



INDOT Research

# TECHNICAL *Summary*

Technology Transfer and Project Implementation Information

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## **Study of the Performance of Acoustic Barriers for Indiana Toll Roads**

### **Introduction**

A recent study of traffic noise from the Indiana Toll Road in Lake and Porter Counties was conducted by the Indiana Department of Transportation (INDOT). This study indicated that in several areas, the noise levels at 152.4 m from the road will exceed the residential noise criterion of 67 dBA in the year 2020. The situation is particularly critical near the section starting at the Service Plaza and extending eastward through the Willow Creek Toll Plaza. The Service Plaza on either side of the road near the west end of this segment is an important source of noise due to the acceleration and deceleration of the vehicles that use this facility.

It was pointed out in the INDOT report that the construction of noise barriers appears to be justified in many areas, including the Portage Barrier Plaza. This assessment is based on predictions made using the Federal Highway Administration (FHWA) Highway Traffic Noise Prediction Model, which takes into consideration traffic volume, speed, and truck percentage. INDOT's policy states that the normal sound reduction needed to justify a noise barrier is 7 dB. The cost of sound barriers per benefited receiver is the key factor in deciding whether a noise barrier is warranted.

Many suggestions have been made about the modification of straight barriers to increase their sound attenuation performance and cost effectiveness. It has been suggested that the use of complex barrier-top maybe useful, and prototypes have been installed along highway in some countries. The application of sound absorptive material to barriers was also studied as a way of maximizing barrier performance with limited vertical height. The current estimate of barrier cost is \$20 per square foot installed. The INDOT has placed the accepted cost per benefited receiver in the \$20,000 to \$30,000 range. The barrier cost is therefore directly proportional to its height. Noise barriers with improved designs may achieve satisfactory performance for lower barrier heights, which would translate into significant cost savings.

The purpose of this study was to develop reliable boundary element models that could be used to predict the performance of barrier having complex geometries. The boundary element method has significant advantages over methods based on a geometrical diffraction approach. The main advantage of the boundary element method is its ability to handle arbitrarily shaped barriers.

### **Findings**

Contributions of the study include the following:

1. A boundary element model for the simple geometry of the circular disk was verified against experimental results. Later, it was shown that the shape of the disk geometry

alters the insertion loss at particular receiver location, a finding that was verified using the numerical model. However, the shaped disks did not result in any significant advantage compared to the uniform disk when the sound power in the shadow was used as a metric for barrier performance rather than the single point insertion loss. It was suggested as a result of these findings that the performance of a barrier having a relatively complicated geometry can be quantified most effectively by using a sound power-based metric.

2. Scale models that were intended to represent highway noise barrier applications were considered next. A two-dimensional analysis was first performed to study the limitations of the widely used diffraction-based model. The performance of the finite length barrier was studied both with a boundary element model and with experiments. A post-processing technique that involves windowing in the time domain and filtering in frequency was successfully implemented to eliminate experimental errors.

3. The performance of various barrier configurations was compared. The performance of T-shaped barriers was compared with that of the equivalent straight barriers with extended height. It was found that the T-shaped barrier does not give a significant improvement over the simple extended barrier. The use of acoustical treatment on the top of the T-shaped was also examined. It was found that the sound absorptive material results in improved insertion loss, but mostly at high frequencies.

4. The use of sound absorptive material to extend the barrier height was considered, as were the effects of material positioning and overlap. It was found that sound absorptive treatments placed on the barrier edge are very effective at increasing the insertion loss at receiver locations in the shadow zone behind the barrier. It was illustrated that a glass fiber extension was more effective than a rigid extension of the same height, for example. In contrast, the use of complex barrier-tops built of rigid materials, a T-shaped top, for example, did not result in a significant enhancement of the noise barrier performance.

## Implementation

Boundary element models were developed first for the simple geometry of a circular disk to solve the diffraction problem that is the key in highway noise barrier analysis. Experiments in an anechoic chamber were used to verify the results from the numerical models. After this verification, boundary element models were employed to predict the performance of various disks with complicated edge geometries to study the effect of an obstacle's shape on barrier performance. It was found out that complex-shaped barriers do not necessarily offer any net performance benefit when compared with an equivalent uniform barrier. However, it would be worthwhile to develop the boundary element model for the scaled barrier to verify this finding if sufficient computational resources are available.

Scale models that were intended to represent highway noise barrier applications were considered. Experiments were performed first to test the post-processing technique that involves windowing in the time domain and filtering in frequency for the straight barrier of the finite length.

The performance of various barrier configurations was experimentally investigated. This investigation shows that a T-shaped barrier does not yield a significant performance improvement over the simple extended barrier. The use of acoustical treatment on the top of the T-shaped was found to improve the insertion loss, but mostly at high frequencies. It was found that sound absorptive treatment placed on the barrier edge is very effective at increasing the insertion loss at receiver locations in the shadow zone behind the barrier. The development of

more sophisticated numerical modeling tools is required to predict the performance of noise barriers when sound absorptive treatments without a hard backing are applied to otherwise

rigid barrier structures to predict the performance of this configuration and to optimize the shape of porous material on the edge of the rigid barriers.

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