Improvement in Broadband Noise Attenuation with Periodic Top-edge of Noise Barriers

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Abstract

With every passing decade, the issue of noise pollution became worse in urban areas and the usefulness of noise barriers increased. With the increase in demand came the challenge of improving the effectiveness of barriers. To facilitate this, extensive studies have been conducted analytically, numerically and experimentally to explore the ways of improving the performance of passive noise barriers. Although a noise barrier acts as a shield for the receiver by blocking the line of sight of the primary sound source, sound waves diffract around the top-edge into the shadow zone. Thus, the top edge acts like a virtual or a secondary sound source. It is well known that the top-edge profile of a noise barrier can be designed to result in a partial destructive interference between diffracted, transmitted, scattered and reflected waves, which in turn increase the performance of the barrier.

Several top-edge designs were tested for this purpose. However, it was observed that Insertion Loss is strongly frequency-dependent, therefore, the barrier performance may not be monotonically increasing or decreasing throughout the bandwidth of interest. Upon reviewing the existing literature and developing numerical models to test various edge-modified barrier designs, it was concluded that the insertion loss is also affected by the receiver positions where SPL measurements are taken. Therefore, while a specific barrier may not be suitable in some cases, it may offer the most favorable results in other cases. As there is limited advice on acoustic design, the aim of this exercise is to provide guidelines of selecting barrier designs and a catalogue for specific frequencies and receivers positions of interest

This paper presents an investigation of the acoustic performance of noise barriers with different top-shapes and studies the suitability of each for different frequencies and receiver distances.

The commercial finite element software COMSOL Multiphysics 5.2 is used to study this two-dimensional linear acoustics problem in the frequency domain to numerically measure the response of inserting a sound hard barrier into an air domain. The choice of boundary conditions for the exterior domain is Radiation Boundary Condition, to model all waves from these boundaries as outgoing waves. This is a good approximation of an infinite domain, as is our case. As seen in figure 1(a), the source point S in 2D represents a cylindrical (line) source. Sound field was measured at receiver locations behind the barrier; the receiver positions P1 and P2 represent a six-story building(22m) and a human (1.5m high) standing on the ground, respectively.

Measurement of noise levels generated in the shadow zone indicate attenuation of upto 10dB at high frequencies, whereas at low frequencies average insertion loss of 1-2dB is

observed. Furthermore, the simulation results show that the barrier can be tuned to certain frequencies of interest by selecting the appropriate well size and depth on the top. A combination of these periodic wells can obtain good attenuation over multiple frequencies, which has been explored in this paper. To study this further, barriers with acoustic diffusers have also been developed numerically.

Figures used in the abstract

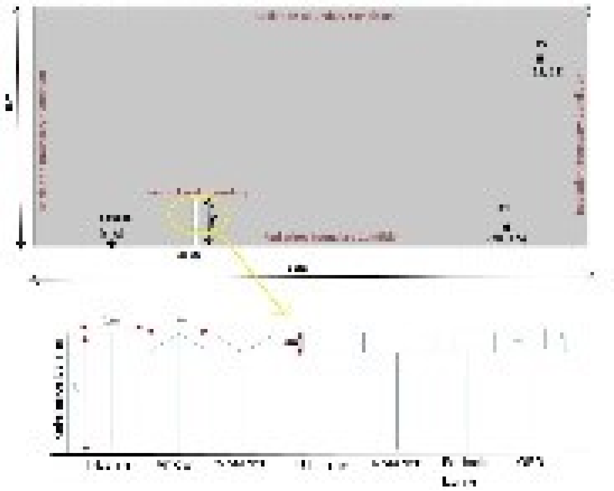

Figure 1: (a) (First figure) A schematic representation of the 2D finite element model in Comsol. This exterior acoustics problem constitutes of air domain and to satisfy Sommerfeld's radiation condition, Radiation Boundary Condition is imposed on all the exterior boundaries. The reference noise barrier is of 3m height and it is modelled as a sound hard surface. The monopole source in 2D represents a line source and is 5m away from the barrier. The Sound Pressure Level(dB) is measured at two receiver regions, denoted as P1 and P2 here. (b) (Second figure) The schematics and nomenclature of some selected barrier designs.