EFFECT OF STOPLIGHTS ON TRAFFIC NOISE

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ABSTRACT

A study was undertaken to determine how the noise level due to free-flowing traffic is affected by the insertion of a traffic light. Field measurements were taken at eight different traffic light locations representing two configurations; that of two intersecting straight roads, and a tee junction. A reference level measured at a point where traffic noise was unaffected by the intersection was used in conjunction with the NRC Traffic Noise Prediction Model to assess the change in noise level in the region about the traffic light.

There are a fairly large number of mathematical models currently being used to predict the noise level produced by automobile and truck traffic. Most of these models are based on the assumption that the traffic is free flowing. This is a perfectly acceptable approach when considering freeway traffic, but it is generally not applicable to urban or suburban situations. In such environments vehicles are constantly accelerating and decelerating in response to traffic control signals. In this context, then, it is useful to consider the effect of stop signs and traffic lights on the noise level emitted by a line of otherwise free-flowing traffic.

The effect of a traffic light is not necessarily the same as that of a stop sign. A traffic light will cause some of the traffic to stop, but a stop sign forces all of the traffic to stop. As insufficient data have been gathered from sites with stop signs, this paper will address only the problem of traffic lights.

When selecting sites for this study, two basic requirements were set down: first, that the main road should be straight and fairly heavily travelled, and that the distance to any other interuption in the traffic flow be sufficiently far removed to permit a free-flow condition; second, that there should be no buildings or other reflecting surfaces in the vicinity of the intersection that could influence the measured levels. Eight intersections were selected for this initial study, including four different configurations as shown in Figure 1. Three sites were the intersections of two divided roadways, one was the intersection of two simple roads, three were tee intersections, of

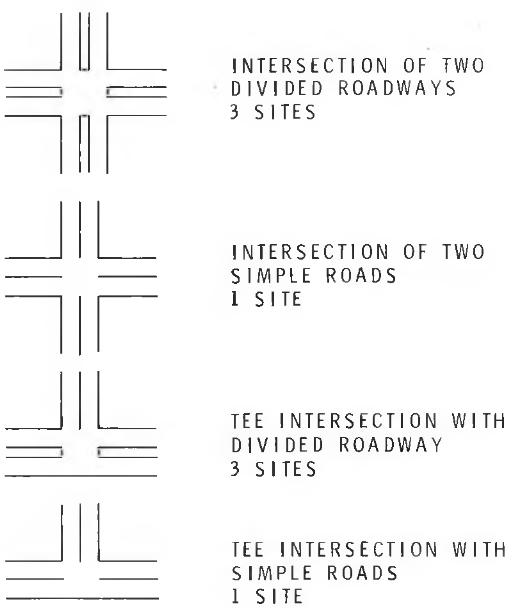

FIGURE 1
INTERSECTION CONFIGURATIONS

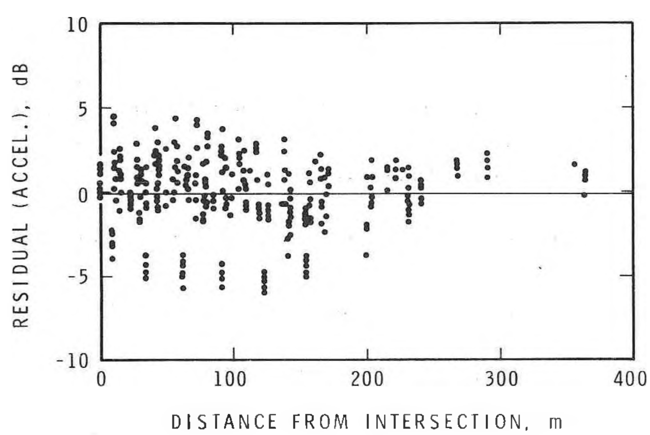

FIGURE 2
RESIDUAL AS FUNCTION OF DISTANCE FROM INTERSECTION ON ACCELERATING SIDE OF ROAD

which the main road was a divided roadway, and one a tee intersection of simple roads. At all eight sites the main road was straight and level, although this was not always true of the second road. Fortunately the traffic on the second road was generally light, so that errors caused by the less than ideal conditions are expected to be small. At some of the sites not all of the second road was visible from all microphones. This tended to be self-compensating because the microphone with the smallest angle of view was also located farthest from the intersection, so that any error due to this factor is minimized.

Data were collected using 6 dB 301 Metrologgers manufactured by Metrosonics Inc. These data loggers have a 1/4-in. ceramic microphone equipped with a windscreen, and meet ANSI S1.4 1971 type II specifications. The A-weighted sound level is sampled four times per second; the equivalent sound level (Leq) is computed at the end of each minute and stored for subsequent readout. The data can be read out of each logger with the appropriate reader unit and the time history of the Leq printed out for 1-min intervals. At the end of each measurement period a calibration signal was included in the data set.

The microphones were positioned along the side of the main road of each intersection in a line stretching from the intersection to a point sufficiently distant for the sound level to be no longer influenced by the intersection. This distance varied from 200 to 300 m depending on the particular intersection. The microphones were stationed 1.5 m above the ground and usually about 2 m from the edge of the pavement.

Measurements were usually made along both sides of the road and occasionally along the central median; for each microphone configuration four to eight measurement runs were made, each lasting 15 min, during which time the traffic density and the percentage of heavy vehicles were recorded.

The first step in analysis is to subtract from each measured level the level that would have been present had the traffic light not been there. The simplest way to accomplish this is to consider only the difference in equivalent level between microphones for any single measurement period. Unfortunately this approach has two inherent limitations: no allowance is made for differences in the distance of microphones from the road or variations in topography along the road, nor is any correction made for traffic on the intersecting road. These difficulties were overcome by considering the residual, that is the difference between the measured level and a calculated level for each microphone rather than the differences between microphones. In this case the residual is the difference between the measured level and the level calculated using the NRC Traffic Noise Prediction model.[1] This was done by assuming that the traffic on both the main road and the intersecting road was free flowing. The residuals, as a function of distance from the intersection, are shown in Figures 2 to 4 for measurements made on the accelerating and decelerating sides of the roadway and along the median. The solid lines are a least squares fit to the data.

The scatter in the data can be reduced somewhat by assuming that the residual at the microphone most distant from the intersection is zero. This is not an unreasonable assumption; the prediction model is based upon an average of many measurements so that measurements at any one site would be expected to deviate from the model because of topographical variations, variations in pavement type, etc. This allows a more meaningful comparison of different intersections. Figures 5 to 7 show the same data as Figures 2 to 4, with this adjustment to remove variations that may be considered site specific. Again, the solid lines are the least square fit through the data.

Some trends are apparent. Figures 5 and 6 for the accelerating side and median show a clear trend towards higher levels closer to the intersection, with this trend more marked for the accelerating side. The trend on the decelerating side (Figure 7) appears to be towards lower levels closer to the intersection, except in the first 40 to 50 m where the levels are higher than for the free-flow situation. More will be said of this feature later.

Aside from the distance to the intersection there are three other obvious parameters that may affect the sound level. These are the speed of the traffic, the percentage of heavy vehicles, and the timing of the light cycle. The eight cases selected for this study do not have sufficient variation in traffic speed or light cycle timing to allow any meaningful statement to be made with regard to these parameters.

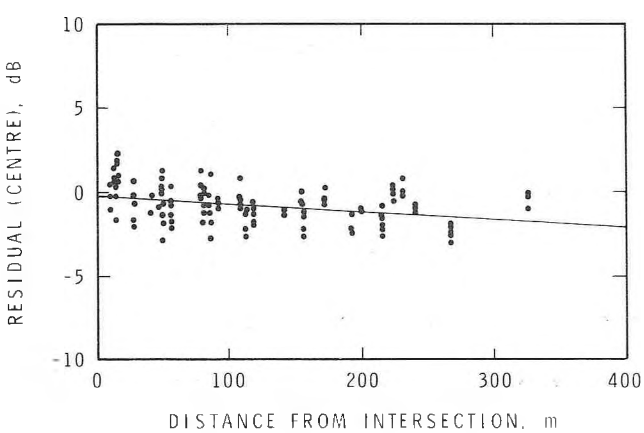

FIGURE 3

RESIDUAL AS FUNCTION OF DISTANCE FROM INTERSECTION ALONG MEDIAN OF ROAD

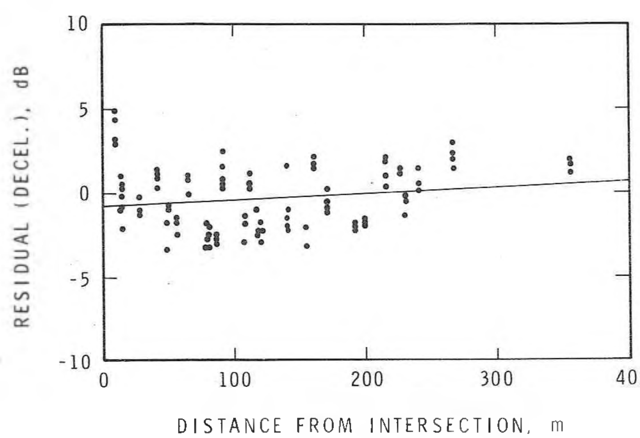

FIGURE 4

RESIDUAL AS FUNCTION OF DISTANCE FROM INTERSECTION ON DECELERATING SIDE OF ROAD

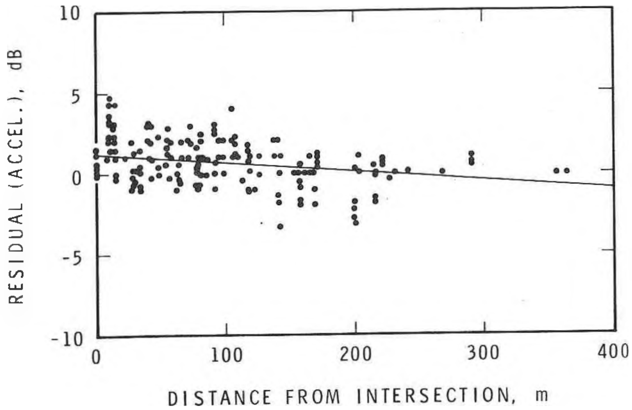

FIGURE 5

NORMALIZED RESIDUAL AS FUNCTION OF DISTANCE FROM INTERSECTION ON ACCELERATING SIDE OF ROAD

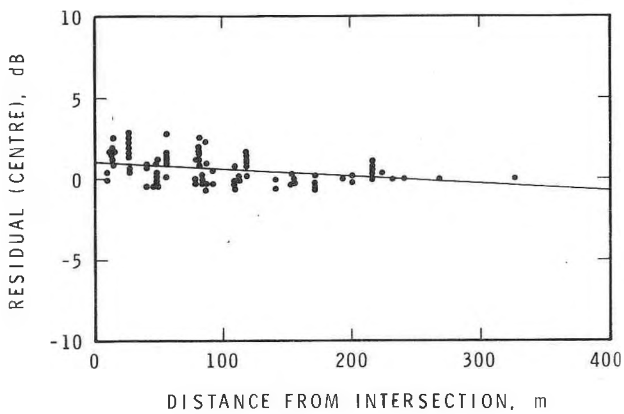

FIGURE 6

NORMALIZED RESIDUAL AS FUNCTION OF DISTANCE FROM INTERSECTION ALONG MEDIAN OF ROAD

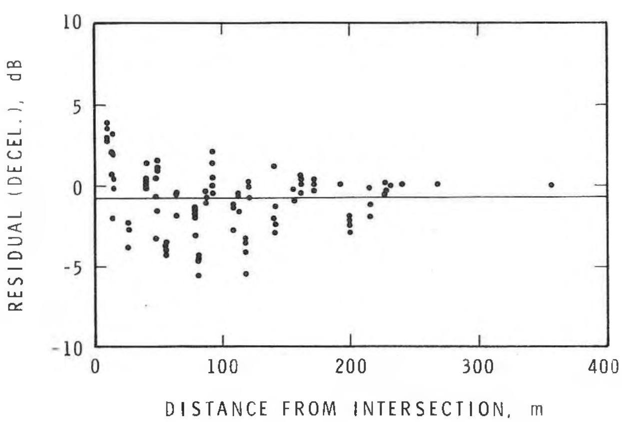

FIGURE 7

NORMALIZED RESIDUAL AS FUNCTION OF DISTANCE FROM INTERSECTION ON DECELERATING SIDE OF ROAD

Measurements were made over a wide range of the percentage of heavy vehicles, and the residuals are plotted against this variable in Figures 8 to 10. No clear dependence on percentage of heavy vehicles is apparent, suggesting that, at least for the sites studied, this is not a necessary parameter for a good first estimate of the effect of traffic lights on noise level.

A consideration of the regression lines in Figures 5 to 7 suggests that there is an increase in noise level as traffic accelerates away from a stop and a decrease as it decelerates to a stop. On this basis a simple correction to the noise level was made as shown in Figure 11. This is a profile of the excess noise level as a function of distance from the intersection for each lane. When this correction is included in the calculated level and the resultant residuals are plotted as a function of distance the results are as shown in Figures 12 to 14. It is apparent that, although not a perfect fit, the regression lines show that the profile used does have the right features. The worst deviations are found on the decelerating side. This is an artifact of the simple model used, which takes the zero of distance to be at the centre of the intersection, not at the stop line. In actual fact cars usually decelerate to the stop line and later accelerate through the intersection, shifting the profile centres from the centre of the intersection to the stop lines.

A model of this type was tested against the data and found to remove the apparent peak in the residual for distances less than 40 m on the decelerating side. The residual, however, still systematically deviated from zero for the decelerating side, and it is believed that further

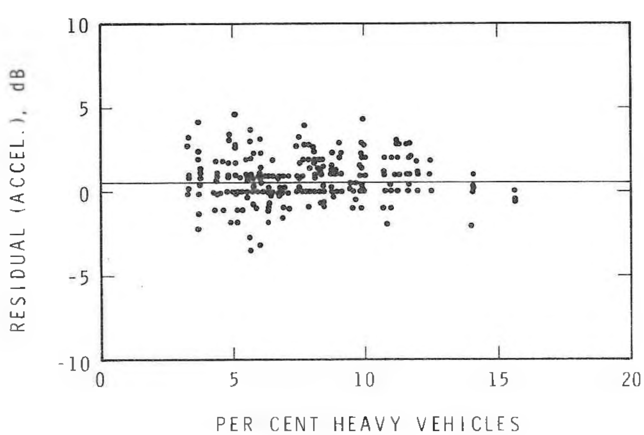

FIGURE 8

NORMALIZED RESIDUAL AS FUNCTION OF PER CENT HEAVY VEHICLES ON ACCELERATING SIDE OF ROAD

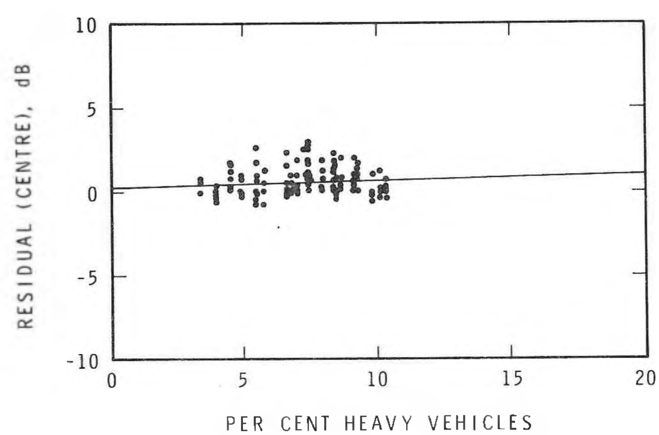

FIGURE 9

NORMALIZED RESIDUAL AS FUNCTION OF PER CENT HEAVY VEHICLES ALONG MEDIAN OF ROAD

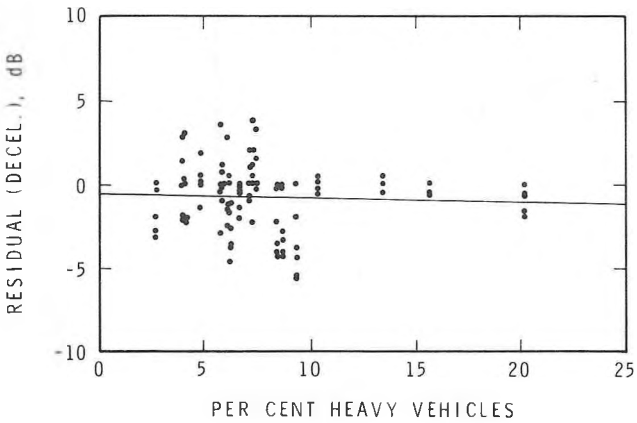

FIGURE 10

NORMALIZED RESIDUAL AS FUNCTION OF PER CENT HEAVY VEHICLES ON DECELERATING SIDE OF ROAD

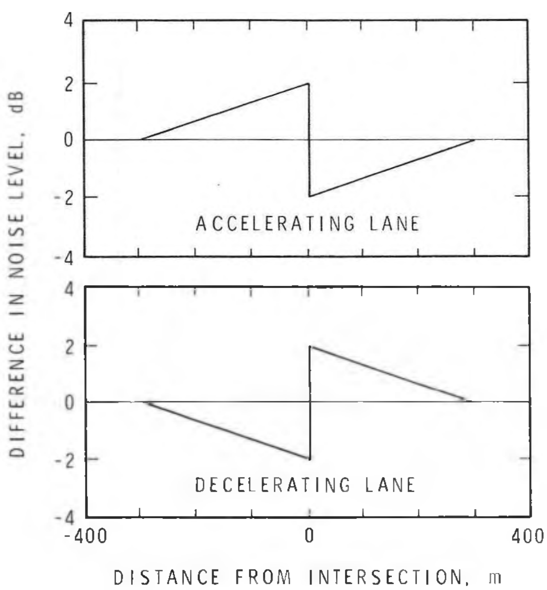

FIGURE 11

SUGGESTED EXCESS NOISE LEVEL PROFILE

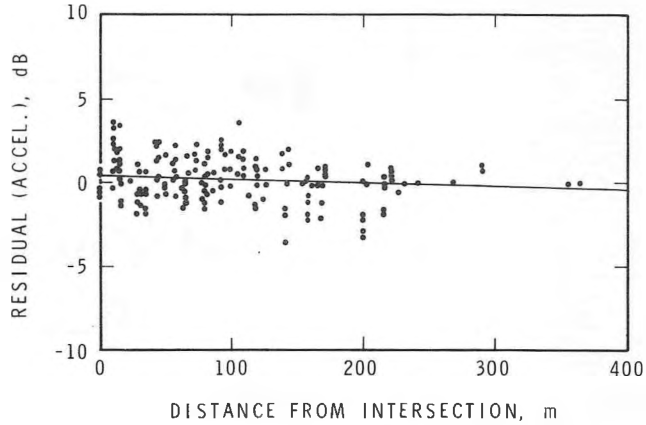

FIGURE 12

NORMALIZED RESIDUAL, AFTER CORRECTION, FROM INTERSECTION FOR ACCELERATING SIDE OF ROAD

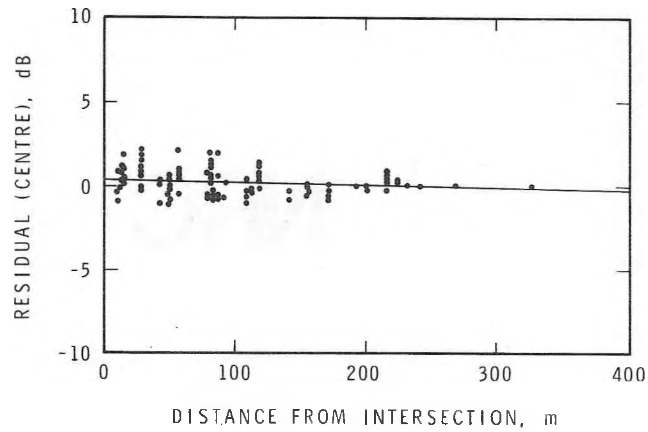

FIGURE 13

NORMALIZED RESIDUAL, AFTER CORRECTION, FROM INTERSECTION FOR MEDIAN OF ROAD

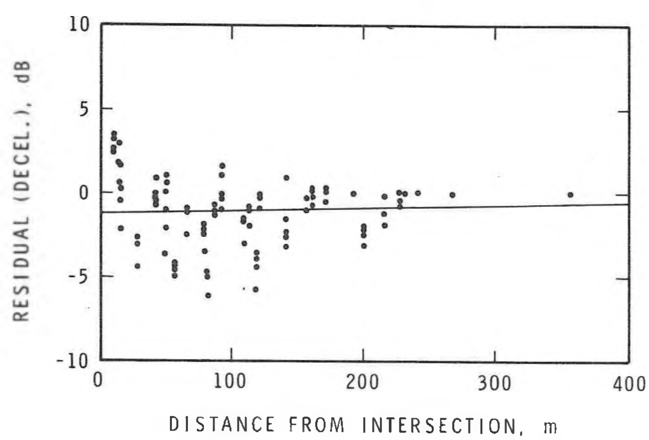

FIGURE 14

NORMALIZED RESIDUAL, AFTER CORRECTION, FROM INTERSECTION FOR DECELERATING SIDE OF ROAD refinements of the model should wait until a larger data base has been established.

It appears that there is a small but measurable increase in noise level in the vicinity of traffic lights and that this increase can probably be modelled in a simple manner.

Acknowledgement

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Reference

1. T.D. Northwood, J.D. Quirt and R.E. Halliwell, "Residential Planning with Respect to Road and Rail Noise," Noise Control Engineering, 13, 2 (1979).