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Road Traffic Noise Prediction Model

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ABSTRACT

In a rapidly urbanizing country, transportation sector is growing swiftly. This has led to overcrowded roads and pollution. Vehicular emissions of dust particles, smog and noise have reached or even exceeded levels of those from industrial production or private households, and are harmful to the environment and human health. Since traffic characteristics and type of vehicle in India differ from those in Western countries, a traffic noise prediction model including traffic flow (vehicle/hour), traffic speed (Km/hour), traffic composition in terms of heavy vehicle(%) is modeled. The basic noise model is used as the first prediction of traffic noise from an individual type of vehicle on highway.

KEYWORDS Traffic noise, traffic volume, heavy traffic

1. Introduction

The recognition of traffic noise as one of the main sources of environmental pollution has led to the development of models that enable the prediction of traffic noise level from fundamental variables like density, flow and speed of vehicles, distance from roads and condition of roads.To create a healthy and noise pollution free environment, a noise prediction model is needed so that the noise level along a busy highway can be forecast and investigated in advance during the planning and design process. The recognition of traffic noise as one of the main source of environment pollution has lead to the development of an accurate noise prediction model that enables to prediction tool development of traffic noise from the commonly used variables such as traffic flow in terms of vehicle per hour, traffic speed, traffic composition in terms of percentage of heavy vehicle, road gradient, road traffic etc. The noise generated by single vehicle in freely flowing traffic was investigated by Lewis (1973). Gilbert (1976) investigated L10 noise levels in urban streets by presenting two regression models for predicting curbside traffic noise. In India Chakraborty et. al (1996) measured road traffic noise at 24 traffic junction of Kolkata. They developed regression equation for predicting the noise level by using equivalent number of light/ heavy vehicles/ hour and distance from the traveling centerline. Lam and Tam (1998) from Hongkong developed a noise prediction tool by using Monte-Carlo technique. The road traffic noise model was also discussed by Bendsten (1998) from Denmark. Donato and Morry (2001) developed a statistical model for prediction of road traffic noise which is based on Poisson type traffic flow. A GIS based road traffic noise prediction model was developed for use in Chaina by Lie.et.el (2002). Calixto et.al. (2003) from Brazil developed a statistical model to road traffic noise prediction in an urban setting. Nassiri and Behzad (2005) examined the reliability of traffic noise estimation and measurement techniques obtained from combined probability distribution of the traffic speed, traffic composition and traffic flow by Monte Carlo Simulation method. Rajkumar and Mahalinga (2008) developed an impirical traffic noise model under interrupted traffic flow conditions. Pamanikud (2008) built a high traffic noise simulation model for free way traffic conditions in Thailand that provides a more accurate measurement of noise energy from each type of vehicle under real conditions.

2. Methodology

For each type of vehicle, regression analysis of noise level (db A) on speed was carried out based on Logarithmic relationship i.e.

$$L = á \log(\text{speed}) + â$$

Where $\alpha and \beta$ are constants and there values differ for each type of vehicle.

3. Traffic noise measurement and study area

The noise level was measured at different hours (8am-9:30am; 11am-12:30am; 2pm-3:30pm; 5pm-6:30 pm), when traffic flow was mild, average and heavy at 20 different locations of Roorkee-Haridwar highway by using noise analyzer (sound level meter).Readings of noise level in db (A) at different locations are given in (Table-1). The sound level meter was set back at the edge of the road on pedestrian side walk at a height of 1.2 meter above the ground surface. Traffic flow in terms of vehicle/hour, average traffic speed in terms of Km. / hour and percentage of heavy vehicle at different locations are given in (Table-2).

4. Traffic noise prediction model

A traffic noise model was then developed by applying the basic noise level from this study. The main equation for predicting the noise level is given by

$$L = 10\log Q + 33\log(V + 40 + 500/V) + 10\log(1 + 5P/V) - 26.6; \qquad (1)$$

Where Q = Traffic flow, P = Percentage of heavy vehicle, V = Average speed of vehicles.

For making sensitivity analysis the values of each factor was changed in order to compute, while other factors were kept fixed. Using the Linear Regression Model, the accuracy of estimated L to the observed value (directly collected from the surveys) is examined. Figure 1 shows the result of regression analysis of the noise level (db A).The coefficient of determination (R^2) of the 45^0 line is 0.8533.

A simple way of modifying prediction procedure is only to recalculate the coefficient of equation and the constant term using the survey data. Regression model of observed L (db A) with the measured L (db A) is given as follows:

$$L_{meas} = 1.01 * L_{calc} - 0.169 \qquad (2)$$

By substituting this equation into equation (1), the general form of revised equation is:

$$L = 10.2 \log Q \ + 33.66 \log (V + 40 + 500/V)$$
$$+ 10.2 \log (1 + 5P/V) - 27.302 \qquad (3)$$

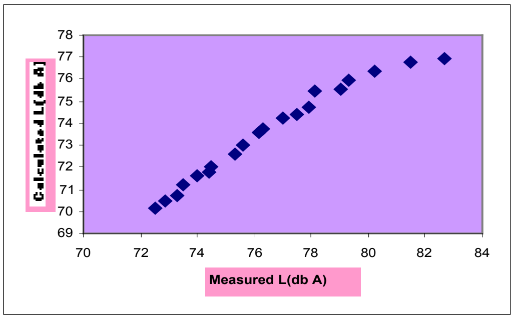

Figure:1 Measured L(db A)against predicted L (db A) for Eq.1 (R^2=0.8533)

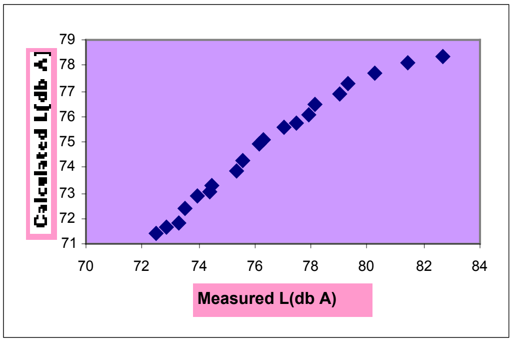

Figure 2: Measured L(db A) against predicted L (db A) for Eq 3 (R^2=0.9165).

5. Model Validation
The new estimated was then compared with the measured values to investigate the accuracy of eq (3). Figure 2 shows that the best fit line generated between measured and new estimated L db (A) values gives a (R^2) value of 0.8533, which is acceptable. R^2 value of 1.0 is considered to be the best fit, where as any value above 0.7 is considered to be good. Also coefficient of determination (R^2) for the regression line of new estimated L is comparatively higher than the previous one.

Using equation 3 the effect of each factor on the traffic noise is assessed and it is found that % of heavy vehicle has great significance in noise prediction.

6. Significance
A t-test is then applied to new estimated noise level values and measured values.

t_{calc} = 2.1105 and t_{tabul}=2.0054 at 20+20-2=38 degrees of freedom.

Since calculated value of t is slightly higher than that of tabulated value, therefore relationship given by equation (3) is highly significant at 95% of confidence level.

7. Conclusion
Road traffic noise is major concern of communities living in the vicinity of road networks in urban areas. In urban areas, traffic flow is very much affected by heavy vehicles. Therefore the study reveals that the noise prediction model developed so far in this study can be used for studying the environment impact of road traffic noise. Calibrating the model by regression analysis led to increase in accuracy of estimated traffic noise.

Table-1 Measurement of Noise Level (db A) in different locations

S.No.	Distance (meters)	Level of Noise(db A)				Aggregate of Noise Level(db A)
		8 AM-10 AM	11 AM-1 PM	2PM-4 PM	5 PM-7 PM	
1.	0-250	68.2375	63.6625	73.425	83.675	72.25
2.	250-500	68.5125	66.35	73.0375	83.625	72.88125
3.	500-750	66.575	67.5875	76.4375	82.675	73.31875
4.	750-1000	69.8875	65	76.05	82.5125	73.5125
5.	1000-1250	71.2375	68.5875	73.0125	82.9875	73.95625
6.	1250-1500	70.075	69.325	76.0125	82.125	74.384375
7.	1500-1750	69.0625	67.8625	77.075	83.8375	74.459375
8.	1750-2000	71.9625	68.675	75.3125	85.3875	75.334375
9.	2000-2250	71.1125	67.575	79.05	84.6125	75.5875
10.	2250-2500	70.875	72.2375	76.65	84.7625	76.13125
11.	2500-2750	74.0125	68.675	81.2125	81.2	76.275
12.	2750-3000	71.825	70.675	77.2	88.425	77.0325
13.	3000-3250	75.425	73.975	76.775	83.85	77.50625
14.	3250-3500	71.15	73.975	78.9375	87.9485	77.9025
15.	3500-3750	75.45	70.3875	80.2875	86.375	78.125
16.	3750-4000	72.85	75.2875	79.75	88.1125	79
17.	4000-4250	75.4875	75.725	78.9125	87.925	79.34375
18.	4250-4500	76.3125	75.1875	77.9875	91.5	80.246875
19.	4500-4750	73.725	74.625	87.1125	90.325	81.4468
20.	4750-5000	79.1125	79.025	84.75	87.9275	82.70375

Table-2 Measurement of Various Parameters

S.No.	Distance(meters)	Traffic Flow(Vehicle/ Hour)	%of Heavy Vehicle	Average Speed (Km/Hour)
1	0-250	821.64	4.6394	49.8
2	250-500	853.73	4.76854	50.4
3	500-750	868.74	4.9134	51.3
4	750-1000	921.79	5.4976	52.8
5	1000-1250	960.54	5.61439	55

6	1250-1500	989.73	5.6333	55.4
7	1500-1750	1031.27	5.682	56.3
8	1750-2000	1109.71	5.735	58.9
9	2000-2250	1166.71	5.965	60
10	2250-2500	1209.52	6.9396	62.8
11	25002750	1217.52	7.41	63.4
12	2750-3000	1289.98	7.86	64.79
13	3000-3250	1305.24	7.967	65.9
14	3250-3500	1361.43	7.99	67.2
15	3500-3750	1400.47	8.6	69.3
16	3750-4000	1456.371	9.0834	70.5
17	4000-4250	1509.43	9.39381	73.1
18	4250-4500	1587.287	9.4843	75.25
19	4500-4750	1679.371	9.4934	76.83

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