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Assessment of Noise Levels in Terminals at Bus Stations

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Abstract At more typical levels of noise in bus stations caused by the rustle and bustle of terminals and noisy vehicles, the acoustic stimulation can have a wide range of effects on people, depending on the level and on the situation in which they are exposed. Hence, it is worthwhile to evaluate the noise levels generated inside the terminals in order to determine whether or not such an environment is unhealthy. In addition, there is a need to improve the available analytical tools for prediction of noise levels considering not only the vehicle sizes but also their engine powers. Therefore, this work was mainly motivated by these reasons and aimed at developing an approach which could address some of the important issues related to noise pollution at bus stations.

The main goal of this work is to propose an empirical model in order to establish a relationship between noise levels and bus flow inside terminals. The model is based on linear regression of data obtained experimentally in terms of sound pressure levels. The measurements were made at Uberlândia bus station, Uberlândia, Brazil. Although the results obtained herein might be useful in assisting the design process of bus stations, no attempt has been made here to develop a general model, as it does not appear to be particular easy to solve or generalize.

1. INTRODUCTION

In the 20th century with the constant growth and development of the urban areas, the number of automotive vehicles increased significantly, like those used for public transportation. Generally, the noise generated in those areas comes mainly from the traffic flow of vehicles. Recently, several researchers have shown the importance of studying and assessing not only the noise pollution in the main cities but also its serious effects on the population general health [1,2, 3,8].

The heavy vehicles, such as buses and trucks, are believed to be the main contributors to the total noise generated. It might be explained by the fact that in general these vehicles have high power engines. In the urban centres, mainly in the great metropolises, the circulation of buses and trucks is usually intense. Moreover, buses are the main public transportation in Brazil. Several transport systems adopt projects that consider the interconnection of several lines which are a particular part of the whole system. They are namely integrating terminals. They should be designed as a functional system that complies with the local standards relating maximum noise level tolerance by the humans. In general the architecture of these places is similar. There are some facades, walls, marquees and coverings that might work as reflectors which reflect the incident sound waves mainly generated by the buses.

One of the main interests in studying traffic noise is the development of empirical models for noise level prediction. The first model for prediction of traffic noise was developed in 1952 [6]. This model provided the 50-percentile-exceed sound level L_{50} (The fast, A-weighted sound level equaled or exceeded 50 percent of the sample time) from the traffic volume per hour and the distance between the source and receiver.

Several models have been proposed for many years. They have become more and more sophisticated as larger number of variables has been considered. Nowadays conventional models for the prediction of traffic noise consider many variables such as traffic volume, vehicle type, road width, vehicle speed, road slope and the distance between the source and receiver. Some models still consider architectural parameter of the surrounding buildings plus meteorological data such as wind speed and air moisture.

The objectives of this work are to evaluate the noise levels in bus terminals by developing a simplified model that should be capable to predict the noise levels generated by intense traffic which is related to the bus flow in the terminals. Five different terminals were used to measure the noise levels and bus flow. They are all located in Uberlândia city (Minas Gerais State).

2. MEASUREMENT PROCEDURES

For the field measurements a Lutron sound level meter (SPL), type 2, model SL-4001 was used. The SPL was then located at a particular position as specified in ref. [10]. First of all, it is recommended that the SPL should be positioned at a minimum distance of 1.5 m and 1.2m from the walls and floor respectively. It was found that the amount of platforms in every terminal, which is a particular 'strip' area (corridor) used for the bus traffic, differed from one another. Thus, it was decided that a reasonable solution should be to position the SPL in the middle of each terminal, keeping an approximate distance of 2.5 m from the centre of the platforms.

Sound pressure level measurements took five days. They were made every day at the rush time (from 5:30PM to 7:30 PM), when there was the highest flow of buses and pedestrians in the terminals.

The used measure was based on the A-weighted sound level, expressed in dB(A). The sample time was 15 seconds over a period of 30 minutes. A short break of 5 minutes was considered between every thirty-minute interval. This methodology was adopted in order to better consider the bus flow variation in the terminals.

Simultaneously, the bus flow volumetric count was accomplished at intervals of 5 minutes. Then, the data was used to establish the correlation between the bus flow count and the equivalent continuous sound levels.

Usually, the models for predicting traffic noise take into account several variables, such as the mean speed of vehicles, the road width, the volume of traffic for light, medium and heavy weight vehicles, medium and heavy, the road slope, meteorological parameters and the information regarding the architectural properties of buildings around a particular road [7].

In the present study, some of the variables mentioned above, such as the meteorological variables and the architectural properties of the surrounding buildings, were neglected for the sake of developing a more simplified model.

The mean speed of the vehicles was considered to be lower than 20 Km/h. The road width was not taken into account as its influence on the noise pollution is usually due to the increase in the traffic volume and to the mean speed. Among the group of vehicles, only the one corresponding to the buses was considered herein. This is obviously because there is an absolute predominance of buses in the terminals. The road slope inside the terminals is very low. Thus, a value of zero was considered for the predictions. In summary, the present model has basically established a relationship between the bus flow and the noise level inside the terminals.

3. RESULTS

After the accomplishment of the measurements, formatting tabulating the collected data, the equivalent continuous was calculated for each five-minute interval.

It was observed that during the measurements the higher noise peaks were related to two main factors. They are the bus engine rotation and the brake-air-system decompression.

Table 1 below shows the Equivalent Noise level and traffic flow values for the terminals considered in this study.

Table 1: Equivalent Continuous Sound level (L_{eq}) and the corresponding Bus Flow value for the terminals

Terminal	Total L_{eq} dB(A)	Bus/h
Central	79,99	249
Planalto	72,14	45
Umuarama	76,00	82
Industrial	73,27	43
Sta. Luzia	77,57	129

Table 1 shows that the higher the L_{eq} values the higher the Bus flow. The highest L_{eq} was obtained for the Terminal Central.

Figures 1-5 show the L_{eq} calculated at a five-minute interval for every bus terminal considered herein.

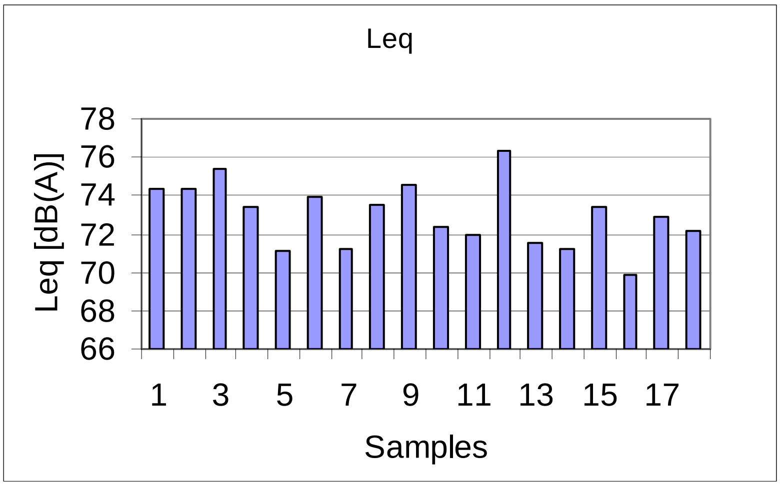

Figure 1: L_{eq} values calculated at intervals of 5 minutes for the Terminal Industrial

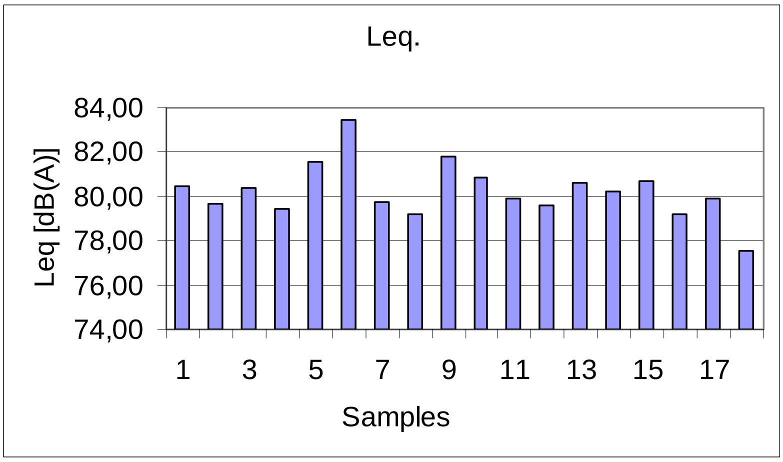

Figure 2: L_{eq} values calculated at intervals of 5 minutes for the Terminal Central

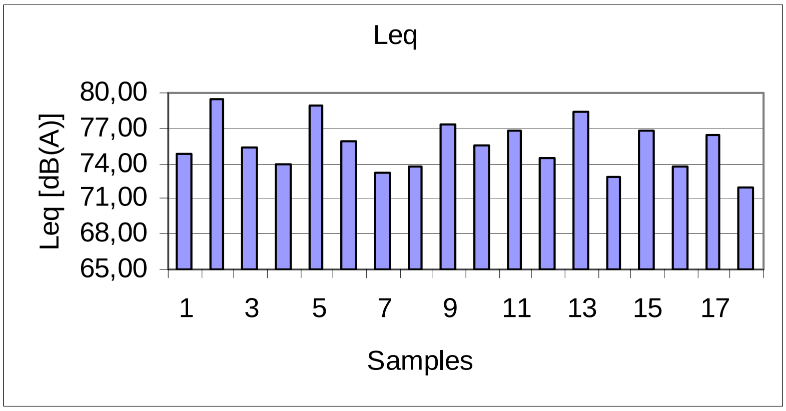

Figure 3: L_{eq} values calculated at intervals of 5 minutes for the Terminal Umuarama

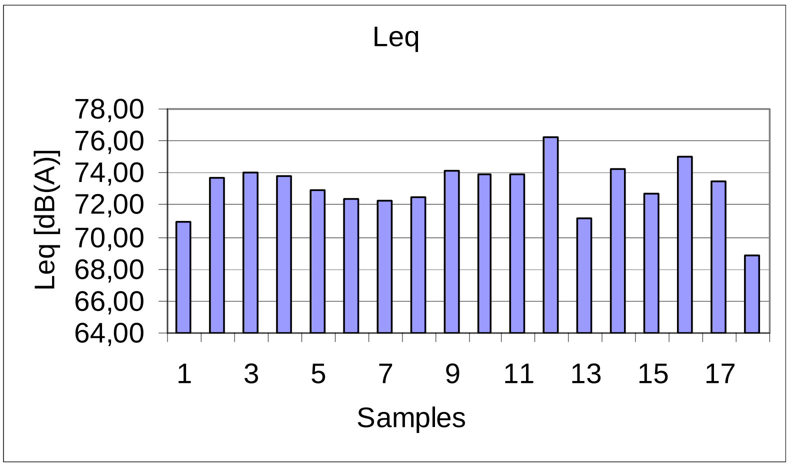

Figure 4: L_{eq} values calculated at intervals of 5 minutes for the Terminal Planalto

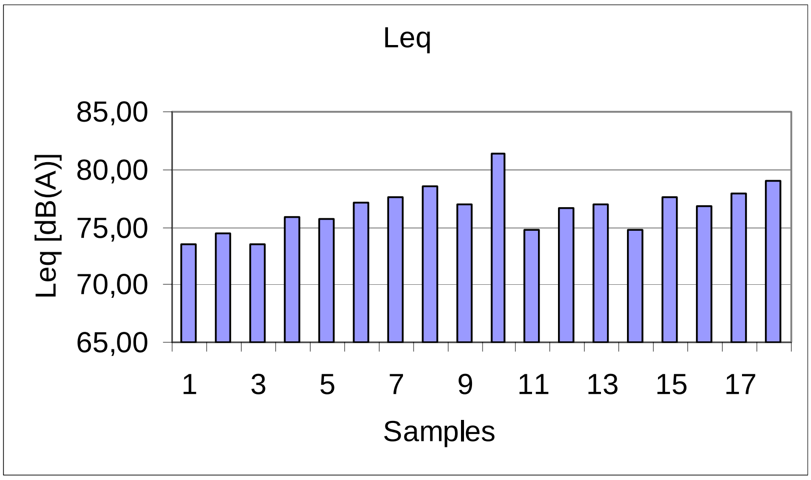

Figure 5: L_{eq} values calculated at intervals of 5 minutes for the Terminal Santa Luzia

According to the Figures above, it is seen that for several samples the Terminal Central (Figure 2) has higher L_{eq} values, (approximately higher than 80 dBA) than those calculated for the other Terminals. On the other hand, lower values were obtained for both Terminals the Industrial and Planalto. These two Terminals also present the lower values for the bus flow parameter, as expected.

4. THE DEVELOPMENT OF MATHEMATICAL MODELS

As mentioned previously, the models developed here will be based on the bus flow parameter inside of the terminals. Firstly, the measured data were tabulated and formatted. The data corresponding to the Terminal Santa Luzia was not included in the calculations. It was due to the high background noise level generated by the occurrence of torrential rain falling on the terminal roof. Therefore, only four terminals were considered. Secondly, the statistical model was obtained using series of linear regressions based on the statistical correlation coefficient which measures the dependence among the variables [5].

Three different models were tested for noise prediction in transport terminals. For the first one the equivalent noise level is based on the bus flow. For the second one the equivalent noise level is dependent on the logarithm of the bus flow parameter and for the last one the equivalent noise level is related to the square root of the bus flow.

The graphs below show the dispersion of each model obtained using linear regressions.

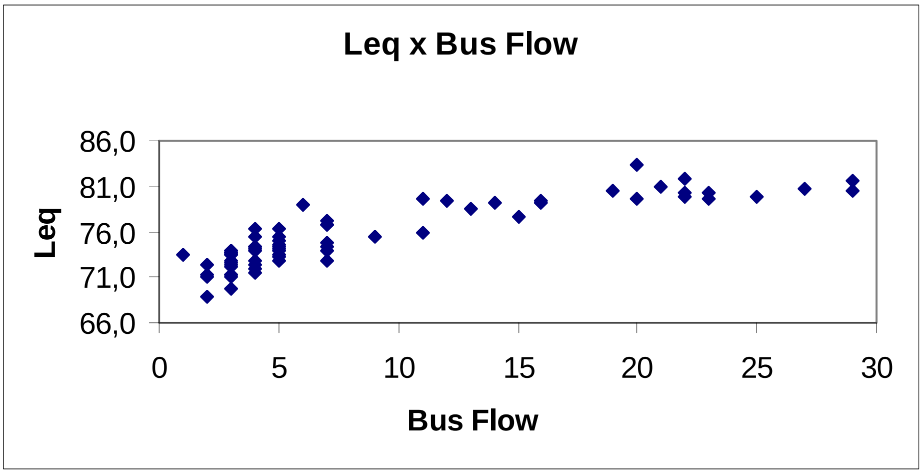

Figure 6: The variation of L_{eq} dB(A) with the bus flow parameter - Model 1

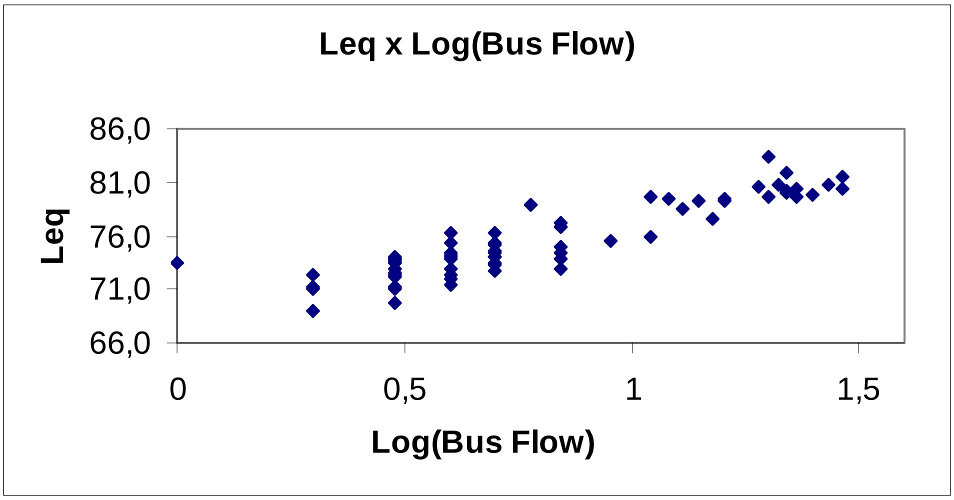

Figura 7: The variation of L_{eq} dB(A) with the logarithmic the bus flow parameter – Model 2

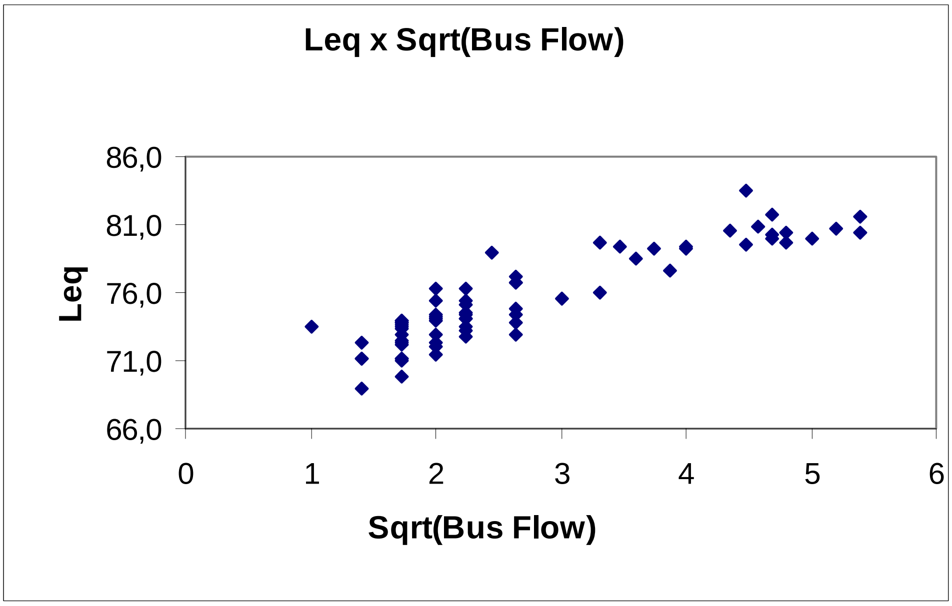

Figure 8: The variation of L_{eq} dB(A) with the square root of the bus flow parameter – Model 3

For the first model tested (Figure 6) the value for the correlation coefficient is 0,769. For the second (Figure 7) and third model (Figure 8) the correlation coefficients are 0,811 and 0,815 respectively. Models 2 and 3 had similar correlation coefficients which presented satisfactory values.

The formulation for each model implemented herein is given by:

$$L_{eq} = 72.12 + 0.38(Q) \quad \text{for Model 1} \qquad (1)$$

$$L_{eq} = 68.63 + 8.64\log_{10}(Q) \quad \text{for Model 2} \qquad (2)$$

$$L_{eq} = 68.45 + 2.59\sqrt{Q} \quad \text{for Model 3} \qquad (3)$$

where L_{eq} is the Equivalent Continuous Sound Level and Q is the vehicle flow in the terminal at intervals of 5 minutes.

Figures 9-11 below show a comparison between the measured and calculated L_{eq} for models 1, 2 and 3 respectively. The values obtained were calculated using Equations (1), (2) and (3). Model 3 (see Figure 11) is the more representative one, as it has the highest correlation coefficient which is equal to 0,815. However, the differences between the models are not considerably significant.

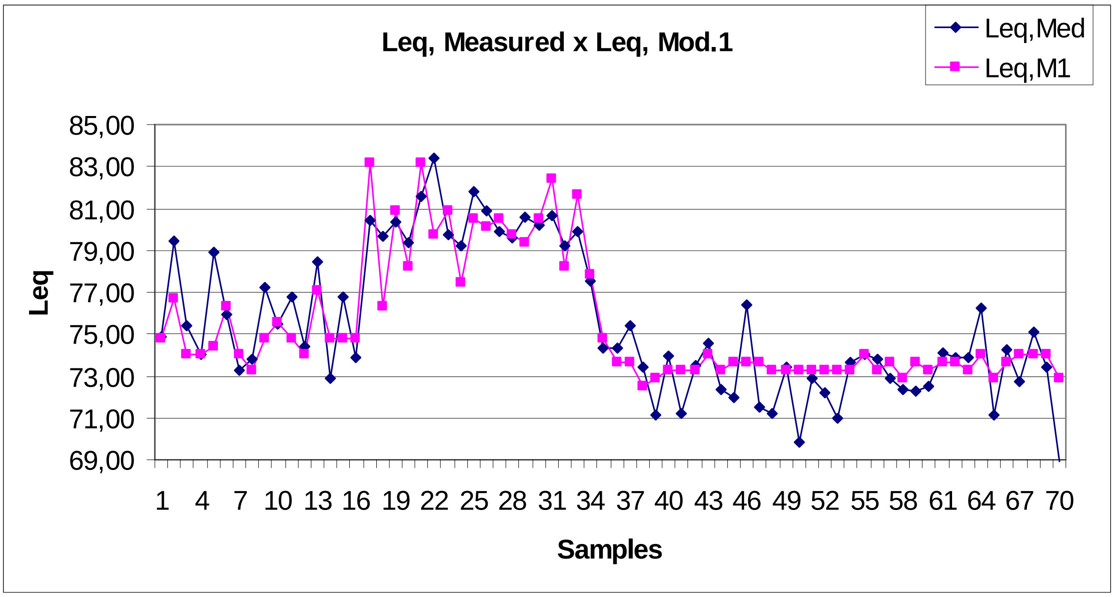

Figure 9 –Comparison between the measured and the calculated L_{eq}. using Model 1.

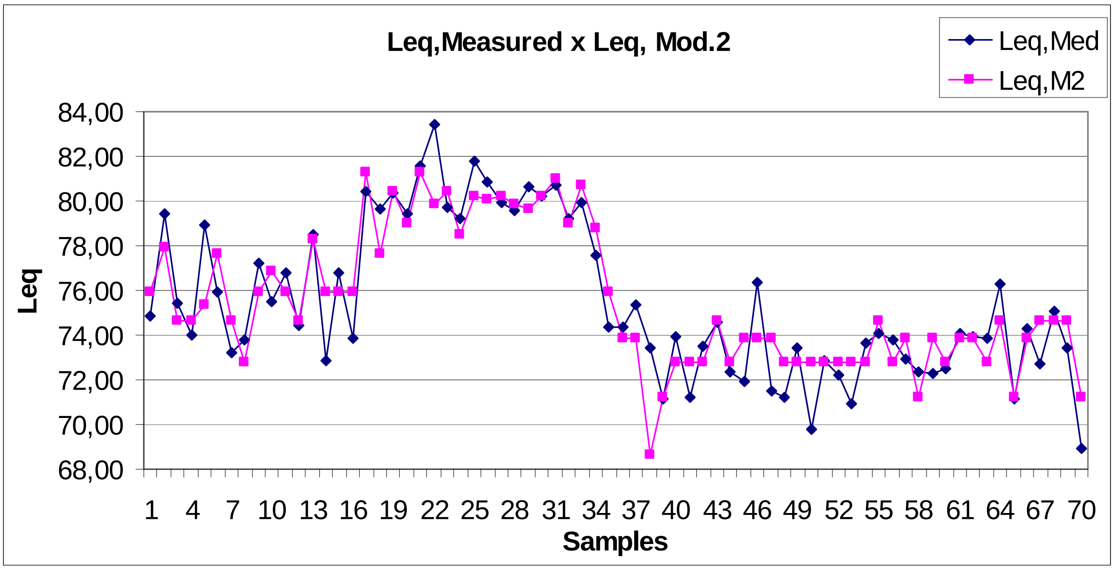

Figure 10 –Comparison between the measured and the calculated L_{eq}. using Model 2.

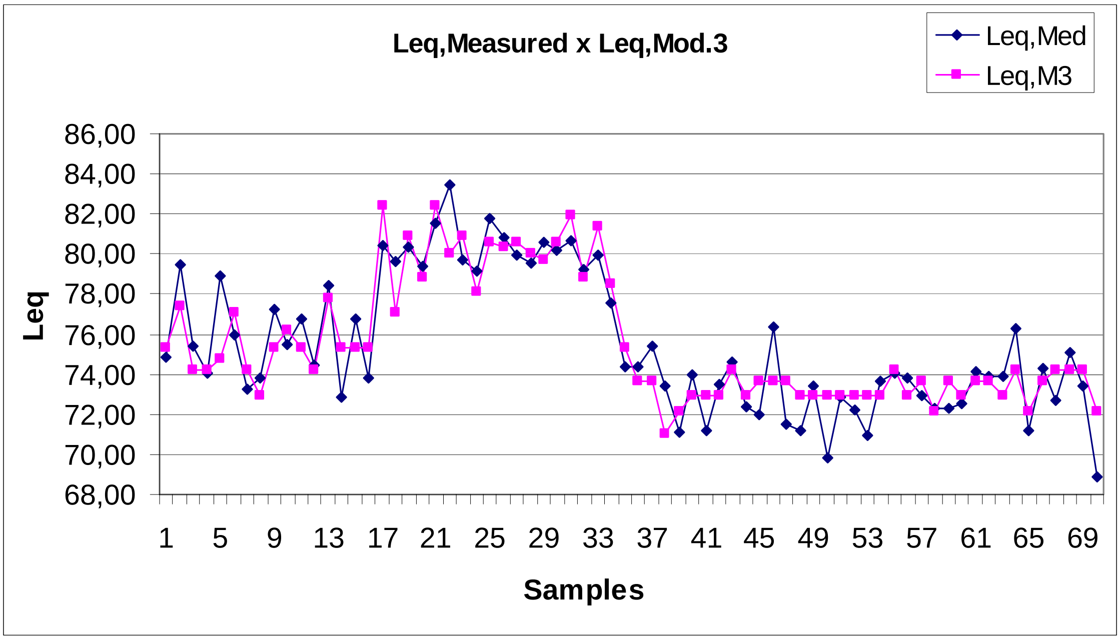

Figure 11 –Comparison between the measured and the calculated L_{eq}. using Model 3.

5. CONCLUSIONS

An interesting situation observed during the measurements was that the noise level inside the terminals was higher when the bus engines were working. Besides, the break air system of the buses also contributed as an extra source of noise in the terminals. Despite the number of vehicles inside a particular terminal during the measurements, it was observed that there is a type of relationship between the noise level generated by a particular vehicle and its engine rotation. It seems that the higher the engine rotation, the higher the noise level generated by it. This may explain the differences between the measured and calculated values shown in Figures 9-11. In future, the drivers should be instructed to maintain the engine working at lower rotation and try to avoid air release from the brake system. In addition to the noise emitted by the vehicle engines, the rustle and bustle of people on the platforms might have contributed to the total noise level inside the terminals. This situation was evident during the field measurements, where dozens of people were always circulating on the platforms. Furthermore, the architectural differences between the terminal buildings were not considered in the model formulation.

According to the Brazilian regulations [11], those terminals are considered to be unhealthy. Preventive measures to reduce the noise levels should be taken as soon as possible. It is believed that this problem can be sorted out by the local authorities with a reasonable budget. This research has not been finished yet. An alternative model is being developed at the Federal University of Uberlândia (UFU). It will consider the acoustical properties of every wall, ceiling and floor surfaces in the terminal, the distance between the source and receiver and the number of platforms in each terminal. This work is part of a M.Sc. project currently sponsored by UFU.

6. REFERENCES

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