# NEW YORK STATE THRUWAY AUTHORITY

## Report on Tire Noise Along Interstate Route I- 95 In The Town of Harrison, New York

May 2001

prepared by
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**NEW YORK STATE THRUWAY AUTHORITY**
**TIRE NOISE STUDY**
**May 2001**

## INTRODUCTION:

The New York State Thruway Authority (Authority) requested that Parsons Brinckerhoff undertake tire/pavement noise studies along portions I-95 (New York Thruway) in the Town of Harrison. The objective of this work effort is to implement a measurement program to determine the sound level differences between two different types of pavement on I-95.

The interaction of rubber-tired vehicles on a roadway surface is a significant source of noise generation at vehicle speeds above approximately 50 miles per hour. Recent studies have pointed out that, in relative terms, the type of road surface has greater influence on tire noise than the type of tire.

This report presents the results of a measurement program conducted by Parsons Brinckerhoff on April 30 and May 1, 2001 to determine the vehicle tire noise emission levels from a continuous stream of vehicles traveling at speeds of over 50 miles per hour on the following two different types of pavement on I-95:

- PCC Pavement with a longitudinal diamond ground surface
- PCC Pavement with "micro-surfacing" asphalt overlay

To characterize the tire/road noise in terms of the human response to noise, two types of measurements were performed. The first determined loudness of pavement and the second determined frequency distribution of noise. The approach used for each measurement and the reasons for taking the measurements are described below.

## NOISE LEVELS

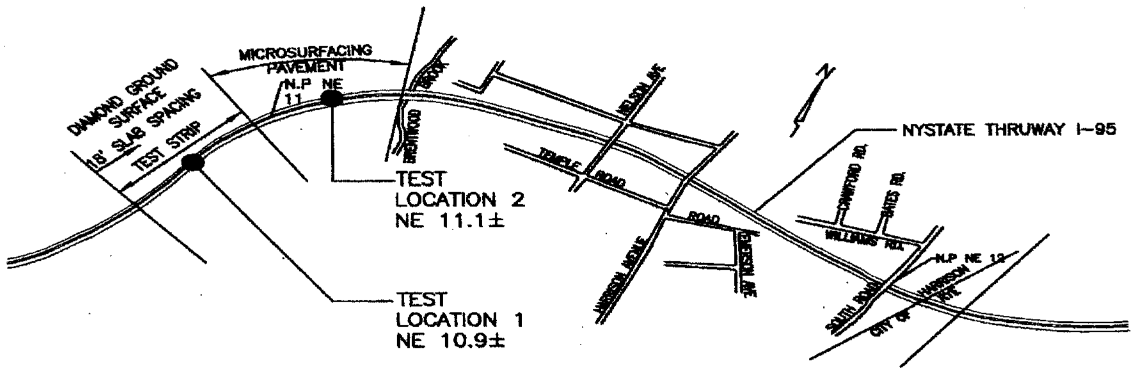
### General

Intensity or 'loudness' of noise (noise level) is represented by equivalent continuous noise level, abbreviated as L eq (higher noise levels are more intensive and more overpowering). L eq is measured over stated time duration, which, is usually one hour. Noise measurements were obtained that provided noise intensity level data to determine 'loudness' from each pavement surface.

Loudness is proportional to the total L eq from each pavement surface and is given by the summation of energy contained in each individual vehicle passage. Loudness determination will enable a comparison of the two pavements to be based on relative differences in the measured loudness represented by the acoustic energies (i.e. noise levels expressed in units of hourly L eq in dBA) from the two pavement surfaces.

## Noise Monitoring Locations

Figure 1 shows the two noise monitoring locations on the New England Thruway (Interstate 95).




TEST LOCATION 1: DIAMOND GROUND SURFACE PAVEMENT
TEST LOCATION 2: MICROSURFACE PAVEMENT

NOISE MONITORING LOCATIONS
FIGURE 1

The two locations are situated within approximately 1000 feet of each other. The diamond ground test strip is 1000 feet long and noise measurements were taken on this surface at approximately milepost NE 10.9. Noise measurements also were taken on the micro-surface pavement at approximately milepost NE 11.1. There are no interchanges between the locations and therefore, the volumes and speeds of the vehicles moving over the two pavements approximately stayed the same during the measurements. During the measurement period, the middle and the far lanes in the southbound direction were closed and traffic was only permitted in the lane with the diamond ground surface and in the lane with the "micro-surfacing" asphalt pavement. The traffic in the northbound direction was unimpeded and moving normally. This provided a unique opportunity, as the conditions were ideal for comparing tire/road interaction noise from simultaneous noise measurements at the two monitoring sites. The climatic and road surface conditions were favorable during the measurements with calm winds (wind speeds less than 18 km/hr) and dry road surface.

## Noise Monitoring Period

It was determined that the early morning hours would provide the greatest opportunity to obtain a uniform high speed and therefore the highest tire-generated noise levels from the two types of pavement. The measurements were taken every ten minutes, between 2:00 AM and 5:30 AM, at the two monitoring locations. During the entire measurement period noise energy levels from each pavement were relatively consistent.

## Equipment Used in Noise Monitoring

Two calibrated Bruel & Kjaer (B&K) Type 2231 Sound Level Meters with calibrated B&K Type 4155 condenser microphones fitted with windshields were used in L eq noise measurements. The measurement procedures conformed to the requirements of NY State DOT publication "Field Measurement of Existing Noise Levels" M.A.P. 7.42 - 7.1, and U.S DOT FHWA DP.45-1R titled "Sound Procedures for Measuring Highway Noise: Final Report".

**Data**
The Noise Energy Levels measurements are shown in Table 1. Table 1 also shows the differences in energy levels between the "micro-surfacing" and the diamond ground surface.

**TABLE 1**
**NOISE LEVEL READINGS**

| | Measured L eq (dBA) | | Difference (dBA) |
|---|---|---|---|
| **Time Period** | **Diamond Ground** | **"micro-surfacing"** | **(micro-diamond)** |
| 2:00 - 2:10 am | 80.8 | 81.5 | +0.7 |
| 2:10 – 2:20 am | 79.7 | 79.7 | 0 |
| 2:20 – 2:30 am | 79.5 | 78.8 | -0.7 |
| 2:30 – 2:40 am | 80 | 80.3 | +0.3 |
| 2:40 – 2:50 am | 80.7 | 81.9 | +1.2 |
| 2:50 – 3: 00 am | 80.4 | 80.9 | +0.5 |
| 3:00 – 3:10 am | 80.6 | 81.4 | +0.8 |
| 3:10 – 3:20 am | 80.6 | 81.4 | +0.8 |
| 3:20 – 3:30 am | 81 | 81.6 | +0.6 |
| 3:30 – 3:40 am | 79.9 | 80.8 | +0.9 |
| 3:50 – 4:00 am | 81.7 | 81.7 | 0 |
| 4:00 – 4:10 am | 81.3 | 81.9 | +0.6 |
| 4:10 – 4:20 am | 82 | 81.9 | -0.1 |
| 4:20 – 4:30 am | 82.1 | 82.8 | +0.7 |
| 4:30 – 4:40 am | 82.3 | 81.1 | -1.2 |
| 4:40 – 4:50 am | 81.5 | 82.2 | +0.7 |
| 4:50 – 5:00 am | 82.3 | 82.2 | -0.1 |
| 5:00 – 5:10 am | 82.5 | 82.6 | +0.1 |
| 5:10 – 5:20 am | 82.1 | 81.4 | -0.7 |
| 5:20 – 5:30 am | 82.4 | 82.3 | -0.1 |
| **Average** | **81.2** | **81.4** | **Average Diff = +0.2** |

## FREQUENCY DISTRIBUTION OF NOISE:

**General**
The frequency distribution of tire/roadway noise can reveal information for determining the "annoyance" factor (high frequency noise will seem more pronounced to human listeners than low frequency noise). A frequency spectrum of the acoustic energy at contiguous frequency bands for each vehicle type and for each pavement surface was measured for each type of vehicle and pavement. The measured frequency spectrum was used to calculate the ratio of sound energy from 'annoying' high frequency bands to the total sound energy from all of the frequency bands. It is an interesting point of semantics that the subjective rating of "noisiness" is different from "loudness", noisiness being more strongly dependent on acoustic

energy (represented by sound pressure levels) at high frequency bands than loudness.

## Noise Monitoring Locations

The two locations used to measure frequency distribution are the same locations as those used and described above for intensity of noise.

## Noise Monitoring Period

The frequency distribution readings were taken over the period from 2:00 AM to 5:30 AM. There were about 20 readings taken to cover the two locations for all vehicle types. As with the "loudness" measurements, the early morning hours were deemed the best time to take the readings as individual vehicle could be easily isolated and the speeds were relatively constant.

## Equipment Used in Noise Monitoring

A "01" Digital Noise Analyzer with a calibrated condenser microphone with its windshield was used to obtain frequency spectra in frequencies centered on 1/3 octave bands. The measurement procedures conformed to those contained in the book titled "Frequency Analysis" by Bruel and Kjaer, 1987.

## Data

The measured noise frequency distribution levels for automobiles are shown in Table 2.

**TABLE 2**
**NOISE FREQUENCY DISTRIBUTION LEVELS**

| Frequency HZ | Automobiles | |
|---|---|---|
| | Diamond Ground | Micro-surfacing |
| 31.5 Hz | 68.9 | 69.4 |
| 40 Hz | 71.2 | 74.5 |
| 50 Hz | 73.9 | 73.9 |
| 63 Hz | 76.3 | 66.3 |
| 80 Hz | 80.9 | 79 |
| 100 Hz | 73.4 | 75.9 |
| 125 Hz | 72.3 | 72.8 |
| 160 Hz | 74.4 | 72.1 |
| 200 Hz | 73.5 | 69.1 |
| 250 Hz | 69.9 | 69.3 |
| 315 Hz | 69.4 | 68.5 |
| 400 Hz | 69.7 | 68.8 |
| 500 Hz | 70.9 | 71.2 |
| 630 Hz | 70.3 | 73.4 |
| 800 Hz | 70.5 | 70 |
| 1 kHz | 69.6 | 67.1 |
| 1.25 kHz | 67.5 | 64.4 |
| 1.6 kHz | 64.6 | 61.7 |
| 2 kHz | 62.8 | 60.1 |
| 2.5 kHz | 61.2 | 58.3 |

## TABLE 2
## NOISE FREQUENCY DISTRIBUTION LEVELS

| Frequency HZ | Automobiles | |
|---|---|---|
| | Diamond Ground | Micro-surfacing |
| 3.15 kHz | 59.1 | 55.9 |
| 4 kHz | 57 | 53.8 |
| 5 kHz | 52.8 | 51.4 |
| 6.3 kHz | 48.4 | 46.9 |
| 8 kHz | 47.1 | 43.4 |
| 10 kHz | 38.6 | 38 |
| 12.5 kHz | 31.6 | 30.1 |
| 16 kHz | 26.3 | 22.7 |

There is no significant difference in the high frequency noise from automobiles traveling on the two different types of pavement surfaces. The results for the heavy trucks also showed similar behavior. The high frequencies from heavy trucks were generally very similar between the two pavement types.

## SUMMARY OF RESULTS & CONCLUSIONS

### Noise Levels

Results

The Noise Energy Level measurements are shown in Table 1. It should be noted that the noise energy levels for each pavement were relatively consistent for the entire measurement period and the measured noise levels include contribution from all vehicles. Variations in noise levels between the two locations reflect very little change (less than 0.5 dBA) in total energy emission levels from the two types of pavement.

As described in the NYSDOT Environmental Procedures Manual, 1995, Chapter 3,-Attachment 3.A.1.E. Highway Traffic Noise Analysis and Abatement, Policy and Guidelines; FHWA (June 1995), a 3 dBA change in noise level represents a barely perceptible change to an average listener. This is also described in references 1 and 2. Therefore noise from both surfaces would not be perceived to be noticeably different to the average listener. This difference would stay the same but would be even less noticeable at lower traffic noise levels, which would typically exist as the listener moves to realistic distances away from the roadside to the nearby homes. Stated differently, residents at their homes would perceive less of this difference than they would if they were standing alongside the highway.

### Frequency Distribution Of Noise:

Results

The frequency distribution of noise measurements shown in Table 2 is graphically presented in Figures 2 and 3.

**FIG 2**
**Average 1/3 Octave Band Spectrum for Diamond Ground Surface (AUTOMOBILES)**

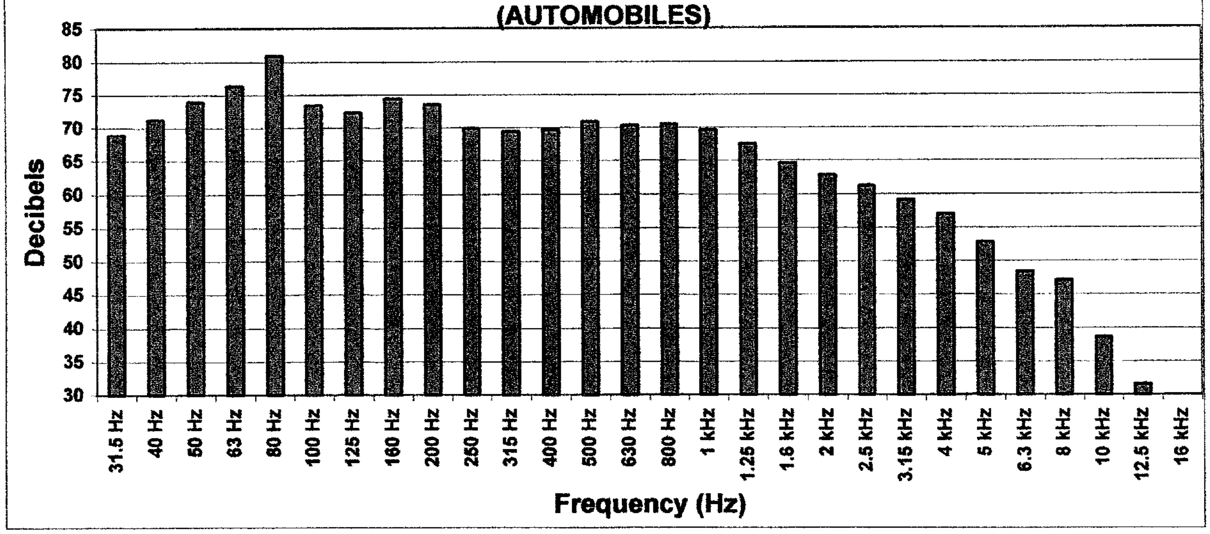
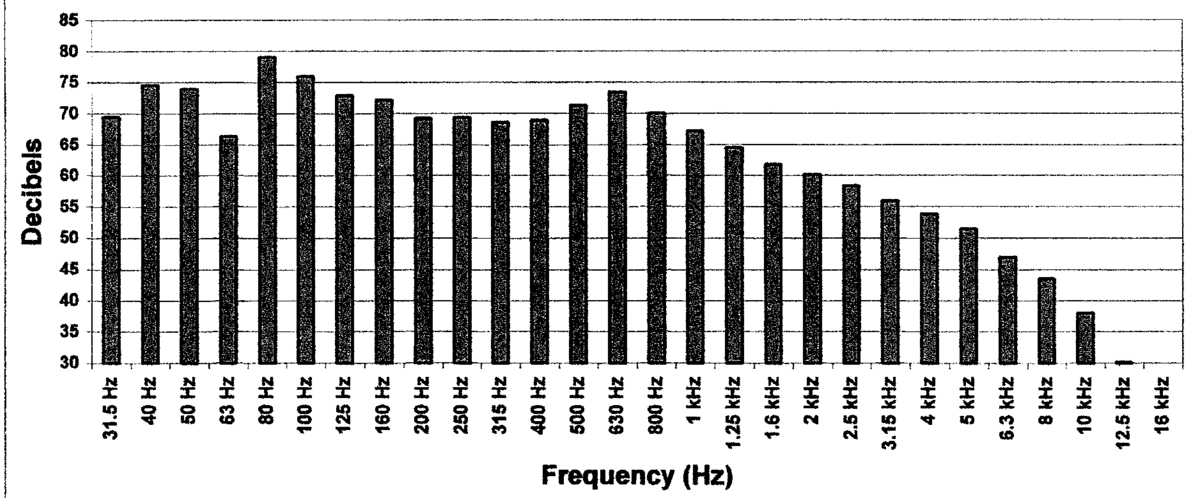



**Fig. 3**
**Average 1/3 Octave Band Spectrum for Pavement with Microsurfacing (AUTOMOBILES)**




The frequency distribution of noise measurements for heavy trucks is presented in Figures 4 and 5. The frequency analysis of sound pressure level in 1/3 octave bands is shown from 31.5 Hz to 16 kHz. The continuous curves represent average spectrum for cars and heavy trucks. An average spectrum is provided for each type of vehicle and for each type of pavement. No significant differences in the annoying high frequency components are found for automobiles and heavy trucks when they travel on the two pavements.

Fig 4
Average 1/3 Octave Spectrum for Diamond Ground Surface

(HEAVY TRUCKS)

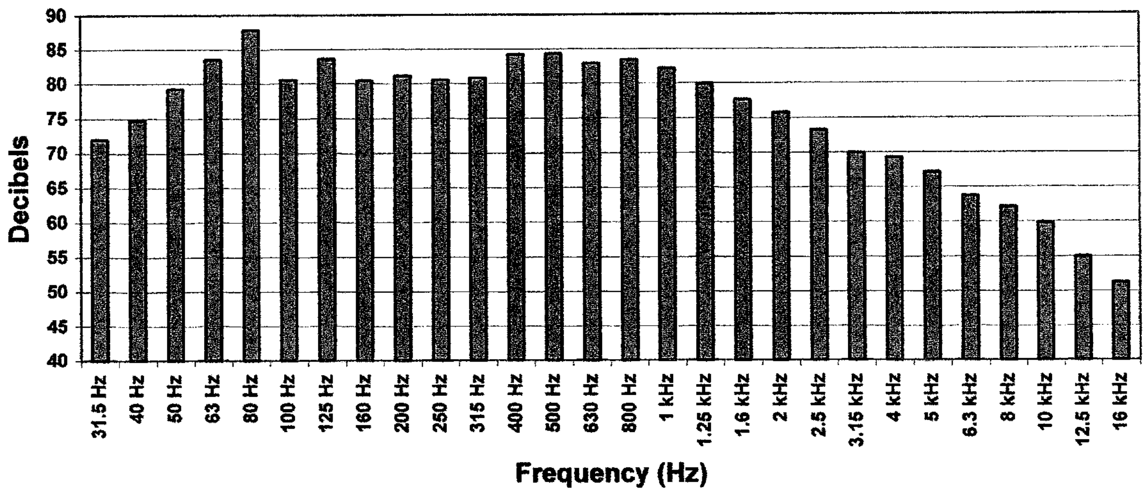
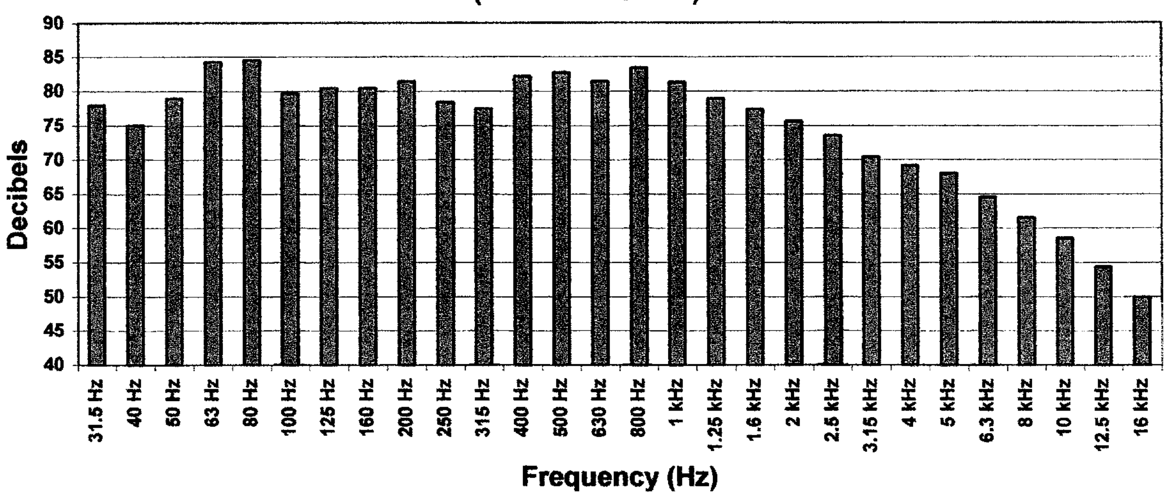



Fig 5
Average 1/3 Octave Spectrum for Pavement with Microsurfacing

(HEAVY TRUCKS)




## Conclusions

Based on the measurements and analyses, vehicles moving on the diamond ground surface produce slightly lower average noise energy levels than the same vehicles on the "microsurfacing" asphalt overlay. Both types of surfaces show similar spectral distribution of noise energy. To an average listener there should be no perceptible difference in the noise levels generated by automobiles and heavy trucks traveling on the two pavement surfaces.

**References**:


1. Fundamentals and Abatement of Highway Traffic Noise, BBN PB-222 703, 1973.
2. Handbook of Acoustical Measurements and Noise Control, Ed. Cyril Harris, 1991.
3. Transportation Noise Reference Book Pub. Butterworths 1987.
4. Frequency Analysis Bruel and Kjaer 1987.