TRAFFIC NOISE MEASUREMENT AND PREDICTION IN PATIALA CITY, PUNJAB (INDIA)

Paras Kumar[1]

[1]*Assistant Professor, Mechanical Engineering Department*

Delhi Technological University, Delhi, (India)

ABSTRACT

The present work discussed the fundamentals and procedure to measure road traffic noise in Patiala city, Punjab (India). A large number of data have recorded at different dates/timings to accommodate variation in traffic flow characteristics. Two mathematical models have developed to predict, equivalent continuous sound level (L_{eq}) and 10 percentile exceeded sound level (L_{10}), traffic noise descriptors. The noise models use vehicle volume (Log Q) and percentage of heavy vehicles (P %) as input variables. The variation between input parameters and predicted noise descriptors shows linear relationship. The measured L_{10} level varies from 75.3 to 78.3 dB (A), while L_{eq} level ranges from 72.9 to 79.4 dB (A). At few instances, a large variation is observed between measured and predicted value due to excessive horn noise. The maximum percentage error between measured and predicted noise levels are 1.9 % and 5.7 % for L_{10} and Leq respectively.

Keywords: Regression, Modeling, Traffic Noise, Vehicle Volume, Percentage of Heavy Vehicles

I. INTRODUCTION

In our modern, rapidly expanding environment one of the major problems is that of noise. The development in transportation and automotive sector lead to overcrowd road and traffic noise. Traffic noise is contributed by various kinds of vehicles including heavy, medium trucks/buses, automobiles and two wheelers. The overall noise is dependent on the characteristics of the vehicle flow and the relative proportions of the vehicle types included in the flow. Knowledge of these factors is thus necessary to define the characteristics of highway noise and to subsequently predict the associated noise level in the surrounding area.

Researchers have attempted a lot of efforts in past to model or to predict highway noise in India and abroad. Johnson and Saunders [1] performed road side surveys of the noise emitted by freely flowing traffic on sites ranging from motorways to urban roads. Harman and Burgess [2] summarized the results of a noise survey made within the Portsmouth City boundaries. Measurements were made throughout the 18-hour day at 33 sites which covered a wide range of traffic conditions. Clayden et al. [3] describe a mathematical model for the prediction of traffic noise levels in an urban or suburban situation. Delany et al. [4] have developed an improved procedure for predicting noise levels L_{10} from road traffic. Yeow [5] determined the time-averaged overall mean-square sound pressure created by statistically stationary traffic traveling a finite, straight road segment explicitly. Yeowart et al. [6] collected responses to a social survey which were from residents of 27 different sites in the Greater Manchester area. The sites were exposed to noise emanating from (a) freely flowing traffic on urban roads, or (b) motorway traffic, or (c) congested or disturbed traffic flow on urban roads. Sy et al. [7] carried out a comprehensive survey and statistical analysis of daytime traffic noise in Singapore. The results are presented in terms of average L_{10}, L_{50} and L_{90} for four different classes of sites. Hammad and Abdelazeez [8] measured the values of the sound pressure level (L_{10}) resulting from traffic noise measurements over periods of 1 hr. and 18 hr. Ramalingeswara and Seshagiri [9] described that the environmental noise level due to motor vehicle traffic to a first approximation is a function of traffic volume. The values of sound pressure level ($L\ A_{10}$) resulting from traffic noise measurements over one-hour periods have been correlated with the equivalent measured numbers of heavy light vehicles per hour (traffic density). Kumar and Jain [10] carried out a survey of traffic noise in the city of Delhi in order to examine the nature and levels of noise inside various types of vehicle. The study involved measurements of average A-weighted levels and power spectra of noise inside buses, auto-rickshaws, cars and trucks from which L_{10}, L_{50}, L_{90} and L_{eq} levels were estimated. Campbell [11] reviewed the most commonly used traffic noise prediction models, e.g. CORTN, FHWA and ASJ etc.

A survey of available literature on traffic noise indicates that the main interest of the various researchers were establishing of various highway noise descriptors and criteria; assessment of highway noise, undertaking traffic noise survey, establishing of different parameters affecting traffic noise and formulation of mathematical models etc. Kumar et al. [12] developed a multilayer feed forward back propagation (BP) neural network (ANN) for predicting highway traffic noise. The ANN has been trained using Levenberg–Marquardt (L–M) algorithm.

The developed ANN model predicts 10 Percentile exceeded sound level (L_{10}) and Equivalent continuous sound level (L_{eq}) in dB (A) The predicted highway noise descriptors, L_{eq} and L_{10} from ANN approach and regression analysis have also been compared with the field measurement. Further goodness-of-fit of the models against field data has been checked by statistical *t*-test at 5% significance level and proved the Artificial Neural Network (ANN) approach as a powerful technique for traffic noise modeling.

In the present work, two highway noise descriptors, equivalent continuous sound level (L_{eq}) and 10 percentile exceeded sound level (L_{10}), are measured and predicted in Patiala city (Punjab, India). The developed noise prediction models use vehicle volume (Log Q) and percentage of heavy vehicles (P %) as input variables. A large number of data have recorded at different dates/timings to accommodate variation in traffic flow characteristics.

II. SITE SELECTION

A mathematical model specific to the situation has to be formulated for predicting the traffic noise. To achieve this objective, first and important task is the site selection. So, according to surveys of different areas and nature of noise problem, a two lane straight patch, where continuous flow of vehicles occurs without any obstructions like traffic signal lights etc, is selected at Sirhind road, Patiala (India). This site is about 4 Km from Dukh Niwarn Sahib Gurdwara at Sirhind road, Patiala as shown in Fig.1.

III. MEASUREMENT PROCEDURE

For traffic noise problems, it is useful to know the equivalent continuous sound level L_{eq} and the 10 percentile exceeded Sound level L_{10}. Such information is obtained using a Sound level meter (CESVA SC-310). The Sound Level Meter is first calibrated before measurement. Microphone is placed at a height of 1.2 m and at distance of 8.5 m from centre of the inner and outer lanes (Fig.1). Noise levels have measured as per ISO recommended vehicle noise test. The noise descriptors, L_{eq}, L_{10}, are measured and recorded in SPL. Number of

Vehicle of each category is measured in inner and outer lanes and then the total vehicle volume (Q) and percentage of heavy vehicles (P %) have computed.

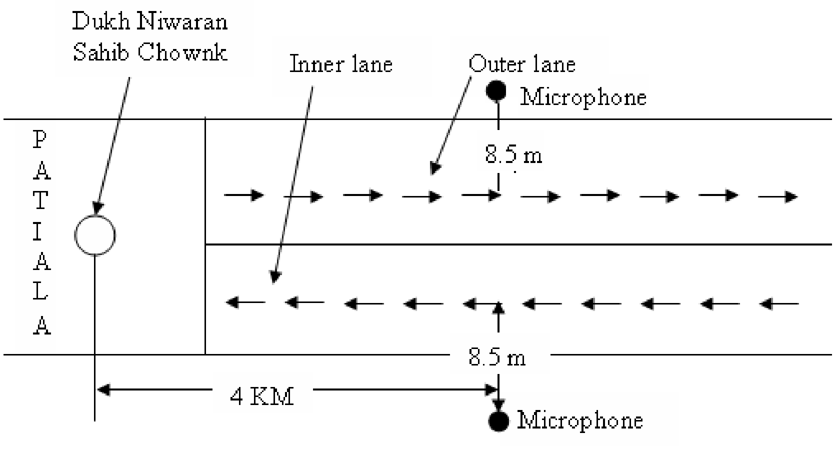


Fig.1 Site for Data Collection [Sirhind Road, Patiala city (India)]

IV. RESULT AND DISCUSSION

After measuring and calculating the input variables and noise descriptors, two different regression models have been developed. The developed equations (1) and (2) predict the equivalent continuous sound level (Leq) and 10 percentile exceeded Sound level (L_{10}) in dB (A). The input variables to the models are total vehicle volume (Q) and percentage of heavy vehicles (P %).

L_{eq} [dB (A)] = 52.513+6.895* Log Q + 0.044* P (1)

L_{10} [dB (A)] = 54.305 +6.884 * Log Q + 0.089 * P (2)

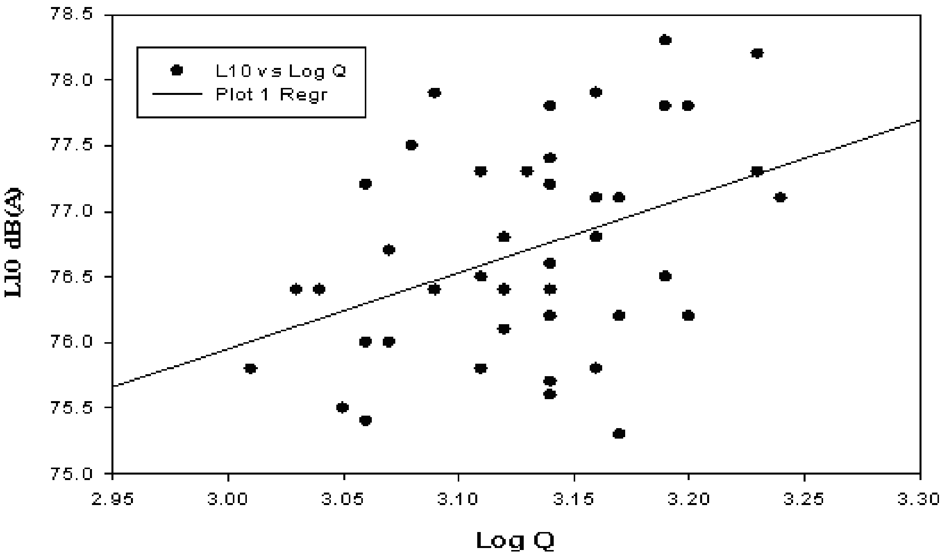


Fig. 3 Variation of L_{10} with Log Q

The measured and recorded data along with predicted Leq and L_{10} are shown in Table-1. Figure-3 shows the variation of L_{10} with Log (Q). The measured data shows scattered behavior, while the predicted shows linear variation. With increase in vehicle volume, L_{10} level increases.

Table-1 Measured and Predicted Data

S. No	Log(Q) Vehicle/hr.	P (%)	L_{10} Measured dB (A)	L_{10} Predicted dB (A)	% Error	L_{eq} Measured dB (A)	L_{eq} Predicted dB (A)	% Error
1	3.14	10.2	77.8	76.8	1.3	75.0	74.6	0.5
2	3.11	11.5	77.3	76.7	0.8	74.5	74.5	0
3	3.09	10.7	77.9	76.5	1.8	76.4	74.3	2.7
4	3.08	18.4	77.5	77.1	0.5	74.8	74.5	0.4
5	3.07	12.2	76.7	76.5	0.3	74.2	74.2	0
6	3.13	10.8	77.3	76.8	0.6	74.6	74.6	0
7	3.14	10.2	77.4	76.8	0.8	75.3	74.6	0.9
8	3.06	9.4	76.0	76.2	-0.3	74.1	74.0	0.1
9	3.03	7.4	76.4	75.8	0.8	73.7	73.7	0
10	3.06	13.3	75.4	76.5	-1.4	73.2	74.2	-1.4
11	3.01	12.9	75.8	76.2	-0.5	74.5	73.8	0.9
12	3.09	10.7	76.4	76.5	-0.1	74.4	74.3	0.1
13	3.14	8.5	76.6	76.7	-0.1	73.7	74.5	-1.1
14	3.16	8.2	76.8	76.8	0	74.3	74.7	-0.5
15	3.17	7.8	75.3	76.8	-1.9	73.3	74.7	-1.9
16	3.12	12.4	76.4	76.9	-0.6	73.8	74.6	-1.1
17	3.16	11.6	77.1	77.1	0	74.5	74.8	-0.4
18	3.19	8.3	76.5	77.0	-0.6	73.8	74.9	-1.5
19	3.20	9.1	77.8	77.1	0.9	75.9	75.0	1.2
20	3.24	7.1	77.1	77.2	-0.1	75.0	75.2	-0.3
21	3.23	8.1	77.3	77.3	0	75.0	75.1	-0.1
22	3.11	10.3	75.8	76.6	-1.1	72.9	74.4	-2.1
23	3.14	7.3	76.2	76.6	-0.5	74.2	74.5	-0.4
24	3.16	7.2	75.8	76.7	-1.2	73.2	74.6	-1.9
25	3.23	10.4	78.2	77.5	0.9	76.1	75.2	1.2
26	3.20	7.8	76.2	77.0	-1.0	73.2	74.9	-2.3
27	3.19	10.7	77.8	77.2	0.8	75.9	75.0	1.2
28	3.12	12.4	76.1	76.9	-1.0	73.8	74.6	-1.1
29	3.14	9.3	76.4	76.7	-0.4	74.2	74.6	-0.5
30	3.17	11.3	76.2	77.1	-1.2	74.0	74.9	-1.2
31	3.16	9.6	77.9	76.9	1.3	75.4	74.7	0.9
32	3.17	8.0	77.1	76.8	0.4	75.6	74.7	1.2
33	3.19	8.0	78.3	77.0	1.7	79.4	74.9	5.7
34	3.05	10.8	75.5	76.2	-0.9	73.0	74.0	-1.4
35	3.11	9.6	76.5	76.6	-0.1	74.0	74.4	-0.5
36	3.14	9.5	77.2	76.8	0.5	75.5	74.6	1.2

37	3.12	8.0	76.8	76.5	0.4	74.6	74.4	0.3
38	3.14	6.9	75.6	76.5	-1.2	72.9	74.5	-2.2
39	3.07	9.2	76.0	76.2	-0.3	74.1	74.1	0
40	3.04	6.4	76.4	75.8	0.8	74.5	73.7	1.1
41	3.06	6.3	77.2	75.9	1.7	75.3	73.9	1.8
42	3.14	4.7	75.7	76.3	-0.8	73.9	74.4	-0.7

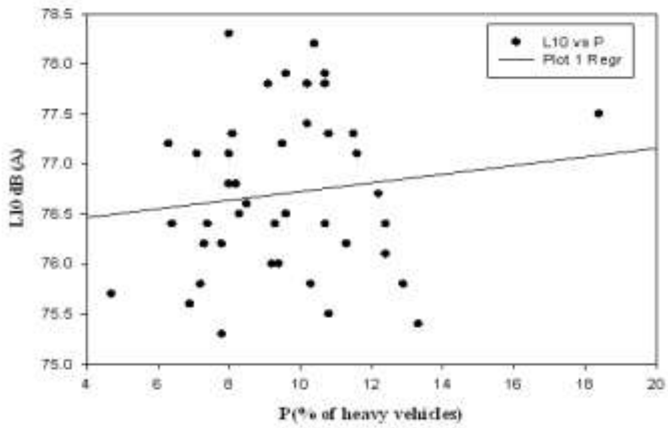
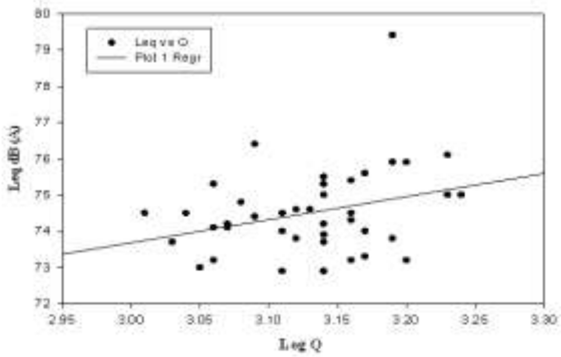


Fig. 4 Variation of L_{10} with P

A similar type of behavior was observed in Fig.-4. The L_{10} level increases with increase in percentage of heavy vehicles (P %). In regression model (1), the effects of both the variables are combined and it is observed that the maximum percentage error in measured and predicted L_{10} level is 1.9 %.

Figure-5 shows the variation of L_{eq} with Log (Q). The measured data shows scattered behavior, while the predicted shows linear variation. With increase in vehicle volume, L_{eq} value increases.



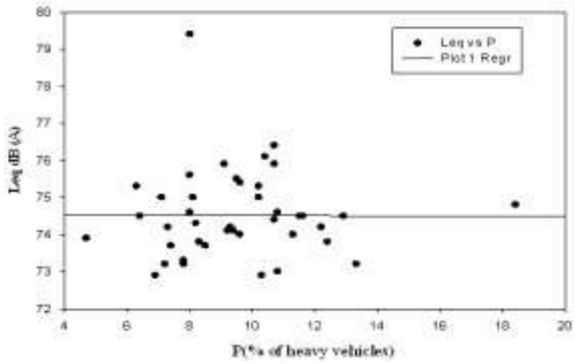


Fig. 5 Variation of L_{eq} with Log Q **Fig.6 Variation of L_{eq} with P**

The variation of L_{eq} with percentage of heavy vehicles (P %) is shown in Fig.-6. The level of L_{eq} remains almost constant with P. The combined effects of both the variables, as shown in regression model (2), show that the maximum percentage error in measured and predicted L_{eq} level is 5.7 %.

V. CONCLUSIONS

The present work, collected data on Noise generating parameters was applied to predict the Vehicular Traffic Noise, and to suggest suitable model based on Indian conditions. From the present study following conclusions are drawn:

- Traffic volume (Q) varies from 1023 to 1737 vehicles/ hr., while Heavy vehicles percentage (P %) was found to be between 4 % to18.4 %.
- Measured L_{10} level was found to be vary from 75.3 to 78.3 dB (A), while L_{eq} level varies from 72.9 to 79.4 dB (A).
- The maximum percentage error between measured and predicted noise levels are 1.9 % and 5.7 % for L_{10} and Leq respectively.
- Excessive horn noise of the vehicles caused some odd noise levels which are different from the normal noise levels.

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