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Diffraction edges perceived efficiency

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Abstract

Today, noise barriers are recognized as the most effective noise minimization measures of road traffic noise near sensitive receptors located in the road surrounding areas. Especially where the urban occupation is characterized by buildings of low height. For higher buildings noise barriers can not be a completely effective solution. One of the additional measures to increase efficiency may consist of placing, on top of noise barriers, an edge for reducing diffraction more efficiently without significantly increasing its height. We present a case study in which diffracting edges were place few years after the implementation of noise barriers, and through the relationship between sound attenuation and noise perception it is possible to conclude that the benefits in population of this intervention are higher than expected.

Keywords: Noise Perception, Noise Barriers, Diffraction Edges

1 Introduction

The use of barriers is a common noise reduction measure from road traffic noise, in some countries of the world. The interposition of noise barriers, between the source and receiver, origin sound diffraction, reflection and absorption effects that are linked with the shape, materials and configurations of noise barriers. From the acoustic point of view, noise barriers can be reflective or absorbent. As for the geometry, noise barriers can be plain, tilted or curved. In order to improve barrier efficiency, without increasing its height, the use of diffraction edges in the barrier top is a solution. Effectively, being Portugal a country of high earthquakes activity, the use of noise barriers with 7 meters height requires an onerous infrastructure with difficult implementation.

Recently they have been developed many systems that apparently seem to have better acoustic performances than the plain barriers, widely used. Those new barriers have diffracting edges with T, Y and cylinder shapes. Many of these systems incorporate sound absorbent materials, or resonant cavities conceived in order to promote interferences between the sound diffracted waves. The use of diffracting edges on the top of a plain barrier, with a height of 2 meters, leads to an average improvement of their effectiveness between 0.5 and 3,5 dB (Anfosso-Lédée et al., 2005).

Ishizuka (Ishizuka and Fujiwara, 2004) did a series of theoretical studies using numerical simulation models for the determination of the effectiveness of noise barriers with 3 m height, with diffraction edges of various shapes and specific acoustical properties (absorbent, rigid, and not-rigid), based in the Boundary Element Method. In these simulations, the normalized European spectrum defined in standard EN 1793-3 was used for the noise of road traffic, The sound source was located to a distance of 8 meters of the central zone of the barrier that had 3 meters of height. The barrier insertion losses had been calculated for 6 positions of the receiver, at distances of 20, 50 and 100 meters of the barrier, and for two heights relatively to the ground (1,5 and 3 meters). In Figure 1 the results got for the average loss value due to the insertion of the barrier are presented (ILmean), for the different types of diffracting edges. Also in this picture presents the effectiveness of the diffracting edges relatively to the corresponding height of a plain barrier. This insertion loss average value (average, in dB, done for the six positions of the receiver) may be considered as a global measure for barriers efficiency, but the standard deviation shows the variation of efficiency of the different edge types.

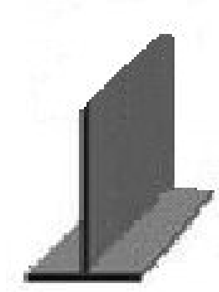
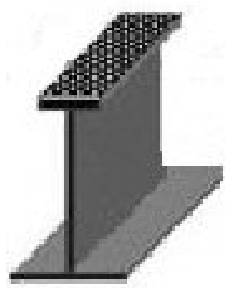
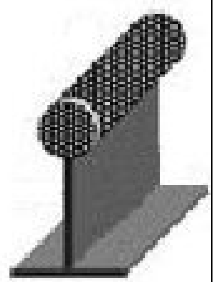
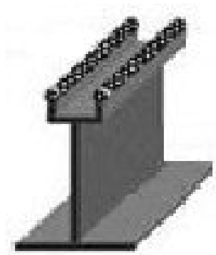
Barrier		ILmean [dB]	Diffractor effectiveness	Equivalent mean height of barrier [m]
Plain barrier (3 m)		15,2	-	-
Plain barrier + edge shaped (absorbing)		20,5	5,3	6
Plain barrier + Cylindrical edge (absorbing)		19,2	4,0	5
Plain barrier+ double cylindrical edge (absorbing)		20,4	5,2	6

Figure 1 – Results of Ishizuka numerical simulations, adaption of [Ishizuka e Fujiwara, 2004].

In 1995 Watts performed a series of experimental measurements in a device especially constructed for the test of the effectiveness of noise barriers diffracting edges. In these experiences a loudspeaker placed at a distance of 5.5 and 7.8 meters of the barrier was used as sound source. The sound levels had been registered at distances of 20, 40 and 80 meters behind the barrier, at the height of 1.5 and 4.5 meters, above the ground. Some types of diffracting edges had been tested, and the results compared with the ones of a simple barrier with a height of 2 meters. In the Figure 2 the results for a diffracting edges with T shape are presented.

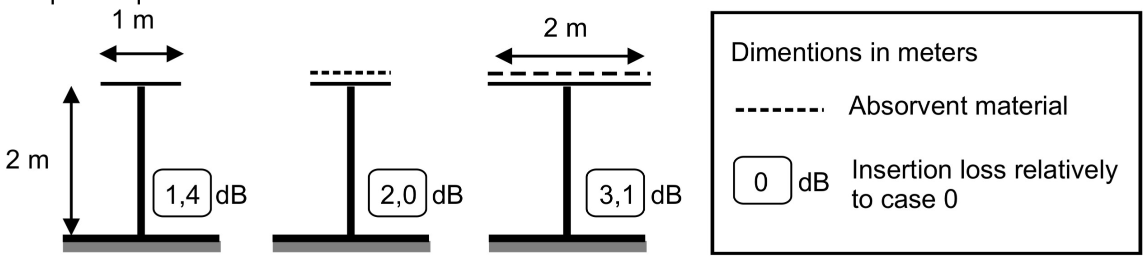


Figure 2 - Experimental results comparing edge performances for different diffractors [from Watts, 1995]

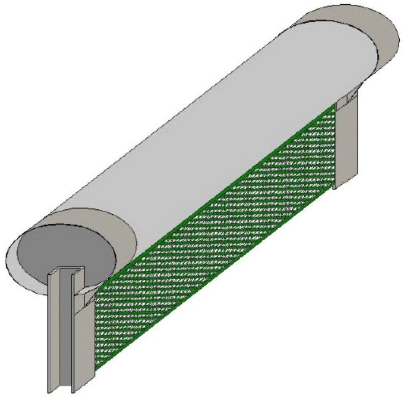
Finally we have to refer that tests were also performed in barriers that integrate active noise control devices, where it was verified the existence of an additional noise attenuation, when compared with the difracting edges with noise absorption characteristics.

2 Case study

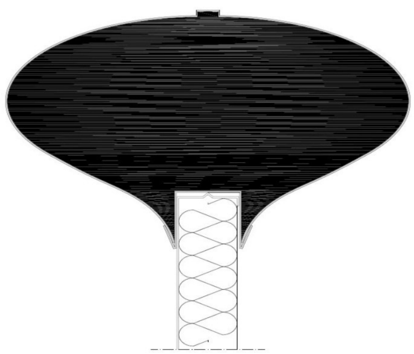
2.1 Scope

BRISA - Auto-estradas de Portugal, installed, in 2007, 6 noise barriers, in the Portuguese A1 highway, section Feira junction - IC 24 junction, those barriers being metallic perforated, with characteristics of noise absorption, with heights that varied between 4 m and 4,5 m, supplied by Complage - Construções e Projectos, S. A.. Later, with the widening and benefitting of the highway for 2 x 3 lanes, the design for noise protection of the environment, recommended the application of noise barriers with highly absorbent panels and with application of diffractors in their tops, to improve their efficiency by 1.5 dB(A) up to 4 dB(A), [4]. In accordance BRISA requested Complage the development of a device that worked as top barrier diffractor.

In Figure 3, it is presented the device developed by Complage, which was applied in 6 noise barriers, in an extension of 840 m. The device is a plate of 1 mm thickness, with punctures of 6 mm of diameter totalizing 18% of perforated area to the total area. The plate has in its interior by polyester wool with 40 mm of thickness and 40 kg/m3.



Height of the difractor - 305 mm
Lenght - 2 m, 3 m or 4 m
Color - Any color of the catalogue



The diffration edges are fixed on top of noise barriers, embemdded to the structural profiles, and fixed by screwing

The device was applied in
6 noise barriers
in a total extension of 840 m

Figure 3 – Cylindrical diffracting edge developed by Complage

The device was applied in 2 years after the installation of the noise barriers. In order to evaluate effectiveness, measurements without and with diffractors, in similar conditions, were performed. The result was a reduction of 2 dB(A). The measurements got with and without diffractor, for the 1/3 of octave frequency bands, range between 63 Hz and 5000 Hz are presented in the graph of Figure 4.

2. 2 Local measurements

During the noise measurements, the technicians were approached by inhabitants of the nearby buildings protected by the barriers, telling that the noise significantly reduced after the installation of the diffractors.
Considered surprising the manifestations of the inhabitants, for such a small effectiveness increase of 2 dB(A), a small study was performed to understand this discrepancy between measured noise reduction and population perception.
The measurements were performed during 30 minutes in one of the situations considered representative; the spectral analysis and the value in dB(A) with and without diffractors are presented in the graph of the following figure.

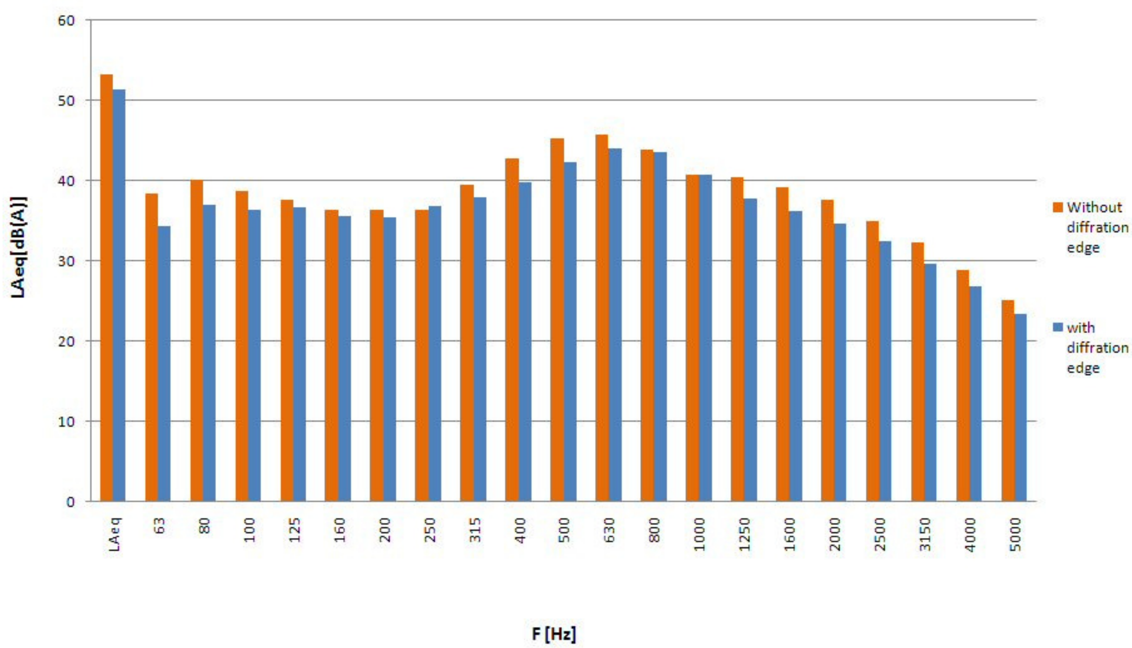


Figure 4 – Local noise spectral analysis without and with diffractor

Recordings with duration of 1 minute were conducted outdoors behind noise barriers. In the study area, some barrier selection was made, in order to choose barriers that have some areas with diffracting edges and areas where these devices weren't present. For theses audio files, analyses of total loudness and time variant loudness (10% percentile loudness, N10, and 5% loudness percentile, N5) were made. Table 1 presents the results for one case.

Table 1 – Sound wave loudness values

Diffraction edge r	Total loudness	Loudness N10	Loudness N5
With	17,4	22,3	22,8
Without	15,8	19,1	19,5

2.3 Residents perception

A simple questionnaire was asked to 20 of the inhabitants of the protected buildings, in order to survey the extension of the opinions initially revealed. All the inhabitants inquired had followed the installation of the barriers and, later, of the diffractors. The summarise results are presented.

A – Inquired people data
60% of the inquired ones were female, with ages between 26 years and 87 years old, and 40% were males, with ages between 28 years and 70 years old;
The inquired inhabitants live in the area for more than 15 years, 40% for more than 40 years.

B - Data referring to the residence
Single family houses of 1 and two floors, and one 2 floors apartment building.

C - Data referring to the sound perception
Asked which traffic was the most annoying, 50% answered no one in particular, 30% referred the heavy trucks traffic, 10% referred the noisy motorbikes traffic, and 10% referred the ambulances;
On effectiveness of the noise barriers, 10% related that they had somehow reduced the noise and 90% considered that they had reduced the noise very much.
As for the improvements resulting of the application of the top barrier diffractors, 20% answered that they did not feel any improvement, 60% felt improvement and 20% felt the improvement very significant.

3. Conclusion

After the study related above, it may be concluded that A1 traffic noise reduction efficiency of top barrier diffractors perceived by most of the inhabitants, was better than the expected in terms of a noise reduction level of 2 dB(A). This fact strengthens the importance of subjective aspects in the reaction of the populations to noise, leading us to conclude that this subjective approach must always be considered.

References

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