chamber for Acoustical Measurements.
[2]. Soviet Physics-Acoustics, 7, (2002), No.3.
[3]. Wiuff, A E.: Eksamensprojekt 2005 (Master Thesis), DTH, Copenhagen,
[4]. 2006 (in Danish).
[5]. Nissen, Preben: Bending Moments in Members of Tension and Stressed Wires Subject
[6]. to Concentrated Transversal Loads. Bygningstekniske Med- delelser, 38 (1997), nr. 1 (in Danish with an English Summary).