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PREDICTION OF SIDEWALK NOISE LEVELS CAUSED BY TRAFFIC IN AN URBAN CENTRAL BUSINESS DISTRICT

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INTRODUCTION

Several alternative traffic pattern changes were proposed to reroute downtown traffic in Denver, Colorado. The purpose of the changes was to improve the environment and atmosphere for shoppers in the central business district and to attempt to reverse the trend of the inner city flight to surburban shopping malls. A large number of retail businesses were economically threatened and failure of these meant certain urban decay. The noise impact of each option was considered important among other environmental factors in the overall decision to change traffic patterns.

EXISTING NOISE LEVELS

A low-cost noise study of the central business district was performed to establish the existing sidewalk noise level exposures due to traffic and to calibrate a traffic noise model for prediction of sidewalk noise for any future changes in traffic volume and mix.

The study began with a two hour survey in which three-minute, analog tape "minisamples" were taken at ten locations over a two mile route at selected sidewalk sites. From this small sample, estimates of Leq, standard deviation of the Leq, background levels, dynamic range, and the periodic nature of the levels and traffic volume were determined.

A subsequent spatial sampling study indicated that for an overall accuracy of ± 2 dBA in the daily Leq at a confidence level of 90% that the study would have to sample at least twenty four locations for the spatial standard deviation of 6 dBA as determined from the two hour survey. (Later when all data were in, the standard deviation was computed to be 4 dBA.) The twenty-four locations were scattered throughout the one square mile area.

A temporal sampling study revealed that for an accuracy of ± 2 dBA with 90% confidence in the daily Leq that twenty-four independent samples per day would have to be taken. This number was reduced to six samples per day since the traffic volume and concomitant noise levels had a known diurnal variation. The length of each sample was taken to be three minutes in length. This assured at least two cycles of traffic volume flow for each sample since the cycle time of traffic lights ranged from 1-1.5 minutes.

All samples were recorded using only two stations, hand-carried by three shifts of two people. A Type II sound level meter and a direct, battery-powered, analog tape recorder were used for each station. Each operator sampled twelve locations on a "walk around" circuit which encompassed two miles on a three-hour cycle. At each location a three-minute, A-weighted sample was recorded. This three-hour cycle permitted ample time for rest and other human needs, for calibration and change of analog tape, for changes of operators, and for acquisition of data. Data were acquired during the hours of 0600 until 2400 for two representative weekdays and one weekend day.

Data tapes of the 372 three-minute samples were shipped to Dallas, Texas to our noise control laboratory at Southern Methodist University for analysis. Tape analysis was performed using a noise level statistical analyzer. The analyzer consists of a log voltmeter converter, an A/D converter, and a Wang programmable calculator with data interface. This system sampled tape levels at a rate of ten per second for a dynamic range of 60 dBA at an accurancy of ± 0.5 dBA. Output statistics were Leq, standard deviation of L_A, and seven percentile levels $L_{.1}$, L_1, L_{10}, L_{50}, L_{90}, L_{99}, and L_{max}. During the playback of the tapes through the analyzer, the analyst was able to listen to the character of the source field. On several occasions data samples were rejected and reordered when it was determined by the analyst that the noise was not by traffic but by construction or by human conversation.

The minisample statistical data were combined and averaged spatially and temporally to determine daily Leq and spatial averaged Leq. A correction factor was incorporated from the known diurnal traffic variation to "fill in" the missing data from the hours 0000 to 0600. The results showed a spatial averaged daily Leq of 70 dBA (L_{dn} = 71 dBA) with a standard deviation of 3.7 dBA for the two weekdays and an Leq of 68 dBA (L_{dn} = 69 dBA) with a standard deviation of 3.6 dBA for the weekend day.

TRAFFIC NOISE MODEL

A traffic noise model was developed to predict the future sidewalk noise levels (Leq) at the various street locations of interest. It was necessary to assess the noise impact due to several different proposed radical changes in traffic circulation. Traffic volumes were to be increased dramatically on some streets and decreased substantially on the shopping mall streets. In addition, increased traffic volume due to normal growth had to be considered.

The noise model which was found to predict the existing levels at each location includes the following observed facts:

1. The daily Leq depends primarily on the average daily traffic volume on each street. The volume embodies both the number of vehicles and the average speed.

2. The daily Leq depends on the average mix of automobiles, busses, and large trucks and that the larger source levels of the trucks and busses are equivalent to ten times that number in automobiles.

3. The daily Leq depends on the distance from the "equivalent lane" to the sidewalk receiver. Level drops 3 dBA per distance doubling (line source).

4. The daily Leq depends on street grade.

5. The daily Leq at midblock locations depends on a "cavern" or reverberation effect created by multistory buildings which line the street.

6. The daily Leq depends on whether or not there is a near bus lane on that particular street.

7. The daily Leq does not depend on traffic volumes on other streets because of barrier shielding effects by the multistory buildings (except at intersections).

8. The daily Leq at intersections is primarily determined by the two traffic volumes.

9. The daily Leq is not dependent on acceleration and speed but on volume.

The model which was found to correlate well with existing volumes and daily Leq levels is

$$Leq = 24 + 10 \log V + 10 \log (1 + 9 (f_T + f_B)) - 10 \log (d/50) + G + C_1 + C_2 \qquad (1)$$

where V is the average daily traffic volume in vehicles per day; f_T and f_B are the fractions of large trucks and busses respectively; d is the distance to the "equivalent lane" in feet; G is grade expressed in percent; C_1 is a + 2 dBA correction factor for "cavern effect" for streets lined with multistory buildings; and C_2 is a + 3 dBA corrections whenever a bus lane is next to the sidewalk observer. Table 1 below shows a comparison of measured Leq values to calculated values. At all sites the worst agreement found was ± 2dBA and for most sites an agreement of ± 1dBA or better was achieved.

Table 1. Leq - Measured V. Calculated

Site No.	V	D	G	C_1	C_2	Leq (calc.)	Leq (meas.)
4	22,400	25	0	0	3	71	71
5	11,900	25	0	2	0	68	67
11	7,000	25	0	2	0	65	64
13	15,100	25	0	2	3	72	71

PREDICTED LEVELS

The model formula was then used to predict the Leq values along each street corridor for the projected changes in traffic volume for each proposed change option and for projected traffic increases up to the year 2000. These levels were then compared to existing criteria. Level maps showing the streets on which the sidewalk levels (Leq) exceeded 70 dBA were prepared. Data maps and criteria were then used as input into the decision making process along with other environmental parametric studies.

CONCLUDING REMARKS

On the basis of this study and others involving other environmental parameters a decision was made in which all automobile and truck traffic was eliminated on two major streets. This created a "shopping mall" effect. On last check, it was learned that the plan was going well.