

Research Report  
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**EFFECT OF PAVEMENT TEXTURE ON  
TRAFFIC NOISE**

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accepted for publication by the  
Transportation Research Board

June 1976

## INTRODUCTION

Noise from highway vehicles emanates primarily from engine exhausts, tire-pavement interaction, gears, and rattles. Studies have shown that at high speeds tires become the dominant generators of noise. Measurements on different road surfaces have produced different noise-versus-speed relationships (1). This led to the road surface adjustment used in the noise prediction procedure developed in NCHRP Report 117 (2). This adjustment called for a 5 dBA reduction for smooth surfaces (very smooth, seal-coated asphalt pavement) and a 5 dBA increase for rough surfaces (rough asphalt pavement with voids 1/2 inch (12 mm) or larger in diameter and grooved concrete). There was no adjustment for normal surfaces (moderately rough asphalt and concrete pavements).

The surface descriptions are vague, and it is left to the discretion of the user to apply adjustments where applicable. Consideration was given initially in this report to "rough" surfaces, but the term was abandoned because it seemed vague and maybe misleading. Also, various degrees of roughness gave a wide range of noise levels. In fact, it appears that the terms "smooth", "normal", and "rough" address only that portion of tire noise generated by drumming or percussion of the tire against knobs in the pavement surface. "Smooth" does not distinguish "smooth and dense" from "smooth and porous". It has been argued that the -5 dBA adjustment should not be used since some truck tires become excessively noisy on very smooth surfaces and inasmuch as such surfaces are presumed to be ready for renewal because of their inherent low friction characteristics (3). Minimum noise is believed to be associated with smoothness and an optimum porosity. In this report, surfaces are identified according to Kentucky specifications.

Noise data were taken on all major types of surfaces presently used in Kentucky. A reference automobile was used to determine any difference in noise. Strip-chart records were made to evaluate the effect road surface type had on the noise of the entire traffic stream.

## PROCEDURE

Noise data were taken on the following surface types: Class I, Type-A, Bituminous Concrete; Class I, Type A (Modified), Bituminous Concrete; Portland Cement Concrete; Sand Asphalt; Kentucky Rock Asphalt; Open-Graded, Plant-Mix Seals; Chip Seals; and Grooved Portland Cement Concrete. All data were taken at locations having zero grade, with the observer level with the roadway, and without any shielding. The distance from the center of the lane tested to the noise-level meter was 50 feet (15 meters). The locations were selected to give as great a range in traffic exposure as possible. A Bruel and Kjaer precision sound-level meter, Type 2203, was used for all measurements. The strip-chart recorder was Type 2305.

Two reference cars were used for single-vehicle tests. Care was taken to insure no error was introduced in using two different cars. Data were taken at 30, 45, and 60 mph (13, 20, and 27 m/s) at each location, when possible. The data taken at 45 mph (20 m/s) were used for direct comparisons since it was not possible to obtain 30- and 60-mph (13- and 27-m/s) tests at all locations. The meter readings were noted by the operator as the reference vehicle passed. Measurements were taken only when the noise from the reference cars could be clearly isolated from the traffic stream. Test runs were made at each speed and until representative measurements were obtained. In all cases, the ground cover between the roadway and observer was short grass. Noise levels were also taken inside the cars at 45 mph (20 m/s). A reference truck was used at one location.

To evaluate the effect of surface type on the noise of the traffic stream, strip-chart records were compared with predicted values. The measured  $L_{10}$  noise level (level exceeded 10 percent of the time) was determined from a 10-minute chart record. Noise levels on the chart were read at slightly greater than 1-second intervals in the laboratory utilizing a digitizing data reduction system and computer cards. The  $L_{10}$  noise level was computed. The predicted noise level was determined by the method developed in NCHRP 117 (2) but then corrected according to the nomograph developed for Kentucky data (4). No adjustment for surface type was used in the noise prediction. The measured  $L_{10}$  noise level was then compared with the predicted level.

## RESULTS

### Reference Car Noise Measurements

After preliminary testing of several locations involving each type of pavement, a relationship was found between noise level and cumulative traffic. A plot of noise level versus cumulative traffic volume was made for each pavement type using the noise level found at 45 mph (20 m/s). The noise level versus cumulative traffic for all pavement surface types (except chip seals) is summarized in Figure 1. A total of 87 tests at 63 locations were conducted.

Sand-asphalt and Kentucky rock asphalt surfaces are the only surfaces which maintained a low noise level (about 66 dBA) with increased cumulative traffic. Class I, Type A (Modified), chip seals, and open-graded plant-mix surfaces were all relatively quiet sometime during their service life, but the noise level of each increased to between 69 to 70 dBA as the cumulative traffic increased. Class I, Type A (Modified), bituminous surfaces were a smooth, dense surface when placed, but became noticeably polished after the cumulative traffic reached about one million vehicle passes. Also, noise levels increased on open-graded plant-mix surfaces with time. On new chip seal surfaces, the exposed aggregate produced high levels, but noise levels dropped as the aggregate is worn and the surface bleeds. Finally, the older surfaces began to crack and break up, and the noise level again rises. Chip seal surfaces are not included

in Figure 1 since they are placed only on low volume roads and are expected to endure for a limited time. Portland cement concrete and Class I, Type A, bituminous surfaces maintained a relatively constant noise level (69.5 dBA). Tests on transversely grooved portland cement concrete surfaces yielded a noise level around 73 dBA.

A few readings were obtained for surfaces which were unusually cracked and bumpy. These surfaces might be classified as "rough" and were not included in any of the preceding surface types. These "rough" surfaces had an average noise level of about 72 dBA.

To assure that the reference car noise data were representative of the "average" car, results from a previous vehicle noise survey (5) were compared to the reference car data. The survey was conducted on Class I, Type A and portland cement concrete surfaces for various speed-limit locations. The data at 45-mph (20-m/s) and 60-mph (27-m/s) speed-limit locations were compared to the reference car data for the corresponding speeds. Admittedly, the survey vehicles were not traveling at exactly the speed limit, but the large number of vehicles in the survey should make the comparisons valid. The median automobile noise level was 68 and 74 dBA for 45- and 60-mph (20- and 27-m/s) speed-limit locations, respectively. This compares to reference car noise levels of 69.5 and 74 dBA at the corresponding speeds. From this comparison, it can be seen that the reference car was representative of the "average" car.

#### **Noise Measurements inside the Reference Car**

To determine the differences in noise levels for occupants of vehicles driving on various surfaces, measurements were taken inside the reference car. In all cases, the vehicle speed was 45 mph (20 m/s). The sound-level meter was held about 6 inches (152 mm) above the back rest of the front seat -- closely corresponding to ear level. The slow response of the sound-level meter was used so variations in the noise could be minimized. The average noise level over a uniform stretch of highway was tabulated for each pavement type. From three to fourteen locations were tested for each surface type. The readings were averaged. The sand-asphalt and Kentucky rock asphalt surfaces gave the lowest noise levels (65.3 dBA). The other surface types ordered in the same way as the data obtained from outside the reference car (Figure 1).

Noise measurements were also made inside the car on some bridge decks. Two bridge decks which had been grooved were compared to one ordinary deck. The average readings for the grooved decks were identical to the average of grooved concrete pavements. Grooved decks gave readings approximately 3 dBA higher than ordinary decks.

#### **Noise Recordings**

A total of 260 noise recordings taken on various surface types were compared to predicted values. A comparison of the predicted  $L_{10}$ -noise levels (NCHRP 117 with Kentucky correction nomograph) with measured values was made. The actual and predicted  $L_{10}$ -values for Class I, Type A; worn Class

I, Type A (Modified); portland cement concrete; sand-asphalt; open-graded, plant-mix seal; and Kentucky rock asphalt surfaces were within  $\pm 1$  dBA. New Class I, Type A (Modified), surfaces were nearly 5 dBA under the predicted levels. This, however, is not indicative of the long-term noise level. Also, at these locations, there was a large number of smaller, quieter trucks which resulted in actual noise levels below the predicted levels. It was not possible to obtain reliable noise recordings for the grooved concrete surface because the only section which had been opened to traffic was on only two lanes of a four-lane highway. The very low traffic volumes on the chip-seal surfaces made noise recordings unreliable. Some recordings were also taken on some surfaces which were very cracked and bumpy and may be classified as "rough". These "rough" surfaces had actual  $L_{10}$ -noise levels which were approximately 5 dBA above the predicted values.

#### Reference Truck Noise Measurements

The truck used was a single-unit, two-axle, six-tire truck. It was loaded to approximately 18,000 pounds (8,165 kg) on the rear axle. Measurements were taken on a new, unopened section of interstate. There were two sections of grooved concrete and one section of ordinary concrete. The data were taken 50 feet (15 meters) from the center of the lane tested. At 45 mph (20 m/s), the truck gave readings of 80.7 dBA, 81.9 dBA, and 81.2 dBA on the two sections of grooved and one section of ordinary concrete, respectively. It can be seen that the grooved concrete did not cause additional noise to be emitted by the truck.

### SUMMARY AND CONCLUSIONS

To develop adjustment factors for noise levels on various pavement types, the individual vehicle readings and the traffic stream recordings were considered. The individual vehicle noise readings showed that after a traffic exposure of ten million vehicle passes, only Kentucky rock asphalt and sand-asphalt surfaces give consistently low values (about 66 dBA). Grooved concrete exhibits noise levels of about 73 dBA. All other surfaces show "normal" noise levels of 69 to 70 dBA. Thus, the car adjustment was considered to be +4 dBA for the grooved concrete surfaces. An adjustment of -3 dBA was considered appropriate for cars on Kentucky rock asphalt and sand-asphalt surfaces.

The truck adjustments were determined from noise recordings on the different surface types as well as the reference truck data on grooved concrete. By comparing predicted with measured noise recordings, several conclusions were reached. Actual values on new Class I, Type A (Modified) surfaces were quieter than predicted; but worn Class I, Type A (Modified) surfaces showed noise levels similar to those predicted. The other surface types showed very little differences between predicted and measured levels. Thus, no adjustment was considered necessary for trucks on the surfaces for which noise recordings were taken. The reference truck data indicated that no adjustment for trucks was necessary for grooved

concrete surfaces.

There is a definite advantage in considering adjustments separately for cars and trucks. In most cases, the  $L_{10}$ -noise level for trucks predominates in the traffic stream. However, in cases where car noise predominates, a separate adjustment for cars would make predicted levels more accurate. The recommended adjustments for car and truck noise levels are given in Table 1.

#### REFERENCES

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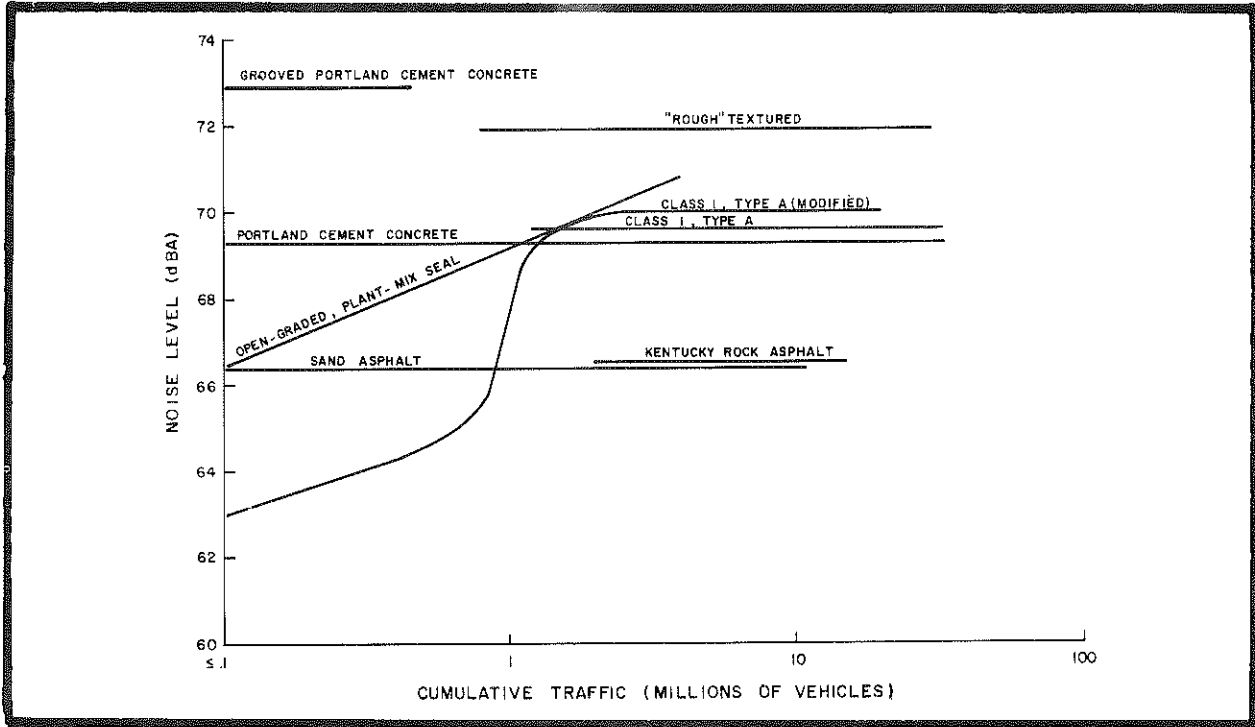


Figure 1. Effects of Cumulative Traffic on Noise Levels of Various Pavement Surfaces.



**TABLE 1**  
**RECOMMENDED SURFACE TYPE NOISE LEVEL ADJUSTMENTS**

SURFACE DESCRIPTION	CAR ADJUSTMENT	TRUCK ADJUSTMENT
Grooved Portland Cement Concrete	+4 dBA	0 dBA
Normal Surfaces:		
Class I, Type A, Bituminous		
Class I, Type A (Modified), Bituminous	0 dBA	0 dBA
Portland Cement Concrete		
Open-Graded, Plant-Mix Seal		
Chip Seals		
Smooth Surfaces:		
Kentucky Rock Asphalt and Sand Asphalts	-3 dBA	0 dBA