A study of different calculation methods for noise barrier top edge designs

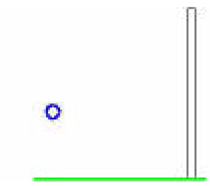
Pál Zoltán Bite and Fülöp Augusztinovicz
Budapest University of Technology and Economics, Department of Telecommunications
H –1111, Budapest, Magyar Tudósok kõrútja 1/b
bite ; fulop @hit.bme.hu

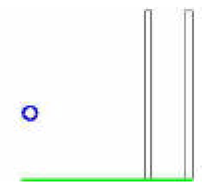
ABSTRACT

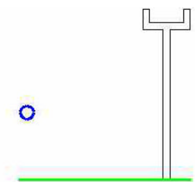
The modelling of noise control by barriers has become a common interest in nowadays environmental planning. A good, and efficient noise barrier must shield the receiver from the predominant portion of sound energy from the source. If the transmission through the barrier is negligible, the acoustic field in the shadow region is due to the diffraction caused only by the barrier edge. This paper presents the application of commercially used engineering software for calculation of diffraction caused by noise barriers. The investigation was based on a model for highway scenario with long barriers. Using coherent line source the three dimensions could be reduced into two. The comparison was divided in two directions: Firstly the prediction of the acoustical performance of vertical barriers with different top edge designs. Therefore a two dimensional BEM model was used, the top edges were modified, and the results were compared with the non modified equivalent barrier. Secondly the aim of this paper is to present a comparison between the some commercially used calculation methods. In order to prove the reliability of the presented investigation some modelled barriers were measured in a real surrounding. The noise absorbing performance of conventional barriers used in traffic-noise control can be significantly improved, by using the right top edge design.

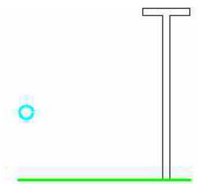
INTRODUCTION

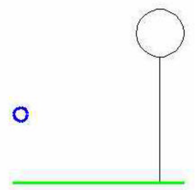
Our presentation discusses studying diffraction at the edges of noise barriers. Earlier studies have shown that, with properly designed noise barriers, even an installation sound reduction of +6 dB may be obtained. I have tested several types of noise barriers. To make the comparison easier, relative height of the barriers, the source and the distances of detection were identical. The distance between the source and the barrier was 2 m, its altitude was 1 m, and the height of the barrier was 2,54 metres. Detection field was made up of a 121-node mesh. The following types of barriers were compared:


Type 1


Type 2

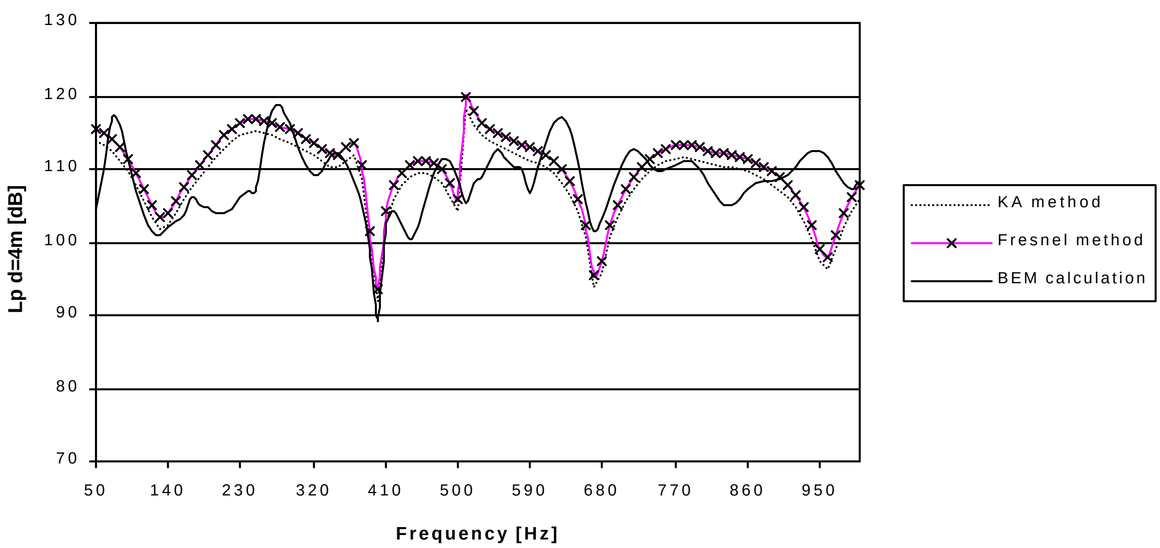

Type 3


Type 4


Type 5

First, sound pressure levels behind Type 1 barrier were compared. The first two results were calculated by the known Fresnel and Kurze & Anderson formulae, while the third graph is the result of the „Sysnoise" simulation. Results for the 121 nodes were calculated 4 m far from the barrier, at the height of 1 m.
Results are illustrated in Figure 1. Figure 1 shows that the process defined in the standards gives such a result, which is significantly different from that of the much more accurate simulation of the sound area. With the mathematical formulae by Fresnel or Kurze & Anderson, the diffraction in question can be calculated, by an approximation, for only 2 types of noise barriers. The other types cannot be processed by the simple mathematical formulae. In addition, the approximation for Type 2 barrier gave an unacceptably inaccurate result. Therefore, it is obvious that installation sound reduction for the 5 different noise barriers can be calculated only by sound area simulation.

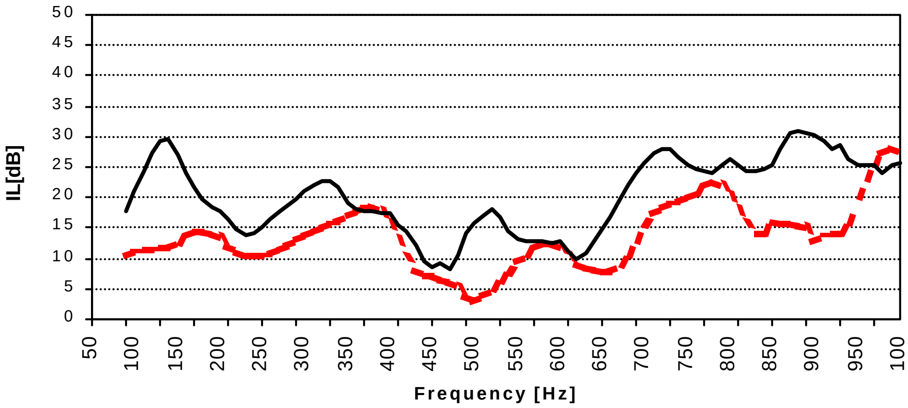
Compare of elemental methods



Noise barriers were modelled by Boundary-element method. Based on earlier studies, it is presumable that, in case the noise barrier is long enough (i.e. l > 300 m), two-dimensional modelling is sufficient. In case of 2D modelling, diffraction occurs only at the upper edge of the noise barrier. Element size was 0,01 m. A frequency range of 50 .. 1000 Hz was tested. I considered the barrier ideal, i.e. sound waves might enter the shadow zone by means of diffraction – through the barrier they may not. The model considered noise barriers and the ground to be made up of rigid elements. Reductor pipe of Type 5 was made up of a special sound absorptive material.

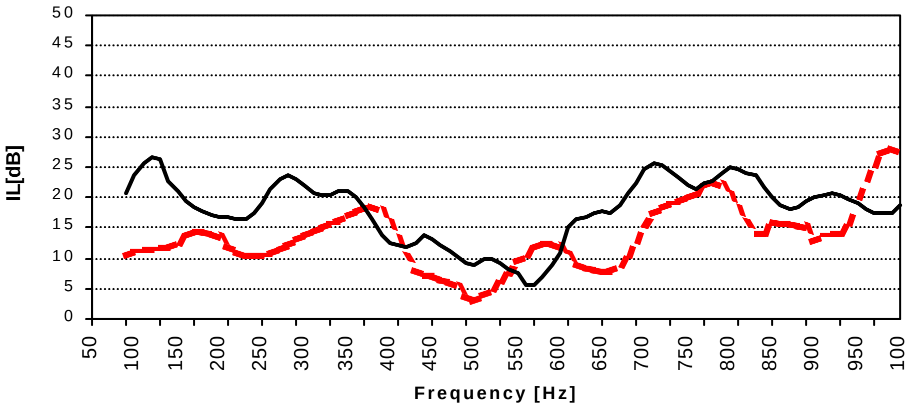
Figures 2 .. 5 show installation sound reductions of noise barriers, 4 m far from the barrier. Type 1 noise barrier of the same height forms the ground for comparison (jagged line).

Type 1 vs. type 2



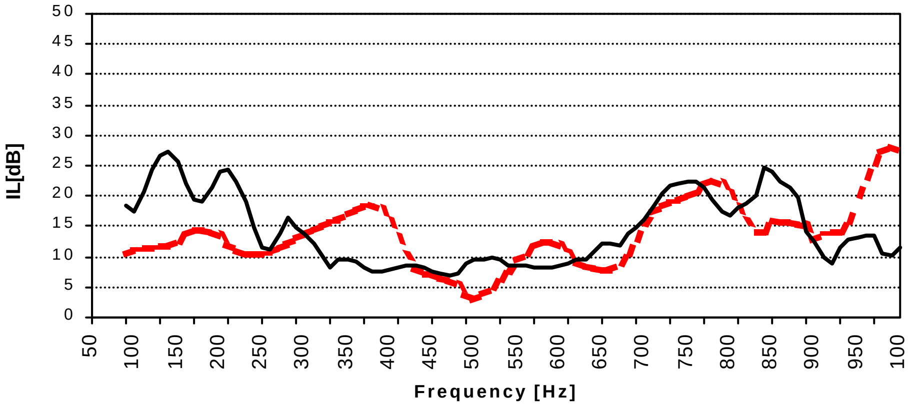
Type 2 features a considerably higher installation sound reduction. This is closely related with the distance of the two barriers. Considering diffraction, double wall represents a higher single wall.

Type 1 vs. type 3



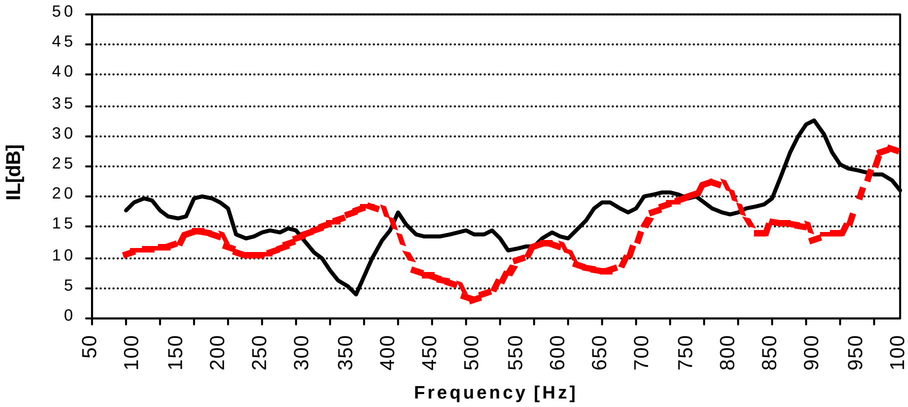
Compared with the above, Type 3 shows a lower reduction. However, its practical applicability is significant, due to its economicalness. It is clearly shown that the difference is considerable only up to approx. 400 Hz.

Type 1 vs. type 4



Our study showed that Type 4, in the size tested, did not give much better reduction than the flat barrier. By changing the dimensions of the T-profile, however, a significant result may be achieved.

Type 1 vs. type 5



Concerning this type, difference between reductions significantly decreased with the increase in distance; therefore this barrier should be used in case of greatly different sound transmission distances, if the observer is close to it.

It can be clearly seen that Type 2 has the best noise reduction, despite that all barriers were considered ideal. The second best is Type 3, then the reductor pipe and Type 4. These types give a considerably higher insertion loss than the flat barrier.

COMPARICON BY MEASUREMENT

Type 5 noise barrier was tested in free field as well. In practice, a 0,4-m high pipe element and a barrier element of the same height – both mounted upon a 2,1-m high noise barrier – were compared. Height of the barrier, the source and the distance of the receiver were identical with those in the model configuration.
The results were close to those from the calculation (see figure above). Up to 900 Hz (between 2,5 and 3,2 kHz), the reductor pipe has a better installation sound reduction than the flat barrier of the same height. Therefore, it is recommended for such applications, where the purpose is to reduce noise in the above range.

CONCLUSIONS

Practical measurement has proven the results of the calculation. It has been showed that, with properly selected noise barrier upper edge, a noise reduction increase by 6 dB can be obtained. Reductor edges, however, may presently not be taken into consideration in noise map calculations. The software programs I tested had, for instance, not shown any difference between Types 1 and 2. The other types could not even be programmed into the software, due to their profiles, which the software did not recognise. The simulation of the sound area behind the barrier would prove the great importance of taking upper barrier edges into exact consideration. The fact that programs do not distinguish between different types is primarily not a programming error. All countries have standards, e.g. RLS-90, NMPB 96, etc., that form the basis of these calculation. The main reason is that noise calculation standards presently in force use only the Fresnel distance-difference method for calculating diffraction, i.e. practical calculations do not use the results from the modern measurement technology yet.

List of references:

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