Traffic noise prediction model at gradients of the highway

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Abstract

Noise is one of the environmental pollutants that are encountered in our daily life. Noise pollution has become a major concern of communities living in the vicinity of major highway corridors. In the rapidly urbanizing country like India, the transportation sector is growing rapidly, which has led to overcrowded roads and traffic noise pollution. Noise emitted by traffic is also influenced by the gradient of the highway in addition to other causative factors. In this study, the vehicles were classified into four categories based on traffic noise levels of individual vehicle and homogeneity. Traffic noise data of individual vehicles were collected at seven locations with different gradients on state highway [SH-17] near Mandya city, Karnataka state, India. In this study a gradient-based noise prediction mathematical model has been developed for each category of vehicles by multiple regression analysis of data. The results of the model indicated that the gradient has more influence on traffic noise due to heavy vehicles than light and medium classes of vehicles. The models developed in this study have been calibrated from the field observed data.

Keywords: traffic noise, road gradient, noise prediction model.

1 Introduction

Noise from road traffic produces more disturbances to people than any other source. Moreover, this menace to health and quality of life has been increasing over the last two decades for a number of reasons [8]. The most important among these reasons is the number of road vehicles, and consequently the density of
road traffic, has been steadily increasing [8]. In a rapidly urbanizing country like India, the transportation sector is growing rapidly and the number of vehicles on Indian roads is increasing at a rate more than 7% per annum [9]. This has led to overcrowded roads and noise pollution. Leaving aside the number and density of road vehicles, the next most important cause of noise on the roads is the speed of traffic. As a general rule, the faster the traffic travels, the greater the volume of noise [10]. It is ironic from the point of view of traffic noise control that modern road development policy encourages higher traffic speeds. The construction of multi-lane motorways, which has been going on at increasing rates in most developed countries and even in many developing nations during the last few decades, allows large volume of traffic to travel at sustained speeds up to 112 km/h for car and 80km/h for heavier vehicles [10]. However, the speed of traffic is not uniform throughout its length of travel. This varies with respect to various causative factors such as traffic speed, traffic volume, road geometry and environmental factors. In this study the gradient of highway has been considered as one of the road geometric elements that influence on traffic noise levels. Generally gradient can cause an increase in traffic noise for upward flows and a decreasing noise for downhill flows [10]. However, there is no model to quantify the influence of gradient on traffic noise level.

2 Field data collection

It consists of identification of locations and collection of data such as traffic noise level of each category of vehicles, vehicle speed and the gradient of highway.

2.1 Study location

In the present study, seven locations with different gradients have been selected for data collection on state highway [SH-17] near Mandya city, Karnataka state, India.

2.2 Data collection

The traffic noise levels of individual vehicles have been recorded at each predefined locations over a wide range of speed. The vehicle type has been also noted along with the noise level. The Micro-15 Noise Dosimeter (Quest Technologies, USA) and SL – 4001 sound level meter have been used for recording traffic noise level of individual vehicles. ISO/R 362 vehicle noise measurement procedure has been followed for noise measurement. The noise sampling survey has been carried out between 6 A.M. – 9 P.M. during weekdays at all the selected locations for a period of four months. While recording the noise level of an individual vehicle utmost care has been taken to see the other vehicle noise does not contribute to the individual vehicle noise.

Further, the speed of each vehicles and the gradient of highway have been measured with the help of radar Gun and Cyclone Ghat Tracer.
3 Development of noise prediction model

3.1 Classification of vehicles

Based on noise emission levels and the homogeneity, the vehicles have been classified into four categories for the purpose of study according to S.S. Jain [8].

a. Two wheeler 
b. Car/JEEP/Van 
c. Bus/Light Commercial Vehicles (LCV) /Mini Bus 
d. Truck 

The above-mentioned classifications have been made to analyze the traffic noise of different vehicles and to develop the noise prediction mathematical models for the same.

3.2 Basic concept in the model development

The traffic noise levels in the vicinity of highway/roadway at grade can be predicted on the basis of vehicle type, vehicle speed, noise level and gradient of highway. Traffic noise data collected over a wide range of speeds for each category of vehicle at different gradient of state highway have been fitted in the general equation of the form:

\[ L_{eq} = a + b \log S \pm c \log G \]

Where, \( L_{eq} \) = Basic equivalent noise emission level for a given class of vehicle in dB(A) 
\( S \) = Vehicle Speed in Km/h 
\( G \) = Gradient (%) 

a, b and c are constants, computed by multiple regression analysis of data for a given class of vehicle. The plus or minus sign in the above equation indicates the nature of gradient.

3.3 Assumptions made in the model development

In this study, the models have been developed based on the following assumptions

e. Vehicles are classified into different group based on their noise level and the homogeneity. 
f. There is no background noise while measuring vehicle noise. 
g. Vehicles are assumed to move in unidirectional only. 
h. There is no interference of noise due to other vehicles while taking individual vehicle noise. 
i. All vehicles are moving with steady speed. 
j. Attenuation of sound due to the influence of meteorological parameters, reflection, distance, ground absorption and refraction is neglected. 
k. All vehicles are fulfilling the requirements of Indian Central Motor Vehicle Act during running conditions.
3.4 Noise prediction models at gradient of state highway

As described earlier, vehicles have been classified into four groups. A multiple regression mathematical model has been developed for each category of vehicles at gradient of state highway to predict the traffic noise. The traffic noise data collected over a wide range of speed for each class of vehicle has been analyzed in Microsoft excel spreadsheet. The plot was drawn between noise levels, log values of speed and log values of gradient. The equation obtained was in the form of basic equation as described in previous section. Table 1 shows a generalized noise prediction model for each class of vehicle at both up and down gradient of state highway [SH-17]. All the models developed in this study have been calibrated with field observed data.

From Table 1 it can be observed that the values of model coefficients of diesel engine vehicles [Bus/LCV/Mini Bus and Truck] are more than petrol driven vehicles [Car/Jeep/Van and Two Wheelers]. This indicates that the gradient has much influence on traffic noise due to diesel engine vehicles than petrol driven vehicles. This is due to fact that the diesel engine vehicles operate at considerably at higher peak combustion pressure and higher rate of pressure rise and thus result in higher noise [10].

Table 1: Generalized noise prediction models at gradient of state highway.

<table>
<thead>
<tr>
<th>Vehicle Class</th>
<th>Up Gradient, $L_{eq}$ in dB(A)</th>
<th>Down Gradient, $L_{eq}$ in dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Two Wheelers</td>
<td>$11.26 + 34.19 \log S + 2.11 \log G$</td>
<td>$11.48 + 34.18 \log S - 2.16 \log G$</td>
</tr>
<tr>
<td>Car/Jeep/Van</td>
<td>$16.40 + 30.96 \log S + 3.60 \log G$</td>
<td>$16.22 + 30.97 \log S - 3.22 \log G$</td>
</tr>
<tr>
<td>Bus/LCV/Mini bus</td>
<td>$15.70 + 36.94 \log S + 3.73 \log G$</td>
<td>$15.97 + 36.94 \log S - 3.17 \log G$</td>
</tr>
<tr>
<td>Truck</td>
<td>$15.09 + 38.14 \log S + 4.30 \log G$</td>
<td>$15.14 + 38.14 \log S - 4.11 \log G$</td>
</tr>
</tbody>
</table>

4 Conclusions

Based on the discussions made in the previous sections, following conclusions were drawn.

a. The basic methodology followed in this paper to develop the noise prediction model at gradient of state highway is in the general form;

$$L_{eq} = a + b \log S \pm c \log G$$

Where, $L_{eq}$ = Basic equivalent noise emission level for a given class of Vehicle
S = Vehicle Speed in Km/h
G = Gradient (%)
a, b and c are constants have been computed by multiple regression analysis of data for a given class of vehicle. The plus or minus in the above equation indicate the nature of gradient.
b. All vehicles have been classified into four groups based on the noise emission levels of individual vehicle and the homogeneity.
c. It can be concluded that the values of model coefficients of diesel engine vehicles [Bus/LCV/Mini Bus and Truck] are more than petrol driven vehicles [Car/Jeep/Van and Two Wheelers]. This indicates that the gradient has much influence on traffic noise due to diesel engine vehicles than petrol driven vehicles.
d. All the noise prediction models developed are based on the assumptions made in the study.
e. The models developed in this study would become a base line source for further investigation of traffic noise with respect other causative factors.

References