"VERIFICATION OF MATHEMATICAL MODELS FOR ROAD TRAFFIC NOISE PREDICTION OF TIRUPATI TOWN AT LEELA MAHAL CIRCLE"

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Abstract: Current increases in population growth have resulted in an increased transportation demand worldwide. Due to increasing motorization and Transport network, the noise level has exceeded the prescribed limits in numerous Indian cities. Migration of people from rural to urban areas, development of urban areas, infrastructure development, population growth and urbanization are important component resulting in motorization and consequent increase in levels of various urban noise pollution. With the advancement of industrialization at an unprecedented pace, the urban centers of today's world have experiencing heavy noise pollution which has become a part of our day-to-day lives.

Traffic Noise pollution is an interfering air-pollutant which has possesses both auditory and a large group of non-auditory effects on the exposed population. Since there is no medicine to cure hearing loss, prevention to over exposure is the only alternative left. Noise pollution not only affects the human beings but also the animals. Hypertension, sleeplessness, mental stress, etc. are the implications of noise pollution. Due to this adverse impact of noise level, it is crucial to assess the impact of traffic noise on residents and road users.

Therefore, the control of road traffic has become a matter of major concern for communities trying to maintain a satisfactory living and working environment. Traffic control systems used in modern cities can solve many traffic problems such as traffic jams, traffic incidents, delays, parking, fuel consumption, noise emission, air emission, and others. One such system, in addition to other things, must include the model for traffic flows imitation and traffic noise prediction model. By utilizing a traffic noise prediction model, one can calculate and examine the noise level in the processes of planning and designing.

The present study measures traffic volume and noise levels during the peak traffic flow in the selected areas of Tirupati town. The traffic volume studies are carried out by means of manual methods prescribed by Indian Standards and noise levels are measured following standard procedure using Sound Pressure Level Meter. The obtaining results are used to validate the existing mathematical models for the prediction of noise levels of Tirupati town.

Keywords: Traffic noise pollution, Traffic volume, octave band analyzer.

INTRODUCTION

Sound is an acoustical energy released into the atmosphere by vibration of moving bodies. Therefore, sound is amenable to objective scientific measurement and investigation. On the other hand noise is undesirable and unwanted. Undoubtedly, noise has always been a major source of friction between individuals. Noise pollution can be defined as undesirable or offensive sounds that unreasonably intrude into our daily activities. It has many sources, most of which are connected with urban development, road, air and rail transport, industrial noise, neighborhood and recreational noise. A number of factors contribute to the problems of high noise levels including increase in the population, especially where it leads to increasing urbanization and urban consolidation. With the increase in urbanization, it leads to the increase in the volumes of road, rail and air traffic.

Currently all the developing countries like India are facing risk because of vehicular noise pollution. Migration of people from rural to urban areas, expansion of cities, infrastructure development, population growth and urbanization are

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important factors resulting in motorization and consequent increase in levels of various urban noise pollution .The total urban population of India has increased considerably over the past three decades, rising from 109 million in 1971 to 160 million in1981 and then 217 million in 1991 and 285 million in 2001. This increase in population coupled with the increase in number of motor vehicles is showing the disturbing levels of traffic congestion, air pollution, and noise pollution and road accidents. Urban traffic noise is one of the most basic sorts of noise and normally considered more interfering than the other types of noises.

Fast developing vehicle population in town in the recent years, has resulted in considerable increase in traffic on roads causing alarming noise pollution and air pollution. Transportation operators are major contributors to noise in modern urban areas. Noise is generated by the engine and exhaust system of vehicles by aerodynamic friction and by interaction between the vehicle and its supporting system (Example: tyre pavements and rail wheel interaction). Noise diminishes with distance from the source. The vehicle by virtue of the movement are not only polluting the atmosphere by emission of poisonous gases but also grabbing off peace from mankind by generating high noise levels that are annoying of irritating to the inhabitants to such an extent that noise pollution caused by the highway traffic has to be studied at great depth, analyzed and has to be controlled

In the new millennium, for protection environmental degradation it is imperative to pay greater attention towards measuring noise pollution, enforcing regulation for noise emission limits, elimination and control noise pollution. Taking a step in this direction, Noise pollution level was measured in Tirupati town.

METHODOLOGY:

The traffic volume study was conducted in Tirupati town at Leela Mahal Junction. To measure the potential effects of traffic noise at Leela Mahal Junction, data on traffic volume, including types of vehicles were measured and roadside sound levels are measured and interpreted using various models. Sound level meters, a manual hand counter, and portable measurement instruments were used to obtain the required data. Data analysis was conducted using Microsoft Excel and SLM (Sound Level Meter).

Traffic volume (composition and flow) and traffic noise were measured at three time periods per day at Leela Mahal Junction. These time periods were the morning peak hour (08:00–10:00 AM), the daytime peak hour (02:00–03:00 PM), and the evening peak hour (05:00–07:00 PM). The volume and composition of traffic were measured for 60 min during each peak period. Traffic composition was determined on the basis of the presence of two wheelers, three wheelers, four wheelers and Heavy vehicles (Buses, Lorries).

Data on the geometric dimensions of road sections, as well as the number of lanes and their widths, were also measured. Sound level measurements were performed using a sound level meter (Real Time Octave Band Analyzer Model No: 407790). Traffic noise was measured using Sound Level Meter in1/3 Octave- band mode index with an A-weighted scale expressed as Leq, in decibel units at an interval of 3 seconds throughout the peak period.

MEASUREMENT PROCEDURE:

Volume studies have been undertaken in this junction at different hours i.e., morning 8 am to 10 am, afternoon 2:00 pm to 3:00 pm and in the evening at 5:00 to 7:00 pm. For traffic volume studies manual method is being used. In this process enumerators count the number of vehicles moving over that section during the peak hours. The vehicles are categorized in to Two Wheelers (2W), Three Wheelers (3W), Four Wheelers (4W) including cars and school buses, and Heavy Vehicles (HV) including buses and lorries as the prediction of traffic noise levels at the intersection total number of vehicles per hour data is required. Since the intersection consists of four roads, the traffic volume is carried out on each side for a time interval of 15mins such that the total intersection is covered in one hour of time.

The sound level meter was placed closest to the noise source, and the microphone was positioned 70 m from the traffic light, at a height of 1.2 m above the ground level corresponding to the ear level of an individual of average height (Onnu, 2000) and 70 m was adopted with the assumption that most vehicles in the traffic stream had already reached steady speed (Burgess, 1997). Measurements were taken at a time interval of 3seconds for about 15mins on each side of the four road intersection in 1/3 octave band frequency mode and L_{eq} values also measured.

MATHEMATICAL MODELS

Traffic noise prediction models are designed to facilitate planning for new roads or account for changes in traffic noise conditions. Most mathematical models adopt Leq as the most representative physical variable that quantifies noise emissions. Leq corresponds to the sound pressure of a fictions stationary noise that emits acoustic energy similar to that emitted by a non-stationary source (Cvetkovic et al., 1997). The equivalent continuous noise level in A-weighted decibels (dBA) is widely recognized as a stable descriptor of motor vehicle noise (Cvetkovic et al., 1997). Mathematical models for the prediction of traffic noise usually extract the functional relationship between noise emissions and measurable traffic and road parameters. The classical functional relationships based on data measured through semi-empirical models, typically regression analyses, are shown below.

$$L_{eq} = 10\log(N_c + 11.7\,N_{hv} + 3.1\,N_b) + 44$$ Cvetkovic et al. (1997) (1)

$$L_{eq} = 38.8 + 15\log Q$$ – Josse R (1972) (2)

Where

L_{eq} =Equivalent Continuous Noise Level (dBA),

P =Percentage of heavy vehicles (%),

L = Road Width (m),

Q = Total number of vehicles per hour,

N_c = Number of light vehicles per hour,

N_m = Number of motorcycles per hour,

N_{hv} = Number of heavy vehicles per hour,

N_b =Number of buses per hour.

Table 1.Number of Vehicles at Leela Mahal Circle

S.No	Date &time	No. of 2W	No. of 3W	No. of 4W	No. of HV	
					Buses	Lorries
1	15-09-14 8.00–0.00AM	5742	1600	1107	280	11
2	15-09-14 2.00 – 3.00PM	1933	523	543	152	0
3	15-09-14 5.00 – 7.00PM	3846	1270	911	251	11
4	16-09-14 8.00–10.00AM	4725	1520	1060	313	0
5	16-09-14 2.00 – 3.00PM	1607	537	515	173	0
6	16-09-14 5.00 – 7.00PM	3600	1216	840	283	9

2W – Two wheelers 4W – Four wheelers
3W – Three wheelers HV – Heavy Vehicles

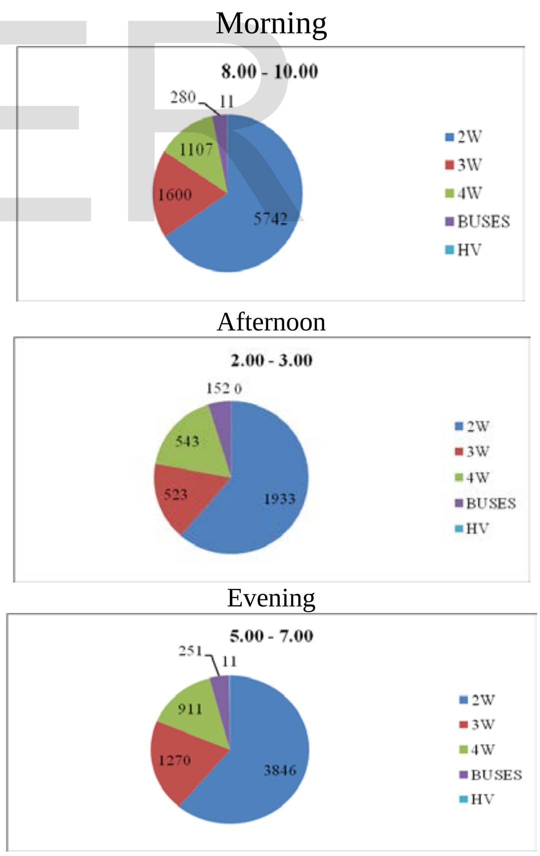


Fig. 4 Proportions of Vehicles at LeelaMahal Junction on 15-09-2014

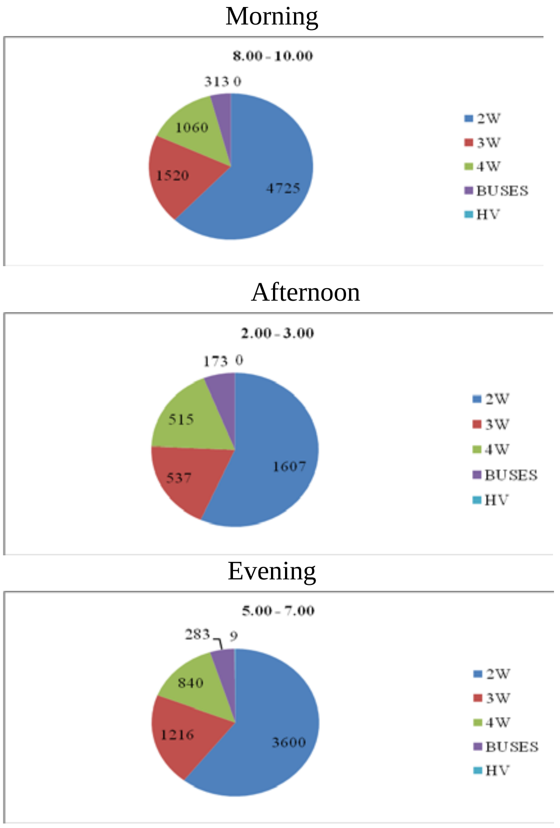


Fig 5 Proportions of Vehicles at LeelaMahal Junctionon 16-09-2014

MATHEMATICAL MODEL FOR THE PREDICTION OF NOISE LEVELS

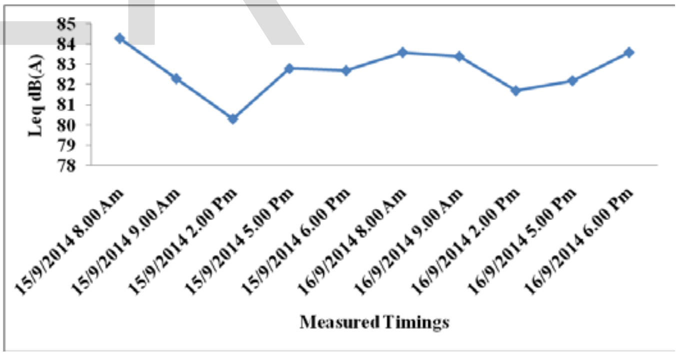
In this project in order to predict the traffic noise levels based on the traffic volume studies four mathematical prediction models, namely Burgess, Fagotti and Poggi, Cvetkovic and Josse, were used. Data analysis was carried out using Eqs. (1), (2), (3), and (4) for each model, respectively and are presented in Table 2. Fig. 5.4 to Fig. 5.7 shows the Leq value measured and Leq values predicted by the Burgess, Fagotti and Poggi, Cvetkovic and Josse models, respectively, at Leela Mahal Junction.

The results of the comparison of the different models show that the Cvetkovic and Josse models are more suitable for selected study area because the measured traffic noise values more accurately corresponded to the values determined by Cvetkovic and Josse models than to the other empirical relationships.

Table 2. Leq comparison between measured and calculated values of traffic noise levels at Leela Mahal Circle.

S. NO	Date & time	Measured Leq dB(A)	*Predicted Leq dB(A)*			
			Burgess	Fagotti & Poggi	Cvetkovic	Josse
1	15-9-2014 8.00-9.00AM	84.3	74.8	76.5	81.2	81.2
2	15-9-2014 9.00-10.00AM	82.3	74.8	76.3	81.1	81.1
3	15-9-2014 2.00-3.00AM	80.3	73.3	76.2	79.9	79.0
4	15-9-2014 5.00-6.00AM	82.8	74.1	76.9	80.7	80.1
5	15-9-2014 6.00-7.00AM	82.7	72.5	73.8	79.2	77.7
6	16-9-2014 8.00-9.00AM	83.6	74.4	76.8	80.9	80.6
7	16-9-2014 9.00-10.00AM	83.4	74.0	76.2	80.4	79.9
8	16-9-2014 2.00-3.00AM	81.7	72.9	76.3	79.0	78.3
9	16-9-2014 5.00-6.00AM	82.2	73.7	76.8	80.3	79.4
10	16-9-2014 6.00-7.00AM	83.6	72.3	73.5	78.6	77.4

From the table 2, it is observed that from the measured values of traffic noise levels there is a variation of traffic noise levels during the day time. There is a slight decrease was observed during the early afternoons followed by a gradual increase during the evening times from 4 PM due to increase in the traffic flow which is shown in the fig. 3.



The correlation values of the predicted noise levels from the four mathematical models and the measured values are ranging from -0.1 to 0.7. Since the correlation values are less than 0.95 to 1.0 the four models used for prediction of noise levels are not suitable for the present study area. The models have to be modified and then applied for the prediction of noise levels for the present study area.

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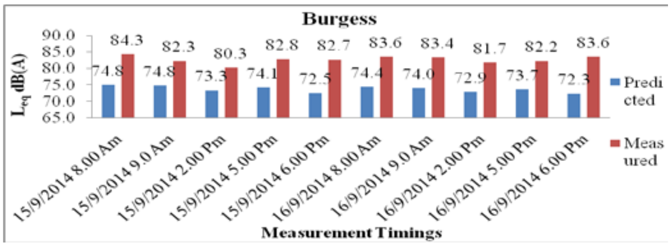

Fig. 5.4 Measured Leq values and calculated values Leq by *Burgess* Model at Leela Mahal Circle

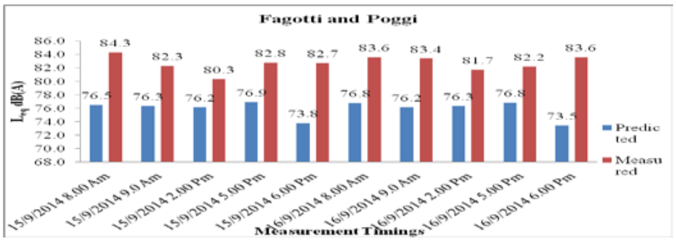

Fig. 5.5 Measured Leq values and calculated values Leq by Fagotti & *Poggi* Model at Leela Mahal Circle

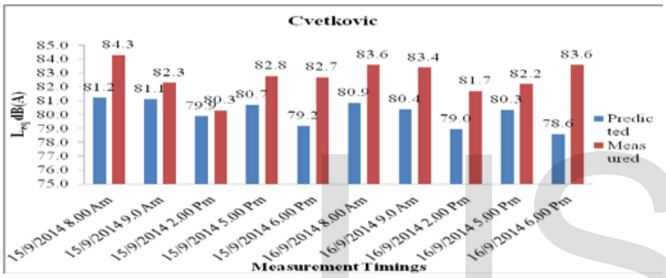

Fig. 5.6 Measured Leq values and calculated values Leq by Model at Cvetkovic Leela Mahal Circle.

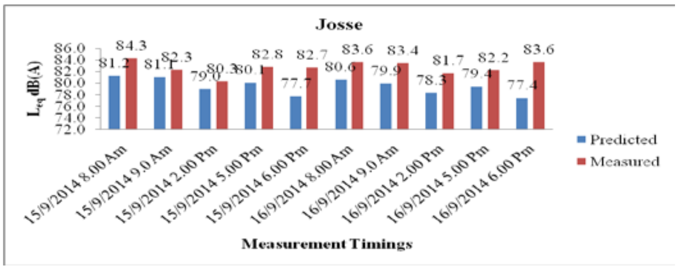

Fig. 5.7 Measured Leq values and calculated values Leq by Model at Josse Leela Mahal Circle.

CONCLUSIONS

The present investigation deals with the measure of traffic noise at Bliss circle, data on traffic volume, including types of vehicles and roadside sound levels, were measured and interpreted using two mathematical models. From the present study, the following concluding remarks may be made.

The traffic flow and volume were high during the peak periods, and the highest volume was recorded during both morning and evening timings.

The measured noise level in Leq for the studied locations varied between 80 and 85 dB (A), which exceeds Indian guidelines of Noise Pollution ACT (1972) of range 70 dB (A).

Since the correlation between the predicted values using the four models used in this study for noise level calculations and the measured values are in the range of -0.1 to 0.7 none of the models used in the present study is not suitable for the prediction of traffic noise levels.

The models have to be modified and then it has to be applied for the present study area.

The L_{eq} was generally higher in the mornings and also during evening times for the study area.

A slight decrease was observed during the early afternoons followed by a gradual increase during the evening times from 4 PM due to increase in the traffic low.

It was recommended to carry further study for the modification of existing models and to design necessary noise attenuating materials to decrease the noise levels as the noise levels in the study area is beyond the permissible limits and their impacts on human beings.

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