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RESEARCH ARTICLE

A MODEL FOR TRAFFIC NOISE PREDICTION IN HETEROGENEOUS TRAFFIC CONDITIONS

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ABSTRACT

This paper describes a traffic noise prediction methodology for heterogeneous traffic conditions. Traffic noise characteristics in cities of developing country like India are slightly varied by virtue of the fact that the composition of the traffic is heterogeneous associated with variance of road geometry and varying density of the buildings on the either side of the road. Traffic noise prediction models developed on the basis of homogeneous traffic are not apt to predict the actual noise levels for Indian countries. A new model has been developed in this study considering different parameters such as traffic volume, composition of traffic, speed, horn using effect, number of lanes, road width, road gradient and local metrological conditions.

INTRODUCTION

Traffic noise has changed the quality of environments considerably in developing countries like India. The growth of traffic in the last two decades was enormous. In metropolitan city like Chennai about 15 lakh vehicles ply around daily (censes 2001). Traffic in this city is highly heterogeneous. Traffic stream consist of two, three wheelers, cars and heavy vehicles like buses and trucks. A study of these environmental noise characteristics becomes a necessary requirement for future growth and planning so as to arrive at an acceptable noise climatic condition. It is with this objective that this work has been carried out.

Earlier traffic noise levels in a few Indian cities have been reported by previous researches [Pancholy, et al 1969, Bose and Bhattacharyya 1973]. In recent years the studies reported are due to Gupta et al 1986, Rao and Rao, 1991, Chakrabarty 1997 etc. In these studies regression equations have been reported for predicting the traffic noise levels by considering traffic flow and speed. Some studies (Kumar and Jain 1994, Nirjar 2003, Agarwal et. al 2009 and Agarwal and swami 2010) also dealt with heterogeneous traffic conditions and arrived at some correction values for mixed traffic flow. Though these studies have been reported about this traffic noise the applicability of these models in the present urban context is not straight forward. Especially the establishment of the base noise level which should also include predominant sources such as honking noise by vehicle horns may have to be considered even while considering continuous flow. The work presented considers a procedure for predicting the noise levels of heterogeneous traffic conditions by considering base noise level, effect of honking conditions and other factors such as road width.

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FIELD STUDY AND DATA COLLECTION:

The city chosen for study (Chennai) encompasses a metropolitan area of 172 km^2 and is connected by four important highways (NH4, NH 5, NH 45 & NH46). Geometry of the roads varies in terms of width and surrounding heights of the buildings. Sketches of six typical representative sites with the traffic center-line, microphone location, and the surrounding buildings have been shown in Fig. (i). Locations 1, 3 & 4 are urban locations and the locations 2,5 & 6 are highways.

Measurements are carried out at peak and lean traffic flow. Field measurements are made by using the Norsonic sound level meter for 15 minutes duration. The sound level meter is calibrated prior to each measurement using a Norsonic sound calibrator type 1251. Sound level meter is mounted on a tripod at 1.2m above the floor level. The distance of the microphone from the traffic center-line was different for different sites, depending on the width of footpath and road. The distance of microphone from the plying traffic center-line for each site has been given in Table (ii). Vehicles are divided into five categorizes like two wheelers, Three wheelers, car, bus and truck. Counts of number of vehicles crosses the point of measurement from either direction on the road is recorded with a video camera. Speeds are measured with a hand held radar gun along with the noise level. A typical measurement site is shown in the fig (i). The average A-weighted noise emitted of the individual vehicles plying on the roads is determined at six different measurement locations with an individual vehicle of each category running at its free speed.

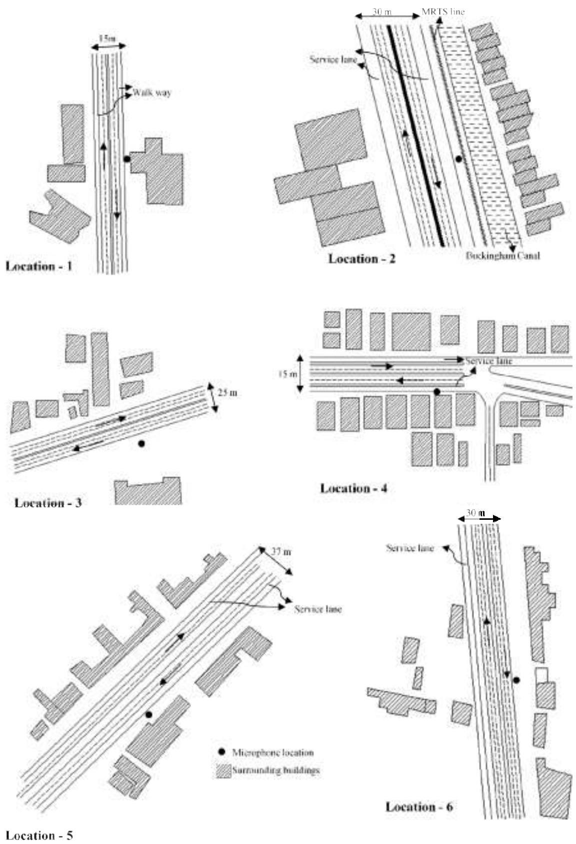


Fig (1): The location of microphone, road width and surrounding layout for all six measurement locations.

Fig (2) a. A typical measuremet location, b. Norsonic sound level meter and c. Hand held radar gun.

EVALUATION OF BASE NOISE LEVEL (Lm15)

Base noise level is identified as the noise level originating at the traffic stream. The basic noise equation is arrived in the form of multiple regression equation with the independent variables such as traffic volume (Qi) and speed (V). The basic equation is the standardized level for the following conditions.

- Road surface non-grooved asphalt
- Gradient < 5%

BASE NOISE LEVEL

Since the characteristics of the urban and highway traffic noise are different, two separate equations are arrived as follows.

Table 1. Measured values of equivalent speed, total no of horns in the measurement duration, Leq and statistical levels at the study locations

Location	Speed Km/hr		Sound level	Statistical levels dB(A)		
	Mean Km/hr	S.D Km/hr	Leq dB(A)	L10	L50	L90
Location 1	34	6.6	81.8	77.3	69.6	63
	36.8	6.79	77.7	77.5	70	61.8
	40.52	7.22	78.4	75.5	70.1	64.2
Location 2	51.24	9.72	80	80	74.6	67.9
	52.05	13	84.1	82.3	77.2	71.3
	54.05	15.1	78.6	79.5	73.4	66.4
	54.4	10.9	81.5	81.3	76.2	70.5
Location 3	35.19	5.6	84.4	82.8	78.5	70.8
	35.67	4.61	84.8	83.1	79.2	73
	37.94	4.84	83.1	82.4	78.3	74.4
Location 4	25.99	8.34	82.5	81.3	75.3	68.5
	27.48	6.21	82.5	80.3	74.2	68
	26.45	5.53	82.7	82.3	75.7	69.4
Location 5	57.46	16.0	79.6	79.3	72.4	64.3
	54.57	11.7	84.5	82.3	75	67.3
	56.91	15.3	79.9	79.6	71.5	62.6
Location 6	65.1	19.3	78.7	80.3	70.7	61.7
	54.98	16.7	80.2	81.2	70.1	60.6
	65.94	18.0	80.9	79.7	68.9	59.8
	61.76	16.6	82.4	80.6	71.6	64.8
	71.43	24.9	78.9	78.7	68.9	62.1
	59.61	17.6	79	78.8	69.7	62.3

In all the places surveyed L10 values range from 77 to 83 dB (A) and L90 values range from 61 to 74 dB(A). Those ranges of noise levels will be a burden on the society, affecting the quality of life, with windows open the L10 values can be around 60dB (A) [Croome D.J 1977]

For Highways

$$L_{m(15)} = 34.31 + 13.9 \log Qi + 9.2 \log V \quad (2)$$

Where Qi is the total number of vehicles/hr in terms of PCNU, V is the speed in km/hr.

These equations have been tested using the't' ratio test and are statistically acceptable. In the above equation, Qi factor is evaluated by PCNU, a unit called passenger car noise unit.

Noise level generated by different types of vehicles varies according to its size and weight. Individual acoustic power levels of vehicles are too complex to be accounted at an instant of time due to a large number. A parameter designated as passenger car noise unit (PCNU) akin to that of passenger car unit (PCU) which is used to describe traffic density in heterogeneous traffic environment has been introduced. Subsequently the values computed are shown in table (3), which is arrived as explained below.

The L, dB (A) of sound corresponding to sound pressure of

SPL of car = 10 log (P^2rms / P^2 ref) (3)

SPL of Truck = 10 log (P^2/P^2ref) (4)

The main significance of PCNU is to explain how much a particular vehicle is noisier than car. For instance in the case of truck

Ltruck = n x L car (5)

n is evaluated as the difference of mean acoustic pressure level of car and mean truck noise.

SPL_{truck} / SPL_{car} = 10 log [(P^2rms_{car}/P^2 ref) / (P^2rms_{truck}/P^2 ref)] (6)

$n = 10^{(SPL\ truck/10)} - 10^{(SPL\ car/10)}$ (7)

n values so obtained are as shown in table 2

Table 2. Mean noise emission level of five different categories of vehicles in heterogeneous traffic condition with the conversion factors for equivalent number of cars

Category of vehicle	Mean dB(A)	S.D dB(A)	PCNU n
Two wheeler (petrol driven).	78.95	5.71	0.8
All passenger cars, all Petrol driven three wheelers and diesel driven two wheelers.	80.29	4.31	1
Passenger or light commercial vehicles including three wheeled vehicles fitted with diesel engine with gross vehicle weight up to 4000kg.	81.29	6.42	1.25
Passenger or commercial vehicles with gross vehicle weight above 400kg and up to 12000kg.	86.08	4.23	4
Passenger or commercial vehicles with gross vehicle weight above 12000kg.	89.05	3.91	8

Pass by noise of vehicle has been measured for different categories of vehicles (table (2)). Measurements have been taken individually for all the vehicles with an acceptable background criterion.

Qi = 0.8 * (Two wheelers) + 1* (Car) + 1.25 *(Three wheelers) + 4* (Light trucks) + 8 * (Heavy trucks or busses) (8)

HORN CORRECTION (C_{HORN})

Another factor to be considered are the number of horn events. In few locations, horn sound occupied more than 25 % of the measurement duration. For studying the contribution of horn noise, the horn noise level is subtracted from Leq measured based on a nomographic procedure [work safe BC 2007].

Table 3. Observed composition of vehicles, and calculated equivalent volume

Location	Composition of vehicles (numbers/hr)					Total vehicles	Qi
	Two wheeler	Three wheelers	Car/ van	Truck	Bus		
Location 1	876	152	624	8	28	1688	1772
	1132	224	828	32	88	2304	2844
	1712	188	888	8	40	2836	2844
Location 2	1500	220	1036	44	120	2920	3648
	1672	268	1020	80	132	3172	4068
	1192	188	888	16	32	2316	2396
	1680	228	1084	36	136	3164	3944
Location 3	2584	636	2004	132	332	5688	8052
	3004	444	1380	96	240	5164	6644
	2288	480	1812	72	176	4828	5940
Location 4	1064	304	820	28	88	2304	2868
	1168	232	852	24	140	2416	3292
	1124	252	796	24	100	2296	2908
Location 5	448	32	660	124	152	1416	2772
	908	52	512	200	176	1848	3512
	460	24	508	132	116	1240	2364
Location 6	224	12	212	160	44	652	1400
	164	16	136	260	56	632	1776
	168	20	236	92	28	544	988
	348	24	288	124	24	808	1284
	200	12	200	96	32	540	1016
	216	12	224	92	28	572	1004

The nomogram considers Leq, Lex, Noise dose and time. Individual measurements of various types of horns have been measured by the authors. An average of 100dB(A) for air pressure horn after considering 3dB attenuation by the surrounding environment at 7m distance from the kerb side for evaluation purposes. Tables (4) and (5) show the influence of horn noise events on the Leq. Fig (3) shows the relation between the number of horn events (in a minute) and increase in corresponding Leq dB(A).

Table 4: Horn correction values

S.No	Average no of horns/min	% of time occupied by horn sound	Increase in Leq dB(A)
1	< 2	3 %	0
2	2-4	3 % – 6%	2
3	4-8	6% - 13%	6
4	8-16	13 % - 26 %	10
5	> 16	> 26 %	12

EFFECT OF ROAD WIDTH AND MULTIPLE REFLECTIONS (C_{REF})

The width of the road has a significant effect on the resulting Leq noise levels as per RLS 90 (1990) the correction term is for hard surfaces.

C_{REF} = 4 * (Building height) / (Road width)

For absorbing surfaces

C_{REF} = 2 * (Building height) / (Road width)

Hence the source noise level for heterogeneous traffic conditions is calculated as.

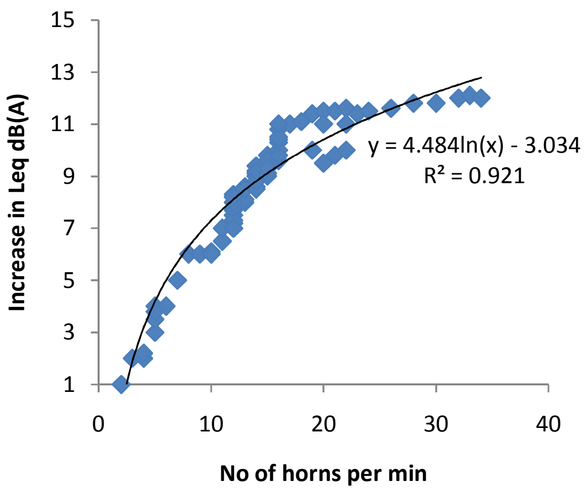


Fig. 3. Relation between Increase in Leq dB(A) Vs No of horns per minute

$$Leq = L_{m(15)} + C_{horn} + C_{REF} \quad (1)$$

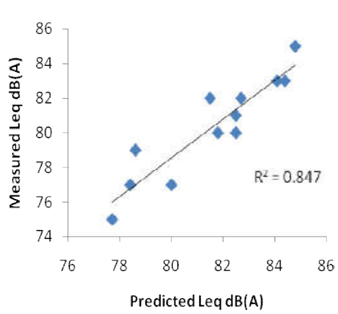
Where

$L_{m(15)}$ is the basic noise level (at 15m from the center of last lane), C horn and C ref are the correction factors for honking conditions and road width / multiple reflection

Table 5: Results showing Leq levels without horns

Average number of horns / minute	% of time occupied by horn sound	Leq with horn sound	Leq without horns	Difference in dB(A)
1	1.7	78.7	78.2	0.5
1.2	2	80.2	79.5	0.7
11.5	19	82.5	74	8.5
6.9	11.4	84.1	80	4.1
1.8	3	80.9	79	1.9
2.0	3.3	82.4	80.3	2.1
4.5	7.5	79.6	76	3.6
4.1	6.8	79.9	76.5	3.4
16.0	26.6	82.7	69	13.7
6.5	10.7	81.5	76	5.5
14.7	24.4	84.8	73	11.8
8.3	13.8	78.4	75	3.4
0.9	1.5	78.9	78.5	0.4
1.1	1.8	79	78.5	0.5
4.2	7	84.5	80.3	4.2
12.7	21.1	82.5	71.6	10.9
5.2	8.6	78.6	73.2	5.4
10.5	17.5	83.1	75.4	7.7

Considering these corrections Leq values predicted and measured are as shown in fig (4)



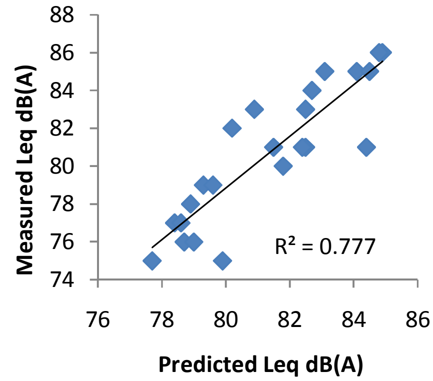


Fig. 4. measured VS Predicted correlation chart for urban areas and highways

CONCLUSION

A modified model taking into account the horn noise correction has been developed. A passenger car noise unit (PCNU) has been introduced to take into account the base noise level to which the horn noise and road width corrections have been applied. Horn noise events occurring around 16 per minute will raise the Leq by 12dB (A). A greater scope exits to reduce Leq due to traffic in such urban environments by a suitable modified horn design and traffic management.

REFERENCES

1. Agarwal, S., Swami, B. L. & Gupta, A. B; 2009, Development of a noise prediction model under interrupted traffic flow conditions: A case study for Jaipur city. *Noise & Health,* 11(45), pp 189–93.
2. Agarwal, S., & B. L. Swami; 2010, Comprehensive approach for the development of traffic noise prediction model for Jaipur city, *Environ Monit Assess*, Vol 172 pp 113-120.
3. Bose,B., Bhattacharyya, A.K.; 1973, Noise and community, *The Indian Engineer*, pp 24-28
4. CPCB; 2000, Central pollution control board, http://cpcb.nic.in/Noise_Standards.php
5. Census; 2001, Census of India**.** Government of India, http://www.censusindia.gov.in/2011-prov-results/prov_results_paper1_india.htmls
6. Croome. D.J; 1977. *Noise buildings and people*. Pergamon Press.
7. Chakrabarty. D, Subhas Chandra Santra, and Abirlal Mukherjee., Status of road traffic noise in Calcutta metropolis, India. *J. Acoust. Soc. Am*. 1997 101 (2) pp 943-949.
8. Gupta.A.K., S F Nigam and J S Hansi; 1986,A Study on Traffic Noise for Various Land Use for Mixed Traffic Flow. *Indian Highways, Indian Roads Congress*, New Delhi.
9. Kumar K, Jain V.K and Rao DN; 1998. A predictive model of noise for Delhi .J Acoust Soc Am, 103(3) pp1677–1679.
10. Nirjar, R. S., Jain, S. S., Parida, M., & Katiyar, V. S.; 2003 Study of transport related noise pollution in Delhi. Journal of the Institute of Engineers, 84 (1), pp 6–15.

11. Pancholy, M., Chhapgar, A.F., Khanna, R.K.and Tyagi, R.C; 1969, Noise survey in Indian cities. J. Scient. Industr. Res., 19A, pp 19-25.
12. Rao, R. P. & Rao, S. M. G. (1991). Prediction of L*A*10*T* traffic noise levels in the city of Visakhapatnam, India. *Applied Acoustics,* 34, pp 101–110
13. Richtlinien fuÈ r den LaÈ rmschutz an Straûen (RLS-90) (Guidelines for Noise Pro-tection on Streets) 1990.
14. work safe BC, (2007) Basic Noise Calculations www.worksafebc.com/.../health.../basic_**noise**_calculations.pdf

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