A Deterministic Approach to the Noise prediction Model of Mount ABU City

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Abstract—This research aims to design mathematical model to predict road traffic noise levels of Mount Abu city. Since, in 1972, WHO announced it as a type of pollution. The word “sound” and “noise” are two different parameters its not similar at all. When the limit of sound level reached above 70db, it comes in the category of noise. Above 80db it proves to be dangerous to human health including hearing loss and it is said to be noise which should be avoided. The present piece of work highlights the possibility of the prediction of the optimum condition for the analysis of traffic noise. This model is obtained by collecting the experimental data of roadways of different locations of Mount Abu City recorded by android based software which is pre-calibrated with digital sound meter instrument. By doing so, it reports the accuracy of Smartphone sound measurement applications (apps) and whether they can be appropriately employed for occupational noise measurements. This research is also important because it proves that noise level of Mount Abu city is less than as compared to other urban cities.

Key words: Noise pollution, Causes of road traffic noise, Noise Control measures on roads, HFWA model

I. INTRODUCTION

There is no denying the fact that in the present schanrio, nature and human beings are in the jaws of noise pollution. The word “noise” is derived from the Latin word “nausea” meaning seasickness. Noise, can be said to be as unwanted serious threat or excessive sound, is an undesirable byproduct of urbanization. It is a harmful environmental hazard. Noise can also be defined as a kind of disturbance towards surroundings, system and also to the human beings. It has been increasing day by day with growing industrialization and urbanization. Global warming is one the result caused by the effect of noise. It is well known, that modes of transportation is the crucial element from the economical point of view. These modes of transportation are being used in accordance with the topography, distribution of population, type of location, for land use and financial assistance. In the present schanrio, Indian railways transport network has been spread all over the India and its transport network also be considered as the world’s second largest railway transport network. And of course, the chance of noise generation gets increased with increasing density of vehicular traffic. The vehicular road traffic gets denser with respect to time, and with increased traffic density, level of noise pollution also gets rising. This research work illustrates comprehensive study on the noise level assessment in Mount Abu City.

A. Study of Location (Mount Abu):

For the present study, Mount Abu is considered as the monitoring station for the noise prediction model, data were collected from its nine different sampling stations. Mount Abu City, is a hill station in the Aravalli Range in Sirohi district of Rajasthan state in western India near the border with Gujarat. Mount Abu is situated at an average height of 1,219m above sea level. It has a fine climate having richness of dense green forest cover. In summers, when typical high temperature of Rajasthan is around 44°C, while Mount Abu's temperature is 31°C to 34°C. In winters the temperature ranges from 10°C to -8°C (in Night), Mount Abu receives the highest amount of rainfall in Rajasthan, average Rainfall during monsoon is 70-180 cm. It the only hilly station in Rajasthan, located at an elevation of 1,220 m (4,003 ft). It has been a famous hill station away from the heat of Rajasthan and neighbouring Gujarat from centuries. The Mount Abu Wildlife Sanctuary was established in 1960 and covers the area of 290 km² of the mountain. It is also named as ’an oasis in the desert’ as its high plateaus are home to waterfalls, lakes, rivers and evergreen forests. Guru Sikhar is considered to be not only the highest peak of Mount Abu but the whole of Aravalí mountain range. Situated at a height of 1722 meters (5,650 ft) above the sea level. Nearest Railway station is Abu Road Railway station which is 27 km away from Mount Abu. Sirohi is the third smallest district of Rajasthan after Dungarpur and Banswara. It has smallest population having an area of 5139 km² (2009 sq. miles). It is situated at the south-west part of Rajasthan between parallel of 24° 20' and 25 °17' North Latitude and 72° 16' and 73° 10' East Longitude.

B. Growth Of Roadways In India:

It is well known, that modes of transportation is the crucial element from the economical point of view. These modes of transportation are being used in accordance with the topography, distribution of population, type of location, for land use and financial assistance. In the present schanrio, Indian railways transport network has been spread all over the India and its transport network also be considered as the world’s second largest railway transport network. And of course, the chance of noise generation gets increased with increasing density of vehicular traffic. The vehicular road traffic gets denser with respect to time, and with increased traffic density, level of noise pollution also gets rising. This research work illustrates comprehensive study on the noise level assessment in Mount Abu City.

II. CAUSES OF ROAD TRAFFIC NOISE

Volume of traffic, speed of traffic & type of traffic are generally the main parameters on which the noise level of traffic depends. Since loudness of traffic noise increased due to traffic density of heavy vehicles, large number trucks and greater speed. Noise produced by engine, exhaust and types combines to form vehicular noise. There may be some other reasons of loudness of traffic noise i.e. Due to defective mufflers or faulty hardware equipment on vehicles. Any situation which causes heavy stress on motor engines will cause to increase of traffic noise levels. (Paoprpayoon, et al 2005). However in addition to this, there are many complex parameters which deeply affects the loudness of traffic noise. Let us consider an example, an observer goes away
from busy roads then noise level of traffic is reduced by the distance, vegetation, terrain, and other natural and artificial obstacles. Traffic noise pollution doesn’t show its hazardous aspects for the people who lives more than 200m away from heavy traffic or more than 20m to 70m away from light areas.

A. Characteristics of Sound Signal:
Characteristics of sound signal has three main quantities i.e. given as under:-
- Loudness of sound signal.
- Pitch of sound signal.
- Type of sound signal.


Pitch may be defined as the frequency of sound signal produced by human ear. High pitch node is raised by a high frequency and similarly low pitch node is produced by low frequency. Single tone sound signal are also called pure tone which have sound of only one frequency, such as it is given by electronic signal generator or a tuning fork (Paoprayoon, S. 2004. Modeling traffic noise at a signalized intersection)

B. Relation of Noise with Vehicular Traffic Volume and its Speed:
It can be understood by taking an example, i.e. while reducing the speed of vehicle from 40kmph to 30kmph is easier than removing 50% of the traffic from the road.

<table>
<thead>
<tr>
<th>Speed (kmph)</th>
<th>Noise level (dB) of automobile at 170cm</th>
<th>Noise level (dB) of medium truck at 170cm</th>
<th>Noise level (dB) of heavy truck at 170cm</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>62</td>
<td>73</td>
<td>80</td>
</tr>
<tr>
<td>31</td>
<td>62</td>
<td>74</td>
<td>80</td>
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<td>32</td>
<td>63</td>
<td>74</td>
<td>81</td>
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<td>33</td>
<td>63</td>
<td>75</td>
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<td>34</td>
<td>64</td>
<td>75</td>
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<td>35</td>
<td>64</td>
<td>76</td>
<td>82</td>
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<td>36</td>
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<td>40</td>
<td>67</td>
<td>78</td>
<td>83</td>
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<td>41</td>
<td>67</td>
<td>78</td>
<td>83</td>
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<td>42</td>
<td>67</td>
<td>78</td>
<td>84</td>
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<tr>
<td>43</td>
<td>68</td>
<td>79</td>
<td>84</td>
</tr>
<tr>
<td>44</td>
<td>68</td>
<td>79</td>
<td>84</td>
</tr>
</tbody>
</table>

Table 2: Relationship between noise level and speed of vehicles
Source: Paoprayoon (2004)

III. NOISE CONTROL MEASURES ON ROADS
The noise control measure includes the following techniques:-
(1) Traffic noise strategies
(2) Noise barrier walls
(3) Speed control

A. Traffic Noise Strategies:
Roadway geometrics and surrounding terrain are interrelated, since the propogation of sound is sensitive to the overall geometry and having diffraction (bending of
sound waves around obstacles), ground wave attenuation, reflection, spreading loss and refraction. Traffic management strategies play an essential role in reduction of sound pressure level specially coupled with effective high technologies and enforcement policies and monitoring of worst noise offenders. A combination of these measures an half reduce daytime noise levels o under 50dB(A), which is the upper limit often used describe a “quiet area” in an urban environment. Simulation tools can be particularly helpful in demonstrating the actual effectiveness of individual or combined anti-noise measures, Couvreur & Laniray (2004) A simple discussion indicates that sound will be minimized when the path of sound is blocked by terrain, or will be enhanced if the road is elevated so as to broadcast; however, the complexities of variable interaction has been considered.

B. Noise Barrier Walls:

Noise barriers are probably the best weapon in retrofiting an existing roadway, and commonly can reduce adjacent land use sound levels by 10dB. Constructing or increasing the height of a barrier wall could result in a noticeable decrease in traffic noise. So, we can say that noise barriers can be applicable for existing or planned surface transportation projects. A buffer of mixed plants can absorb and deflect sound waves (Gauvard et al., 1998; Couvreur et al., 1998; Ma et a., 2003a,b). This mix of plant is quite important because different types of leaves (layers) reduce different types of noise. How much noise control they provide depends upon the parameters such as frequency, intensity and direction of sound propagation, and location, width, height and density of plantation.

C. Speed Control:

Speed control is a crucial measure. In order to prevent and control ground traffic noise pollution, guide the rational planning and construction of infrastructure such as traffic and housing, safeguard people’s health, protect and improve the living environment, and promote the economic and social development. Traffic noise increases with higher speed limits and with shorter distances from the road to the home. Experience has shown that reductions in vehicle speed may also lead to reductions in noise, although excessive use of low gears and frequent acceleration and deceleration may increase noise levels. Recessing the roadway can reduce the noise impact. Use of quiet pavement such as rubberized asphalt can also reduce the impact by 4-5 decibels (see table below). Unlike conventional asphalt, rubberized asphalt maintains its noise reduction properties over several years. Thus a scheme with measures that allow the constant use of 3rd gear will result in lower noise levels than a more severe scheme that require frequent changes to 2nd gear. (Fortuna et al., 2004; Dougherty & Cobbett, 1997; Ledoux, 1997; Dia, 2001; Yin et al., 2002) In this case the higher average speeds achieved with the former would have to be traded off against the higher noise of the latter. Where speeds have been reduced from 50 to 30kph, typical reductions in noise levels of between 4-5 dB (A) have been measured.

D. FHWA Model:

Modeling is the process of producing a model; a model is a representation of the construction and working of some system of interest. A model is similar to but simpler than the system it represents. On the one hand, a model should be a close approximation to the real system and incorporate most of its salient features. FHWA stands for Federal Highway Administration’s Environmental Policy that considers a commitment to ensure that all reasonable and feasible noise mitigation measures to be implemented into project works to minimize the effect of noise. The FHWA TNM® is a registered copyright and trademark. FHWA traffic noise model approach, the FHWA Model (FHWA-RD-77-108), or “108 model,” were used since past twenty years. Since that time, significant advancements have been made in the technology and advancement for traffic noise prediction, barrier analysis and design, and computer software designing. FHWA demonstrated the need of designing, developing, testing, and documentation of highway traffic noise prediction model that utilized these techniques and advancements. One purpose of a model is to enable the analyst to predict the effect of changes to the system. These requirements for a new vehicular traffic noise prediction model resulted in the FHWA TNM methodology. It should not be so complex that it is impossible to understand and experiment with it. A good model is a judicious tradeoff between realism and simplicity. However, in addition to this, An important issue in modeling is model validity. FHWA model validation does not promote any individual implementation or consultants who performed or authored the respective documents regarding the issue. FHWA model is only an attempt for compiling the limited data on the topic in accordance with the research work. The algorithms are based on the concepts of a series of adjustments to reference sound level. This reference sound level should be at a distance of 15.2m for a single vehicle traveling along a infinitely long straight road, with no shield of source.

The FHWA traffic noise prediction model considers the following aspects discussed here:

- Modeling is based on the fact that vehicles are categorized into three types, i.e.
- Automobiles
- Medium trucks and
- Heavy trucks
- Contour analysis, consisting of sound level contours, sound-level difference contours, and barrier insertion loss contours.
- Attenuation through vegetation and topography has been taken for consideration.
- Parallel barrier analysis.
- Modeling considers the effects of different graded roadways and pavement types. This study also investigates the effects of using specific pavement types, as opposed to Average pavement, when the pavement type is known. The results of this study indicate that improvements in the correlation between predicted and measured results can be achieved by selecting the best ground type and pavement type for the model.
- A sound level calculation has been based on a one-third octave-band data base and algorithms.
- Graphically demonstrative noise barrier design and optimization.
- Multiple diffraction analysis.
Modeling recommends the implementation of both interrupted and uninterrupted traffic flow by using a 1994/1995 measured field-data base.

IV. RESULT AND ANALYSIS

A Table representation in the form of observed and predicted values of noise levels at Dilwara Temple sampling stations which is given here.

<table>
<thead>
<tr>
<th>time/station name</th>
<th>observed value</th>
<th>predicted value</th>
<th>%error</th>
</tr>
</thead>
<tbody>
<tr>
<td>9:30 to 10:30am</td>
<td>67</td>
<td>70.3</td>
<td>-3.3</td>
</tr>
<tr>
<td>10:30 to 11:30am</td>
<td>78</td>
<td>76.4</td>
<td>1.6</td>
</tr>
<tr>
<td>11:30 to 12:30pm</td>
<td>75.2</td>
<td>73.8</td>
<td>1.4</td>
</tr>
<tr>
<td>12:30 to 1:30pm</td>
<td>79.1</td>
<td>78</td>
<td>1.1</td>
</tr>
<tr>
<td>1:30 to 2:30pm</td>
<td>88.2</td>
<td>89.1</td>
<td>-0.9</td>
</tr>
<tr>
<td>2:30 to 3:30pm</td>
<td>88.5</td>
<td>83.4</td>
<td>-5.1</td>
</tr>
<tr>
<td>3:30 to 4:30pm</td>
<td>88.3</td>
<td>89.9</td>
<td>-1.6</td>
</tr>
<tr>
<td>4:30 to 5:30pm</td>
<td>74.7</td>
<td>78</td>
<td>-3.3</td>
</tr>
<tr>
<td>5:30 to 6:30pm</td>
<td>77.2</td>
<td>75.2</td>
<td>2.0</td>
</tr>
<tr>
<td>6:30 to 7:30pm</td>
<td>78.1</td>
<td>79.1</td>
<td>-1.0</td>
</tr>
<tr>
<td>7:30 to 8:30pm</td>
<td>89.1</td>
<td>88.2</td>
<td>0.9</td>
</tr>
<tr>
<td>8:30 to 9:30pm</td>
<td>83.4</td>
<td>88.5</td>
<td>-5.1</td>
</tr>
<tr>
<td>total average</td>
<td>80.6</td>
<td>81.3</td>
<td>-0.7</td>
</tr>
</tbody>
</table>

Table 4: Dilwara Temple sampling station observed and predicted noise levels

V. CONCLUSIONS

The analysis and demonstration of data has revealed that the observed noise level over the Mount Abu City is comparatively low along the roadways, perhaps it is due to the fact the Mount Abu City is far away from dense population and industrialization. One more reason may be, it is rich in vegetation and other natural resources. Among the nine sampling stations, the highest noise level has been occurred in Brahmakumaries universal palace as compared to other sampling stations.

The analysis has also revealed that FHWA model can be successfully used to predict the vehicular traffic noise in India within a fair degree of accuracy. It is obvious that the regulation of traffic volume and speed at any place may bring desired results with a view to control or minimize traffic noise levels along roadways. It is expected that FHWA model can be used as a successful tool predicting the noise using traffic parameters.

The outcome of the research work is proved to be immense help in traffic planning and environmental assessment of the roadway projects of Mount Abu City with respect to traffic noise. It is recommended that traffic noise regulation may be considered on all roadways in India as length of roadways being increasing day by day in India.

REFERENCES


