Modification of the Diffracted Sound Field by Some Noise Barrier Edge Designs

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The use of noise control by barriers has become a common measure for environmental protection. An efficient sound barrier must shield the receiver from the predominant portion of the sound energy radiated from the source which is directed toward the receiver. The acoustic field in the shadow region of a barrier, when transmission through the barrier is negligible is due to diffraction at the edge alone. The aim of this paper is to present some results of acoustical scale modelling experiments covering some noise barrier edge designs. A summary of the details of the theory of diffraction by a single edge is presented as well. The top edges were modified by means of the addition of a horizontal cap in order to compare the results of the diffracted sound field with a non-modified equivalent barrier. Conventional barriers used in traffic-noise control can be improved in some cases, producing a significant increase in insertion loss.

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1. INTRODUCTION

Noise barriers are commonly used to reduce the high levels of environmental noise produced by traffic on highways. For their proper use, aspects of their design, economics, construction details and durability must be considered, in order to ensure good performance. Many studies have been made with the objective of improving the noise attenuation properties of barriers. In general, provided that algorithms are considered to calculate the reduction of sound obtained by a specific barrier, reference is made to a bare one, that is to say, one with a straight profile and without any reflecting or absorbent element on the top. All the studies show that the use of some kind of element over the top of the barrier or the modification of its profile will change the original diffracted sound field. In some cases this alternative barrier design can produce a significant improvement in the attenuation. Since the pioneering works on barrier diffraction of Sommerfeld, Macdonald[1] and others, several models to predict the acoustical performance of barriers have been developed. Design charts of Fehr[2], Maekawa[3] and Rathé[4] plus the use of physical and geometrical theories have made possible the development of some equations and convenient algorithms to predict the attenuation of simple barriers. The work of Kurze and Anderson[5] simplified the task of obtaining the attenuation by the use of geometrical parameters, such as the Fresnel number. Elementary studies of the basic theories show that to increase the degree of isolation, the height of the barrier must be increased. But with this approach, to obtain the necessary reduction in the noise levels the barrier cost may become very high. Because of this reason, new barrier forms and profiles have been used to increase their acoustical attenuation.

A theoretical study on the diffraction of sound by a rigid screen with a soft or perfectly absorbent edge has been reported by Rawlings.[6] He concluded that absorbing material placed on the top edge of the barrier needs to be at least a wavelength in length to have approximately the same effect on the sound attenuation in the shadow zone as a completely absorbent screen. Fujiwara and Furuta[7] have presented a study on the effect of two types of cylindrical element located on the top of a typical barrier. These were a hard cylinder and an absorbing one. They concluded that the absorbing cylinder gave an improvement of about 2 to 3 dB(A) in experiments. This effect is equivalent to the excess attenuation obtained by the use of a thin noise barrier that is 2 m higher than the original one and which has no modifications. The theoretical study used by Fujiwara and Furuta was developed based on Keller's geometrical theory of diffraction, usually denoted as GTD.[8] Several profile forms have been tested by May and Osman using scale models in typical noise situations experienced with highways.[9] May and Osman have also presented experimental results obtained in-situ using a T-profile barrier in Toronto.[10] This barrier was 4 m high and had absorbent material on both sides. A horizontal cap 75 cm wide was added to its top and measurements of the sound pressure level in residential areas behind the barrier were made. The results showed increases in attenuation of 1 to 1.5 dB(A) compared to a barrier without a cap. However, significant statistical differences were not found between barriers with absorbing and reflecting treatments. Theoretical and experimental studies have been carried out by Hothersall et al. using the boundary element method, BEM.[11,12] They have demonstrated good agreement between theory and scale-model experiments with many forms of barriers and multiple barrier edges. A good review of the mathematical modelling of barrier performance can be found in the work of Hothersall.[13] More recently, Fahy et al. developed a modular form of absorbing barrier for traffic noise use.[14] This design is designed based on coupled resonators, which allows it to