Determination of Effectiveness of Noise Barriers Along I-285, Atlanta

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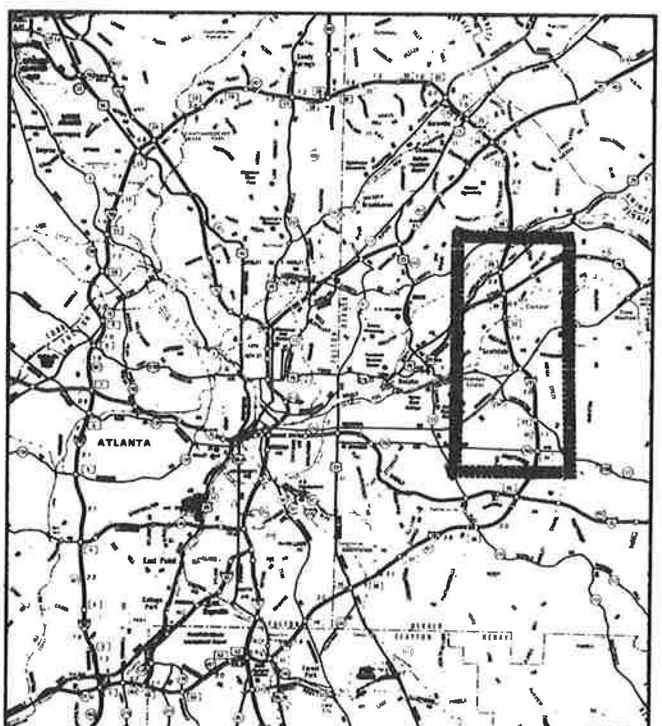
A study was conducted to compare the field insertion loss with the calculated insertion loss of four noise barriers along Interstate 285 in Atlanta, Georgia. Field insertion loss was determined in accordance with the latest guidelines promulgated by the Federal Highway Administration (FHWA). The calculated insertion loss was obtained through the use of STAMINA 1.0, the level-2 computer model based on the FHWA highway traffic noise prediction model. The study indicates a high level of confidence in the accuracy of the computer model. Also included are the results of a survey administered to the affected population behind each noise barrier. Results of this survey indicate general public support for a noise-abatement program and the need for more public involvement prior to the construction of a noise barrier.

Highway-generated noise and public reaction to it have become a real problem in recent years, especially in densely populated areas such as Atlanta, Georgia. The ever-growing central business district of Atlanta continues to attract growing volumes of commuter- and production-related traffic. In addition to this business-oriented traffic, thousands of interregional vehicle trips pass through and around the city annually. These high traffic volumes have led to increased noise levels in areas that abut most of the Interstate highway mileage in and around Atlanta.

In an effort to mitigate highway-traffic-induced noise impacts, the Georgia Department of Transportation has constructed noise barriers at selected locations along the Interstate highway system. Four of these barriers have recently been constructed along Interstate 285, east of Atlanta (see Figures 1 and 2). The intent of this paper is to compare the measured insertion loss with the insertion loss predicted by state-of-the-art computer modeling techniques. In addition, public reaction to this abatement effort is examined in order to determine whether support exists for an active noise-abatement program.

Figure 1. Project location.

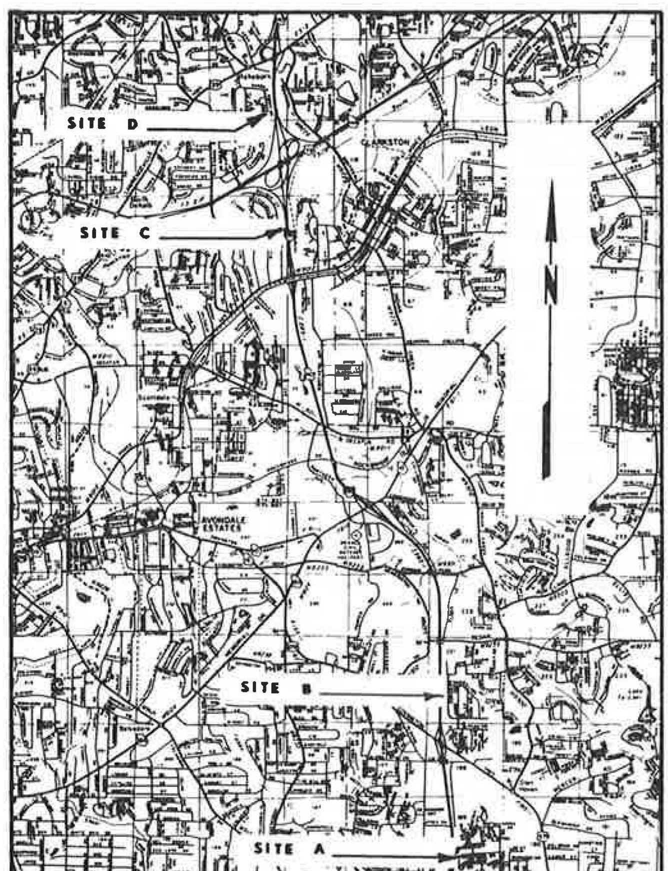


PROBLEM STATEMENT

Barrier acoustic design was accomplished through the use of STAMINA 1.0 (1), the level-2 computer model based on the Federal Highway Administration (FHWA) highway traffic noise prediction model (2). This model considers actual site geometry along with vehicle mix and operating characteristics and, through a series of adjustments to a reference energy-emission level, calculates the noise level at a receiver before and after the construction of a barrier. The difference in these two calculated noise levels is the predicted insertion loss.

Since these barriers were constructed on an existing highway, a set of before and after noise measurements was made at sites representative of

Figure 2. Site location.



each location. These sound levels were then used to calculate the field insertion loss for each barrier, which was then compared with the predicted insertion loss as determined by the computer model. An evaluation of the expected accuracy of STAMINA 1.0 is then presented.

The physical performance of a noise barrier in reducing traffic-generated noise is important, but the perceived effectiveness of the barrier by the people who live behind it is a more meaningful measure of the success of the abatement attempt. In the absence of any quantifiable data on citizen reaction to traffic noise before the barriers were constructed, only the results of a survey conducted after the barriers were completed will be included in this paper. Although a valid comparison of reaction to traffic-generated noise before and after construction of the noise barrier cannot be made with these data, useful conclusions can be drawn from it.

METHODOLOGY

Since construction of the barriers took a short amount of time, we could closely duplicate the ambient conditions during the before and after field measurements. On-site measurements of temperature, wind speed, and wind direction were recorded throughout the sample period on both occasions. Relative humidity was obtained from a local office of the National Oceanic and Atmospheric Administration. These data are presented in the table below. Meteorological conditions did not vary significantly enough to introduce an appreciable source of error in the measurements of noise level for this study.

Item	Before	After
Wind speed (mph)	1-7	1-9
Wind direction (north azimuth)	180	300
Temperature (°F)	60-62	80-85
Relative humidity (%)	71	89

Measurement of noise levels in this area during the 12 months prior to the beginning of this test indicated that average traffic flow conditions are consistent for the same day of week and the same time of day for similar seasons. Traffic flow conditions vary with time. However, past experience with this section of highway revealed that noise levels rarely varied by more than 2 dB at the same location and for the same sample period. For this study, all sample periods were 10 min. We therefore assumed that traffic count, mix, and speed would not change significantly in the short period of time between the before and after field measurements. Consequently, care was taken to make the field measurements on the same day of the week and same time of day. The time period between field measurements was short enough so as not to be influenced by seasonal variations in traffic flow.

Under this assumption, traffic flow conditions were measured only during the after set of noise level measurements; these data are presented in the table below and are incorporated into the STAMINA model for both the pre- and post-barrier conditions. Note that this assumption is not valid unless sufficient past experience indicates that little variation in measured noise levels exists for a given section of highway at the same location. All four barriers were geographically close enough so that the same traffic flow conditions were assumed to apply equally to each site.

Traffic	Vehicles per Hour	Speed (mph)
Automobiles	3980	53.8
Medium trucks	190	53.8
Heavy trucks	624	51.8

Field measurements of noise levels were conducted in a manner similar to procedures contained in the report, Determination of Noise Barrier Effectiveness (3). A reference microphone was established 50 ft from the centerline of the nearest travel lane at a point longitudinally beyond the end of the noise barrier for both sets of measurements. This microphone was used to detect any significant changes in the noise source that might have occurred between the two measurement dates. A second sound level meter (microphone 1) was placed in the backyard of a home determined to be typical of the topography in the neighborhood behind the noise wall. Simultaneous measurements were made at each location for both the before and after conditions. A Metrosonics dB-602 sound level analyzer was used as the reference microphone in all cases; a General Radio 1565-B sound level meter was used for the simultaneous measurement in all cases. Both meters were set up in accordance with the report, Sound Procedures for Measuring Highway Noise (4), and were calibrated before and after each measurement to ensure accuracy.

A survey questionnaire was constructed by using examples contained in the report, Proceedings of Conference on Highway Traffic Noise Mitigation (5). As mentioned previously, no suitable data are available to quantify citizen reaction to highway-traffic-generated noise before construction of the noise barriers. However, an attempt was made to determine how the affected citizens perceived the effort to mitigate their noise problem. The questionnaire was administered through a door-to-door survey to preselected homes identified from aerial photography. The areas were chosen with the intent of obtaining information on how perceived effectiveness differed between those people who live adjacent to the Interstate and those who live at greater distances from the facility. Interviews were conducted during late afternoon and evening hours to ensure that a maximum number of people could be reached.

FINDINGS

Field Insertion Loss

The field insertion loss was calculated in a manner similar to that recommended by Reagan and Hatzi (3). The Leq(h) measured at the reference microphone after the barrier was constructed was subtracted from the Leq(h) at the same location before the barrier was constructed. Mathematically, this is stated as

$$\Delta L = Leq(h)_B^R - Leq(h)_A^R \quad (1)$$

where $Leq(h)_B^R$ is the hourly Leq measured at the reference microphone before the barrier was constructed and $Leq(h)_A^R$ is the hourly Leq measured at the reference microphone after the barrier was constructed.

In cases where $|\Delta L|$ is 1 dB(A) or less, the field insertion loss (IL) is calculated according to Equation 2:

$$IL = Leq(h)_B^1 - Leq(h)_A^1 \quad (2)$$

where $Leq(h)_B^1$ is the hourly Leq measured at the location behind the noise barrier before the barrier is constructed and $Leq(h)_A^1$ is the hourly Leq measured at the same location after the barrier is constructed.

In cases where $1 < |\Delta L| \leq 3$ dB(A), field IL is calculated according to Equation 3:

$$IL = [Leq(h)^1_B - \Delta L] - Leq(h)^1_A \qquad (3)$$

The field insertion loss for each site (refer to Figure 2) is presented in Table 1.

Calculated Insertion Loss

Calculated insertion loss is simply the difference in the calculated Leq(h) at the location behind the noise barrier before and after construction of the barrier. These data are also presented in Table 1.

Attitudinal Survey

The interviews were conducted by personnel from the

Table 1. Insertion loss.

	Before		After		Insertion Loss	
Site	Measured	Calculated	Measured	Calculated	Measured	Calculated
Reference microphone						
A	79	79	80	79	10	9
B	76	79	78	79	10	8
C	82	79	80	79	8	7
D	80	79	78	79	8	7
Microphone one						
A	71	73	61	64		
B	66	71	58	63		
C	70	70	60	63		
D	69	69	59	62		

Figure 3. Sample questionnaire.

I-285 NOISE BARRIER SUVEY

1) HOW LONG HAVE YOU LIVED AT THIS ADDRESS? _____ Years _____ Months

2) HOW OFTEN DO YOU USE I-285? _____ Trips Daily

TYPE OF TRIP: _____ Work _____ Shopping _____ Pleasure

3) PRIOR TO THE IMPROVEMENTS TO I-285, DID YOU NOTICE NOISE AS A PROBLEM IN THE FOLLOWING ACTIVITIES?

___ Conversation or TV ___ Outside Activities
___ Work or Study ___ Other: ______________
___ Sleep

4) AFTER THE IMPROVEMENTS, HAVE YOU EXPERIENCED ANY BENEFITS OF REDUCED TRAFFIC NOISE?

___ Conversation is easier ___ Use Yard More
___ Improved Sleeping Conditions ___ Other: ______________
___ More Relaxing Environment ___ None

5) HOW WOULD YOU DESCRIBE THE VISUAL EFFECTS OF THE NOISE BARRIER?

___ Enhances Facility Appearance ___ Creates Closed-in Feeling
___ No Effect ___ Visual Eyesore: Unsightly
___ Limits or Restricts View ___ Other: ______________

6) WHAT IMPROVEMENT ELEMENTS TO I-285 HAVE/WILL BENEFIT YOUR NEIGHBORHOOD?

___ Improved Riding Surface ___ Noise Barrier
___ Reduced Congestion ___ Quieter or Reduced Noise Levels
___ Improved Safety ___ Other: ______________

7) IF QUIETER RESPONSE WAS GIVEN, WHAT ATTRIBUTED TO THIS EFFECT?

___ Smoother Surface ___ Noise Barrier
___ Improved Operating Conditions (ie: Speeds and/or Congestion) ___ Other: ______________

8) IT HAS BEEN DETERMINED THAT NOISE BARRIERS COST $11,200 PER PROTECTED RESIDENCE. DO YOU THINK DOT WAS JUSTIFIED IN SPENDING THIS AMOUNT?

___ Yes ___ No ___ No Opinion

TO BE COMPLETED BY INTERVIEWER AFTER SURVEY:

SEX OF RESPONDENT: ___ Male ___ Female

RACE: ___ White ___ Non-White ___ Other

ESTIMATED AGE OF RESPONDENT:

___ 29 or under ___ 40 - 49 ___ 65 or older
___ 30 - 39 ___ 50 - 64

TYPE OF DWELLING: ___ Wood ___ Masonry

DESCRIBE ATTITUDE OF RESPONDENT: ___ Positive ___ Neutral ___ Negative

ADDRESS: ____

Planning Data Services Section, Systems Usage Branch, Georgia Department of Transportation, and the results were tabulated in the final report (6). A total of 233 homes at the four sites (see Figure 2) were chosen to be surveyed. Of this total, 49 either were not at home or would not respond to the questions, which left a total response of 79 percent of the population of interest. The results of this survey are considered an accurate indication of the affected citizens' perception of the effectiveness of the noise barriers constructed for their community. A sample questionnaire is shown in Figure 3. The consensus of all four communities is presented in the following paragraphs.

The noise problem was perceived in a similar manner by residents who had lived in the area more than 10 years and those who had just moved in during the last few years. The average time of residence in the area was 6.6 years, which indicates that a number of people have willingly moved into an area that has high noise levels. Further analysis shows that 55 percent of the residents have lived there less than 10 years and 78 percent of these found noise to be a problem; 87 percent of those who lived there more than 10 years complained of a noise problem.

Nearly 50 percent of the respondents indicated that noise was a problem in conversation or sleep, 17 percent listed interference with work or study, and 33 percent said noise was a problem in outdoor activities. We also determined that 13.7 percent of the residents did not consider noise a problem.

Approximately 40 percent of the residents listed improved communication and sleeping conditions as a benefit of the noise wall. In addition, 44 percent found the environment more relaxing, and 37 percent said they used their yards more as a result of the noise wall. In describing the visual effects of the noise barriers, 65 percent of the respondents felt the barrier actually enhanced the appearance of the facility; only 10 percent felt they were detrimental.

An interesting item was that 32 percent of the residents thought that the reduced noise levels would benefit their community. However, almost 62 percent thought this would be a result of a smoother riding surface from the widening of I-285 and only 4 percent attributed the quieter environment to noise barriers.

By counting only those houses expected to experience noise levels in excess of 70 dB(A) (L10), we determined that the noise barriers cost $11 200/residence protected. More than 82 percent of the respondents thought this cost was justified and only 12 percent were not in favor of this expenditure.

CONCLUSIONS

The data in Table 1 show that the STAMINA 1.0 model provides an accurate means of calculating highway traffic-generated noise. In every case except at site B, the difference in field measured and calculated noise levels was no more than 3 dB(A). Site B consisted of hilly terrain that broke the line of sight between source and receiver. The terrain was modeled to illustrate this shortcoming of the STAMINA 1.0 program. In fact, all cases in which a barrier was inserted yielded calculated noise levels higher than measured noise levels. This is apparently due to the loss of excess attenuation provided by surrounding trees and shrubs, since STAMINA 1.0 ignores this factor when the line of sight is broken. However, the STAMINA 1.0 model is still an accurate tool when used with this deficiency in mind. It provides the user with conservative estimates of the expected insertion loss.

Results of the survey indicate public support for a noise-abatement program. Also apparent is that efforts are needed to educate the public on what noise barriers are and how they are expected to work. This could be accomplished through meetings with affected communities after it has been determined that noise abatement is feasible for a given location.

A distinct difference in the perceived noise problem between residents adjacent to the Interstate and those beyond the second row of houses from the Interstate was found at sites A and B. Site C displayed virtually no difference over the entire sample area and site D exhibited only a slight decrease in the perceived noise problem with increased distance from the source. This inconsistency is believed to be a result of inexperience in constructing and administering the survey as well as lack of public awareness of what the noise barriers were and why they were erected.

REFERENCES

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Evaluation of Noise Barriers

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This study was performed to evaluate Federal Highway Administration (FHWA) noise prediction and barrier design model 77-108, used by the California Department of Transportation. Barrier costs and community attitudes to barriers were also studied. Nine microphones were positioned at various heights and distances behind the barrier location before and after the barrier was constructed. One microphone was positioned 5 ft above the barrier to serve as a control. Sound levels were measured before and after the barrier was constructed at seven locations. Two sets of measurements were obtained at four