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AN INVESTIGATION OF THE USE OF TOP EDGE TREATMENTS TO ENHANCE THE PERFORMANCE OF A NOISE BARRIER USING THE BOUNDARY ELEMENT METHOD

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Abstract

The acoustical performance of a simple barrier is limited by the height of its top edge relative to the source of sound and the receiver. A considerable amount of research has been undertaken on the modification of the top edge with a view to enhancing barrier performance. The objective has been to achieve the performance equivalent to a higher simple barrier with potential savings in costs and the degree of visual intrusion. In this paper the relative effectiveness of a number of different treatments is investigated using the Boundary Element Method. Treatments investigated include the addition of absorbent material and geometrical configurations. The range of potential benefits is examined.

INTRODUCTION

Increasing urbanisation will lead to an ever increasing need to control noise of all forms. Noise mitigation by the use of noise barriers is a long established technique and many different designs and variations have been used. Several theoretical and predictive methods have been devised to account for diffraction at the edges for simple barrier forms. The principle factor affecting barrier performance is the barrier height. Several theoretical methods exist for evaluating barrier performance based on diffraction theory and these have recently been the subject of a comprehensive review by Li and Wong[1]; these tend to yield complex expressions which can be too difficult to integrate into standards. As a result, Maekawa's design chart, which has been developed and improved on by others [2-4], is still widely used as the basis of most practical barrier prediction methods.

Various techniques have been proposed to enhance the performance of a simple barrier including the use of absorptive material on the barrier face or edges, shaping of the barrier edges or face to deflect sound energy or to promote destructive interference [5]. One objective of the EU sponsored project Holiwood (Holistic Implementation of European thermal treated hard wood in the sector of construction industry and noise protection by sustainable, knowledge-based and value added products) is the development of a traffic noise barrier system using thermally treated European hardwood, a sustainable material, to replace other energy and resource consuming materials such as concrete, aluminium and plastics. The advantages of thermal treated hardwood include excellent durability and dimensional stability. These advantages, coupled with the general suitability of timber for the manufacture of complex forms, mean that this material may be suitable for the practical realisation of novel barrier top edge treatments.

TOP EDGE TREATMENTS

Novel barrier designs were first proposed by Wirt [6, 7]and May and Osman [8, 9] and have generated a considerable amount of research related to alterations to the edge of the barrier, either to the profile or to its lateral extent. Many studies have shown that altering the barrier profile can be beneficial and that, according to some experiments, including absorptive material in the profiled edge can further improve attenuation.

Watts [10] has provided a useful review of the measured improvement achieved by a variety of top edge treatments. This improvement was normalized with respect to the performance of a simple 2m high barrier and the data are summarised in Table 1. It can be seen that the improvement is typically only 1.5 to 3 dBA which although small is comparable with the improvement to be gained by increasing the height of the simple barrier.

NUMERICAL MODELING

The complexity introduced when the barrier shape is modified beyond that of simple barriers (thin or wide, infinite or finite) makes prediction of the diffracted sound field mathematically intractable. To solve this problem, two methods have been developed; one is mathematic modelling and the other scale model testing.

For mathematical modelling a numerical method has been used known as boundary element analysis. Seznec [11] first demonstrated that the boundary element method maybe applied to noise barriers of any arbitrary shape or conditions. Seznec also noted that computation times could become excessive. However, given the vast increase in computational power since Seznec’s work in 1980 this is less of a problem today. This numerical method means that the attenuation of these enhanced barriers can be modelled with relative ease.

Table 1: Performance of 2m high Barriers with Top Edge Treatments Relative to that of Simple 2m High Barrier (after Watts[10])

Configuration		Average Attenuation Relative to Simple 2m Barrier (dBA)
Simple	**Height (m)**	
	2	0
	2.5	1.7
	3	3.6
T shaped	**Width (m)**	
	1	1.4
	1 with absorptive top	2.0
	2 with absorptive top	3.1
Multi-edge	**Width/Depth (m)**	
	1/0.5	2.4
	1/0.5 with absorptive top edge	2.5
	1/1 with absorptive top edge	2.6
	2/0.5 with absorptive top edge	2.7

Hothersall [12-21] et al have described the application of the boundary element method to the investigation of a range of barrier configurations. Both the traffic noise source (a line of vehicles) and barriers are linear in nature and this suggests that a 2D representation could be adequate for modelling purposes with a potentially enormous saving in computation time. Hothersall et al [12]compared the performance various barriers using two dimensional analysis and found good agreement with three dimensional results of previous work. The method proved highly useful for determining comparative performance of different barrier configurations.

Gerges and Calza [22] recently compared analytical models based on the work of Maekawa, Kurze and Anderson and Pierce with numerical methods (boundary element analysis). They pointed to the long computation time for numerical methods and the simplicity of the design charts and analytical methods of Maekawa [2], Kurze and Anderson [4] and Pierce [19] they also noted the greater flexibility of the numerical methods. Ishizulka [23] and Fujiwara compared the relative performance of various barrier profiles using the boundary element method; they also altered the absorptive properties of the barrier. They found the method suitable for comparing the performance of different barriers using two dimensional models and were able to show the relative effectiveness of the different barrier configurations.

BARRIER CONFIGURATIONS

The objective of this preliminary study was to establish the suitability of the SYSNOISE software to investigate the benefits to be gained from modifications to the barrier top edge. In this work a similar approach was adopted to that of Watts [10] and details of the configurations simulated are shown in Figure 1. As discussed above, simple 2D meshes were produced to keep computation times short. As the objective was to compare the performance of different top edge treatments a further simplification was to assume a perfectly reflecting ground plane which enabled the use of symmetry with the source and receivers positioned on the ground (plane of symmetry) as shown in Figure 2.

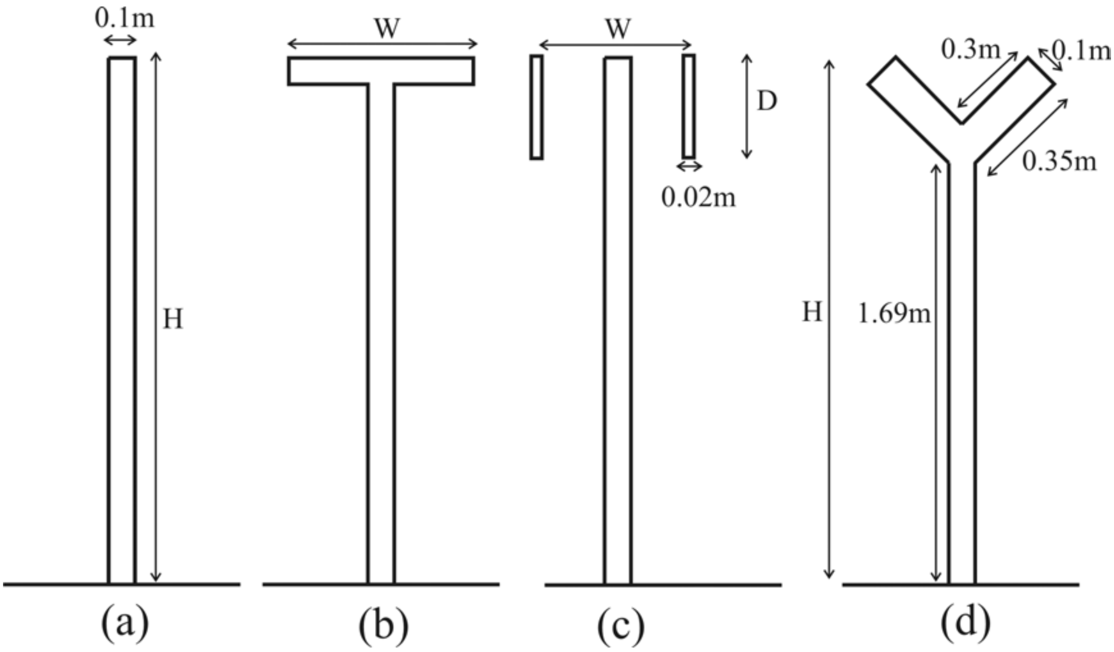

Figure 1 –Barrier configurations

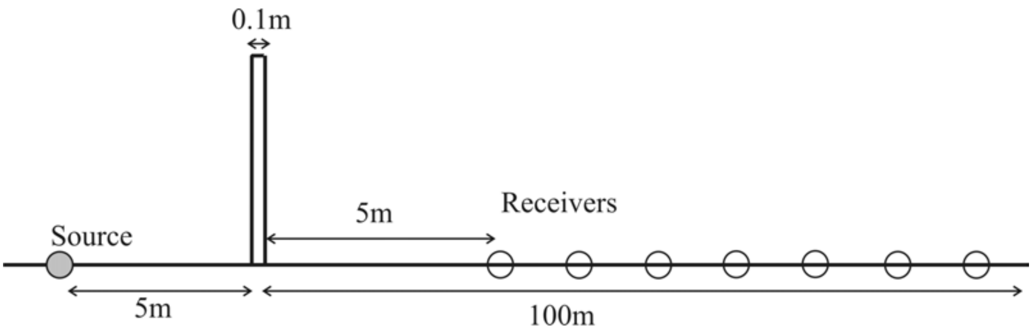

Figure 2 –Mesh for simple 2D barrier

RESULTS

Figures 3-5 shows the predicted A weighted noise level behind a number of barriers with the different top edge treatments calculated for the broadband traffic noise spectrum specified in EN 1793-3:1998.

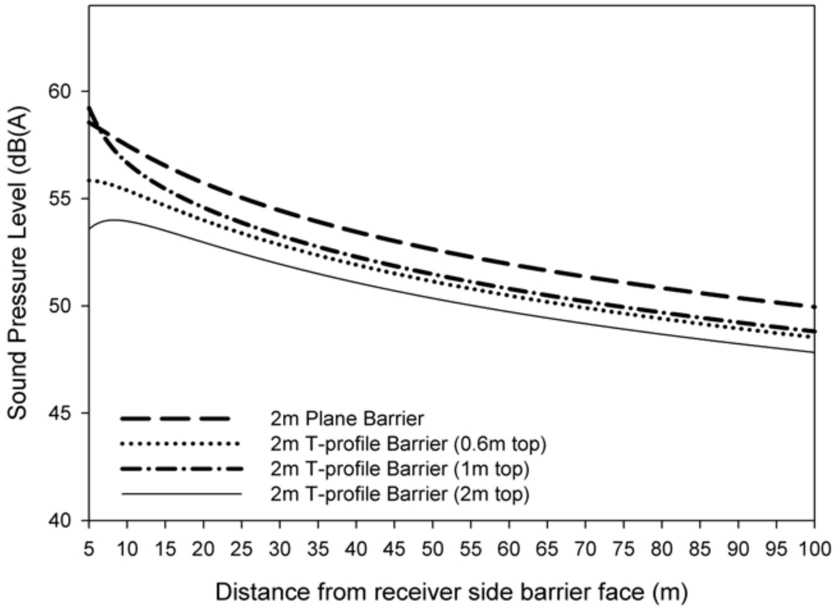

Figure 3 – Sound pressure level versus distance in the shadow zone at the ground from different T-profile edged barriers of 2m high, with different length tops.

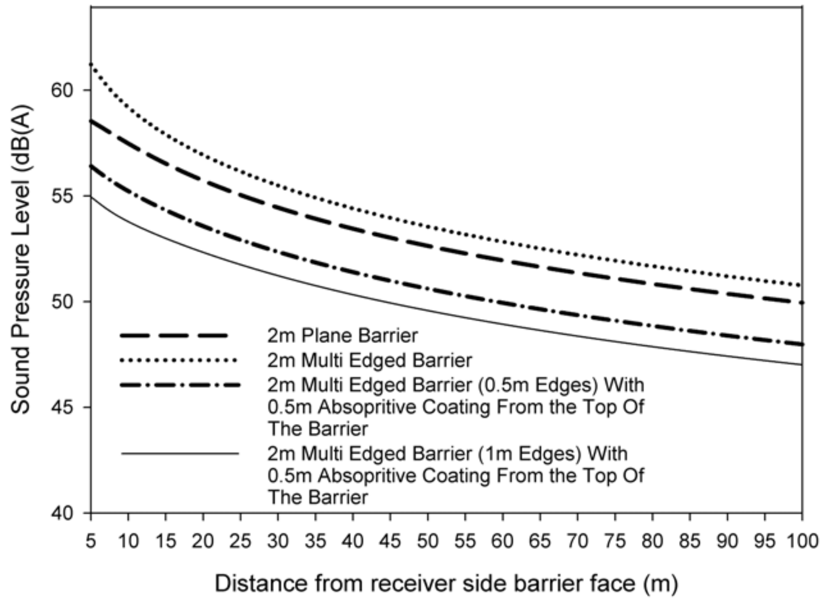

Figure 4 - Sound pressure level versus distance in the shadow zone at the ground from different multi edged barriers of 2m high.

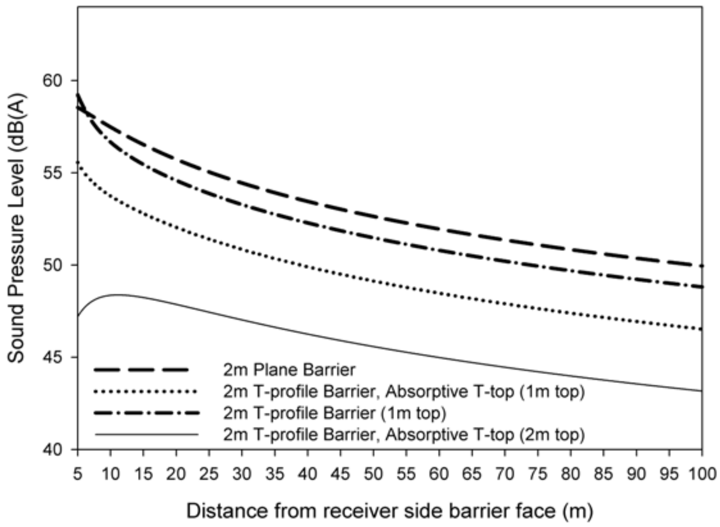

Figure 5 - Sound pressure level versus distance in the shadow zone at the ground from two T-profile edged barriers of 2m high with an absorptive coating covering the top edge of the T-top only.

Table 2: Comparison of the Mean Attenuation Determined from Simulations with Data Reported by Watts[10]

Barrier Type and Dimensions	**Mean Attenuation Relative to a Simple 2m Barrier dBA**	**Mean Attenuation of Barrier in Watts Review dBA**
Plane Barrier (H=2m)	0	0
Plane Barrier (H=2.5m)	1.3	1.7
Plane Barrier (H=3m)	2.5	3.6
Absorptive Barrier (H=2m)	1.9	-
Multi-edge Barrier (H=2m, W=1m, D=0.5m)	-1.0	2.4
Multi-edge Barrier (H=2m, W=1m, D=0.5m) With Absorptive Coating On Main Barrier From 1.5m – 2m.	2.1	2.5
Multi-edge Barrier (H=2m, W=1m, D=1m) With Absorptive Coating On Main Barrier From 1.5m – 2m.	3.2	2.6
T-profile (H=2m, W=0.6m)	1.6	-
T-profile (H=2m, W=1m)	1.1	1.4
T-profile (H=2m, W=2m)	2.5	-
T-profile Absorptive T-top edge (H=2m, W=1m)	3.5	2.0
T-profile Absorptive T-top edge (H=2m, W=2m)	7.4	3.1
Y-profile (H=2m)	0.8	-

Table 2 shows a comparison of the mean attenuation determined from these simulations with those reported by Watts. It can be seen that although there is not a precise agreement between the two sets of data, the general trends reported by Watts are replicated in the simulations.

SUMMARY

A considerable amount of research has been undertaken on the modification of the top edge with a view to enhancing barrier performance. The objective has been to achieve the performance equivalent to a higher simple barrier with potential savings in costs and the degree of visual intrusion. In this paper the relative effectiveness of a number of different treatments has investigated using the boundary Element Method. Treatments investigated include the addition of absorbent material and geometrical configurations. The results obtained have been compared with published data and the agreement is generally good.

Future work on the Holiwood project will involve further simulations in order to determine the most promising barrier configurations. The use of sustainable absorbers to enhance barrier performance will also be investigated.

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