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INFLUENCE OF DIFFERENT BARRIER SURFACE PARTS ON THE INSERTION LOSS

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ABSTRACT
Insertion loss of barriers can be improved by variation of the surface impedance. The boundary element method has been used to study the importance of the boundary conditions at different parts of a 1 m tall noise barrier situated on rigid ground. The boundary conditions used are either rigid (v_n=0) or soft (Z=0). It has been shown that by changing the boundary conditions at the barrier edge from rigid to soft, the insertion loss is increased 3 dB for frequencies up to 350 Hz for low receiver heights. This was valid for both a low and a high source location. The insertion loss improvements was smaller if any other combination of barrier parts was used. The survey was constrained to low frequency because of program limitations.

1 - INTRODUCTION
Noise barriers are a common tool for noise abatement near highways, railways and other noise sources. Beside meteorological effects the efficiency of barriers is closely connected to its height, geometry and the acoustic properties of its surface. The influence of these parameters has been subject to numerous studies especially focusing on the barrier geometry and the impedance of its surface [1-2]. Barrier modifications have often been applied to the barrier edge [3]. It is a common view that modifications of the barrier edge result in the largest insertion loss improvements. It has been shown that an acoustic impedance close to zero increases the barrier performance in comparison to rigid or absorbing barrier surfaces. This has been demonstrated theoretically and experimentally for barrier caps consisting of resonators [4]. It has also been indicated that the optimum passive impedance is the zero impedance, at least for low source heights [5]. A further improvement can be achieved by applying an actively controlled surface impedance [6].
However, surface treatment methods, either active or passive, are costly. Costs might be minimised by locating such special surface elements (e.g. resonators) only at the most efficient positions. Therefore this paper focuses on the question which part or parts of the barrier that influences the barrier performance most, i. e. where the surface treatment should be applied in order to give as large improvement as possible.

2 - PROBLEM DESCRIPTION
The boundary element method (BEM) is used to calculate the insertion loss achieved by a 1 m tall and 0.2 m wide rectangular barrier with rounded corners using a mixture of rigid (v_n=0) and pressure-release (Z=0) boundary conditions. The geometry of the problem is shown in Figure 1. The barrier surface has been divided into seven parts; two parts on the front face (the side facing the source), three parts on the top face and two parts on the back face (see Figure 1 for details). The ground plane is rigid. Throughout this study two source heights have been used; 0.1 m and 2 m. The sources were located at a horizontal distance of 8 m in front of the barrier. The receiving points were located at a vertical line 20 m behind the barrier, between the ground and 10 m height. Due to high-frequency limitations in the BE program the insertion loss could only be calculated up to 350 Hz. Starting with a rigid barrier, the boundary conditions at combinations of parts have been assigned zero acoustic impedance. Combinations of one to six barrier parts have been used.

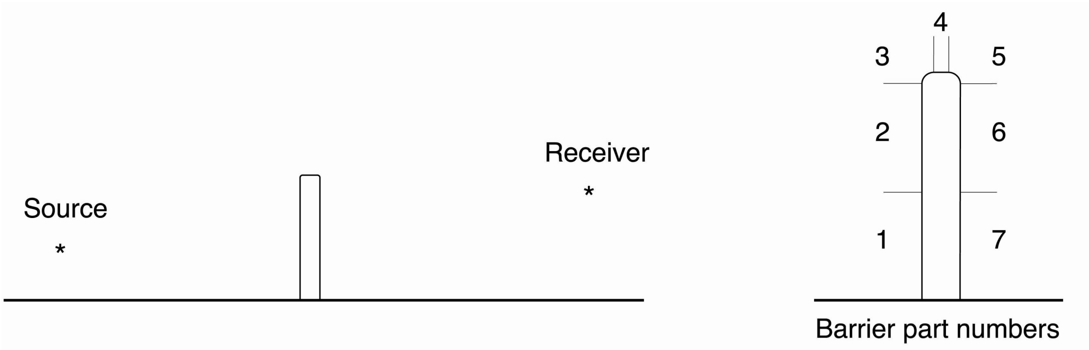


Figure 1: Problem geometry and specification of the barrier parts.

3 - INSERTION LOSS RESULTS

An example of the insertion loss achieved from a barrier with mixed boundary conditions is shown in Figure 2 together with insertion loss results for a rigid barrier and a zero impedance barrier. Mixed boundary conditions mean a combination of rigid and zero impedance surfaces. In Figure 2 either the front, top or back face has been given a zero impedance. Figure 2 shows also the relative insertion loss, *RIL*, for barriers with mixed and rigid boundary conditions at different frequencies.

$$RIL = IL_{test} - IL_{Z=0}, \text{ where test = mixed, rigid}$$

From the results in Figure 2 it is obvious that the largest differences are found at low receiver heights. Substitution of the rigid boundary conditions at the top face of the barrier into a zero impedance gives about 3 dB better insertion loss at low receiver heights than a rigid barrier. An increase of about 1 dB is achieved if either the front or the back face is substituted. The results are similar for all frequencies included in the survey.

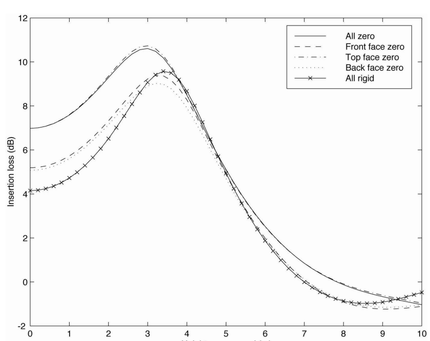


Figure 2(a): Insertion loss at 350 Hz for different zero impedance substitutions.

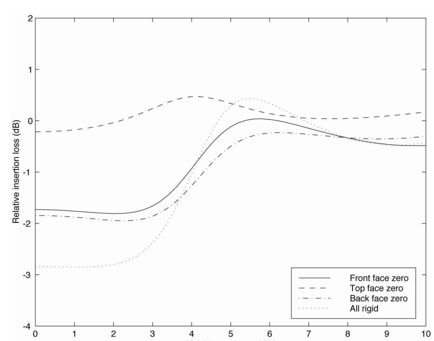
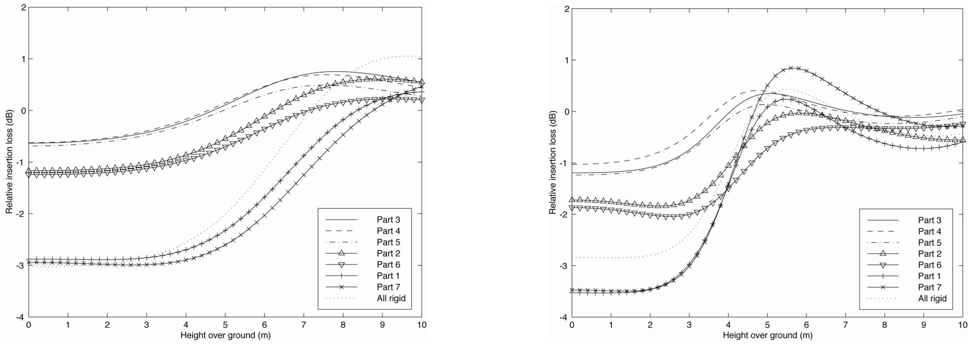


Figure 2(b): Relative insertion loss for zero impedance substitutions at 250 Hz.

It can further be seen in Figure 2 that the relative insertion loss for a zero impedance at the top face becomes closer to zero with increasing frequency. This may indicate that the barrier edge becomes more significant for the barrier's noise shielding capabilities.

A more detailed survey has been done to study which part of the top face that is most important. In this case only one of the seven parts was substituted with a zero impedance. Results from this survey can be seen in Figure 3.

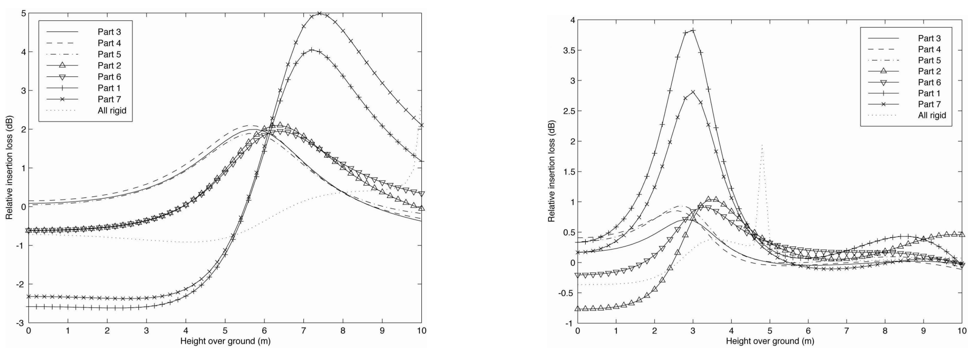
From Figure 3 it is clear that the relative insertion loss for the mixed boundary conditions form three different groups. The two barrier parts that are closest to the ground form one group (parts 1 and 7), the middle parts form one group (2 and 6) and the parts on the top face form one group (3,4 and 5). The difference in relative insertion loss between the parts in one group is small. Again it is clear that assigning a zero impedance to the parts on the top face gives better insertion loss than any of the other parts. However, the insertion loss does not become as good as when the boundary conditions at the entire top surface was substituted. According to Figure 3, the insertion loss can in fact be lowered by assigning a zero impedance to the parts closest to the ground (1 and 7).



(a): 125 Hz. **(b):** 250 Hz.

Figure 3: Relative insertion loss for zero impedance at one barrier part; the relative insertion loss for a rigid barrier is also included.

Calculations were also made for a barrier with zero impedance at all barrier parts but one. In this case the insertion loss decrease was small, irrespective of which part that was left rigid. Many other combinations of parts were also used, but no significant differences could be found. Most results were similar at the other frequencies included in the survey.



(a): 125 Hz. **(b):** 250 Hz.

Figure 4: Relative insertion loss for the high source location.

The results for a higher source location are slightly different. The barrier parts that seem to influence the insertion loss most are in fact the parts closest to the ground. As can be seen in Figure 4, assigning a zero to these parts results in a decrease of 2 dB at 125 Hz, but an increase of maximum 3 dB at 250 Hz. The results at 350 Hz showed only differences smaller than 1 dB.
The insertion loss results from the impedance substitutions are grouped in the same way as for the low source height, i.e., parts 1 and 7 give almost equal results etc. Assigning a zero impedance to any of the top face parts results in a slight insertion loss increase at two of the three frequencies, compared to the zero impedance barrier. The difference between the results inside a group are slightly larger. The relative insertion loss was small for combinations of more than one part.

4 - DISCUSSION AND CONCLUSIONS

The insertion loss results for the two source heights showed different dependency on the frequency and the boundary conditions. For the low source height the insertion loss was increased the most, compared to a rigid barrier, when the whole barrier was given a zero impedance. The insertion loss for a zero impedance barrier edge was not significantly lower. For the high source location a zero barrier edge increased the insertion loss slightly compared to a zero impedance barrier. Therefore it can be sufficient, and in some cases even better, to assign a zero impedance only to the barrier edge.
In a special case a larger increase was found when the barrier parts that were closest to the ground were assigned a zero impedance. This indicates that the source height is a significant variable when trying to optimise the boundary conditions. The results for the high source location appears to be more sensitive to boundary condition changes. Further studies on impedance distributions are needed, especially at higher frequencies. Convergence problems in the used BE program have limited this survey to frequencies lower than 400 Hz. This limitation will hopefully be removed during further development of the code.

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