Nature Environment and Pollution Technology © Technoscience Publications	Vol. 6	No.4	pp. 601-607	2007

A STUDY OF TRANSPORT RELATED NOISE POLLUTION IN ASANSOL TOWN, WEST BENGAL USING MODELLING TECHNIQUES

S. K. Chakraborty and D. Banerjee*
Post Graduate Department of Physics, Banwarilal Bhalotia College, Asansol-71304, W.B., India
*Department of Environment & Water Management, Banwarilal Bhalotia College, Asansol-713 304, West Bengal, India

ABSTRACT

With rapid urbanization of our cities and towns and resultant increase in the number of vehicles on roads, noise pollution is growing at an alarming rate. About 60% of total noise in the any urban environment can be credited to road traffic. The objective of the present study was to model and predict the road traffic noise and compare the results with observed values in an urban environment. Two models, namely, 'Calculation of Road Traffic Noise' (CORTN of U.K.) and 'Federal Highway Administration' (FHWA of U.S.A.) were used in the study. The study area selected for the investigation was Asansol town, an urban-industrial town, situated in eastern India. The values predicted by each of the models were analysed and compared with observed data collected at ten locations in the study area. Three tests, namely, '*t*'-test, correlation coefficient (*r*) and deviation between predicted and observed values was used to validate the modelling results. Based on the test criterions, statistical validation and comparison with other similar works, it can be said that both models gave acceptable results under Indian road conditions, with certain degree of error. The CORTN model (*r* = 0.8313) provided better prediction than the FHWA model (r = 0.8031). The deviation range of the CORTN was also lower 1-4 db(A) against the FHWA predicted range of 1-6 db(A). Refinement of the model inputs is required as per Indian road conditions to enhance the quality of prediction.

INTRODUCTION

Noise is unwanted sound and a cause of concern for all the urban areas around the world. Motor vehicles, which are significant part of the urban environment, are the main source of noise emission, contributing about 55 % to the total noise pollution (Bhattacharya et al. 2003). The growing vehicle population gives rise to unrestrained noise pollution associated with significant health effects. Noise can cause both short term as well as long term psychological and physiological disorders, particularly among those living in close proximity to busy roads, streets and highways. However, because of complexity, variability and the interaction of noise with other environmental factors, the adverse health effects of noise do not lend themselves to a straight forward analysis. Noise is a very complex phenomenon in its physical dimension, as well as its manifestations in psychological and medical dimensions. In consequence, it is practically indispensable to measure, predict or describe noise in a simplified way (Banerjee & Chakraborty 2005). The Central Pollution Control Board of India (CPCB), in its notification on Ambient Air Quality (AAQ) standards has included noise as an air pollutant under Section 20 of the Amended Air Act of 1987 and has laid down the ambient noise standards (CPCB 2000, 2001).

The prediction and assessment of noise levels from transport activities can be achieved either by measurement, by computation or by hybrid methods using measurement results in computations. For reasons of reproducibility, the methods used for measuring or calculating noise levels within the framework of legal regulations have been standardized on an international scale (Leeuwen 2003).

Research works conducted based on traffic noise modelling and prediction include studies carried out by Bhattacharya et al. (2003) relating to development of highway noise prediction model under Indian condition. Banerjee & Chakraborty (2005) attempted to compare CORTN, FHWA & Lyon noise models under Indian road conditions and developed a regression model for road noise prediction. Work done by Nirjar et al. (2003) relating to prediction of road traffic noise in New Delhi using FHWA, CORTN and STOP & GO Models can be cited as significant contribution to this field of research.

The objective of the present work was to record noise level and traffic flow parameters along with site geometry at representative locations in an urban environment and fit the measured data into two noise prediction models, namely Federal Highway Administration (FHWA) and Calculation of Road Traffic Noise (CORTN) to compare the predicted noise levels with actual monitored values and evaluate the suitability of the models under Indian road conditions using suitable statistical tests.

MATERIALS AND METHODS

Sampling

For the present study data were collected at ten locations in the Asansol city, an urban-industrial area situated in the eastern part of India. The town is a fast growing and rapidly urbanizing industrial zone of this subcontinent. The area has 100% urban population consisting of 50 wards with 4,75,439 inhabitants. The town has grown in all sectors, and in recent times has become an important hub for business and commercial activities. The increase in new settlement areas, business and commercial units have increased the personal vehicle population of the town. Although there is good public transport system, but personal vehicles are preferred. Along with the infrastructure growth there have been no expansion of the road network or its improvement, resulting in overflowing traffic conditions chocking the major roads and giving rise to severe noise pollution all around the town. The Delhi-Kolkata National Highway (NH-2) passes through this town which is well connected by rail and bus routes with all major locations of the country. The city has diverse types of roads i.e., arterial roads, secondary roads and also dense network of lanes and bylanes, all of which are used for the movement of vehicles. The data collection sites were chosen based on presence of vulnerable receptors, land use pattern and distance of road from housing quarters. The sampling locations represented different zones like commercial, residential and sensitive areas. The locations used for field data collection are shown in Fig. 1.

A digital sound level meter, Type 2 with frequency weighting network as per IEC651 specifications, frequency range of 31.5Hz to 8,000Hz and measuring range between 0-150 dB was used for the study. A ‘B & K’ (Bruel & Kjaer) multi-function acoustic calibrator (Model: 4226) was used for calibration at 94.0 dB(A) before and after sampling. All readings were taken on the ‘A-weighting’ frequency network, at a height of 1.5 meters from ground level and on the ‘Fast’ range Time Weighting. The A-weighting characteristic and ‘Fast’ range is simulated as ‘Human Ear Listening’ response. This is typically required if making the environmental sound level measurement. All measurements were carried out during working days and under suitable climatic condition setting. Concurrent recording of on site traffic flow parameters like classified vehicle volume and average speed etc. were also done along with collection of geometric parameters of location, including road type, width, ground cover reflective facade and angle of view, etc. for each site.

Modelling and Prediction

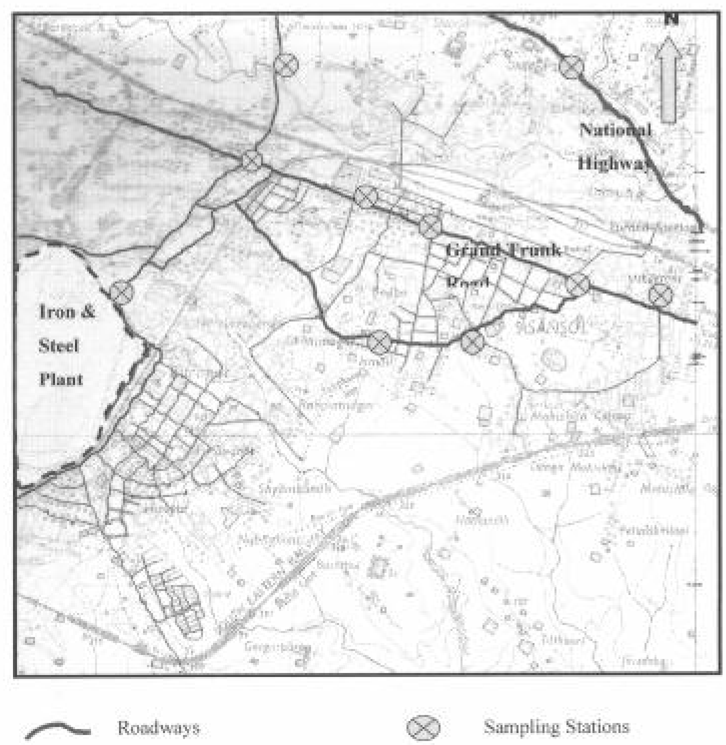

Fig 1: Map showing study area and field data collection locations.

For the present investigation two different empirical noise prediction models were used, namely FHWA and CORTN. The comparative features of the two models are given in Table 1. The noise levels predicted by the models were compared with data collected from field using regression analysis and statistical tests. The paired ***t***-test technique was applied to compare the output of the models with the actual road noise level to examine how well the models work under Indian conditions (Nirjar et al. 2003). The null hypothesis taken into consideration was that, the 'mean value of difference between pair of measured and predicted traffic noise is equal to zero'. The null hypothesis was tested using the paired ***t***-test.

FHWA Model

The Federal Highway Authority in USA, developed this very useful and important model for road noise prediction. In this model traffic noise levels in and around roadways can be predicted on the basis of individual noise levels, vehicle volume and observer distance, etc. The FHWA Model can be written as:

$$L_{eq} = L_o + A_{vs} + A_d + A_b + A_f + A_g + A_s$$

In this model vehicles are classified into categories like car/jeep/van, scooters/motorcycles, light commercial vehicles, bus/truck, auto rickshaw and tractor trailers. Here, the reference energy level for each category of vehicles is separate and obtained in the form Y = A + B logS, where S is speed of vehicles in kmph. The hourly Leq value for each category is calculated using the following equation:

$L_{eq} = L_o + A_{vs} + A_d + A_s$

The equation for volume and speed correction is given as:

$A_{vs} = 10 \log_{10} d_0 v/s - 25$

The distance corrections at the receiver point are given by:

$A_d = \log_{10} (d_0/d)^{1-\alpha}$

Noise level for each lane is evaluated and then combined logarithmically to get the total L_{eq} value, and the combined hourly L_{eq} value is calculated by logarithmic summation of hourly L_{eq} values for each category.

CORTN Model

Developed by UK Department of Transport in 1988, this model can predict noise at an observer location at a certain distance from the road. The parameters on which this model works are vehicle composition, road surface, type, ground absorptive factors, site geometry and reflections, etc. This model does not take into account background noise such as trains, aeroplanes and industry, etc. Here vehicles are not classified into categories and it combines the flow of all vehicles in vehicles/hour and takes into account hourly flow of all vehicles and heavy vehicles in particular. The standard equation for L_{10} (hourly) is used for the calculations. The basic model for this calculation is given by:

$L_{10} = 42.2 + Log_{10} q$

The hourly L_{10} value for each category (light and heavy vehicles) is calculated using the following equation.

$L_{10} = L_0 + A_{bv} + A_d$

RESULTS AND DISCUSSION

The data collected from field were analysed and have been presented here. The Noise standards as prescribed by the Central Pollution Control Board of India are given in Table 2. The results of the noise prediction using the two models along with their summarized based criteria results of testing are given in Table 3. The scatter plot for FHWA model, showing relation between observed and calculated L_{eq} values is given in Fig. 2, and for CORTN model showing relation between observed and calculated L_{10} values in Fig 3. For proper analysis of data, the traffic counts have been summa-

Table 1: Comparative criteria for road noise models.

Sl.No.	Criteria	Models	
		FHWA	CORTN
A	Noise Index Predicted	L_{eq}	L_{10}
B	Vehicle categories	Automobiles, Medium & Heavy Trucks	No separate classification
C	Adjustments & Correction	Applicable	Applicable
D	Hourly Vehicle Flow	Calculated as Vehicles/hour	Calculated as Vehicles/hour
E	Geometric mean of cross-section	Not required	Not required
F	Separate Lane concept	Not applied	Not applied
G	Basic Equation	$L_{eq} = L_o + A_{vs} + A_d + A_b + A_f + A_g + A_s$	$L_{10} = 42.2 + Log_{10} q$

Table 2: Central Pollution Control Board standards for noise.

Sl.No.	Area	Noise levels in dB (A)	
		Day (0600 to 2000 hours)	Night (2000 to 0600 hours)
1.	Silence zone	50	40
2.	Residential zone	55	45
3.	Commercial zone	65	55
4.	Industrial zone	75	70

Table 3: Summarized comparison of predictive noise models and validation.

		Present Study		Bhattacharya et al. 2003		Nirjar et al. 2003	
	Statistical	FHWA	CORTN	FHWA	CORTN	FHWA	CORTN
A.	Paired *t*-test						
	n	90	90	352	347	131	131
	d	1.12	1.24	0.93	2.55	-	-
	S.E.	2.32	2.24	4.49	4.24	-	-
	'*t*' value	4.58	5.22	3.9	11.205	4.60	5.30
B	Difference range between measured and calculated noise level	1 - 6	1 - 4	-	-	1 - 7	1 - 4
C.	*r* value	0.8031	0.8313	-	-	0.8193	0.8233

rized in the form of total traffic volume for both directions for every hour, whereas the traffic speeds have been summarized in the form of average traffic speed values, calculated for every hour, for both the directions (Nirjar 2003). In order to correctly compare the noise level predicted by the models in relation to that observed in the field, three criteria were used for deciding the suitability of the models, i.e., difference between observed and estimated noise level, the *r* value and paired *t*-test estimated at 5 % level of significance.

FHWA Model Analysis

Applying the three criteria system to validate the model, it is observed that the difference between observed and estimated noise level varies between 1 to 6 dB(A); the best fit regression plot between observed and estimated L_{eq} produced an *r* value of 0.8031 (Fig 2); whereas the paired *t*-test between observed and estimated L_{eq} gives a '*t*' value of 4.58 at 5% level of significance and 88 degrees of freedom. The noise variation range is within the acceptable criteria and also the *r* value, which is very much in the acceptable range, since any *r* value above 0.7 up to 1.0 is a good correlation. It is observed that the predicted values tend to differ much, when the actual levels are on the higher side. The *t*-test value of 4.58, does not lie within the acceptable region and hence the null hypothesis can be rejected. Since majority of the acceptable criteria among the three are satisfied by the model, it can be said that the FHWA model can predict noise level satisfactorily under urban Indian conditions.

CORTN Model Analysis

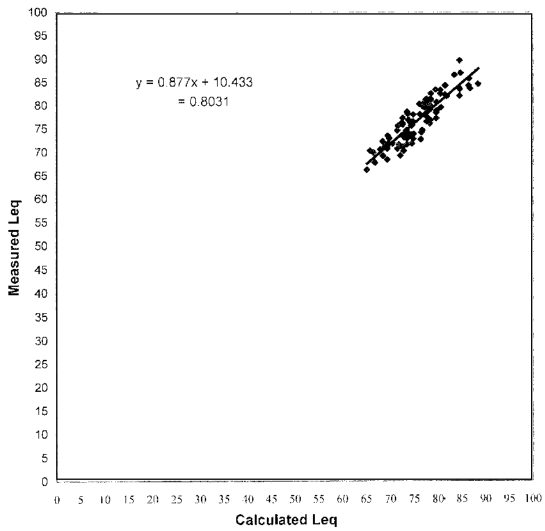

Fig 2: Scatter plot of measured and predicted noise values using FHWA model.

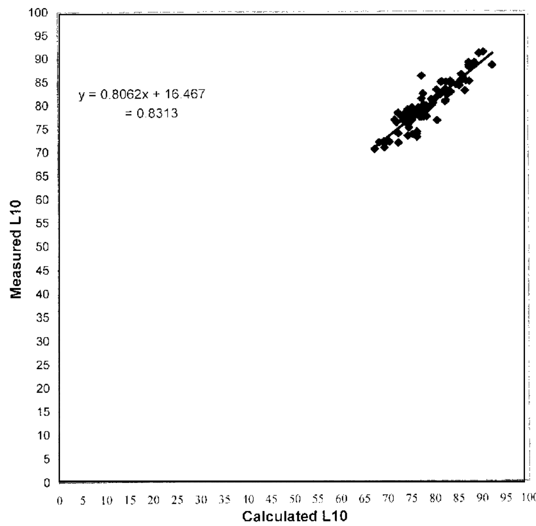

Fig 3: Scatter plot of measured and predicted noise values using CORTN model.

Applying the same three criteria system to validate the model, it is observed that the difference between observed and estimated noise level varies between 1 and 4 dB(A). The best fit regression plot between observed and estimated L_{eq} produced an *r* value of 0.8313; whereas the paired *t*-test between observed and estimated L_{eq} gives a '*t*' value of 5.22 at 5% level of significance and 88 degrees of freedom. The noise variation range is within the acceptable range and also the *r* value is in the satisfactory region. The *t*-test value of 5.22 is out side the acceptable limit, hence the null hypothesis can be rejected. Since majority of the acceptable criteria among the three are satisfied by the model, it can be said that the CORTN model can predict noise level satisfactorily under urban Indian conditions.

CONCLUSION

The comparison of the two models based on statistical analysis is given in Table 3. The statistical data analysis between predicted and observed noise levels collected from field investigation was carried out to determine the suitability of the FHWA and CORTN model for use under the Indian road conditions. It can be concluded that the both FHWA and CORTN models give desirable results. Among the two, the correlation coefficient estimated value for CORTN model is marginally better than FHWA model. The assessment test shows that both models can predict the noise level within acceptable limits in comparison to observed noise values with certain degree of error. Overall CORTN gives better prediction based on the present study conditions and limitations as evident from the three tests conducted to evaluate their suitability under Indian road conditions.

ACKNOWLEDGMENT

The authors desire to express thanks to University Grants Commission (UGC), ERO, India, for funding the work in the form of Minor Research Project. Sincere thanks are also due to the Head of the Institution, Dr. U. C. Sarkar for constant encouragement and granting consent to publish this work.

REFERENCES

Banerjee, D. and Chakraborty, S.K. 2005. Mathematical modelling for assessment of urban road traffic noise. Poll Res., 25(1): 133-138.

Bhattacharya, C.C., Jain, S.S., Singh, S.P. and Parida, M. 2003. Development of comprehensive highway noise model for Indian conditions. Indian Road Congress Publication.

Central Pollution Control Board (CPCB) 2000. Ambient Air Quality in Respect of Noise, Schedule-Part II, Sec-3(ii), CPCB, New Delhi.

Central Pollution Control Board (CPCB) 2001. Noise Pollution Regulation in India, CPCB, New Delhi.

Leeuwen, H.V. 2003. The sound of cars and trucks or road traffic noise. Traffic Noise-Traffic Technology International, Netherlands.

Nirjar, R.S., Jain, S.S., Parida, M., Katiyar, V.S. and Mittal, N. 2003. A study of transport related noise pollution in Delhi. J. Inst. Engrs., India, 84: 6-15.

ABBREVIATIONS

L_{eq} - Hourly equivalent continuous energy level
L_o - Reference energy mean emission levels
A_{vs} - Volume and speed correction
A_d - Distance correction
A_b - Barrier correction
d - distance from the centre of road to observer
dB (A) – Decibel in A-scale
L_{10} - percentile noise level (10% of time)
± - ground cover coefficient
A_p - Flow correction
q - flow of vehicles
f - hourly flow of heavy vehicles
A_G - Gradient correction
A_{bv} - correction for mean traffic speed & percentage of heavy vehicles
A_s - Ground cover correction.
v - Volume of vehicles in vehicles/hour
s - Speed of vehicles in kmph
d_0 - Reference distance
t- test - Student's t-test