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# Design of Noise Barriers for Four Lane National Highways

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**Abstract** —*Population growth and development of activities in cities have a great influence on the development of transportation sector. The high growth rate of private vehicles is mainly due to increase in the population. This condition has enlarged environmental degradation, not only in terms of fuel consumption but also in terms of air pollution and traffic noise generated by vehicles. Noise generated by traffic is having many adverse effects such as increase of stress, sleep disturbance, communication difficulty and also hearing problem. In order to overcome these problems, it is required to estimate the level of traffic noise produced by traffic volume and average speed of the vehicles. In the present work, the traffic noise along a highway corridor on NH-58 Delhi-Haridwar Road. The locations were taken for the study is Km-112, NH-58. Traffic noise is perhaps one of the major environmental concerns for the residents living in the society. It interferes with the smooth life of the individuals and so there is a great requirement to adopt measures to reduce noise. Noise has many adverse impacts on human beings categorized under bodily effects and psychological effects. To have a good sleep, noise level should not exceed 35 dB (A) Leq as per WHO. Increased noise levels reduce the efficiency of work and performance. So to counteract these problems, a strong necessity is required to adopt measures to mitigate noise. The following study is done to know the measures for noise reduction through noise barriers. The main objectives of this study are to model noise levels at receivers due to four lane National Highway traffic operation through measurement of traffic volume, speed, noise and other site geometrical parameters. To design noise barrier for village locations on four lane National Highway.*

***Keywords-*** *Noise Barrier Design, NH-58, Traffic Speed*

## I. INTRODUCTION

Development of Transportation System has greatly affected the development of the world in form of economic and social benefits to mankind. Its seemingly unrelenting growth has been instrumental in reshaping the landscape of the world. There would be hardly anybody who can deny that his life is not affected by the transport system. In developing countries due to mixed traffic composition there is an acute appreciation of the impacts of transport on National Highways. Highways are the most important infrastructure contributing towards nation building. But, transportation on highways has adverse effects in terms of environmental pollution. Air and noise pollution are the two most commonly cited problems of highway development. Noise is most ubiquitous as it is easily detected by human ear. Some of the most pervasive sources of noise in our environment today are those associated with transportation. The recognition of noise as an environmental problem with an impact on both the community and occupational environment is rapidly growing.
India, having one of the largest road networks of 41.09 lakh km, consists of National Highways, Expressways, State Highways, Major District Roads, Other District Roads and Village Roads. The National Highways have been classified on the basis of carriageway width of the Highway. Generally, a lane has a width of 3.75 m in case of single lane and 3.5 m per lane in case of multi-lane National Highways.
The most common source of transportation noise is due to automobiles movement. Along with that there are sources also as discussed below:

- Vehicle-air interaction: When a vehicle is in motion, the friction present between the body of the vehicle and the surrounding air creates a gradient in the air pressure field and thus noise is generated.
- Tire-pavement interaction: The tyre-pavement noise generates due to the friction and small impacts that occur due to the rolling of tyre on the pavement or road surface. Such noise generated is normally more pronounced for concrete pavements and less subjected to asphalt concrete pavements. In the case of rail transportation, friction generated between the wheel and the track generates noise, mostly in curve areas.
- Vehicle engines: Noise levels due to vehicle engines are generally higher in areas of greater speed or areas where the vehicle is forced to accelerate or decelerate. So, the heavier transportation vehicles i.e. heavy trucks, trolleys, aircraft etc generate more noise than the noise generated due to smaller vehicles.
- Vehicle exhaust system: Exhaust systems of vehicles lead to noise levels which is higher, especially in case of improper noise-control devices. Noise levels generated due to exhaust systems are related to noise levels coming from vehicle engines, due to higher speeds and also larger vehicles emit higher levels of exhaust noise.
- Vehicle horns and brakes: Vehicle horns are the most important source of noise generation and thus it is responsible for a significant and irritating source of traffic noise. Brakes are also a major contributor towards the noise generation part, particularly for heavy vehicles.

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Noise generated due to traffic movement on highway can move over a considerable distances and the frequency has an acoustic spectrum which ranges from 120 to 4000 Hz. This frequency range is very unpleasant to human ears and so this noise creates discomfort to residents.

Noise has many adverse impacts on human beings categorized under bodily effects and psychological effects. Bodily effects comprise effects like problem in hearing, increase in blood pressure, frequent headache. Psychological effects include emotional disturbances like distraction, aggravation, disruption in sleep etc.

Noise pollution causes irritability, high blood pressure, deafness, ulcers, disruption in sleep, indigestion and heart disease. Many times even low noise levels may be of irritating nature and can cause disturbances. Noise also interferes with the speech. People can wake from sleep due to high noise levels. To have a good sleep, noise level should not exceed 35 dB(A) Leq as per WHO. Increased noise levels reduce the efficiency of work and performance.

## II. LITERATURE REVIEW

Traffic due to transportation is becoming the major source of noise pollution all over the world. Traffic noise is more easily detected by humans than other types of pollution. In developing country like India, the problem due to noise is becoming a major environmental problem. Various studies have been done in India as well as abroad.

Jung and Blaney (1988) designed a model similar to 'STAMINA MODEL'. The model was very helpful in predicting noise due to hourly traffic for different conditions. The model [20] was prepared to determine noise level from the available data. The model was also helpful in designing of noise barriers for particular data set.

Fujiwara, Hothersall and Kim et al. (1997) discussed that now a days barriers are used for the reduction of noise nuisance, particularly from noise pollution due to road traffic. Noise barriers performance can only be verified in trials done at field, and also the conditions existing at site make the design of noise barriers a little bit typical and also lead to a increase in the cost of its design.

Different noise barrier were examined viz, T-shaped, rectangular and cylindrical edge barriers. And then various parameters like transmission loss [8] were calculated by varying the noise barrier positions and keeping the receiver at the same height. The material used for noise barriers were soft and had an absorbing surface. Barrier with T-shape was found out to be the most effective barrier for all the trials done on different noise barrier materials with different positions.

Watts et al. (1998) made a study to determine the reduction in sound due to vegetation on the roads. It was found out that the reduction in noise was large if the vegetation belt was large enough to absorb the noise. Many studies were conducted and found out that a closely packed group of trees was much more efficient in noise reduction than a small belt of trees. Further, according to a study made by Perfater, it was found that the reduction in noise was better in case of densely planted vegetation than in case of a brick barrier. Although the exact reason for better noise reduction in vegetation was not known but it was vegetation had better benefits both in pleasant look as well as in noise reduction.

From the study [46] it was further concluded that when the source was visually screened then the residents were a bit extra sensible to noise due to the screening of the source.

Gupta *et al.* (1986) carried out their study in Roorkee at selected locations and determined the road traffic noise for the combined traffic flow. Different parameters were calculated in their study [13] like L10, L50, L90, Leq . Also, noise pollution levels at these locations were found out.

Sarin *et al.* (1990) carried out his study at a residential apartment along a highway in delhi and calculated various parameters related to road traffic noise. From his study, [41] it was found that noise levels were exceeding all the prescribed limits upto 7th floor.

Gupta *et al.* (1994) conducted a study and developed a model named "Traffic Noise Analysis Package". The package had four different options [12]. Different noise parameters like L10, L50, L90 and Leq were calculated using the first parameter of the package. The noise level (Leq) was predicted using the second parameter. For a particular traffic volume given at a unit hour time, Leq can be estimated for a particular distance (m). The third parameter is used to get the combined noise level for a particular mixed traffic flow stream by providing their respective noise values as input data. And the 4th parameter helps to close the running program.

## III. METHODOLOGY DEVELOPMENT

### 3.1 Noise standards and selection of sites

Noise levels of various zones are decided by the concerned administration governing that particular area. As per Central Pollution Control Board (CPCB), noise level should not exceed 55 (dBA) in terms of Leq in the surroundings of a residential building For study purpose, only those sites were selected and observed where there is noise problem i.e. noise levels observed exceed the prescribed noise limits.

### 3.2 Traffic noise prediction

Traffic volume counts and their corresponding spot speeds were taken for nine hours in a day. Noise levels were also noted down for every fifteen seconds lasting for fifteen minutes in an hour. By feeding the above quoted inputs into

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FHWA models, noise levels were predicted. A comparison is then made between the observed noise levels and the predicted noise levels to get the range within which noise levels fall.

**3.3 Evaluation of barrier effectiveness**

Noise levels were predicted at the locations considering as if there were no barrier at the location. This helps in knowing the amount of noise reduction by barrier.

**3.4 Design of noise barriers**

If the noise barriers to be designed are not resulting in required noise reduction, then noise reduction can also be done by redesigning the existing barriers in terms of extra height to meet the required levels.

**3.5 Noise Model**

The major source responsible for the degradation of environment and its features is the transportation traffic. Traffic noise can be assessed by monitoring and also by modelling. Various noise models have been developed and used in all over the world. The popularly used models are US"s Federal Highway Administration Model (FHWA), UK"s Calculation of Road Traffic Noise (CORTN), Bangkok model and some Numerical models like Edinburgh model, Sheffield model and Australian model. Some Software are also used for Estimating Traffic Noise Pollution like SOUND PLAN and ENM. FHWA has been used in the following thesis work.

**3.6 Noise Barrier**

Noise barriers are mainly comprised of solid obstructions built between the highway and the residences along a highway. Noise barrier do not completely block all the noise, rather they only reduce the noise levels by some particular level. Effective noise barriers typically reduce noise levels by 5 to 10 decibels (dB. For example, a barrier which achieves a 10-dB reduction can reduce the noise produced by a tractor to the noise generated by an automobile.

**Figure 1: Prefabricated Barrier**

## IV. FIELD STUDIES AND DATA COLLECTION

**4.1 General**

NH-58 was taken as the study area. The locations were taken for the study is Km-112, NH-58.


**Figure 2: Google Earth Map of section of NH-58**

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Various categories of vehicles ply on roads and proportion of these categories depend on relative importance of road and time of the day. For the purpose of prediction of noise, vehicles are categorized into seven types as per FHWA model. These categories are:-

- Car,
- Minibus,
- Truck,
- Bus,
- Motor Cycle,
- Auto Rickshaw And
- Tractor Trailer.

At each site following data was collected

1. Traffic volume
2. Spot speed
3. Ambient noise levels
4. Geometrics of road which includes lane width, no. of lanes, shoulder width, median width, gradient if any, type of pavement, barrier height, thickness, distance from barrier to receiver and to source
5. Other parameters like ground cover, layout of receivers.

**4.2 Description of Study Locations**

The study is mainly intended to assess the noise levels, to evaluate effectiveness of barriers in reducing noise, designing further height of barrier required, if not resulting in desired reduction of noise. The following are the characteristics of the locations:-

**4.2.1 Location Km-112, NH-58**

This site is situated at Km-112 on NH-58. NH-58 is a Four-Lane divided National Highway that connects capital of our country i.e. New Delhi to Haridwar. On one side of the road there are industries. The location identified was on the side towards Roorkee. Due to industries a need is there to provide noise barriers to reduce the noise. The following sketch shows the geometrical feature of the location.

**Figure 3: Google Earth Map of km-112, NH-58**

**4.3 Data collection**

**4.3.1. Traffic Speed**

The traffic volume was collected at all the selected locations. The counting was done manually for a period of 9 hours from 9:00 am to 6:00 pm. Due to heterogeneous traffic condition, the vehicles were categorized into seven categories i.e. car, mini bus, bus, two wheelers, truck, tractor/trailer and auto-rickshaw. Each category of vehicle was counted on both sides of the identified locations for noise assessment. Speed data was collected for all the four lane of the National Highway. The following parameters Minimum Speed, Maximum Speed and Mean Speed were obtained from the speed data for all the four lanes.

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**Table 1: Inner Lane Towards Delhi, Speed km-112, NH-58**

| S.No. | Vehicle Category | Min. Speed | Max. Speed | Mean Speed |
|---|---|---|---|---|
| 1 | Car/Jeep/Van | 67 | 86 | 76 |
| 2 | Mini Bus | 53 | 67 | 60 |
| 3 | Bus | 58 | 71 | 63 |
| 4 | Truck | 47 | 61 | 54 |
| 5 | Motorcycle | 48 | 62 | 55 |
| 6 | Auto | 35 | 47 | 40 |
| 7 | Tractors/Trailors | 26 | 34 | 29 |

**Table 2: Outer Lane Towards Delhi, Speed km-112, NH-58**

| S.No. | Vehicle Category | Min. Speed | Max. Speed | Mean Speed |
|---|---|---|---|---|
| 1 | Car/Jeep/Van | 64 | 81 | 73 |
| 2 | Mini Bus | 49 | 63 | 58 |
| 3 | Bus | 54 | 67 | 60 |
| 4 | Truck | 47 | 57 | 52 |
| 5 | Motorcycle | 46 | 59 | 52 |
| 6 | Auto | 35 | 46 | 39 |
| 7 | Tractors/Trailors | 24 | 32 | 28 |

**Table 3: Inner Lane Towards Roorkee, Speed km-112, NH-58**

| S.No. | Vehicle Category | Min. Speed | Max. Speed | Mean Speed |
|---|---|---|---|---|
| 1 | Car/Jeep/Van | 69 | 83 | 77 |
| 2 | Mini Bus | 54 | 67 | 61 |
| 3 | Bus | 57 | 71 | 63 |
| 4 | Truck | 48 | 62 | 56 |
| 5 | Motorcycle | 49 | 62 | 55 |
| 6 | Auto | 34 | 43 | 39 |
| 7 | Tractors/Trailors | 24 | 33 | 28 |

**Table 4: Outer Lane Towards Roorkee, Speed km-112, NH-58**

| S.No. | Vehicle Category | Min. Speed | Max. Speed | Mean Speed |
|---|---|---|---|---|
| 1 | Car/Jeep/Van | 68 | 81 | 74 |
| 2 | Mini Bus | 52 | 62 | 57 |
| 3 | Bus | 55 | 67 | 61 |
| 4 | Truck | 48 | 61 | 54 |
| 5 | Motorcycle | 47 | 59 | 52 |
| 6 | Auto | 32 | 43 | 38 |
| 7 | Tractors/Trailors | 25 | 32 | 28 |

### 4.3.2 Ambient Noise Level Study

Noise level meter was used to measure the ambient noise level at different locations. The noise levels were recorded in dB (A) using noise level meters. A set of 30 readings were taken for every 15 minute interval period for each lane. Then

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the noise for the whole highway was calculated during the 15 minute interval period. The following table shows the L10, L50, L90 and Leq values for each location.

**Table 5: Various Noise Parameters at km-112, NH-58**

| S.No. | TIME | L10 | L50 | L90 | Leq Measured |
|---|---|---|---|---|---|
| 1 | 9:00am - 9:15am | 83.5 | 74.6 | 68.3 | 78.6 |
| 2 | 9:15am - 9:30am | 84.2 | 75.1 | 68.6 | 79.8 |
| 3 | 9:30am -9:45am | 87.1 | 77.1 | 69.2 | 83.5 |
| 4 | 9:45am - 10:00am | 84.8 | 76.8 | 70.1 | 80.4 |
| 5 | 10:00am - 10:15am | 87.9 | 79.4 | 69.4 | 85.9 |
| 6 | 10:15am - 10:30am | 86.7 | 77.9 | 70.2 | 83.1 |
| 7 | 10:30am - 10:45am | 87.5 | 78.3 | 69.3 | 83.8 |
| 8 | 10:45am - 11:00am | 85.3 | 78.1 | 70.3 | 82.3 |
| 9 | 11:00am - 11:15am | 89.6 | 82.1 | 71 | 87.8 |
| 10 | 11:15am - 11:30am | 88.9 | 81.6 | 70.4 | 87.8 |
| 11 | 11:30am - 11:45am | 86.7 | 80.1 | 70.2 | 84.3 |
| 12 | 11:45am - 12 noon | 87.1 | 80.7 | 69.7 | 85.7 |
| 13 | 12noon - 12:15pm | 90.1 | 83.4 | 71.1 | 88.2 |
| 14 | 12:15pm - 12:30pm | 84.2 | 76.8 | 68.7 | 81.3 |
| 15 | 12:30pm - 12:45pm | 87.8 | 82.1 | 70.4 | 87.0 |
| 16 | 12:45pm - 1:00pm | 86.1 | 80.3 | 71.4 | 84.2 |
| 17 | 1:00pm - 1:15pm | 84.1 | 78.4 | 70.2 | 82.7 |
| 18 | 1:15pm - 1:30pm | 88.3 | 81.4 | 69.4 | 87.2 |
| 19 | 1:30pm - 1:45pm | 84.6 | 78.1 | 68.9 | 82.3 |
| 20 | 1:45pm - 2:00pm | 87.5 | 81.7 | 70.3 | 86.8 |
| 21 | 2:00pm - 2:15pm | 85.6 | 80.6 | 71.2 | 84.3 |
| 22 | 2:15pm - 2:30pm | 87.5 | 79.8 | 69.7 | 85.6 |
| 23 | 2:30pm - 2:45pm | 88.5 | 83.2 | 70.1 | 87.9 |
| 24 | 2:45pm - 3:00pm | 86.9 | 81.2 | 70.6 | 85.7 |
| 25 | 3:00pm - 3:15pm | 87.7 | 81.8 | 69.9 | 87.1 |
| 26 | 3:15pm - 3:30pm | 87.0 | 80.7 | 70.3 | 85.7 |
| 27 | 3:30pm - 3:45pm | 85.9 | 79.8 | 69.8 | 84.8 |
| 28 | 3:45pm - 4:00pm | 88.2 | 81.4 | 69.5 | 87.6 |
| 29 | 4:00pm - 4:15pm | 84.6 | 79.5 | 68.7 | 83.4 |
| 30 | 4:15pm - 4:30pm | 89.2 | 83.1 | 70.4 | 88.0 |
| 31 | 4:30pm - 4:45pm | 87.9 | 82.5 | 70.9 | 87.4 |
| 32 | 4:45pm - 5:00pm | 85.5 | 80.3 | 69.1 | 84.7 |
| 33 | 5:00pm - 5:15pm | 87.8 | 81.7 | 70.5 | 87.4 |
| 34 | 5:15pm - 5:30pm | 88.5 | 82.1 | 69.4 | 88.0 |
| 35 | 5:30pm - 5:45pm | 86.4 | 81.3 | 70.2 | 85.8 |
| 36 | 5:45pm - 6:00pm | 85.9 | 79.8 | 68.9 | 84.8 |

## V. RESULTS AND DISCUSSION OF ANALYSIS

A comparative analysis of predicted and observed noise level has been carried out along with percentage error of every selected location along the selected locations.

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**Table 6: Comparison of Leq Calculated and Leq Measured at km-112, NH-58**

| S.No. | TIME | Leq Calculated | Leq Measured | % Difference |
|---|---|---|---|---|
| 1 | 9:00am - 9:15am | 76.8 | 78.6 | -1.8 |
| 2 | 9:15am - 9:30am | 77.0 | 79.8 | -2.8 |
| 3 | 9:30am -9:45am | 77.6 | 83.5 | -5.9 |
| 4 | 9:45am - 10:00am | 77.0 | 80.4 | -3.4 |
| 5 | 10:00am - 10:15am | 77.9 | 85.9 | -8.0 |
| 6 | 10:15am - 10:30am | 77.2 | 83.1 | -5.9 |
| 7 | 10:30am - 10:45am | 77.3 | 83.8 | -6.5 |
| 8 | 10:45am - 11:00am | 77.1 | 82.3 | -5.2 |
| 9 | 11:00am - 11:15am | 78.0 | 87.8 | -9.8 |
| 10 | 11:15am - 11:30am | 77.9 | 87.8 | -9.9 |
| 11 | 11:30am - 11:45am | 77.3 | 84.3 | -7.0 |
| 12 | 11:45am - 12 noon | 77.6 | 85.7 | -8.1 |
| 13 | 12noon - 12:15pm | 78.3 | 88.2 | -9.9 |
| 14 | 12:15pm - 12:30pm | 76.9 | 81.3 | -4.4 |
| 15 | 12:30pm - 12:45pm | 77.7 | 87.0 | -9.3 |
| 16 | 12:45pm - 1:00pm | 77.3 | 84.2 | -6.9 |
| 17 | 1:00pm - 1:15pm | 77.1 | 82.7 | -5.6 |
| 18 | 1:15pm - 1:30pm | 77.8 | 87.2 | -9.4 |
| 19 | 1:30pm - 1:45pm | 77.1 | 82.3 | -5.2 |
| 20 | 1:45pm - 2:00pm | 77.7 | 86.8 | -9.1 |
| 21 | 2:00pm - 2:15pm | 77.3 | 84.3 | -7.0 |
| 22 | 2:15pm - 2:30pm | 77.6 | 85.6 | -8.0 |
| 23 | 2:30pm - 2:45pm | 78.0 | 87.9 | -9.9 |
| 24 | 2:45pm - 3:00pm | 77.6 | 85.7 | -8.1 |
| 25 | 3:00pm - 3:15pm | 77.6 | 87.1 | -9.5 |
| 26 | 3:15pm - 3:30pm | 77.7 | 85.7 | -8.0 |
| 27 | 3:30pm - 3:45pm | 77.5 | 84.8 | -7.3 |
| 28 | 3:45pm - 4:00pm | 77.8 | 87.6 | -9.8 |
| 29 | 4:00pm - 4:15pm | 77.3 | 83.4 | -6.1 |
| 30 | 4:15pm - 4:30pm | 78.1 | 88.0 | -9.9 |
| 31 | 4:30pm - 4:45pm | 78.1 | 87.4 | -9.3 |
| 32 | 4:45pm - 5:00pm | 77.4 | 84.7 | -7.3 |
| 33 | 5:00pm - 5:15pm | 78.2 | 87.4 | -9.2 |
| 34 | 5:15pm - 5:30pm | 78.5 | 88.0 | -9.5 |
| 35 | 5:30pm - 5:45pm | 77.9 | 85.8 | -7.9 |
| 36 | 5:45pm - 6:00pm | 77.9 | 84.8 | -6.9 |

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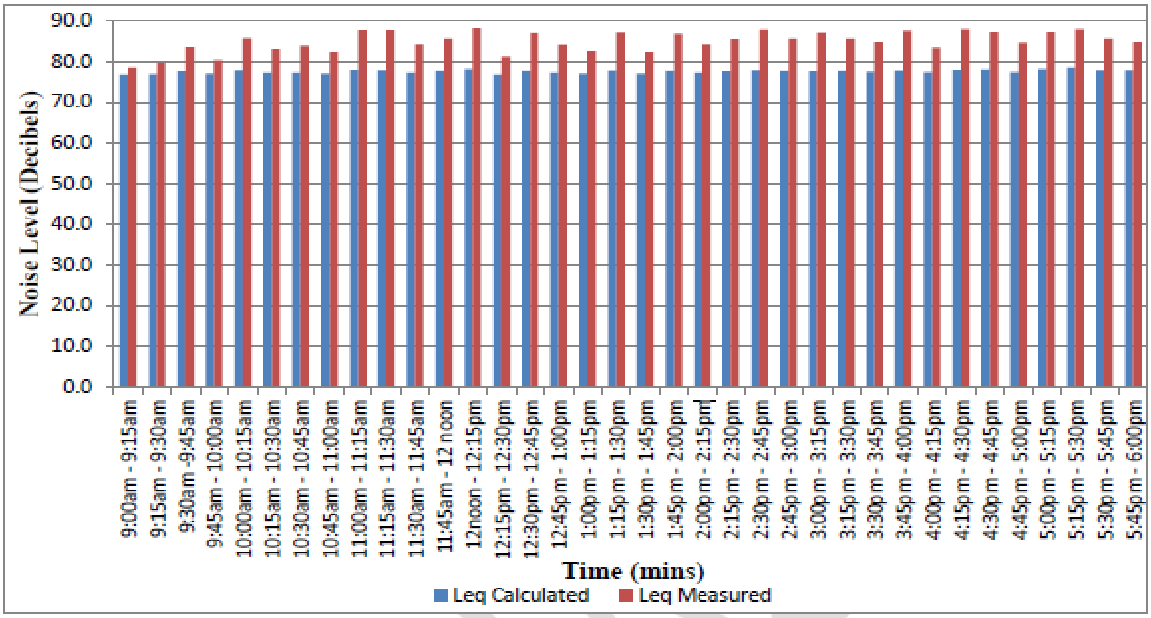


**Figure 4: Graph showing variation of noise levels w.r.t. time at km-112, NH-58**

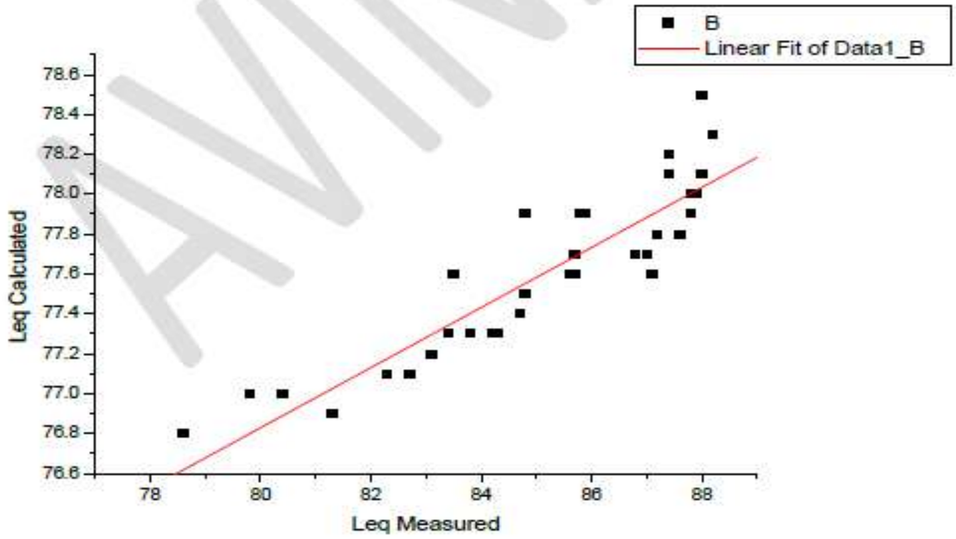


**Figure 5: Graph plotted between Leq Calculated and Leq Measured at km-112,NH-58**

Table 5 depicts the comparison between measured and calculated noise level. It is clear from the figures that time period 5:15pm to 5:30pm shows maximum measured (88.0 dBA) and calculated value (78.5 dBA). On the other hand minimum measured and calculated value is found 78.6 dBA and 76.8 dBA. Table 5 also presents the percentage error found between measured and calculated noise. The range between the maximum and minimum percentage justifies that the proposed modified model can be used to predict noise level successfully. From the graph plotted between Leq Calculated and Leq Measured, a regression analysis has been carried out. And the value of regression R2 comes out to be 0.8220 as shown in the table 7.

**Table 7: Regression analysis between Leq Calculated and Leq Measured at km-112 NH-58**

Linear Regression for Data1_B:

Y = A + B * X

| S.No. | Parameter | Value |
|---|---|---|
| 1 | A | 64.77812 |
| 2 | B | 0.15064 |
| 3 | R2 | 0.8220 |
| 4 | SD | 0.18016 |
| 5 | N | 36 |
| 6 | P | <0.0001 |

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Where,
A is the intercept, B is the slope. S is the standard deviation, N is number of samples used in the fit (N), and P is the probability (probability that R=0).

## VI. DESIGN OF NOISE BARRIERS

### 6.1 Barrier designing at km-112, NH-58

From the data analysis at this location, it is observed that the average maximum predicted and observed noise level has been exceeded the prescribed limits. Noise levels of vehicles moving towards Roorkee are greater than noise levels of vehicles moving towards Delhi. From this analysis, it is found that such a higher noise level may affect the physical and mental health of people working in the industrial buildings along this particular location. To keep away people from this noise pollution it is very essential to design noise barrier. The barrier height has been calculated by using the developed model and it presents the prerequisite of 4.6 meter height of the barrier at one side i.e. towards Roorkee direction. Cross section and general layout of this location with the designed noise barrier is presented in Figure 6.

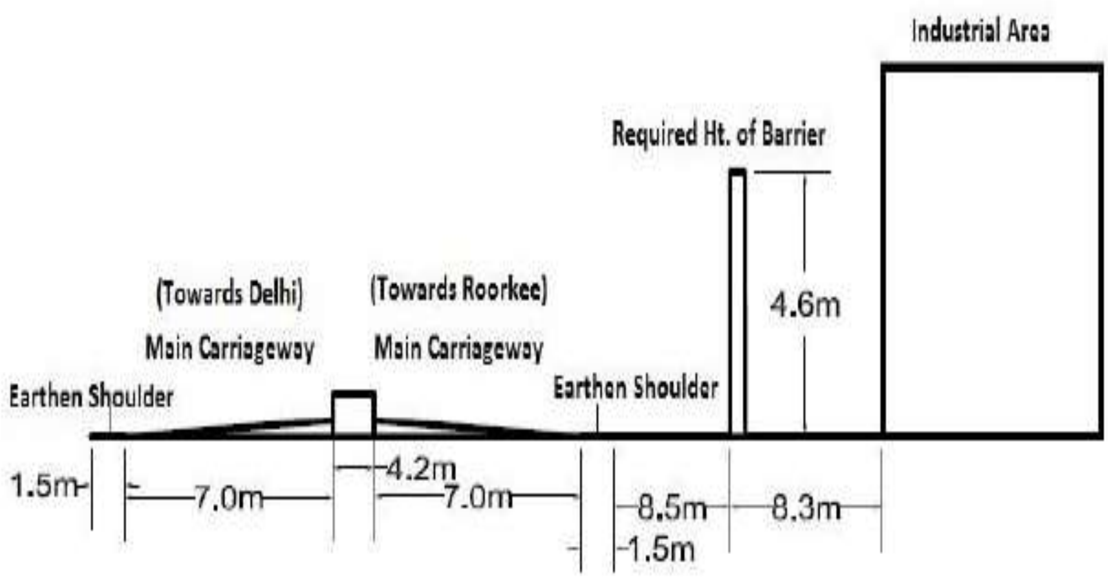


**Figure 6: Design of Noise Barrier at Km-112, NH-58**

## VII. CONCLUSIONS

In the present study, environmental problem related to transportation system i.e. Traffic Noise has been taken up. Data related to traffic noise has been collected at selected locations and analyzed to assess the status of noise pollution. There are different methods of mitigating noise through noise barriers. The selection of a particular noise barrier depends upon the level of noise generated and the amount to which it should be reduced. Topography, road conditions also govern the selection of a noise barrier. In India, noise barriers are being implemented but yet they are to be used at a large scale.

***The following conclusions are drawn regarding the performed experimental study:***

1. On comparing observed noise level with CPCB standards, it was found that the noise levels at all the study locations were exceeding the permissible limits. Not a single location along NH-58 was found under prescribed noise limit.
2. During the collection of various data it was found that receivers are located far away from road at km-112 NH-58 and hence barrier height needed to meet prescribed limits was less i.e. 4.6m.
3. The barrier height required at km-112 NH-58 comes out to be 4.6m, due to fact that the distance of the observer from the highway center is less i.e. 27.4m for locations km-112 NH-58.
4. It was observed from the calculations that in spite of designing and providing noise barrier at required locations, the reduction in noise is 13.7 dBA for locations km-112 NH-58 and reduction in noise cannot be exceeded beyond 15 dBA.
5. The percentage difference between observed and calculated traffic noise level is in the range of -1.8 dBA to -9.9 dBA for km-112 NH-58.
6. The value of regression R2 after regression analysis comes out as 0.8220 for km-112 NH-58, which shows the validation of FHWA model at these locations.

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