Sound reduction of open noise screens

Jan Hardlooper

Cauberg-Huygen Consulting Engineers, Postbus 9222, 3007 AE Rotterdam, Netherlands
j.hardlooper@chri.nl

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Abstract Open noise screens consist of vertical absorbing screens with a depth of 1 meter, placed perpendicular to a building with a mutual distance of 1 meter. Open noise screens combine a sound reduction of 13 dB with a very open character for ventilation and daylight admittance. Measurements are carried out on a scale model (1:40) in a laboratory and in situ on a real size mock-up, built in a 40-ft container. The results of the mock-up are comparable to the laboratory results. Frequency analysis shows the acoustical principles of the screens and the effect of several parameters. A calculation model is developed tot predict the results for other configurations. The principle of open noise screens is successfully applied for 200 new dwellings in Amsterdam. Suggestions are given for applying open noise screens near highways and railroads, instead of traditional closed screens.

1 Introduction

When buildings are situated near roads, railways or industrial areas the noise of these sources sound be minimized to reduce nuisance for people in the buildings. The choice for adequate measures should start with the source and should end with the receiver. First of all measures on the sound source itself should be investigated. Silent roads and vehicles provide the best means to eliminate the sound. These measures however are in common very expensive en not easy to realize. Useful results require legislation on national and European scale and will take several years. The placing of screens between sound source and receiver is a second and quite efficient way to reduce the nuisance at the receiver point. The disadvantage of placing of screens is the creation of barriers in the landscape or in the city. In some situations screens should be avoided for reasons of safety and efficiency of the road. Therefore screens pose not only major problems in town planning, but reduces the view from the road on the city and vice versa as well. Usually the third and final step is to isolate the building facade and reduce the sound in the building. The major disadvantage of applying only the third step is that the acoustical situation around the building is not improved.

Recent developments in town planning and architecture show a tendency to place screens at a short distance of buildings, approximately 1 – 3 meters. By doing so the direct surrounding of the building is improved and town planning is not affected. Especially when the sound source is situated on the desired south side of the building the space between screen and building can be used as balcony or winter garden with a climate that can be characterized as semi open. In the Netherlands this solution is also applied due to the national legislation. When the sound level on a certain location exceeds the legal maximum realization of buildings is only possible when a screen is attached to the building or when the building facade has no parts that can be opened. Both solutions have a quite negative influence on the quality of the building; for comfort reasons a building facade should have parts that can be opened. Placing a screen at a very short distance from the building on the other hand influences the fire safety of the building. Between screen and building fire and smoke will accumulate, due to insufficient ventilation. Therefore solutions should be found that can be qualified as open for ventilation but still have a significant sound reduction. The solution also should provide a sufficient daylight admittance to make it possible to situate rooms on the high sound level facade. The optimum solution should be open for light and ventilation, but closed for sound. The purpose of the present investigation is to determine the acoustical properties of a proposed solution for this problem: an open screen.

2 Description of open screens

Open screens consist of vertical sound absorbing panels, placed perpendicular to the building. The depth of the panels vary from 0,5 to 1,0 m. The thickness of the panels is 0,2 m with a mutual distance of 0,5 to 1,0 m. The panels are placed at a distance of 1,5 m from the building. The panels can be made of perforated aluminum or steel, thickness approximately 1 mm, resulting in an absorption coefficient of approximately 0,8 from 125 to 4000 Hz. The panel should be filled with an open structured absorption material which sufficient sound isolating properties (+/- 15 dB). Placing a closed structure in the center of the panel is also possible, but will reduce the absorption characteristics. Figure 1 shows the floor plan of a building with an open screen attached to it. The depth of the panels is 1,0 m with a mutual distance of 0,5 m. From the figure it can be seen that a total angle of 35 degrees for daylight admittance is realized. This angle is sufficient to fulfill the minimum requirements. The figure also shows that the view on the road, seen from the building, is reduced from 180 to 35 degrees. When sound is only described as traces (which is not a correct way, as will be shown in chapter 3.3) a very rough estimation of the sound reduction of 7 dB is obtained. The screens can be characterized as 80 % open for ventilation.

With the chosen dimensions it is possible to place the entrance of dwellings behind the open screen. The vertical structure gives architects enough possibilities to create an acceptable facade. Figures 1 shows a possible facade. The facade shown consists of vertical screens placed to reduce sunlight admittance.

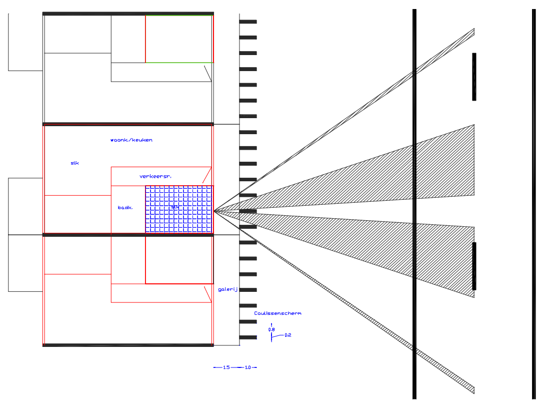


Figure 1 Floor plan of dwelling with open screens.

3 Measurements

3.1 Scale model

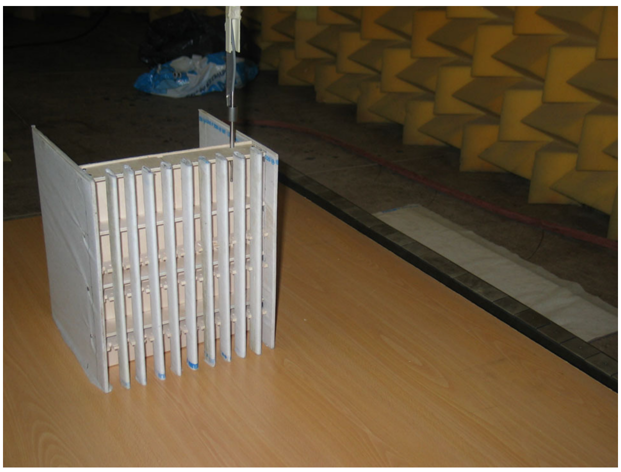
At the Technical University of Delft measurements were carried out to determine the sound reduction of open screens. For reasons of efficiency and costs the measurements are carried out using a scale model, 1:40. The purpose of the investigation is to obtain an indication of the sound reduction that can be achieved with open sound screens.

For practical reasons the frequency ranges from 63 to 4000 Hz. The road was simulated with a pneumatic line source. Figure 2 shows the scale model used. The model is made of wood and the panels are covered with a thin sound absorbing material. Three configurations are examined as described in table 1.

Table 1 Configuration of scale models for open screens. The shown dimensions are not scaled.

Name	orientation building to road	panel length (m)	panel thickness (m)	mutual distance (m)
PAR 1	parallel	1,0	0,2	1,0
PAR 2	parallel	1,0	0,2	0,5
PER 1	perpendicular	1,0	0,2	1,0

PAR 1 corresponds figure 1. The building is placed parallel to the road. The view on the road, seen from the building is 35 degrees. PAR 2 has the same orientation, but has twice as much panels as PAR 1. PER 1 has the same number and configuration of panel as PAR 1, but the building is placed perpendicular to the road. The total angle for daylight admittance of PAR 2 is not enough to fulfill the minimum requirements.



3.2 Mock-up

The scale model results give a good indication for the acoustical insertion loss. In the housing project “Laan van Spartaan”in Amsterdam the open noise screens are applied for approximately 200 dwellings. A further investigation in form of a mock-up scale 1:1 was the next step.

In order to get a good understanding of the acoustical principles and to determine the sound reduction for several combinations of mutual distance, the angle of the screens , true road noise as sound source and the orientation towards the road a mock-up was made. The mock-up consists of a 40 ft container in which absorbing panels are placed. The container is transported to a placed near the highway Rotterdam – Antwerpen. Figure 3 shows the mock-up.

Figure 3 Mock-up, scale 1:1

The angle of the screens can be varied from 0 to 30 degrees

4 Results

4.1 Scalemodel

Figure 4 shows the results for the scale model

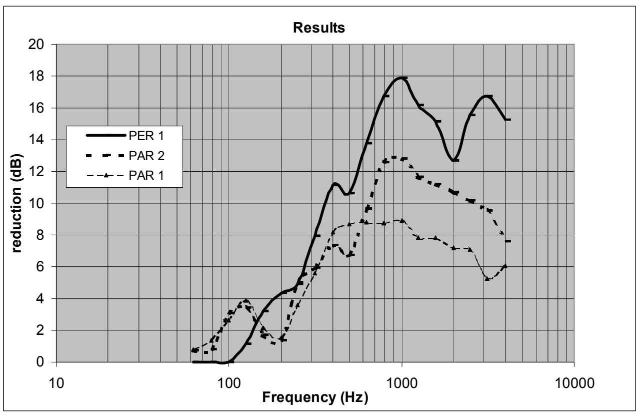


Figure 4 Measerements results scale model

The overall road noise weighted insertion loss for the configurations PAR1 en PER2 are respectively 8 and 12 dB.

4.2 Mock-up

Tabel 2 shows the resultst for the mock-up measurements. The results are presented as road noise weighted insertion loss.

Tabel 2 Results mock-up measurements

Orien-tation	Mutual distance (m)	Angel	Insertion loss in (dB)
PER	0,9	0°	11
PER	0,9	30°	13
PER	1,2	0°	9
PER	1,2	30°	11
PER	1,8	0°	6
PER	1,8	30°	8
PAR	0,9	0°	8
PAR	0,9	30°	9

PER indicates that the container is placed perpendicular to the road, PAR indicates a parallel orientation. An angle of 30 degrees indicates that the screens are turned away from the road, a higher reduction therefore can be reached.

It sound be noted that the first and the seventh configuration are comparable with PER1 and PAR1 in the scale model.

5 Discussion and conclusion

5.1 Discussion

The results of the mock-up compared quite well to the scale model, not only spectral, but also in the road noise weighted overall reduction.
Turning the screens with 30 degrees give an extra reduction of 1,5 dB.
As was expected, the insertion in perpendicular orientation is higher than when the container is placed parallel to the road.
A significant reduction is found for higher frequencies, with a maximum of 15 dB at 4 kHz (perpendicular, 0,9 m, 30 degrees)
Below 125 Hz the reduction of the open noise screens can be neglected.
Closing half of the openings between the screens with transparent glass give an extra reduction of 3 dB. The daylight admittance is very little reduced and ventilation is still enough to meet the Dutch rules for dwellings.
The acoustical behavior can be understood in terms of reflection and transmission. The line character of roads and railroads lead to a situation where most of the line source can not be seen from the receiver. With point shaped noise sources like industrial machines a lower reduction that measured in this survey is expected.
A reduction of 8 or 9 dB for an orientation parallel to a road is enough to make open screens an acceptable alternative for closed screens. Increasing the width of the screens or lowering the mutual distance can increased the insertion loss. The open character in terms of view through the screens, wind effects, pollution and graffiti, make open noise screens a better solution than traditional screens which often lead to problems as mentioned.

5.2 Conclusions

With open noise screens a sound reduction of 8 to 13 dB can be reached in combination with sufficient daylight admittance and an almost completely open behaviour for ventilation.

Open noise screens have proven to be a successful alternative for traditional closed screens and can be applied for dwellings.

Further investigation is proposed to determine the effect of open noise screens placed near highways and railroads.