Quantitative Differences In Highway Noise Levels Due To Pavement Type: Impact On Modelling Future Noise Emissions

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1 Introduction

This article provides an overview of three highway-noise models in use in Canada or the USA, the capacity of these models to accurately represent noise emissions from different types of pavements, and the constraints that are imposed in some jurisdictions that compromise the accuracy of modeling, particularly with forecasting of future noise levels. Ideally, calculated noise levels will agree with measured levels of highway noise. In Canada and the United States, there are three commonly used computer models used to predict noise levels due to highways: STAMSON 5.0, an older model developed in Ontario, Canada that follows a defined model [1]; STAMINA 2.0, an older model developed in the USA [2]; and the Traffic Noise Model (TNM) [3, 4] that has superseded STAMINA 2.0 and was also from the USA.

STAMSON 5.0 and the TNM allow for some user-defined control over the type of pavement that is assumed for modeling purposes; whereas STAMINA 2.0 does not unless an alternative version of the software is used that incorporates alternative noise-emission properties (e.g., Sound2000 as developed for the State of California).

The general classifications of pavement for this article include three types: Portland cement concrete (PCC), dense-grade asphalt concrete (DGAC) and open-grade asphalt concrete (OGAC). A PCC pavement is typically tined, or grooved, either longitudinally in the direction of travel or transversely. An OGAC pavement has increased porosity to airflow relative to a DGAC pavement. American Federal regulations stipulate that the "average" pavement is used which is calculated by averaging the noise emissions of measurement results for DGAC and PCC pavement types.

2 Ontario, Canada highway noise emissions / STAMSON 5.0

Figure 1 shows a comparison of the Reference Energy Mean Emission Levels (REMELs) for three vehicle types as used in STAMSON: automobiles, medium trucks and heavy trucks. The horizontal axis is the speed, in miles per hour (mph), and the vertical axis is the noise-emission level in A-weighted decibels. The noise-emission levels shown are typically at a reference distance of 15 m (50 ft) from the center of the lane traveled by a passing vehicle. These calculations assume typical asphalt or concrete (i.e., DGAC pavement type). The STAMSON model allows for adjustments of the calculated sound level for OGAC (-2.5 dBA), DGAC (0 dBA) and PCC (+7 dBA).

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3 USA highway noise emissions: reference energy mean emission levels (REMELs)

STAMINA makes use of REMELs for vehicle noise that describe noise emissions from vehicles over a range of speeds. The coefficients for the National REMELS for the three STAMINA vehicle types are based on data collected in 1975 in the states of North Carolina, Florida, Washington, and Colorado. These STAMINA coefficients were never revised by the USA Federal Highway Administration (FHWA). Concerns arose that this first-generation of National REMELs was leading to noise-level predictions that were too high. In the 1980s, at least two state DOTs (California [5] and Georgia [6]) derived their own REMELs.

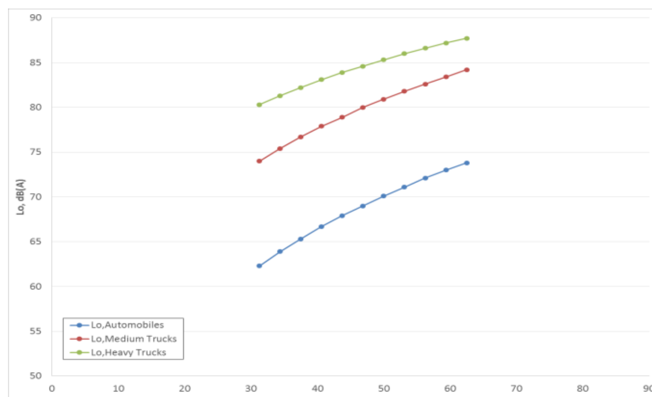

Figure 1: REMELs for automobiles, medium trucks and heavy trucks from STAMSON 5.0 assuming DGAC pavement type.

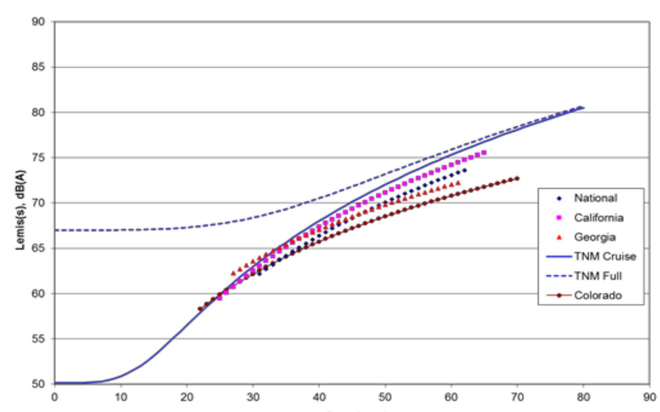

Figure 2: REMELs for automobiles from STAMINA 2.0/TNM.

New National REMELs for the TNM were developed [7]. From measurements in California, Florida, Massachusetts and Tennessee, parameters were developed to describe speed-dependent changes due to vehicle type (A), vehicle and pavement type (B), and vehicle and throttle condition (C). Regressions were performed against the L(A),fmax as a function of speed to derive the coefficients A, B, and C for the cruise condition of a passing vehicle. Under full-throttle conditions, the measurements were repeated and values of coefficient C was derived in accordance with techniques for measuring noise from vehicles under acceleration. Due to the influence of parameter C at lower speeds, the values of A and B derived for the TNM will be altered so they are not, strictly speaking, directly comparable to the values derived for use with STAMINA which are limited to an A and B value of the form B + A log10(speed).

The REMELs for National, California, Georgia, and TNM are presented in Figure 2 for automobiles, Figure 3 for medium trucks, and Figure 4 for heavy trucks. The horizontal axis is the speed, in mph, and the vertical axis is the noise-emission level in A-weighted decibels. TNM curves were calculated from the coefficients for "Average" pavement.

4 Discussion and summary

For STAMSON there are three distinct classifications of pavement type. For each of these pavement types, the adjustments shown for noise emissions are presumably some sort of an average that corresponds to each distinct type. However, the supporting documents for STAMSON do not provide literature references to substantiate the recommended pavement-type adjustments. For STAMINA, the software employs a National "Average" that does not differentiate between the noise emissions for each type of pavement.

For the TNM, the "Average" in this context can refer to both the noise emissions that are claimed for each distinct type of pavement along with an "Average" that has been determined in some unspecified manner from the reported noise emissions of PCC and DGAC. However, the methodologies used for averaging are not entirely clear.

The regression coefficient B differs for both the DGAC and PCC pavement types and for the resulting average of those two pavement types. Inexplicably an examination of these regression coefficients indicates the following when it comes to the average pavement type: for automobiles, the assumption is 84% DGAC and 16% PCC; for medium trucks, the assumption is 75% DGAC and 25% PCC; and for heavy trucks, the assumption is 59% DGAC and 41% PCC.

5 Conclusion

For assessments of environmental impacts of highway noise, the forecast of future noise levels will ideally agree with post-construction measurements. Many factors come into play including the type of pavement. When predictions are inaccurate, impacts may incorrectly be forecast, or not, depending on the adjustments to parameters involved as part of the calculations. As such, this paper has provided information that is relevant to those with an interest in accurate forecasts of future noise levels. The assumption of either an incorrect pavement type or an "average" noise emission of some kind when it comes to noise emissions from pavements does not support this reasonable objective. The varying proportions of DGAC and PCC used to calculate the TNM REMELs average deserve more investigation.

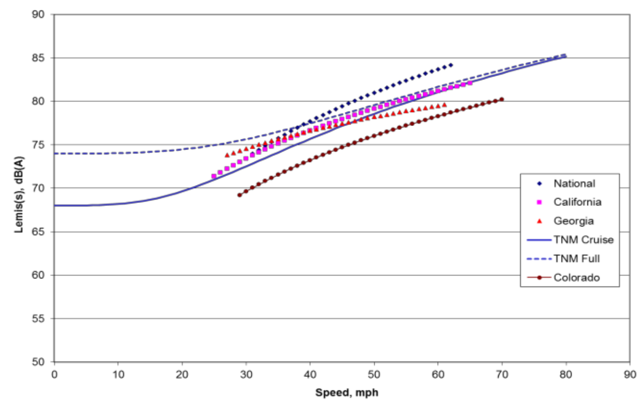

Figure 3: REMELs for Medium Trucks from STAMINA 2.0/TNM

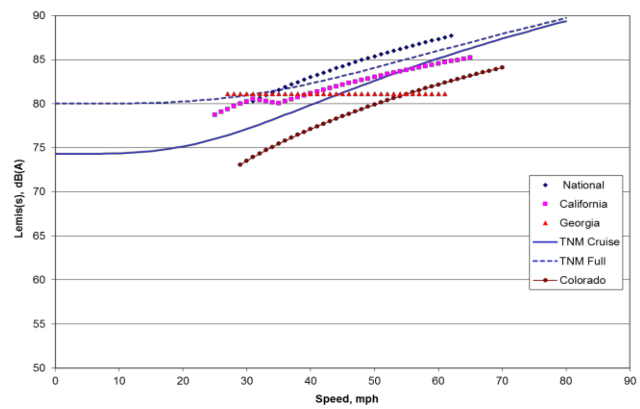

Figure 4: REMELs for heavy trucks from STAMINA 2.0/TNM

References

[1] ORNAMENT Ontario Road Noise Analysis Method for Environment and Transportation, October 1989.

[2] FHWA Highway Noise Prediction Model (FHWA-RD-77-108).

[3] FHWA Traffic Noise Model, Version 1.0 Users's Guide (Report No. FHWA-PD-96-009, January 1998).

[4] FHWA Traffic Noise Model Technical Manual (Report No. FHWA-PD-96-010, February 1998).

[5] Hendriks, "California Vehicle Noise Emission Levels," California Department of Transportation, August 1984.

[6] Harris, "Determination of Reference Energy Mean Emission Level in Georgia," Transportation Research Record 983, 1984.

[7] "Development of National Reference Energy Mean Emission Levels," Report No. FHWA-PD-96-008.