NOISE PREDICTION MODELS—THEIR IMPORTANCE AS A KEYSTONE IN APPLYING NOISE STANDARDS

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Analytical noise models are extremely important in highway work. They are needed for the planning and design of highway projects. They are needed in research activities and special studies to better understand how noise impacts are created.

Use of Noise Models

A more detailed look at these models would show a widespread use and demand. Models are an important supplement to measurements of existing noise levels. Where the noise is predominantly from highway traffic, the model can be used as a time- and money-saving aid to interpolate between sites where measured data have been obtained. Such measured data are needed on approximately 5,000 federal-aid highway projects annually to describe existing background noise levels. Measured noise data are also needed in research and special impact studies.

Noise prediction models serve an important function in examining various mitigation strategies. One of the more important is the assessment of the reduced noise doses to which the public would be exposed if motor vehicle noise emission levels were reduced at the source by various amounts. Another problem of concern is establishing the relationship between noise levels and residential property values. FHWA presently has several contracts under way to examine different abatement strategies and their costs on a national basis. Included are barrier construction, soundproofing of private structures, and acquisition of impacted properties. In each of these special studies analytical models are a substantial if not the sole basis for determining the noise exposure.

A very great responsibility for preventing future noise impacts rests (or should rest) with local officials and developers of undeveloped property in the vicinity of busy highways. The future noise levels (on which local government controls and future development plans are based) must come from highway traffic noise models.

The use with which most highway designers are concerned is in forecasting future traffic noise levels. These levels are used for the assessment of noise impacts on highway improvements. In recent years, many people have expressed concern about the lack of uniform measurement procedures and equipment for determining existing noise levels. The keystone, however, in determining noise impacts for FHWA's standards is the design year noise levels. Only the noise model can predict what these noise levels are going to be.

As a continuation of this assessment, models are used to examine different location and design alternatives. Decisions to soundproof public-use buildings and to construct costly barriers will depend on the outcome of studies using these models.

Stakes in Use of Noise Models

An idea of the stakes involved in the use of noise models can be obtained from some facts and figures on the highway program. In FY 1974 about \$13 billion was spent in local, state, and federal funds on highway improvements. Nearly \$5 billion of this amount was from the federal trust fund.

The best current estimates indicate that about \$32.5 million per year will be spent on noise barriers as part of the construction or reconstruction of freeways and expressways on the federal-aid system. This is over and above the \$730 million that could be spent for barriers to correct existing noise impacts. These substantial figures only account for those situations where noise barriers can be built. If we were to try to solve the remaining noise impacts by buying the impacted residences, it would increase the annual bill by \$3 billion and the backlog bill for existing problems by nearly \$70 billion. This clearly shows how costly significant errors in our models could be.

To illustrate in another fashion, assume that the 70 dB contour was calculated with one of our models to be 800 ft (243.84 m) from the edge of the roadway. If the model overpredicted by 5 dB, the 70 dB contour would be only 300 ft (91.44 m) from the roadway. If the overprediction were 10 dB, the 70 dB contour would be only 100 ft (30.48 m) from the roadway. These kinds of errors (whether high or low) are serious. If the errors are overprediction, there may be unwarranted and expensive expenditure of public funds. If the errors are underprediction, there may be unwarranted exposure of the public to unnecessary noise impacts.

Essential Ingredients of a Noise Model

Because of the many needs that noise models serve, their essential ingredients are very demanding. Most models, especially the basic ones, must be versatile and comprehensive. They must be able to account for traffic characteristics (volume, speed, and truck traffic), topography (vegetation, barriers, height, and distance), and roadway characteristics (configuration and grades). In special situations, meteorological conditions and pavement characteristics may be necessary variables.

The models must be easy to use. Because of the large number of highway projects involved, and the large number of potential locations of impact, the models must be relatively simple and not too time consuming to exercise. In order to serve the wide range (very large to very small) of highway agencies that use the models, they must include both manual and computer options.

The most important criterion for the noise model is accuracy. Since most of our noise abatement decisions are based on predictions, it is imperative that they be used with confidence. They must have the confidence of the highway agencies that use them, the public that will be affected by them, and the courts that may someday be called on to arbitrate disputes.

Noise prediction models are the keystone to dealing with highway traffic noise impacts. It is imperative that we have the very best models we can get.

RECENT DOT STUDY EVALUATING NCHRP 117 AND TSC HIGHWAY NOISE PREDICTION METHODS

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Let me begin this discussion by giving you an overview of where the Transportation Systems Center fits into the highway noise prediction program. This is not intended to be one of the formal organization, but rather an indication of how information flows and of how we communicate with other groups involved in highway noise prediction. As shown in Figure 1, there are two divisions within TSC that give technical support to the Office of Noise Abatement within DOT. The Mechanical Engineering Division has the people, equipment, and expertise for recording and analyzing highway noise measurements, while the Information Sciences Division is more involved in the prediction of highway noise values using various computer models. Our responsibilities in this area include the implementing of various prediction models, debugging of these models to some extent, maintenance, upgrading, and distribution of the TSC model, and the comparison and analysis of the various models for validation purposes.

Since most of you are quite familiar with the TSC and 117 models, I will not go into the models themselves to any great extent. Figure 2 gives the basic equations for each model, shows that the 117 model is fundamentally an empirical one, while the TSC model is based on theoretical considerations. As far as use of the models is concerned, the TSC model, using roadway and barrier endpoints and receiver locations expressed in a Cartesian coordinate system, greatly reduces the structuring of the input case and does not require that the user calculate the various subtended angles. The running of subsequent cases with changes to only individual parameters is more straightforward with the TSC model. Both models were intended to be used in free-flowing traffic situations and do not behave well (or at all) in urban or interrupted traffic flow situations.

TSC has recently undertaken a study of the TSC and Michigan 117 models (and BBN's revised design guide in the near future) for the purposes of comparison of the models and validation against field measurements. Figure 3 illustrates the primary functions involved in the study. Hourly noise measurements, traffic counts and mix, site geometry, and single-truck spectrum measurements are being taken at 3 locations [50 ft (15,24 m), 100 ft (30.48 m), and 200 ft (60.96 m) from the roadway] for several sites in each of four states. Included in each state is a site where measurements are taken for 24 consecutive hours. At TSC, the noise measurement data are handled by the Mechanical Engineering Division where they analyze it to determine the L_{10}, L_{50}, and L_{eq} levels at each location for each hourly interval of measurement. The traffic flow and site geometry is formatted by the Information Sciences Division for input to the noise prediction models. The models are then used to predict the L_{10}, L_{50}, and L_{eq} levels for each hour. The field measurement and prediction models results are then combined and input to a program that produces 9 graphs. Each graph shows the TSC, 117, and field data versus time for one receiver [50 ft (15.24 m), 100 ft (30.48 m), and 200 ft (60.96 m)] and one measurement type (L_{10}, L_{50}, or L_{eq}). A sample of one of these graphs is shown in Figure 4.