Noise Investigation of the Pennsylvania Turnpike Widening

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The existing four-lane Delaware River Extension of the Pennsylvania Turnpike reaching from Valley Forge to the Delaware River traverses the most developed region in the state. The net effect of growth over 30 years is congestion and traffic-generated noise. At present, the turnpike is a four-lane, controlled-access highway with 10-ft shoulders along its length and a 10-ft median with guide rail. The project described in this paper involves the installation of extensive noise wall barriers and the widening of the turnpike to six lanes. A total of 57 noise receptor points were analyzed. The 2006 design year L_{eq} noise level for the noisiest hour of each receptor was predicted by means of the calibrated STAMINA 2.0/ OPTIMA computer program. This provided the individual noise contributions of the Pennsylvania Turnpike, various arterials and local roads, and the logarithmic addition of all roadway noise to provide a total noise level at each receptor site. An inspection of the data yielded the following: the predicted noise levels exceeded established noise abatement criteria at 16 sites, and noise mitigation in the form of noise barrier walls was required. The location, dimensions and cost of the barriers were determined along with the predicted reduction and noise levels. An after study was later completed that compared actual with predicted and existing noise levels. The decrease ranged from 2.9 dBA to 13.0 dBA.

The existing four-lane Delaware River Extension (I-276) of the Pennsylvania Turnpike reaching from Valley Forge to the Delaware River traverses the most developed region in the state. Since the opening of this section of the turnpike in 1954, heavy residential, commercial and office development has taken place along this corridor. The net effect of this growth is that congestion is common along this section of the turnpike.

The Pennsylvania Turnpike Commission completed the widening to six lanes of certain sections of the Pennsylvania Turnpike on land it already owned (*1*,*2*). The design constraint of no new right of way applied to all construction elements including noise barrier placement. The westernmost section is the subject of this report. The project site is located in Montgomery County between the communities of Cold Point and Fort Washington. Financing for the construction is from the tolls generated by the commission, which is not required to conform to the various design standards of the Pennsylvania Department of Transportation.

The turnpike was a four-lane, controlled-access highway with 10-ft (3.05-m) shoulders along its length and a 10-ft (3.05-m) median with guide rail. Widening of this section of the turnpike to six lanes with 12-ft (3.66-m) usable shoulders and a 10-ft (3.05-m) maximum, 4-ft (1.22-m) minimum median with concrete barrier along the center of the median would provide for the safe and efficient flow of traffic now and in the future, relieving the congestion problem.

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NOISE STUDY—BEFORE

Purpose

The purpose of this study is to investigate and describe existing and future noise levels on both the Pennsylvania Turnpike and local roads in the vicinity of the study section.

Under the scope of this study, ambient noise conditions are described, including recent noise measurements of the communities adjacent to the Pennsylvania Turnpike and various local roads. Noise impacts are analyzed for both the existing and predicted (design year 2006) conditions. From this analysis noise mitigation recommendations are developed. These recommendations are made after integration of geometric design with design optimization and value engineering, involvement of the community, and coordination with the design of adjacent sections.

Methodology

The existing noise results were obtained by field measurements and determination of representative levels by analogy with similar sites (*3*,*4*). Predicted noise results were obtained by computer modeling of traffic, geometry and site conditions. Prediction of the 2006 (the design year) noise levels that would result from the widening of the Pennsylvania Turnpike was made by means of a noise program based on the methods detailed in the Federal Highway Administration report, FHWA-RD-77-108, *FHWA Highway Traffic Noise Prediction Model: Highway Noise* (*5*). The FHWA's computer program, STAMINA 2.0 (an acronym for Standard Method in Noise Analysis, version 2.0), which is in concert with Federal-Aid Highway Program Manual, Volume 7, Chapter 7, Section 3 (FHPM 7-7-3) of the Federal Highway Administration, U.S. Department of Transportation, was run on an IBM Computer 3081 and included all necessary adjustments relating to distance, gradient, highway section characteristics, vertical height, flow conditions, ground and shielding effects, and height adjustments for receivers, autos and trucks (*6*,*7*).

Traffic

Turnpike traffic is the principal source of noise in the community. The existing peak hour one-directional traffic volume

on this turnpike section is 3,060 vehicles distributed over two lanes. Field noise measurements and 24-hour truck classification counts indicated that the noisiest time period was between 3:00 p.m. and 5:00 p.m. and that the traffic during this time does not vary because of the consistent nature of the commuter work-to-home trip. Simultaneous recording of traffic and noise levels was, therefore, not considered necessary. This existing volume exceeds the Level of Service (LOS) C service volumes according to the *Highway Capacity Manual*, and indicates operation at an unacceptable peak hour level of service. At this volume, the turnpike was operating at LOS E because the volume to capacity (*V/C*) ratio was computed at 0.98 at LOS E. Therefore, the proposed widening to six lanes was needed to improve the level of service.

The peak hour one-directional traffic volume in 2006, the design year, is estimated to be 3,430 vehicles. Because this projected volume is less than the Level of Service C service volume, the proposed widening of this turnpike section to three lanes in each direction will provide an adequate Level of Service for the design year 2006 traffic conditions.

Predicted Noise Levels and Impacts

A total of 57 receptor points, including 18 monitoring sites, 25 analysis points and 14 supplementary analysis points were devised and identified.

The design year L_{eq} noise level of each receptor was predicted by means of the calibrated STAMINA 2.0 computer program. Calibration was achieved by comparing existing field noise measurements with predicted noise levels, using existing traffic and model input parameters. Tabular values for the noisiest hour yield the individual noise contributions of the Pennsylvania Turnpike, various arterials and local roads, and the logarithmic addition of all roadway noise to provide a total noise level at each receptor site. An inspection of the data yields the following observations:

1. There is a maximum increase of 0.7 dBA in L_{eq} between the existing and design year conditions at two sites. The average increase is 0.4 dBA at a distance of 300 ft (91 m) from the near lane of the turnpike.
2. For 16 sites the noise level during the noisiest hour for the 2006 design year meets or exceeds the Pennsylvania Turnpike Commission Noise Abatement Criteria, which specify 65.5 dBA. The highest level is 71.4 dBA, an increase of 0.4 dBA from the existing 71.0-dBA noise level. This level is attributable mainly to the elevated position of this receptor above the turnpike and the lack of natural sound protection from the turnpike noise.

Mitigation Measures

Because of the limited right of way along the Pennsylvania Turnpike, one mitigation measure, noise barrier walls, is most effective for this project. Through consideration of the views expressed by the community, the needs of the turnpike maintenance policy and aesthetics, a system of precast concrete planks with exposed aggregate surfaces set between posts was selected. The planks were approximately 12 ft 3 in. by 4 ft by 6 in. (3.7 m by 1.2 m by 0.15 m) with a density of 150 lbs/ft^3 (2400 kg/m^3).

The total predicted 2006 design year noise levels at 16 receptor sites indicate the need for mitigation measures. Noise at 15 of the sites can be effectively mitigated through the use of noise barrier walls. The noise at one site can be mitigated through a combination earth berm/noise wall design.

A description of the noise barrier locations and noise mitigation effectiveness follows. Determination of actual costs was not possible because of the contractor's bid price; however, the estimate was approximately \$25/ft^2 (\$269/m^2).

Location A

This barrier will provide noise protection for receptor sites located on the south side of the turnpike. The proposed wall will be 14 ft (4.27 m) high and will provide at least a 3.5-dBA reduction to the affected receptors.

Location B

This 14-ft (4.27-m) noise wall, located along the north side of the turnpike and spanning a turnpike bridge structure, will provide noise shielding on the north side of the turnpike. The 6.4-dBA reduction will bring the projected noise level under the Pennsylvania Turnpike Commission's 65.5-dBA noise level criterion.

Location C

This noise wall will be 1,000 ft (305 m) long and will consist of a noise wall on earth berm design with a total height of 18 ft (5.49 m). The noise barrier will be situated on the south side of the turnpike. Noise mitigation will be 6.8 dBA, thus bringing the receptors under the 65.5-dBA noise level criterion.

Location D

This noise mitigation wall, 750 ft (229 m) long and 16 to 18 ft (4.88 to 5.49 m) high, will be situated along the north side of the turnpike. The noise reduction will be 4.9 dBA.

Location E

The proposed noise wall at this location, 3,600 ft (1099 m) long and 8 to 18 ft (2.44 to 5.49 m) high, will provide mitigation to the community south of the turnpike. For all receptors affected, the predicted noise will be reduced to a level below the 65.5 dBA criterion.

Location F

This noise abatement structure, 1,760 ft (536 m) long and 14 to 16 ft (4.27 to 4.88 m) high, is located along the north side of the turnpike. All projected noise levels at the affected

communities will be reduced to a level below the 65.5 criterion.

Location G

The proposed noise mitigation wall at this location will shield receptor sites and the community located north of the turnpike. This 830-ft- (253-m) long and 10-ft- (3.05-m) high barrier wall will reduce the noise in this community to a level below the 65.5 dBA criterion.

NOISE STUDY—AFTER

Purpose

A noise study was undertaken after the turnpike widening project, including the described noise walls, to verify the noise levels predicted before construction. This task was prompted by requests of those property owners who were not affected by the mitigation measures and desired an extension of the newly constructed noise barriers.

Methodology

Noise monitoring was conducted at 20 noise sites in the same vicinity of the Pennsylvania Turnpike previously described. These noise sites included 8 primary sites and 12 secondary sites. The primary sites are residences of those who have filed complaints and the 12 secondary sites were chosen so that the 65.5-dBA (L_{eq}) noise contour could be established on both sides of the study section as a result of the field monitoring.

The noise monitoring procedures and techniques conform to the guidelines detailed in the FHWA Report, *Sound Procedures for Measuring Highway Noise: Final Report* (FHWA-DP-45-1R), and were conducted again during the noisiest time period between 3:00 p.m. and 5:00 p.m. (*8*). A type 1 Bruel and Kjaer Integrating Noise Meter (Model 2230) and Calibrator (Model 4230) were used. Both the noise meter and calibrator were factory calibrated before the field monitoring.

Results

The noise monitoring results reveal a decrease in noise level after the installation of noise walls. The decrease ranges from 2.9 dBA to 13.0 dBA and closely matches the predicted levels, adjusted for current traffic, before the installation of the barriers.

None of the noise levels at the eight primary sites exceed the Pennsylvania Turnpike Commission's noise abatement criterion of 65.5 dBA. Only one secondary site indicates a noisiest hour noise exposure of 66.2 dBA. This is attributable to the site's close proximity to a local road.

CONCLUSIONS

The methods employed in ambient noise monitoring, prediction, and mitigation design in the form of noise walls appear to be reasonably accurate, as demonstrated by a subsequent noise verification study following construction. This project involved noise impacts created by a high-speed, high-volume roadway.

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