



The Ohio Department of Transportation Office of Research & Development Executive Summary Report

Effectiveness of Noise Barriers Installed Adjacent to Transverse Grooved Concrete Pavement

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Problem

In recent years the Ohio Department of Transportation (ODOT) has reconstructed a number of roadways where asphalt pavements were replaced with concrete pavements which were finished with a random transverse grooved surface texture (ODOT specification 451.09). Upon completion of these projects, residents living adjacent to the reconstructed roadways have complained of increased noise levels. Complaints have been received from residents near locations where random transverse grooved concrete pavement replaced asphalt pavement and where no traffic noise barriers were constructed as well as those locations where noise barriers were constructed. In these cases, one might expect that the addition of noise barriers would provide acceptable abatement of the higher traffic noise levels associated with the replacement pavement type. However, the complaints received at these locations suggest that the abatement was not adequate to compensate for the louder source levels. Therefore, this research project was initiated to address the noise barrier design issues associated with the abatement of traffic noise for the ODOT random transverse grooved concrete pavement. It is known with certainty that the interaction of vehicle tires on this pavement produces the highest traffic noise levels of any of the ODOT pavement types.

ODOT does not usually receive complaints from residents in cases where the roadways have been reconstructed with other new pavement types

and traffic noise barriers. In these cases the traffic noise barriers are effective and performing as designed.

A traffic noise simulation model is an indispensable tool used in the process of mitigating traffic noise impacts. The Federal Highway Administration (FHWA) Traffic Noise Model (TNM) is used by ODOT during the environmental process to determine if predicted traffic noise levels warrant abatement, and if warranted, the model is used to design the abatement structures. The desired outcome from use of the model can only be attained if the model accurately simulates noise levels. If the model predicts noise levels that are lower than actual, either the abatement will not be designed because it appears not to be warranted or if it is designed, it will not reduce the traffic noise to an acceptable level. The public perception problem described above suggests that the model does not result in adequate barrier designs to abate the traffic noise from the ODOT random transverse grooved concrete pavement type.

Objectives

The overall goal of this project was to support the FHWA in its effort to provide ODOT and other states with accurate noise predictions from TNM when modeling highways constructed with random transverse grooved concrete pavement types. During the contract period in which work was underway to achieve the original project objectives, ODOT elected to re-texture the surface of a portion of I-275 in the Cincinnati area through diamond grinding. The project was initiated in an effort to mitigate tire pavement noise and thus address the complaints of the residents living adjacent to the highway. In order to quantify

the effectiveness of the diamond grinding the project scope for this research project was expanded to compare the noise results before and after the diamond grinding.

Description

Three random transverse grooved PCC roadway sites were chosen for study. High quality sound recordings were made at carefully documented, recoverable locations within these sites and later analyzed. Sites 1 and 2 were chosen to represent the noise quality experienced by residents adjacent to the roadway. Site 3 was chosen to study the attenuation of road noise with distance in an easily-characterized environment.

Site 1 (Cincinnati I-275) and Site 2 (Troy I-75), were residential areas separated from the roadway by sound barriers. Site 3 (Madison County I-70) was open soybean cropland essentially level on both sides of the roadway with no noise barrier.

Fourteen sound recordings were made at Site 1, organized as Area A (five recordings), Area B (seven recordings) and Area C (two recordings). Areas A and B were adjacent to depressed roadways and Area C was adjacent to elevated roadway. Areas A and B included reference microphones situated above the barrier.

Site 2 included five Areas, all of which were practically at-grade with the roadway. A total of sixteen recordings were made at Site 2. Three of the Areas (Area A, five microphones; Area B, four microphones; Area C, four microphones) were behind noise barriers and each included one reference microphone above the barrier. Area D (one microphone) was behind a

barrier. Area E (two microphones) was an open area with no noise barrier.

Eight recordings were made at Site 3, which was located between the intersections of SR 29 with I-70 and SR142 with I-70 in Madison County. The recorders were situated on a line perpendicular to the roadway (one side only) at distances that increased by doubling out to 480 meters (1575 feet). One microphone failed, leaving seven good recordings.

Traffic volume, classification, and speed data were collected while traffic noise measurements were being made. Speed data for Sites 1 (Cincinnati), 2 (Troy) and 3 (Madison) was collected manually by laser speed detection while traffic count data was video-taped from an overpass observation location for extraction in the laboratory. The data that corresponded with the collected acoustical data was organized by travel lane in a spreadsheet. Once in the spreadsheet, lane specific values were combined to create total volumes and the corresponding mean speed for each vehicle classification.

Noise models for this project were prepared using the FHWA Traffic Noise Model version 2.5. The United States Department of Transportation (USDOT) Volpe Center Acoustics team provided a specialized version of the TNM that included ODOT specific REMELs for transverse tined PCC pavements (TTPCC) and a 1/3-octave band output function. Due to limitations of the REMEL dataset, this model is only appropriate for use in modeling highway speed traffic. All study areas investigated for this project involve traffic at highway speeds.

The traffic noise data that was acquired at each study location was also post-processed to yield noise levels in one-

third octave frequency bands. The TNM modeling procedure also produced predicted noise levels for both the average pavement type and the ODOT random transverse grooved pavement type in one-third octave frequency bands for each study location.

The specific differences between predicted and measured noise levels in one-third octave frequency bands for TNM configured for the average pavement type and the differences for TNM configured for the ODOT random transverse grooved pavement type (ORT) were quantified

Conclusions

The comparison of the TNM model to the field surveyed noise results resulted in the following findings.

1. The error for the prediction based on the average pavement type ranged from an under-prediction of -7.3 dB to an over-prediction of +1.7 dB with a mean value of -4.1 dB. By contrast the error for the prediction based on the ODOT random transverse grooved pavement type ranged from an under-prediction of -5.8 dB to an over-prediction of +2.8 dB with a mean value of -3.1 dB. The over and under-prediction of the TMN configurations were based upon the Model with REMELs for “average” pavement type and the model with the REMELs for the ODOT transverse grooved pavement type.
2. The paired t-test determined that the sample means of the TNM average pavement and the ODOT random transverse grooved pavement were not equivalent based upon a level of confidence of 95 percent.

3. The mean errors for the predictions of the TNM configured for the average pavement type and of the TNM configured for the ODOT random transverse grooved pavement are statistically different than zero.
4. An examination of the one-third octave band frequency levels indicates that at frequencies greater than 500 Hz, the measured traffic noise levels exceeded both the TNM average pavement type and TNM ODOT random transverse grooved pavement predictions for the majority of microphone positions. However, at frequencies less than 500 Hz the predictions tended to exceed the measurements.
5. The TNM configured for the ODOT random transverse grooved concrete pavement type is slightly more accurate and a slightly more consistent predictor of noise levels than the TNM configured for the average pavement type.
6. The ODOT construction project to re-texture the surface of a portion of I-275 in the Cincinnati area (Site 1) by diamond grinding was effective in reducing broadband traffic noise levels at the microphone locations by an average of -5.3 dB. One-third octave band analysis indicated that most of the noise level reduction was in the frequency range of 200 Hz to 8 kHz.

Recommendations

1. The experimental version of TNM developed for this project, using the current ODOT random transverse grooved concrete pavement REMEL, should not be used in practice due to its potential to under-predict traffic noise levels.
2. The experimental version of TNM developed for this project should be refined to eliminate the tendency to under-predict noise levels. This development should be accomplished by implementing a REMEL developed from traffic noise data acquired from those random transverse grooved concrete pavements that exhibit noise producing characteristics in the higher end of the typical range. The data collection for the REMEL development should be made in accordance with the standard USDOT/FHWA REMEL data collection procedure.
3. Diamond grinding should be considered as a mitigation measure for locations where ODOT is concerned about traffic noise levels at sites with random transverse grooved concrete pavement.
4. A new surface texture specification should be developed for concrete pavements to replace the current specification (451.09) in order to reduce tire/pavement noise levels while maintaining or improving safety and durability characteristics.