inter-noise 2007 istanbul

INTER-NOISE 2007

28-31 AUGUST 2007
ISTANBUL, TURKEY

Development of a Predict Traffic Noise Model in highways: A Comparison with a Appraised Model

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ABSTRACT

Predicting noise level proceeding of highways is a task highly required in all over of the world, especially in stage of project. Models to predict has been developed from more than 50 years an, in this way, some of them has been showed to be very accuracy and, therefore, it has been utilized in so many cases. Hence, this paper intends to compare the accuracy of a recently developed model from a research in a highway from Brazil with a traditional and appraised model, which has been used from more than 30 years. The results has showed a satisfactory accuracy to the developed model. The existent model needed to be recalibrated and, in this way, has also showed a satisfactory accuracy.

1 INTRODUCTION

The noise emitted for the auto machine vehicles as well as those produced by the contact between the floor and the tires characterize a type of pollution that has been each time more common in medium and large urban area in the current days, the traffic noise.

However this pathology is not exclusive of urban ways. Highways, outside of cities, also, are sources of noise, mainly, for the transit of vehicles. The basically difference between the noise from traffic in the interior of cities and the noise in highways is the frequency spectre. The noise inside cities is more concentrated in low frequencies, with peak around 70 Hz [3]. This occurs because in low speed the biggest parcel of the noise is proceeding from the combustion system of the engines. When the speed increase, the parcel of the engine becomes insignificantly and gives place for the noise proceeding from the contact tire-floor [4]. The noise emitted for this contact generates sound waves characterized as medium frequencies, around 500 Hz [3].

Constantly, researchers and professionals of the acoustics area have the necessity to know the present noise in a highway still during the project. To do this they use prediction models. Various models have been calibrated all over of the world and some of them has show a good accuracy and has been sufficiently used.

Recently, close to Belo Horizonte, Brazil was carried a large research in a highway. From the database was possible to calibrate a model to carry through prediction of traffic noise in highways.

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In this context, the objective of the present work is to validate a model calibrated from this database comparing it with one appraised used model.

2 METHODOLOGY

2.1 Database

The database used in this work was collected in the Highway MG-010, next to Belo Horizonte, capital of the state of Minas Gerais, Brazil. A total of 10 points was selected, where the noise levels and the flow of vehicles in the highway had been measured simultaneously. The reference microphone was always 10 meters distant from the ground (next to the highway).

Besides the Leq (Equivalent sound level), the parameters Lmin, Lmax, L_{10}, L_{50} and L_{90} had been collected too. The NBR 10151 recommends that the evaluation of the traffic noise is effected from the Equivalent sound level [2]. For each point two samples of 15 minutes had been measured. The distance of the microphone was varied between the source (highway) and the receiver in the sample of the 10 selected points.

The counting of vehicles also was made in intervals of 15 minutes and was synchronized with the measurements of noise. The vehicles were classified in cars, trucks, buses and motorcycles. The schedule chosen for accomplishment of the measurements and counting of traffic objectified to get a significant sample, of the statistical point of view. For this, moments with basses and high volumes of traffic of vehicles had been characterized, mainly around the hours peaks of the morning and the afternoon.

2.2 Model Calibration

To calibrate the model from the database collected statistical procedures of linear regression had been used. For identification of the best independent variables to be used in the model a correlation array was constructed. From this was possible to get the most accuracy variables.

The validation of the model was made through the Coefficient of Determination Statistics (R2) and Absolute Average Error. Moreover, the model was applied and the gotten values had been compared to the values gotten for measurement in field, and to the values predicted for the appraised model of Rosse [1].

2.3 The Rosse Model

The model has a constant equal to 52 and takes in consideration the flow of vehicles, the distance of the source, the percentage of vehicles weighed, the speed of the traffic and the slope of the way (Equation 1).

$$L_{Aeq} = 52 + 10 \log(Q/d) + CV + C\% + CI \qquad (1)$$

- Q is the hourly flow of vehicles;
- d is in the distance direct between the source and the receiver;
- CV the speed is the correction due;
- C% are the correction due the percentage of vehicles heavy;
- CI is the correlation due the slope of the track.

Tables 1, 2 and 3 show the values for the corrections suggested for the model.

Table 1 - Correction due the speed

Speed(km/h)	33	47	53	60	67	73	80	87	93
CV dB(A)	-4	-2	-1	0	1	2	3	4	5

Table 2 - Correction due the vehicles heavy

% heavy vehicles	7	20	35	47	60	73	87	100
C% dB(A)	0	1	2	3	4	5	6	7

Table 3 - Correction due the slope of the track

Track slope (%)	0	2	4	6
CI dB(A)	0	1	2	3

3 DEVELOPED MODEL

To calibrate the traffic noise prediction model the data of the 10 points of measurement had been used. Initially have been tested the variables to check those more significant statistically. The validation of the model precision was made through the determination coefficient statistics (R^2) and analysing the absolute average error, that if it relates to measured of the error of each point, calculated according to Equation 2.

$$E_{ma} = \sum_{i=1}^{n} \frac{\sqrt{\left(X_r - X_p\right)^2}}{n} \tag{2}$$

- E_{ma} is absolute average error;
- X_r is the real noise level;
- X_p is the predicted noise level.

A correlation between all those possible independent variable was founded. It was checked:

- Flow of light vehicles;
- Flow of vehicles heavy;
- Flow of motorcycles;
- Distance of the source.

The biggest correlations had been gotten for the logarithms of the total vehicles flow and for the logarithms of the inverse of the distance. In this a way, the calibrated model is presented in equation 3.

$$L_{eq} = 54{,}56 + 5{,}2.\ln\left(\frac{Q}{d}\right) \tag{3}$$

- Leq is the equivalent sound level;
- Q is the total flow of vehicles;
- d is in the distance between the source and the receiver.

The model presented a coefficient of determination (R^2) equal to 0,91 and the absolute average error was 1,15 dB (A).

4 COMPARISION BETWEEN THE MODELS

To verify the consistency of the statistics accuracy identified for the presented parameters, one graph has done. In this graph there are the real values measured in field and the values predicted for the model developed and the Rosse model (Figure 1).

For the graph is possible to verify that the curve of the model is similar to the curve of the real data with significant precision, as was waited. The biggest differences between the real and the measured noise level had been around 2,5 dB (A).

However, the model of Rosse should have being calibrated in urban environment and, in this context, the particular characteristics of the researched place are significantly different from the ones of urban ways. Hence, the model of Rosse [1] had to be recalibrated. The equation got optimum as shown on equation 4:

$$L_{Aeq} = 46 + 10 \log(Q/d) + CV + C\% + CI \quad (4)$$

It was necessary to deduct 6 dB (A) from the constant of the model to get a satisfactory precision. The real values, predicted for the model of Rosse and the model calibrated in the present work, are presented in Table 4:

Table 4 – Values of measured and predicted Leq`s

Leq dB(A)		
Measured	Predicted	Predicted (Rosse)
71,7	71,7	70,9
72,3	71,4	70,6
71,1	72,2	71,2
71,2	71,8	70,9
69,5	67,5	67,3
68,6	67,9	67,6
64,7	67,4	67,2
67,5	68,6	68,2
62,8	64,5	64,8
63,5	63,0	63,6
62,7	61,1	62,0
63	61,9	62,7
70,4	68,8	68,4
70,2	69,2	68,7
62,3	60,8	61,7
61,8	62,2	62,9
62,4	61,7	62,5
58,5	61,0	61,8
59,4	60,3	61,3
60,2	60,7	61,6

The Figure 1 allows an easy visualization of the points of the two models and the real values of Leq dB (A).

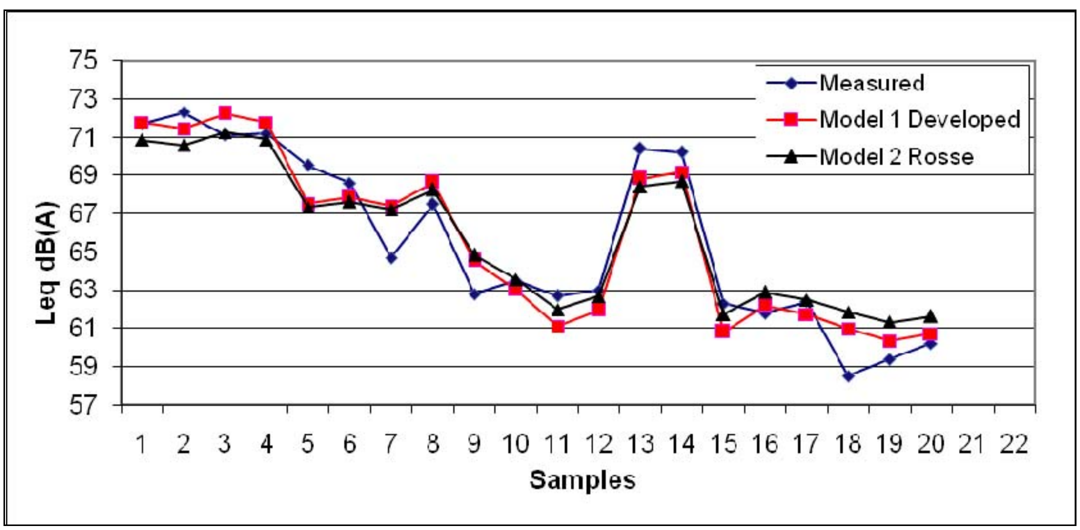

Figure 1 – Comparison between the models

The absolute error of the Rosse model, 1,23 dB(A), was bigger than the error of the developed model, 1,15 dB(A).

5 CONCLUSIONS

As was verified by the parameters used for validation statistics of the model, this showed sufficiently accuracy. Moreover, the comparison of the values predicted with the real values also pointed with respect to a significant precision of the calibrated model, presenting an error of the order of 1 dB (A).

The application of the model of Rosse (1975) for the case of highways disclosed the necessity of a new calibration of the model, that is, it was needed to modify the value of the constant of the model so that this if showed necessary.

The comparison between the two models showed that the precision of these is significant and sufficiently similar (after the recalibration of the model of Rosse). The necessity of the recalibration of the model of Rosse was necessary because of the differences between urban and highways environments.

Hence, the carried through evaluations indicate that the developed model has precision enough to be applied for the prediction of noise in highways. However, the model must be tested in other circumstances before an application and definitive use.

6 REFERENCES

[1] ROSSE, R., *"La acustica em la construccion"*. Editora Gustavo Gill, S.A., Barcelona, 1975.

[2] ABNT - ASSOCIAÇÃO BRASILEIRA DE NORMAS TÉCNCAS. NBR 10151: Avaliação do Ruído em áreas habitadas visando o Conforto da Comunidade. ABNT, 2000.

[3] VALADARES, V. M.; SUYAMA, E., *"Traffic Noise on Arterial Street in Belo Horizonte City: a Comprehensive Database"*, 32nd International Congress and Exposition on Noise Control Engineering - Inter-noise. 2003.

[4] RODRIGUES, F., *Análise de Ruído em terminais de Transporte Coletivo Urbano: Desenvolvimento de Modelos de Previsão*. 2006. Dissertação (Mestrado em Engenharia Civil), Universidade Federal de Uberlândia.