Original Article

J Res Health Sci, Vol 7, No 1, pp. 13-17, 2007

Road Traffic Noise Model

***Golmohammadi R. PhD, **Abbaspour M. PhD, ***Nassiri P. PhD, ****Mahjub H. PhD**

**Occupational Safety and Health Department, School of Public Health, Hamadan University of Medical Sciences, Iran*
***Dept. of Mechanical Engineering, Sharif University of Technology, Iran*
****Dept. of Occupational Health, School of Public Health, Medical Sciences/ University of Tehran, Iran*
*****Dept. of Biostatistics, Hamadan University of Medical Sciences, Iran*

(Received 25 Jan 2007; accepted 8 July 2007)

Abstract

Background: The recognition of road traffic noise as one of the main sources of environmental pollution has led to develop models that enable to predict noise level from fundamental variables. Traffic noise prediction models are required as aids for designing roads and highways. In addition, sometimes are used in the assessment of existing or envisaged changes in traffic noise conditions. In this paper a statistical modelling approach has been used for predicting road traffic noise in Iranian road conditions.

Methods: The study was performed during 2005-2006 in Hamadan city, in the west of Iran. The data set consisted of 282 noise measurements. The entire data set was utilized to develop a new model for Iranian condition using regression analysis.

Result: The developed model has twelve explanatory variables in order to achieve a proper fit for measured values of L_{eq} (r^2= 0.913).

Conclusion: The proposed road traffic noise model can be effectively used as a decision support tools for prediction of traffic noise index of $L_{eq(30min)}$, in Iran's cities.

Keywords: *Noise, Traffic Noise, Occupational noise, Model*

Introduction

Noise pollution is one of the important issues of environmental pollutant in metropolitan areas and is almost one of the harmful agents, therefore many countries have introduced noise emission limits for vehicles and other legislations to reduce road traffic noise (1, 2). In the recent years in some countries, new restricted rules were regulated for controlling civic road traffic noise.

The recognition of road traffic noise as one of the main sources of environmental pollution led to design models that enable us to predict traffic noise level. Several models have been developed from fundamental variables such as the traffic flow, speed of vehicles and sound emission level using regression analysis of experimental data 2.

Criteria of road traffic noise in Iran is based on Leq(30min), therefore any model that estimates L10, such as CORTN is not applicable. As the type of vehicle noise emission and road structure in Iran differ from other countries, the empirical models such as FHWA 3, Stefano 2, Li 4, 5, Parida 6, Gundugdu 7, Tansatcha 8 and Lam 9 are not suitable for prediction of Iranian road traffic noise index. Traffic noise prediction models are required as aids in the design of highways and other roads and sometimes in the assessment of existing or envisaged changes in traffic noise conditions. They are commonly needed to predict sound pressure levels, specified in terms of L_{eq}, L_{10}, etc., set by government authorities 3.

***Corresponding author:** Dr R Golmohammadi, Fax: +98 811 8255301, E-mail: golmohamadi@umsha.ac.ir

In this paper a statistical model for predicting A-weighted equivalent level is proposed for Iran's situation. The objective of this study was to design a road traffic noise prediction model from traffic variables and conditions of transportation in Iran.

Materials and Methods

The present study was conducted in Hamadan city, in the west of Iran during 2005-2006. The main roads of the city were classified into 64 parts. The basic data were gathered using digital maps and field observations. In each road restriction, ten probable stations at two sides of the road were specified, and then two random stations were selected.

After the elimination of repeated stations or neighbour and opposite stations, finally 94 stations were chosen. In the pilot stage of the study, for optimizing duration of noise measurement time at each station, as well as determining the effect of background noise over traffic noise, 30 random stations were selected. At each pilot station, background noise levels of L_{eq}, L_{max} and L_{10} during 10, 20, 30, 45 and 60 min intervals were simultaneously measured. The days and hours of sampling were random. Noise measurements were at a distance of three meters from the nearest road band on the height of 130cm above the road surface. A B&K sound level meter type 2260 was used for measurements.

The results of the pilot stage of this study showed that the 10 min interval measurement of equivalent sound pressure level could forecast the hourly values of L_{eq} 30 and 60 min effectively (*P*= 0.998). Based on the mean and standard deviation of equivalent noise pressure level at the pilot stations and consideration of maximum sampling error equal to 0.5 dB(A) with a 99% Confidence Interval, the minimum required sample size was estimated 282. Therefore, in the main stage of the study, totally 282 noise measurements were observed including two 10 min noise measurements on day's hours (7 Am to 10 Pm) and one on night hours (10 Pm to 7 Pm). For each sample the following parameters were simultaneously measured: L_{eq} dB(A), SPL_{min} dB(A), SPL_{max} dB(A), L_{10} dB(A), number of vehicles, vehicles' speed in four vehicle groups of cars: light trucks and minibuses, heavy trucks and buses, and motorcycles. Moreover, air temperature and humidity, plus the road dimensions such as length of road section, road pathway width, gradient of road and buildings height around the road were recorded.

All of the collected data were entered in statistical sheet of Excel and SPSS software. Multiple regression models were applied to develop a new model for Iran's cites. The scatter plot of the data showed there is a logarithmic relationship between L_{eq} and mean vehicles' speed as well as vehicles flow. Therefore, for the fitted model, the logarithmic transformation of flow and speed of vehicles were considered.

The developed model has as most possible as entrance variable for estimation traffic noise (L_{eq}). Four groups of variables were considered in the model, including: dimension parameters (road length, road width, road gradient and buildings' height around the road segment), traffic flow, vehicle speed, and noise emission levels of four groups of vehicles.

Traffic flow was considered, linear in two sides and free flow. This designed model can predict L_{eq} in distance of 3 m from the roadsides edge.

Results

The results of the pilot stage of the study showed that the mean equivalent sound pressure level at measuring stations for 10 min interval was 70.76± 2.11 dB(A), for 30 min one was 70.88±2.19 dB (A) and for 60 min one was 70.93±2.13 dB(A). The results showed that there was no significance difference between the L_{eq} in time intervals of 10, 30 and 60 min (*P*= 0.998). In the pilot stations the mean of background sound pressure level was 60.77±5.04 dB(A). The background level did not have not considerable effect on traffic noise level.

The results of the main stage of the study showed that the mean of L_{eq} at all stations was 69.04± 4.25 dB(A). The average of vehicles speed was 44.57±11.46 km/h and the mean of vehicle flow 1231.9±910 per hour. The mean values of the main variables are shown in Table 1. The mean of L_{eq} in day-night hours is significant (P= 0.003).

In this study, for the fitted regression model there are four explanatory factors to predict equivalent sound pressure level L_{eq} in 3 meters of the near road sides. The four explanatory factors, consisting twelve variables, are as follows: 1-Noise emission level; 2- Road dimensions; 3- Traffic flow factor; 4- Traffic speed factor. The developed model has twelve explanatory variables in order to achieve a proper fit for measured values of L_{eq} (r^2= 0.913). The following subsections show the algorithms of the explanatory factors and suggested model for predicting equivalent sound pressure level L_{eq} in 3 meters of near road sides and other distances of road sides.

Main Equation of road traffic noise prediction:

Proposed fitted model for predicting equivalent sound pressure level L_{eq} in 3 meters of near roadsides:

$$L_{eq} = 54.013 + \Delta N + \Delta V + \Delta D \quad \text{dB(A)}$$

Traffic flow factor:

$$\Delta N = (3.542 \times \log N_{car}) + (0.308 \times \log N_{mini}) + (2.361 \log N_{truck}) + (0.173 \log N_{cycle})$$

, where

N_{car}	*Number of cars (v/hr)*
N_{mini}	*Number of mini-buses or mini-trucks (v/hr)*
N_{truck}	*Number of buses or heavy trucks (v/hr)*
N_{cycly}	*Number of motorcycles (v/hr)*

Traffic speed factor:

$$\Delta V = 0.668 \times \log V_{car} + 0.907 \log V_{mini} + 0.176 \log V_{truck} + 0.302 \log V_{cycle}$$

, where

V_{car}	*Mean speed of cars (km/hr)*
V_{mini}	*Mean speed of mini-buses or mini-trucks (km/hr)*
V_{truck}	*Mean speed of buses or heavy trucks (km/hr)*
$V_{motorcycle}$	*Mean speed of motorcycles (km/hr)*

Road dimensions factor:

$$\Delta D = (0.001L) - (0.104W) + (0.24H) + (0.068S)$$

, where

L	*Length of road section (m)*
W	*Width of road section (m)*
H	*Height of buildings around the road (m)*
S	*Gradient of road section (%)*

The results of verification of designed model in this study showed the mean of predicted L_{eq} is 69.69±3.45 dB(A). Comparing the means of predicted L_{eq} and measured L_{eq} (69.04±4.25 dB(A)) showed a small mean difference of 0.365 dB(A). The plots of predicted and measured values of L_{eq} are shown in Fig. 1.

Table 2 shows a comparison between measured L_{eq} and predicted values based on different empirical models containing the suggested model.

Table 1: The details of noise measurement, environmental and dimensional factors of the roads

Parameter	n	Mean	SD
Number of cars (v/hr)	282	1006.6	777.68
Number of mini bus or mini trucks (v/hr)	282	33.21	54.28
Number of buses or heavy trucks (v/hr)	282	44.28	61.83
Number of motorcycles (v/hr)	282	147.82	114.14
Mean speed of cars (km/hr)	282	53.23	14.87
Mean speed of mini bus or mini trucks (km/hr)	227	41.52	12.18
Mean speed of buses or heavy trucks (km/hr)	239	40.99	13.39
Mean speed of motorcycles (km/hr)	263	48.08	14.77
SPL_{min} dB(A)	282	52.32	8.62
SPL_{max} dB(A)	282	82.94	4.21
L_{eq} dB(A)	282	69.04	4.25
L_{10} dB(A)	282	71.69	5.43
Road section length (m)	282	1045.0	889.6
Road section gradient (%)	282	2.01	1.5

Table 2: Compression of measured and predicted L_{10} and L_{eq} for the study data by some empirical models containing suggested model

parameter	Mean dB(A)	SD dB(A)	Difference dB(A)
Measured L_{eq}	69.04	4.25	-
Suggested model	69.69	3.45	+0.365
Prediction of FHWA - STAMINA	66.82	7.68	-2.22
Prediction of Lam W H K, 1998	64.07	5.71	-4.97
Prediction of Li B,2002	65.43	5.21	-3.61
Prediction of Parida M,2003	72.24	4.50	+3.20
Prediction Calixto 2003	71.85	4.02	+2.81
Prediction of Gundogdu O, 2005	59.98	1.36	-9.06

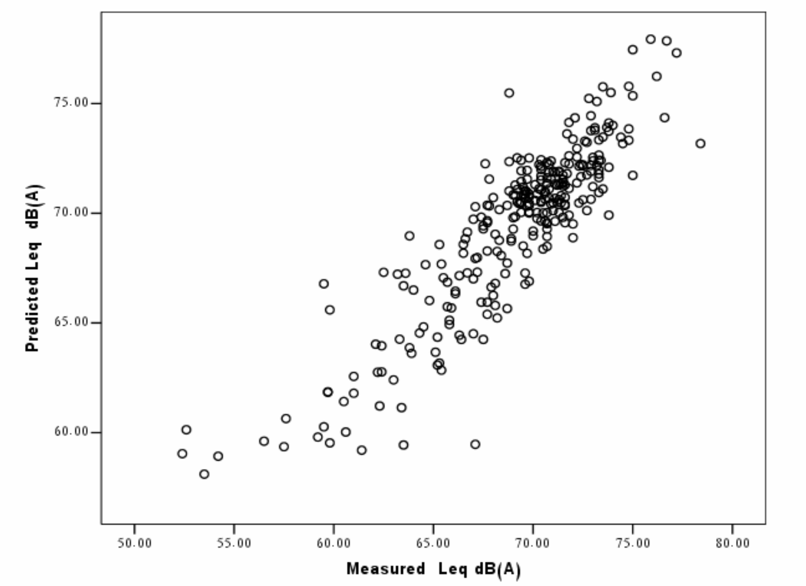

Fig. 1: Distribution of predicted L_{eq} by model and measured values in reference distance from roadside

Discussion

The present study has introduced a suitable model for prediction of road traffic noise in Iran. Traffic noise prediction models are required as aids in the design of roads and sometimes in the assessment of existing or envisaged changes in traffic noise conditions. They are commonly needed to predict sound pressure levels, specified in terms of $L_{eq\ i}$- L_{10}, etc. Several models have been developed via a regression analysis of experimental data, from fundamental variables such as traffic flow, speed of vehicles and sound emission level 2.

This paper is the result of a study that was performed during 2005 in Iran. The data set consisted of 282 samples, utilized to develop a new model for Iran condition using regression analysis. The research was performed at two stages including pilot and the main stages. The developed regression model can be suitably applied for all urban areas in the country. The suggested model has a high coefficient of determination, which indicates adequacy of the model. The proposed model is applicable only for urban roads with speeds below 90 km/h and traffic flow below 5000 v/h.

The results of the pilot stage of this study showed that the average of background noise pressure level at measuring sites did not have considerable effect on the traffic noise around the roads. In addition, in that stage, it was suggested that a 10 min measurement suffices to predict L_{eq} of 30 min to 60 min in the main stage of the study. Logarithmic transformation between speed of vehicles and traffic flow showed a nice condition for designing a linear regression model of L_{eq}, as other researchers performed 3, 5-8, 11, 12 and 13.
The developed model has twelve explanatory variables in order to achieve a proper fit. The important point in this study was the number of entrances compared to that of the empirical models like as FHWA 3. In this model, some additional variables such as road length, gradient and height of buildings around the roads were considered. The mean difference between measured and predicted L_{eq} by some empirical models showed that the suggested model has the minimum difference compared to the others. In this study vehicles were divided into three groups and because of importance of motorcycles, those were considered as a separate group 8. In countries such as Iran where motorcycles are used in civic transportation, they have a high role in traffic noise emission. The suggested model has a high determination coefficient for predicting L_{eq} compared to other models 5, 9-13. Finally, it can be concluded that the suggested model could nicely predict road traffic noise index $L_{eq(30min)}$ in Iranian cities.

Acknowledgements
This paper is based on the first author PhD thesis which was conducted in Islamic Azad University (IAU), Iran, Sciences and Research Section in 2005-2006.

References

1. Ross MB, wolde TT. Noise from traffic as a worldwide policy problem. *Noise control Eng J*. 2001; **49(4):** 159-61.
2. Stefano RD, Morri B. A statistical model for predicting road traffic noise on poisson type traffic flow. *Noise control Eng J*. 2001; **49(3):**137-43.
3. Steele CM. A critical review of some traffic noise prediction models. *Applied acoustics*. 2001; **62:**271-87.
4. Li B, Shu T, Dawson RW, Lam K. A GIS based road traffic noise predication model. *Applied acoustics*. 2002; **63:** 679-91.
5. Li B, Shu T, Dawson RW. Evaluation and analysis of traffic noise from the main urban road in Beijing. *Applied acoustics*. 2002; **63:**1137-42.
6. Pardia M, Jain S, Mittal N. Modelling of metropolitan traffic noise in Dehli. *ITPI J*. (2003)**; 21(1):**5-12.
7. Gundogdu O, Gokdag M, Yuksel F. A traffic noise predication method based on vehicle composition using genetic algorithms. *Applied acoustics*. 2005; **66:** 799-809.
8. Tansatcha M, Pamanikabud P, Brown AL, Affum JK. Motorway noise modelling based on perpendicular propagation analysis of traffic noise. *Applied acoustic*s. (2005); **66:**135-150.
9. LAM WHK, Tam ML. Reliability analysis of traffic noise estimates in Hong Kong. *Transportation research part-D*. 1998**; 3(4):**239-48.
10. Zannetti P. *Environmental Modeling Vol (I)*, CMP & Elsevier, New York, 1997.
11. Tang SK, Tong KK. Estimating traffic noise for inclined roads with freely flowing traffic. *Applied acoustics*. 2004; **65:**71-81.
12. Calixto A, Fabiano BD, Zannin PHT. The statistical modeling of road traffic noise in an urban setting. *Cities*. (2003); **20:**23-9.
13. Pamanikabud P, Vivitjinda P. Noise prediction for highways in Thailand. *Transportation research part-D*. 2002; **7:** 441-49.