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NAISS model validation based on measured data of noise monitoring

Momir Praščević[1,*] - Dragan Cvetković[1] - Darko Mihajlov[1]
[1] University of Niš, Faculty of Occupational Safety of Niš

Starting from the measurement results collected by systematic traffic noise monitoring in urban areas of Nis city, mathematical model for prediction of traffic noise called NAISS model has been formed by extracting function relation among the equivalent noise level and the traffic parameters. In the optimization process of the models, the model constants were obtained by experimental data fitting by Nelder - Mead method using computer program.

The used experimental data in optimization process were collected near the main city traffic arteries with typical properties of commercial, residential, industrial and hospital areas. All measurements were taken on working days of the week during 1995, excluding all atypical conditions. Each of the measurement points was to be determined from an acoustic point of view by the equivalent noise level. In addition, data relative to the urban circumstances of each point were taken, as well as measurement of traffic density, according to the number of each type per hour.

In order to examine validity of formed model, data collected by traffic noise monitoring in urban areas of Nis city in 2008-2010 has been analyzed and compared with the values predicted by NAISS model based on collected traffic parameters. Scatter plot for model validation will be shown in this paper as well as the results of statistical analysis of measured and calculated data differences.

Keywords: traffic noise, noise prediction, noise monitoring, model validation

0 INTRODUCTION

Noise is one of the environmental pollutants that are encountered in daily life. Noise pollution has become a major concern of communities living in urban areas. In view of the rapid development it is essential to study environmental noise with respect to various causative factors.

With urbanization and corresponding increase in number of vehicles in cities, the pollution is increasing at an alarming rate. Main areas of concern are related to air and noise pollution. More than 70% of total noise in our environment is due to vehicular noise. Noise levels are showing an alarming rise and infact level exceeds the prescribed levels in most of the areas. Investigations in several countries in the past decades have shown that noise has adverse effect on human health, living in urban areas near traffic lane, [1] - [5].

Therefore, the control of traffic noise has become a matter of major concern for communities trying to maintain a satisfactory environment in which to live and work.

The level of traffic noise depends mainly on the following factors:

- Volume of the traffic,
- Speed of the traffic,
- Number of the heavy vehicles in the flow of traffic.

To create a healthy and noise pollution free environment a noise prediction model is needed so that the noise level can be predicted and investigated in advance during the planning and design process.

In order to modeling traffic noise and selecting corresponding noise control measures it is necessary to know functional relationships between noise emission and certain numbers of traffic parameters.

The classical functional relationships available in literature have been stated based on data measured through semi-empirical models, typically regression analysis.

Of all the mathematical models available in literature, the ones which present this feature are those proposed by Burgess [6], Josse [7], Fagoti [8], CEE [8]. These functional relationships are essentially based on statistical analysis (i.e. regression techniques).

Although these correlations are nonlinear they do not provide very accurate approximation of the trend followed by sound pressure level

[*]Corr. Author's Address: Faculty of Occupational Safety of Niš, Čarnojevića 10a, 18000 Niš, Serbia, momir.prascevic@znrfak.ni.ac.rs

according to a certain number of physical parameters because any models itself includes the flow and composition of the road traffic which may be different than examined urban areas. Because of that, the prediction model of motor vehicle noise which to be valid for the flow and composition of the road traffic of Nis city is formed by Laboratory of Noise and Vibration, [9] - [11].

In order to examine validity of formed model, data collected by traffic noise monitoring in urban areas of Nis city in 2008-2010 has been analyzed and compared with the values predicted by NAISS model based on collected traffic parameters.

1 MATHEMATICAL BACKGROUND OF NAISS MODEL

Starting from the measurement results collected by systematic traffic noise monitoring in urban areas of Nis city, mathematical model for prediction of traffic noise of motor vehicle is formed by extracting function relation among the equivalent noise level and the traffic parameters, [9] - [11]. The model was named as NAISS model.

Traffic noise on observed measurement points are mainly caused by the motor vehicle. In order to make it easier to appreciate the variability of three components of urban traffic, the total number of motor vehicles was decomposed into the number of light vehicles N_c, the number of heavy vehicles N_{hv} and the number of buses N_b. The scheme of NAISS model is shown in Figure1.

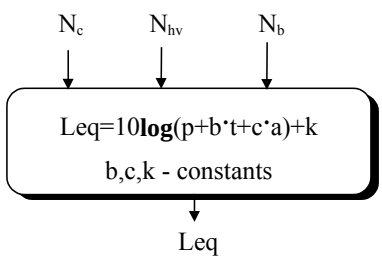

Fig. 1. *The scheme of NAISS model*

In the optimization process of the models, the model constants were obtained by experimental data fitting by Nelder - Mead method using computer program. Three variants of model are formed.

The experimental data collected near the main city traffic arteries with typical properties of commercial, residential, industrial and hospital areas on working days of the week during 1995, excluding all atypical conditions, are used in the optimization process.

Based on the analysis of different variants of traffic noise prediction model the authors were noted that prediction traffic noise of motor vehicles in urban areas of Nis city by separate equations for two ranges of noise level, listed below,

$$Leq = 10\log(N_c + 3.7N_{hv} + 1.9N_b) + 38.2 \quad 55dB(A) < Leq < 65dB(A) \tag{1}$$

$$Leq = 10\log(N_c + 11.7N_{hv} + 3.1N_b) + 44.3 \quad 65dB(A) < Leq < 75dB(A) \tag{2}$$

is rather correctly with satisfactory precision, [9] to [11]. In addition, selected variant of model is very easy for use regard to its simplicity based on only two equations for describing traffic noise in urban areas of Nis city.

2 COMPARATIVE ANALYSIS WITH OTHER MODELS

In order to give as satisfying and complete results as possible, it is necessary to confine the comparison to classical prediction methods available in literature, which show the greatest possible number of analogies with the hypotheses underlying the proposed method. These analogies essentially consist of the number of parameters on which the equivalent noise level is made to depend.

The comparison between NAISS model and selected prediction model available in literature (Burgess [6], Josse [7], Fagoti [8], CEE [8]) was made based on measured data collected by systematic traffic noise monitoring in urban areas of Nis city during 1995. Therefore, the comparison was made on the basis of measured data used to form NAISS model.

In order to compare different models, statistical analysis of differences of measured noise levels referring to urban areas of Nis city and calculated noise levels according to the model equations and the flow and composition of the road traffic in urban areas of Nis city was carried out. The average values of absolute differences of noise levels and standard

deviations of differences (σ) have been calculated. The parameters of comparative analysis of different models are given in the Table 1.

Table 1. *The results of comparative analysis of models*

model	measured data group			
	55 ÷ 65 dB(A)		65 ÷ 75 dB(A)	
	$\overline{\Delta L}$	σ	$\overline{\Delta L}$	σ
Burgess	7.94	2.10	2.46	1.63
Josse	3.53	1.23	1.61	1.29
Fagoti	6.04	2.52	3.18	1.31
CEE	4.36	2.52	4.60	3.13
NAISS	1.07	0.75	1.29	0.92

The results of comparative analysis clearly show that the NAISS model based on equations (1) and (2) allows better prediction of noise pollution of motor vehicles in urban areas of Nis city than any other empirical relationship.

The success of the NAISS model can without doubt be attributed to performance of model formed on the basis of measured data used in the comparative analysis of different models.

Therefore it was necessary to validate the NAISS model based on measurement data different from those used for forming models.

3 NAISS MODEL VALIDATION

For the validity of NAISS model for road traffic noise prediction in urban areas given by equations (1) and (2), the equivalent noise levels calculated by equations (1) and (2) are compared with measured values of the equivalent noise levels obtained by systematic traffic noise monitoring in urban areas of Nis city during year 2008-2010.

The measured data were collected near the main city traffic arteries with typical properties of commercial, residential, industrial and hospital areas, five times during daytime period for all locations. All measurements were taken on working days of the week during year 2008-2010, excluding all atypical conditions. Each of the measurement points was to be determined from an acoustic point of view by the equivalent noise level. In addition, data relative to the urbanistic circumstances of each point were taken, as well as measurement of traffic density, according to the number of each type per hour. The standard apparatus based on the statistical noise level analyzer was used to determine the equivalent noise level.

For model validation scatter plots of measured and calculated values are shown in figure 2 to figure 4 for year 2008, 2009 and 2010, respectively. In the same figures the regresion line of 45° slope is shown.

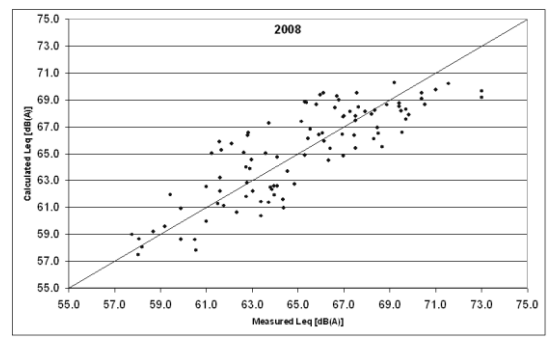

Fig. 2. *Measured L_{eq} against calculated L_{eq} by NAISS model for year 2008*

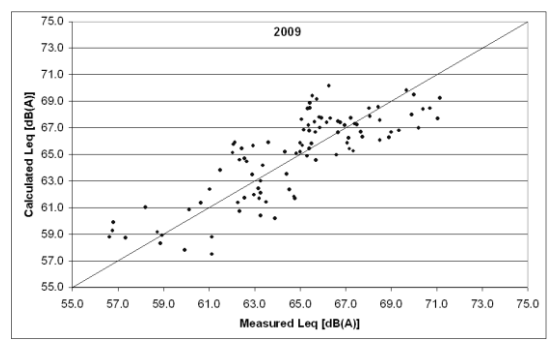

Fig. 3. *Measured L_{eq} against calculated L_{eq} by NAISS model for year 2009*

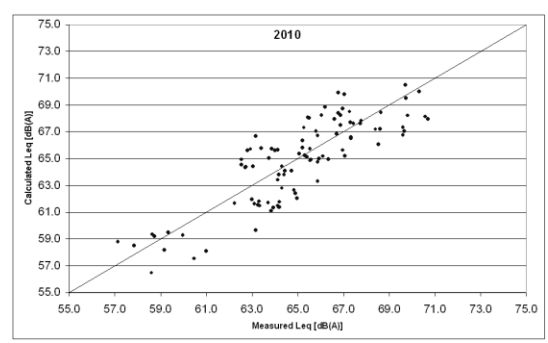

Fig. 4. *Measured L_{eq} against calculated L_{eq} by NAISS model for year 2010*

In order to examine validity of NAISS model, statistical analysis of differences of measured and calculated equivalent noise levels according to the model equations, the flow and composition of the road traffic was carried out.

The average values of absolute differences of calculated and measured equivalent noise levels $\overline{\Delta L}$ and standard deviations of differences (σ) have been calculated. The parameters of statitistival analysis are given in the Table 2, where N is number of measured data.

Table 2. *The results of statistical analysis of differences of calculated and measured data*

	2008	2009	2010
$\overline{\Delta L}$ [dB(A)]	1.63	1.66	1.52
σ [dB(A)]	1.08	1.10	0.95
N	110	97	98

4 CONCLUSION

The NAISS model described in the present paper can be used for traffic noise prediction for the urban areas of Nis city based on the flow and composition of the road traffic.

The results of comparative analysis clearly show that the NAISS model allows better prediction of traffic noise pollution of motor vehicles in urban areas of Nis city than any other empirical relationship.

The good results obtained in the comparasion with classical prediction methods available in literature have been confirmed in the validation process of NAISS model. The measured values during 2008 to 2010 year are compared with the calculated values by NAISS model.

The obtained values of average values of absolute differences of calculated and measured equivalent noise levels and standard deviations of differences show the validity and enforceability of the NAISS model for traffic noise prediction in urban areas of Nis city.

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6 ACKNOWLEDGEMENT

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