ASSESSMENT AND MLR MODELING OF URBAN TRAFFIC NOISE AT MAJOR ARTERIAL ROADS OF SURAT, INDIA
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ABSTRACT

In India, transportation demands in urban areas continue to increase rapidly as a result of both of population growth and changes in travel patterns. The recognition of road traffic noise as one of the main sources of environmental pollution has led to develop models that enable to predict noise level from fundamental variables. Therefore, this study was carried out to generate a noise prediction model and to analyze various parameters affecting road traffic noise. The model, when validated gives quite satisfactory results. The study reveals that present noise level at all three major arterial roads exceed the limit prescribed by CPCB. Based on the finding, it can be said that the persons nearby these roads are exposed to significantly high noise levels and hence necessary mitigation measures should be adopted.

Key Words: Urban traffic noise, Arterial roads, Modeling, Multiple linear regression, Transportation

INTRODUCTION

Though technological advance has brought many conveniences, it has also resulted in many hazards. Pollution of various types is one of them. These include air pollution, water pollution, soil pollution, thermal pollution and noise pollution. The peace of countryside and the sounds of jungle have been shattered, perhaps forever, by the internal combustion engine, both on the ground and overhead. Inside our homes, power gadgets and outside our homes, powerful vehicles surround us, each is a source of noise pollution.

In the early times, noise was limited to the work places like industries and construction sites. But today, the profile of noise source has changed with music / entertainment in indoor environment and transportation in outdoors making a major contribution. Among all of the sources responsible for noise pollution, traffic related sources are of great environmental concern and increasing level of discomfort in urban areas with increasing traffic concentration. It will be a larger and serious problem in the future, if effective precautions are not addressed and attended to. The sources of traffic noise are primarily vehicle engines, exhaust systems, tyre-pavement interaction and aerodynamic friction. Therefore, several studies have been made on different aspects of traffic noise and have led to development of various models for recent purpose.

Arterial road corridors play many roles within the region. These roads are a fundamental component of the transportation network that carries a broad range of private and service vehicles. In Indian environment, less work has been carried out and reported for noise prediction modelling of arterial roads. Also, few researches worldwide, have found to incorporate building height and open space between arterial roads and buildings as input variables in traffic noise prediction models.

Hence, this study was carried out with an objective to develop a relationship between input variables like building height and open spaces and urban traffic noise, using a linear regression model. Also, some general and specific measures to control this traffic noise at arterial roads have been suggested.

Literature review

Traffic noise prediction models have been built and developed using various approaches.
The method most widely adopted generally is classical multiple regression modelling. Till the end of the 20th century, much of the research in road traffic noise was focused on highways i.e. uninterrupted traffic flow conditions. A detailed discussion on this early traffic noise prediction models such as FHWA model and STAMINA used in the USA and CoRTN in the UK can be found in the review by Steele. Al-Mutairi et al developed a regression traffic noise model to predict noise pollution from traffic using the analysis of noise, flow and their inter-relationships. Golmohammadi et al developed a statistical regression model based on a-weighted equivalent noise level for Iranian road conditions using variables like road dimensions, types of vehicles and traffic speed. da Paz and Zannin designed a daytime traffic noise prediction (regression) model for urban highways for correlation between equivalent sound pressure levels and traffic variables. The standout characteristics of this model include linearity and application of class intervals. There is very little documentation on noise pollution research in India. Such studies have been reported only since the dawn of the 21st century. Bhattacharya et al. studied that in urban areas, typical of Indian nature most of the traffic flow is of interrupted and heterogeneous nature. Nirjar et al. studied that traffic noise resulting from interrupted traffic flow conditions on urban roads create substantially different noise characteristics from free flow traffic on rural highways. Parida et al. adopted an analytical approach to develop a traffic noise prediction model for typical Indian conditions of interrupted and heterogeneous traffic. Banerjee et al. carried out a study to monitor and assess the road traffic noise in its spatial-temporal aspect in an urban area, Asansol, the eastern part of India. Noise maps were also created for impact analysis and formulation of Noise Risk Zones. Rajakumar and Gowda developed a regression noise prediction model under interrupted traffic flow conditions using two analytical approaches, first being the acceleration lane approach and second being the deceleration approach. Agarwal and Swami by developing an empirical noise prediction for the calculation of road traffic noise under interrupted traffic flow conditions depicted that the light motor vehicles are the main source of noise pollution in the city. Based on the literature review, it is transpired that:

a. Less work has been carried out and reported for traffic conditions in Indian environment.
b. The building height and open space between arterial roads and buildings have not been taken as input variables for traffic noise prediction models.
c. Most of the noise prediction models in India and worldwide have been built using regression modelling.

AIMS AND OBJECTIVES

The study was carried out with following objectives:
1. To establish relation between arterial roads parameters and urban traffic noise
2. To build a linear regression model for predicting urban traffic noise
3. To suggest specific measures to control this traffic noise

METHODOLOGY

Study area

In India, geographical point of view Surat city is 260 km north of Mumbai city and 224 km south of Ahmedabad city, India. On map it is located at Latitude 21° 12’ N and Longitude 72° 52’ E near bank of river Tapi. Surat is well known as the hub for rough diamond polishing. Owing to its rapid industrialization and better job opportunities, observation is made for the migration from all over India and particularly from Orissa, U.P. and Bihar. Surat is now the tenth largest city of India having an estimated population of 45 lakhs plus at present. An inconceivable population growth rate of 76.02% was observed in the last decade as a result of rapid industrialization (Fig. 1). The enormous growth of the textile and diamond industries within the city and setting up of large scale industries in Hazira and other industrial pockets like Padesara, Sachin and Palsana around the city have resulted in the
increase in trade and commerce activities and upliftment of the socio-economic status of the people of Surat city. This is evident from the exponential growth of vehicles (Fig. 2). Car ownership per 1000 persons increases every year. In 2011, cars per 1000 population are 35, which was only 22 cars per 1000, before a decade. Increased car ownership has resulted in higher traffic congestion. Lack of needed mass transportation has further created more concentration of personalized and para-transit mode of transportation, reducing the effective road capacities.

Arterial roads pass through the most diverse physical settings the region has to offer from urban, rural and natural areas to residential, auto-oriented commercial and historic main streets. A more context sensitive arterial corridor strategy will promote the liveability and quality of the surrounding land uses, while maintaining the transportation capacity of the roadways. Arterial road corridors play many roles within the region. These roads are a fundamental component of the transportation network that carries a broad range of private and service vehicles.
Total there are six arterial corridors in Surat city (Fig. 3). These corridors are (i) Kamrej-Varachha corridor (ii) Olpad-Rander corridor (iii) Hazira-Adajan corridor (iv) Sachin-Udhna corridor (v) Kadodara-Sahara corridor (vi) Dumas-Athwa corridor. These six corridors mean six arterial roads, which include diversified activities of business, residence, commerce and industries. A mix type of traffic has been observed on these corridors / arterial roads. Different type of land- use pattern is seen along these arterial roads / corridors. Due to these reasons, out of the six corridors, Dumas-Athwa, Kadodara-Sahara and Sachin-Udhna corridors were selected for the study purpose.

The sound level meter used for this study was Larson Davis System UTI 824 integrated sound level meter. The step wise procedure followed in the study has been illustrated below:

Profile of the road and its surroundings was prepared i.e. height of the building along the road and open spaces along the road are the main factors affecting the traffic noise generation in most of the cities. In study the main factors like traffic flow (vehicles/min), open space, building height along the road were measured.

The noise levels were measured at peak hours (5-8 pm). The readings were taken on 3 major corridors of Surat city viz. (i) Kadodara-Sahara Darwaja road (ii) Dumas-Athwa Gate road and (iii) Sachin-Udhna Darwaja road. The readings were taken at an interval of 150m. A total of 32 reading (16 on each side) were taken on 1 corridor. Following this procedure a total of 96 readings were taken on the three corridors. The urban corridor noise model was built on the basis of readings of two Corridors-Sahara Darwaja road and Athwa Gate road and the model was tested on the third Corridor-Udhna Darwaja road.

For a one single corridor, the 1st point was taken as 0 m and number of vehicles i.e. 2-wheelers, 3-wheelers, 4-wheelers passing through that section in 5 minutes were counted and a total of 16 readings were taken on one side of the road. Following this procedure, 32 readings on both sides of the road were taken for one single corridor. After this the number of vehicles were converted in Passenger Car Unit i.e. PCU. A factor of 0.75 for 2-w, 1 for 3 and 4 wheelers, 2.8 for buses and trucks respectively was adopted.

RESULTS AND DISCUSSION

The traffic noise survey at three major arterial corridors is presented in Table 1. The data collected at the 96 locations have been analyzed to develop a better understanding of the various parameters and the variation of noise due to these parameters maximum noise was observed on Sahara corridor,
The reason for this being, that on this corridor many business activities take place. Average noise is highest on Udhna corridor due to small scale industries and their related traffic movement. Maximum buildings are on Athwa corridor, which greatly affects the noise produced by traffic. Maximum open spaces are available on Sahara corridor and thus Sahara corridor has minimum average noise produced. On all study corridors, the maximum noise limits were ranging between 112-118 dB which was almost 1.5 times the permissible limits (CPCB 2000) for commercial zone. The minimum noise level values were ranging between 69-78 dB, which was still crossing permissible limits. Average noise level values were between 92-98 dB.

**Multiple linear regression modelling**

Multiple Linear Regression Analysis (MLRA) was done for the combined effect of PCU, building height and open spaces. The regression was done by the help of ORIGIN Software. The noise levels were regressed against the different building heights and observed $R^2$ value was found 0.81 (Fig. 4). This is indicating fairly strong relationship between urban corridor noise and building height.

![Fig. 4: Relationship between building height and noise level](image)

**Table 1 : Noise level at arterial corridors**

<table>
<thead>
<tr>
<th>Corridors</th>
<th>Noise level</th>
<th>Noise dB(A)</th>
<th>PCU</th>
<th>Building Height (m)</th>
<th>Open Space (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Athwa</td>
<td>Maximum</td>
<td>115</td>
<td>294</td>
<td>30</td>
<td>152</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>78</td>
<td>173</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>95.6</td>
<td>202.15</td>
<td>12.15</td>
<td>36.92</td>
</tr>
<tr>
<td>Sahara</td>
<td>Maximum</td>
<td>118</td>
<td>288</td>
<td>30</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>69</td>
<td>145</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>92.6</td>
<td>212</td>
<td>10</td>
<td>37.16</td>
</tr>
<tr>
<td>Udhna</td>
<td>Maximum</td>
<td>112</td>
<td>332</td>
<td>24</td>
<td>116</td>
</tr>
<tr>
<td></td>
<td>Minimum</td>
<td>76</td>
<td>98</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Average</td>
<td>97.3</td>
<td>192.81</td>
<td>9.12</td>
<td>32.8</td>
</tr>
</tbody>
</table>

Permissible noise limit –
residential zone 55 dB(A) / commercial zone 65 dB(A)
When noise levels were regressed against the PCU, observed $R^2$ value was found 0.77 (Fig 5). This proves existence of direct relation between PCU and corridor noise level. There is an inverse relationship between open space and noise level, with $R^2$ value 0.60.

![Fig. 5: Relationship between PCU and noise level](image)

On the basis of the experimental values, the major parameters, PCU, building height and open space were regressed in combine with noise level and a noise prediction model for urban corridors in Indian conditions was built which is as follows.

$$Y = 73.99 + 0.05 \times X1 + 1.14 \times X2 - 0.088 \times X3$$

Where $Y$ denotes noise (decibels dB)
X1 denotes road PCU (per minute)
X2 denotes building height along the road side (m)
X3 denotes open space for section considered (m)

This model has $R^2$ value 0.76, which indicates good combined relationship of the three parameters upon noise. If PCU and building height increases the noise increases, but when the open space increases, the noise level decreases. In addition to these three inputs, other variables which can be added to the noise prediction model are on street parking, road gradient, vehicular speed, individual vehicular composition in total traffic.

**CONCLUSION**

Following conclusions can be derived from the current research:

(a) Arterial road corridors play many roles within the region and are a fundamental component of the transportation network that carries a broad range of private and service vehicles.

(b) On all study corridors, the maximum noise limits were ranging between 112-118 dB, which is almost twice the permissible limits for commercial zone.

(c) The minimum noise level values were ranging between 69-78 dB, which is still above the permissible norms.

(d) It is clearly observed that the contribution of 2 wheelers and 3 wheelers in the PCU values are 38% and 43% respectively. This means that the maximum noise is produced by 2-W and 3-W only.

(e) On the basis of the experimental values, the major parameters, PCU, building height and open space were regressed in combine with noise level and a noise prediction model for urban corridors in Indian conditions was built.

(f) The noise prediction (regression) model but was checked on one of the corridors and an error of 7.53% was observed.

While planning cities and its arterial corridors, due attention should be given to parameters which affect traffic noise, like road width, open space, green belt, activities along the
corridor, land use pattern. It is also concluded that there is a need for scrupulous implementation of noise regulation within the city of Surat. For the effective mitigation of urban road traffic noise and thereby reduce the health effects on exposed persons, following general and specific measures are suggested:

1. Ban on pressure horns must be effectively implemented.
2. Public transportation system should be promoted over private transportation, so that noise pollution can be decreased.
3. At urban roads and medians, wherever possible, tree plantation should be done.

REFERENCES