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Road Traffic Noise Level Assessment at an Institutional Area

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ABSTRACT
Unplanned and rapid urbanization, industrialization, increasing number of vehicles, poor traffic management, poor road condition etc. are the major causes of higher noise levels in most of the Indian cities. Prolonged exposure to higher noise levels can lead to irreversible Noise Induced Hearing Loss (NIHL). Noise-induced hearing loss is contributing one-third to the total persons suffering from hearing loss in every country in the world. The present study aims at measuring the noise levels in the university campus to analyze the current situation and suggesting noise control measures to be adopted in University campus and along MMA Jauhar Marg. The numbers of vehicles were counted during November 17-21, 2012 and noise levels were measured at various pre decided locations. The traffic load in horizon years 2013, 2017, 2022, 2027 and 2032 on the MMA Jauhar Marg Road is predicted on the basis of observed traffic data and expected annual growth rate as 8.0% for pre Metro and 3.5% for post Metro. The noise levels were measured using Larson Davis Model 831 Class 1 Sound Level Meter on both sides of road at foot paths along MMA Jauhar Marg and at various receptor locations inside the different buildings in the university campus. Model RLS-90 is used for prediction of noise levels. The prediction of metro noise is carried out using statistical calculations. The combined noise levels were compared with standard criteria for silent zone and found on higher side. Installation of environment noise barrier is suggested as one of the noise control measure to be adopted along MMA Jauhar Marg and along metro viaduct to save students and staff from exposure of higher noise levels.
Keywords: Noise Pollution, Road Traffic Noise, Institutional Area, Noise Induced Hearing Loss (NIHL), Noise Barriers.

I. INTRODUCTION

Unplanned and rapid urbanization, industrialization, increasing population as well as number of vehicles, poor traffic management, poor road condition etc. are the major causes of higher noise levels in most of the Indian cities that increases the noise pollution to an alarming level. Prolonged exposure to noise above the decibel level of 60 can lead to irreversible Noise Induced Hearing Loss (NIHL). Noise-induced hearing loss is contributing one-third to the total persons suffering from hearing loss in every country in the world. Noise pollution disrupts the activity or balance of human or animal life. Noise has several different effects on health including short term and long term. Among the types of noises-continuous, intermittent and impulsive-impulsive noise is the utmost disturbing one to most of the people. The primary effects of excessive noise exposure may include annoyance**.** The working performance of persons may be affected as they may be losing their concentration. The higher noise levels in night may affect sleeping there by inducing the people to become restless and lose concentration and presence of mind during their activities. Higher noise causes pain, ringing in the ears, feeling of tiredness. The physiological features like breathing amplitude, blood pressure, heart-beat rate, pulse rate, blood cholesterol are also affected. Long exposure to high sound levels cause loss of hearing.

A study carried out to evaluate the noise pollution problem in the Varanasi city and its effects on the exposed people revealed the fact that 85% of the people were disturbed by traffic noise, about 90% of the people reported that traffic noise is the main cause of headache, high BP problem, dizziness and fatigue. Traffic noise was found to be interfering daily activities such as at resting, reading, communication etc [1]. A similar study carried out in Greater Cairo, Egypt also indicated that noise levels in city were higher than those set by the Egyptian noise standards. A social survey carried out simultaneously indicated that 73.8% of respondent residents were highly or moderately irritated by road traffic noise [2]. The main roads in Beijing urban area are overloaded by traffic flow during daytime and noise levels due to road traffic along these roads are above relevant environmental standards [3]. All these study indicate road traffic is the main source of noise pollution in most of the cities. The noise level depends on composition of vehicles. The heavy vehicles cause the peaks in the overall noise profile in urban traffic noise [4, 5]. A study carried out in Central London to observe the noise contributions made by different types of vehicles also revealed that trucks and buses are responsible in contributing to high noise levels. [6]. The L_{eq} values are mainly influenced by the hourly traffic volume [7]. The exposure to noise levels is the highest in auto-rickshaws, followed by trucks, buses and cars [8, 9, 10]. The various models and methods are in practice for prediction of noise levels due to road traffic. The prediction of road traffic noise may be carried out using genetic algorithms [11]. Simple prediction equations are useful in prediction of the attenuation of road traffic noise with distance [12]. Digital simulation is also useful in predicting L_{eq} created by urban traffic [13].

The noise levels along all the major roads are on higher side in all over Delhi [14]. This is due to negligence of control measures, policies and regulations. Higher noise levels are affecting the health of people residing or working near these roads. If appropriate measures are not taken to check the increasing noise levels then the loss to the society may be irreparable [15]. The higher noise level near institutional areas which comes under silent zones is becoming a great challenge for the students and affecting the health as well as studies. The higher noise levels affect communication and interference with speech. It also affects concentration of students. The present study aims at measuring the noise levels in the University campus to analyze the current situation and suggesting noise control measures to be adopted in the University campus and design of noise barriers for MMA Jauhar Marg which passes through University campus and carries heavy traffic.

II. METHODOLOGY

This section describes the methodology adopted in the present study. It includes selection of study area, locations and collection of hourly traffic data including different categories of vehicles in the morning & evening peak hours and measurement of noise levels. The future traffic is predicted based on observed traffic and expected annual growth rate for pre Metro and post Metro. The noise levels are measured using Sound Level Meter at various pre decided locations. Model RLS-90 is used for prediction of noise levels due to road traffic. The noise level from the metro train is predicted based on the statistical calculations. The combined noise levels are compared with National Ambient Noise Quality Standard for silent zone. The installation of noise barriers is suggested all along MMA Jauhar Marg and along viaduct of Metro as noise pollution mitigation measure.

2.1 Selection of Study Area

The location selected for traffic survey is towards left side of main gate of Faculty of Engineering and Technology, Jamia Millia Islamia, on Maulana Mohammad Ali (MMA) Jauhar Marg, Jamia Nagar, New Delhi as shown in the map in Fig.1.

Fig.1: Location of Traffic Survey

2.2 Traffic Survey

The observed traffic comprises of Heavy Commercial Vehicles (Bus Trucks), Light Commercial Vehicles, Cars, Three wheelers (3Ws) and Two wheelers (2Ws). The number of vehicles was counted under my supervision on hourly basis in the morning and evening peak hours for all the categories. The flow pattern of observed hourly traffic during morning and evening peak hours is given in Fig.2. The vehicle composition of observed traffic is given in Fig.3.

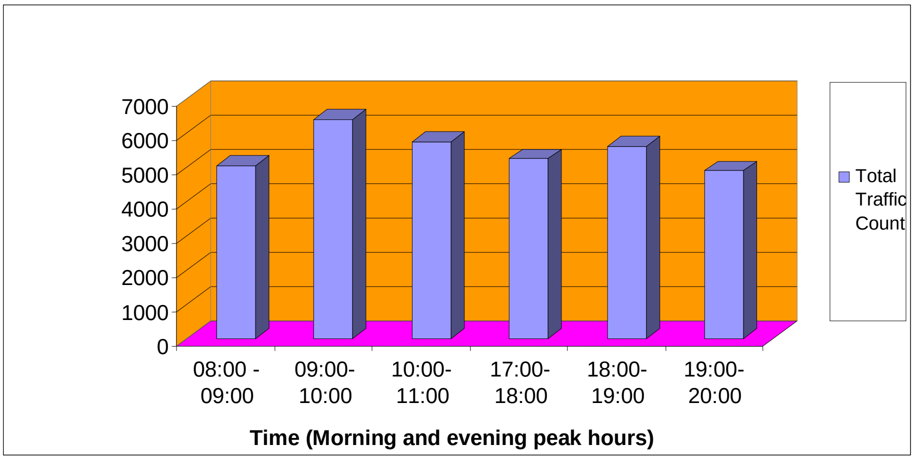

Fig.2: Observed hourly traffic

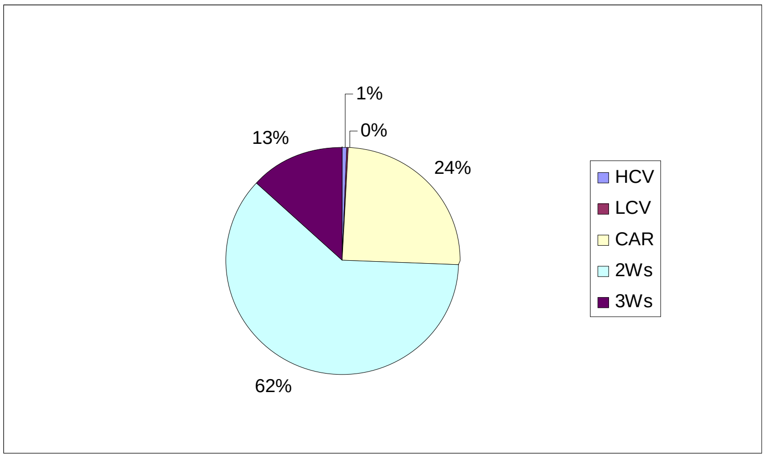

Fig.3: Vehicles composition

2.3 Prediction of Road Traffic

The studies reported on traffic prediction for various locations pre and post MRTS (Mass Rapid Transit System) shows different growth rates. The traffic growth rate as per CRRI-SIAM Report 2009-10 (study carried out by CRRI for Society of India Automobile Manufacturers in the year 2009-10) shows an annual growth rate as 8.0% for without Metro and 3.5% for with Metro. Accordingly, the traffic load in horizon years 2013, 2017, 2022, 2027 and 2032 on the MMA Jauhar Marg Road is predicted based on the observed traffic and expected annual growth rate as 8.0% for pre Metro and 3.5% for post Metro.

2.4 Measurement of Noise Levels

Noise levels were measured using Larson Davis Model 831 Class 1 Sound Level Meter on both sides of road at foot paths along MMA Jauhar Marg and at various receptor locations inside the different buildings in the university campus. The noise levels were measured in the morning and evening peak hours at pre decided locations.

2.5 Noise Prediction Procedure

Noise Modeling is essential for designing of a noise barrier. For the purpose of highway noise modeling, CoRTN (UK), RLS-90 (Germany), FHWA-TNM (USA), Stop & Go (Bangkok) models are available, which are based on sound pressure, and ASJ (Japan), ISO (Switzerland), Harmonoise (Switzerland), models are based on sound power. The results of a study undertaken by CRRI in the year 2008 entitled, "Validation of Noise Prediction Model for an Urban Area"-, reveals that RLS-90 model gives better prediction values in comparison to other models (CoRTN, Stop & Go, and FHWA-TNM) for Indian Urban Conditions. Therefore, RLS-90 model is used in the present study.

2.5.1 Prediction for road traffic noise

Model RLS-90 is a German Model. It uses the point source method with spreading ground attenuation, screening and reflection. Source model is for prediction of noise levels for given traffic data. Following equation is used to calculate source level emission developing MS Excel sheet:

LME = (LM 25, basic) + C speed + Croad surface + Cgrdient + Cref

Whereas:

LM (25, basic): It is standardized level for speed as 100km/ h for cars and 80km/h for trucks, non-ground asphalt road surface, Gradient < 5% and free field propagation.

LM (25basic) =37.3 +10*log {m *(1+0.082)}

M = mean hourly traffic volume (vehicles/hr)

P =% of trucks exceeding 2.8tonnes

Speed correction (C speed):

C speed=Lcar -37.3+ 10*log [100+ (10 0.1*c)*P} / (100+8.23*P)}

Lcar =27.8+10*log [1+ (0.002*Vcar) 3]

L truck =23.1+12.5*log (Vcar)

C =L truck – Lcar

V car = speed of cars (min 30km/h), (max130km/h)

V truck =speed of trucks (min 30km/h) (max 80km/h)

P =% of trucks exceeding 2.8tons

Road surface correction (C road surface):

C road surface= -4dB for bitumen road

Gradient correction (C gradient):

C gradient = 0 (If gradient<5)

= 0.6*|gradient|-3

Reflection correction (C ref):

$$C\ ref = 4 * \frac{\text{Height of obstruction}}{\text{Distance of obstruction}}$$

2.5.2 Prediction for Metro Rail Noise

As per literature survey carried out, a model to predict noise levels for metro train is not available. Therefore, the noise level from the metro train is predicted based on the following statistical calculations.

Leq = 10 log { [t/T x 10 0.1 x L1] + [(T-t)/T x 10 0.1 x L2] }

Where L1 is the noise level during passing of metro train and L2 is the average noise level for the remaining time period. T is the total exposure time in hour for calculation one hour is considered. t is the total time in hours for the crossing of trains in one hour.

2.6 Transmission of Sound

The reduction in sound levels with distance is due to the divergence of sound waves. As per inverse square law, the sound intensity at any radial distance r from the sphere is inversely proportional to the square of distance. Using this law following equation may be used to calculate the noise levels at desired location if levels at any particular location are available:

$$Lp2 = Lp1 - 20 \log \frac{r2}{r1}$$

where Lp2 and Lp1 are the noise levels at a distance of r2 and r1 meters respectively.

There may be attenuation beyond wave divergence due to grass, shrubs, trees, rain, sleet, snow, fog, ongoing wind, etc. However, effect of these is ignored in the present study as the effect of these parameters is insignificant.

2.7.1 Noise Barriers

Noise barriers are the most effective method of mitigating roadway noise. Noise barriers, often referred to as 'Sound abatement walls' are commonly constructed using different materials such as steel, concrete, masonry, wood, plastics, poly carbonate, acrylic, insulating wool, or composites. Effective noise barriers typically reduce noise levels by 5 to 12.5 decibels (dB). These can be given various shapes like parabolic, partial curve, inclined or even straight to meet desired aesthetic appeal or different land-use pattern. Cost and aesthetics play a role in the final choice of any noise barrier. The noise barriers may be broadly classified in following two types based upon their characteristics to absorb or reflect noise.

2.7.1 Absorptive Noise Barrier

As the name suggests, they absorb sound energy. A porous surface material and sound-dampening content material is said to be absorptive. The amount of incident sound that a barrier absorbs is typically expressed in terms of its Noise Reduction Coefficient (NRC). The NRC is the arithmetic average of the noise absorption co-efficient at 250, 500, 1000 and 2000 Hz. Thus a lower NRC indicates the barrier will reflect the entire sound incident upon it, and higher value indicates the barrier will absorb the entire sound incident upon it. A typical NRC for an absorptive barrier is required within the range from 0.6 to 0.9.

2.8 Reflective Noise Barrier

The noise barriers which reflect incidental noise are called reflective barriers. This means that sound energy actually bounces from one side to the other. The barriers without any added absorptive treatment or design, such as block, concrete, polycarbonate sheet, glass, acrylic sheet, wood or metal, are considered reflective noise barriers. Reflective barriers may either be on one side or on both sides of the road. From the visibility point of view reflective noise barriers are preferable on roads as well as on elevated viaduct.

III. RESULTS AND DISCUSSION

In this study, the measured noise levels compared with the predicted noise levels to check the compatibility of model used. The noise levels for anticipated future road traffic and for Metro have been predicted. The combined noise levels have been compared with the standard noise levels for silent zone. The environmental noise barrier has been suggested as noise mitigation measure.

3.1 Noise Measurement Results

The noise levels are measured on both sides of road at foot paths along MMA Jauhar Marg and various receptor locations inside the university campus at different buildings during morning and evening peak hours and results are as follows:

3.1.1 Results of Noise Levels at Location 1 (Footpath along Faculty of Engineering & Technology side)

The noise levels measured at footpath along Faculty of Engineering & Technology Side found to be varying from minimum value of 65.2 dB to maximum value of 70.8 dB. The average of measured noise levels is works out to 68.4 dB.

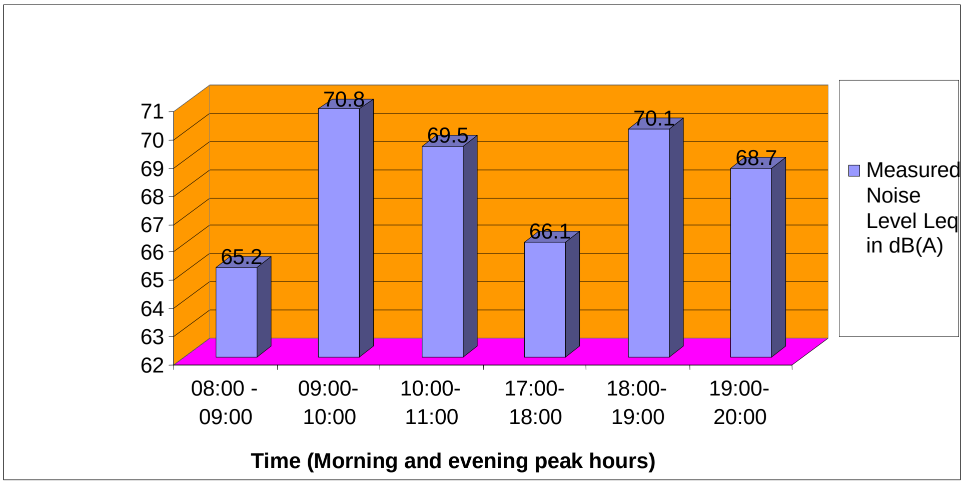

Fig. 4: Noise levels at location 1

3.1.2 Results of Noise Levels at Location 2 (Footpath along Doctor Zakir Hussain Memorial Museum side)
The noise levels measured at footpath along Doctor Zakir Hussain Memorial Museum Side found to be varying from minimum value of 65.2 dB to maximum value of 71.1 dB. The average of measured noise levels is works out to 68.2 dB.

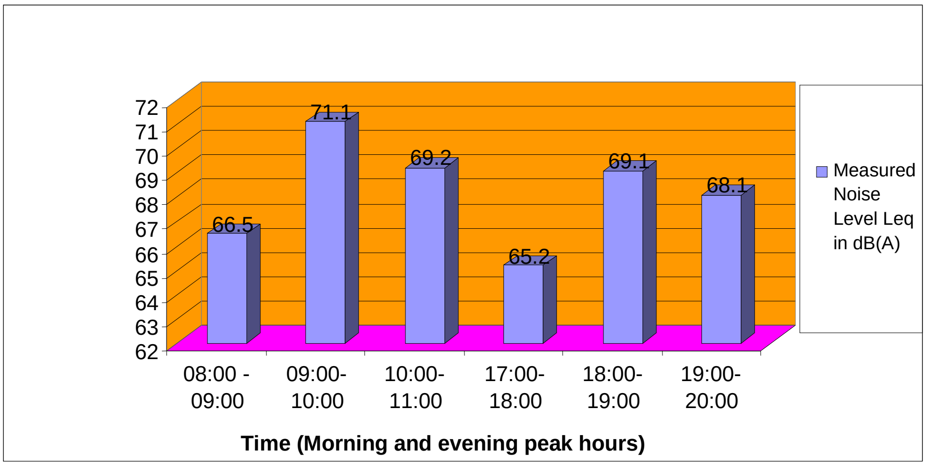

Fig. 5: Noise levels at location 2

3.1.3 Results of Noise Levels at Location 3 (Faculty of Engineering & Technology building)
The measured values of noise levels at Faculty of Engineering & Technology building – Ground floor to Third floor with open window and closed window are found to be varying from minimum value of 51.6 dB to maximum value of 62.5 dB. The comparison of sound levels with standard for silent zone is shown in Fig. 6.

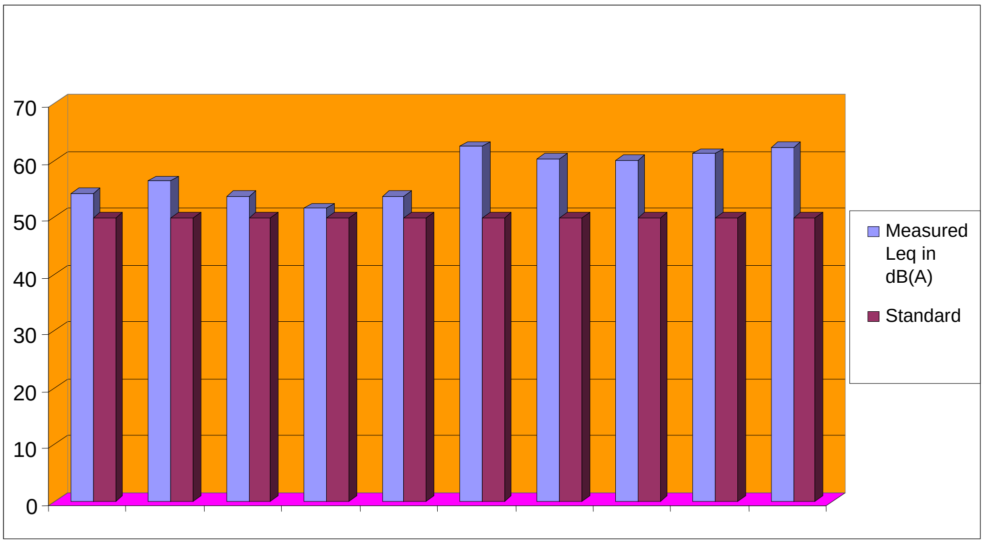

Fig. 6: Comparison of standard noise levels and measured noise levels at various locations at Faculty of Engineering and Technology building

3.1.4 Results of Noise Levels at various locations in other buildings
The noise levels also measured at various buildings of university campus which were – Gulshan-e-Khusro building, Faculty of Humanitarian Languages building, Sports complex building, Gulistan-e-Galib building and Al-Beruni Block and found to be varying from minimum value of 53.3 dB to maximum value of 66.2 dB

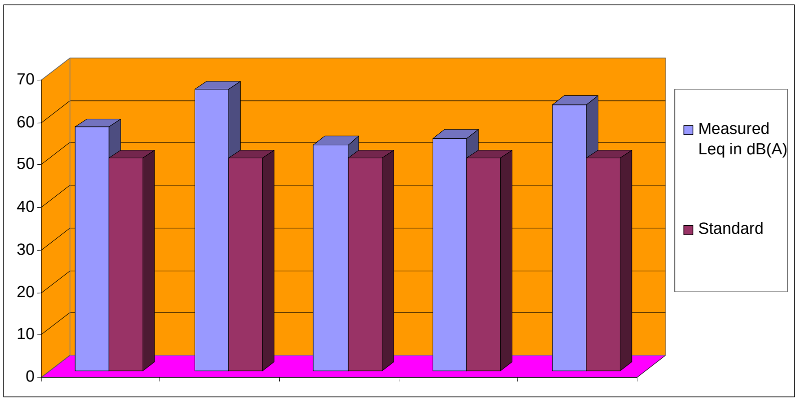

Fig. 6: Comparison of standard noise levels and measured noise levels at various buildings

3.2 Prediction of Road Traffic Noise
Noise levels are predicted based on RLS-90 model at the locations depending upon the source parameters. Noise levels are predicted for morning peak hours and evening peak hours for the year 2013, 2017, 2022, 2027 and 2032. The predicted average noise levels are ranging from 67.1 dB for the year 2012 to 71.1 dB for year 2032.

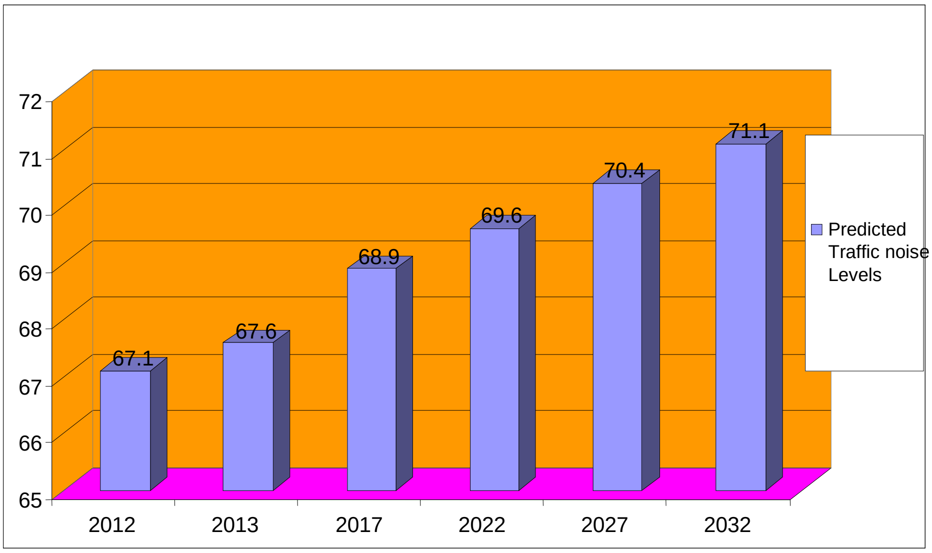

Fig. 7: Predicted noise levels

3.3 Comparison of Measured and Predicted Noise Levels
The noise levels measured with Sound Level Meter are compared with the predicted noise levels using RLS 90 model to ascertain compatibility of the model. The average of noise levels measured during morning and evening peak hours works out to 68.3dB whereas predicted noise level for same is 67.6dB. The measured values and predicted values are in a close range and the difference in two values is only 0.6dB which is not significant. Therefore, the prediction model is compatible for present study.

3.4 Prediction of Metro Rail Noise
The noise level from the metro train is predicted based on statistical calculations for the year 2017 and 2032. The expected commissioning of Metro on this corridor is in 2017. Therefore year 2017 is considered for prediction of noise levels to calculate combined noise levels in due course. The predicted noise levels for year 2017 works out to 64.1 dB with proposed frequency of metro trains @ 4 minutes from one direction and for the year 2032 it is 66.2 dB with proposed frequency @ 2 minutes.

3.5 Combined Noise Levels
The combined noise from road traffic and metro train is calculated using the addition and subtraction graphs. The combined noise levels expected to be generated by vehicles and the metro rail for the horizon years of 2017 and 2032 are found to be 70.1 dB and 72.3 dB.

3.6 Noise Attenuation

The attenuation in noise levels due to distance between source and receptor is considered. The building line on Faculty of Engineering & Technology Side is 23 m from the center of the road at some locations and 51 m at other locations. The building line on Doctor Zakir Hussain Memorial Museum Side is 29 meter from the center of the road at some locations and 46 m at other locations. The attenuation in Noise Levels due to distance between source and receptor is calculated using following equation and shall be as under:

$$Lp2 = Lp1 - 20 \log \frac{r2}{r1}$$

For 23 meter:	70.1 − 20 log (23/11)	=	63.7 dB
For 29 meter:	70.1 − 20 log (29/11)	=	61.7 dB
For 46 meter:	70.1 − 20 log (46/11)	=	57.7 dB
For 51 meter:	70.1 − 20 log (51/11)	=	56.8 dB

Due to attenuation in noise levels substantial reduction is observed. However, the reduced levels are still on higher side than standard noise levels for silent zone. Therefore, provision of any noise mitigation measure is essential.

3.7 Design of Noise Barrier

The noise levels for the buildings nearer to the road are 11.7dB to 13.7dB higher than the standard noise levels and for the buildings far away to the road these are 6.8dB to 7.7dB higher. Therefore noise barriers of different heights shall be required for different locations based upon the distance of buildings from the road.

There are various types of panels available in the market with different materials and specifications manufactured by various companies in different trade name. The panels may be selected based on its efficiency in reduction of noise level, its structural ability to withstand wind load, cost, durability & service life, safety and maintenance requirement etc.

The absorptive noise barrier with acoustic panel having inner face of weather protected porous absorptive material and outer face of metallic sheet of suitable color without any retro reflection is considered. The Noise Reduction Coefficient is 0.75. The thickness of panel may be 50mm and air gap between panel and metal sheet atleast100mm.

The reflective noise barrier of transparent reflective panel of polycarbonate sheet of minimum 8 mm thickness is considered. The noise absorbing coefficient of material may be from 0.1 to 0.3 with Sound Transmission Class rating more than 45. The polycarbonate sheet may be plain or coloured as per the requirements of visibility and privacy.

The reduction in noise levels which can be achieved by providing any of the above noise barriers depends upon the height of barriers. As a thumb rule every 1 meter height of noise barrier above line of sight reduces noise levels by 1.5 dB.

3.7.1 At Faculty of Engineering & Technology

The least building line is at 23 m distance from the center of the road on Faculty of Engineering & Technology Side and at 29 meter on Doctor Zakir Hussain Memorial Museum Side for 330 meter stretch. The reduction in noise levels required is 13.7dB and 11.7dB. Absorptive type noise barrier is shown in Fig. 8 and reflective type noise barrier is shown in Fig. 9. For this stretch, a 2.0 meter high noise barrier has been suggested on both sides of MMA Jauhar Marg and on both sides of elevated viaduct. A reduction in noise levels up to 8 dB can be achieved providing 2.0 m high noise barrier.

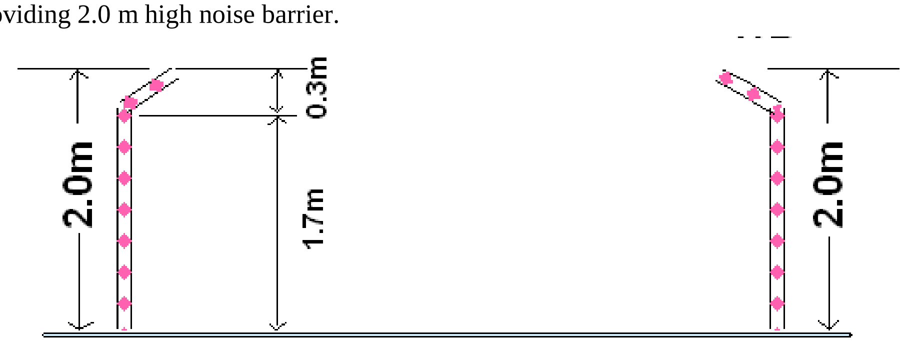

Fig. 8: Absorptive Noise Barrier of height 2.0 meter

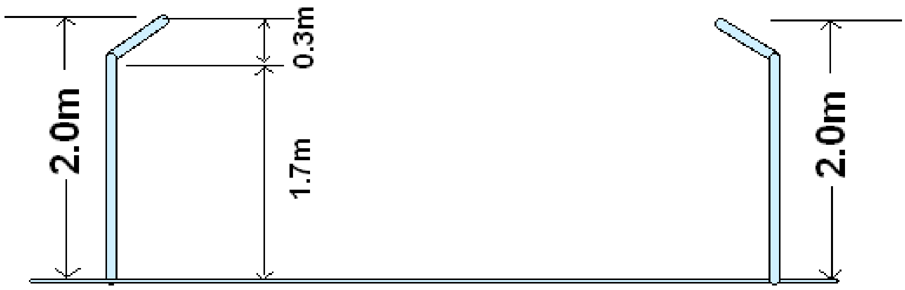

Fig. 9: Reflective Noise Barrier of height 2.0 meter

3.7.2 At Ansari Auditorium

The least building line is at 46 m distance from the center of the road on Doctor Zakir Hussain Memorial Museum Side for next 350 meter stretch. There is no building in the vicinity of road on this stretch on Faculty of Engineering & Technology Side. Therefore, noise barrier on Faculty of Engineering & Technology Side for this stretch is not required. The reduction in noise levels required is 7.7dB. Reduction in noise levels up to 6 dB can be achieved by providing 1.5 m high noise.

3.8 Other Measures

The exposure to higher noise levels inside the buildings can be minimized up to some extent by providing double glazed windows. Repairing of broken glasses of existing windows is also important. The timely servicing and repairing of ceiling fans will be helpful. Acoustic treatment of walls and wooden flooring may be good abatement tools.

IV. CONCLUSIONS

The measured noise levels inside the university buildings were found above the standard noise levels for silent zone. This is due to heavy traffic plying on MMA Jauhar Marg. Hourly traffic is observed more than 6000 vehicles in the morning peak hours. The cars and two wheelers dominate the composition percentage. The commercial vehicles percentage is nearly 1% out of total vehicles. The traffic load in horizon years 2013, 2017, 2022, 2027 and 2032 on the MMA Jauhar Marg Road is predicted based on the observed traffic and expected annual growth rate as 8.0% for pre Metro and 3.5% for post Metro as per CRRI-SIAM Report 2009-10. The prediction of noise levels is carried out using RLS-90 model which gives better prediction values for Indian urban conditions. The predicted noise levels at source works out as 68.9dB in 2017 and 71.1 dB in 2032. The noise level from the metro train is predicted based on statistical calculations. The noise levels calculated using statistical equation shows noise levels in 2017 as 64.1dB and in 2032 as 66.2dB. Due to noise from Metro there would be further increment of 1.2 dB (A) in the predicted noise levels from road traffic. The combined noise levels would be 70.1dB in 2017 and 72.3 dB in 2032 which are on very higher side. The attenuation in noise levels due to wave divergence is considered and substantial reduction in noise levels is observed based upon the distance between source and receptor location. However, the attenuated noise levels are still on higher side from 6.8dB to 7.7dB and 11.7 to 13.7dB based upon the distance of buildings from the road. Since the study area is university campus, the impact of high noise level would be significant on the study as well as on the health of students and staff. Therefore, the noise barriers, for MMA Jauhar Marg and Metro viaduct, for different locations as per requirement are suggested. 1.5 meter high noise barrier is suggested where reduction in noise level upto 6.8dB is required and 2.0 meter high noise barrier is suggested where reduction in noise level upto 13.7dB is required.

The choice of barrier depends upon various parameters. The cost and aesthetics play a role in the final choice of any noise barrier. Absorptive type of barriers block the line of sight and vision permanently and hence these type are suitable where either blockade of vision is either desirable or of not much concern such as in case of highways. In case of an urban area, if the line of sight is completely blocked , it may give rise to a tunnel vision which may be not desirable aesthetically and not acceptable from safety and operational considerations. The reflective material is lighter in weight and better able to withstand meteorological conditions, with much less deterioration over a longer period of time. It is relatively maintenance free and overall cost effective. For monotonous journey and safety reason also, a clear vision is more acceptable even though the absorptive type of barriers offer slightly better noise attenuation than the reflective type. Other noise mitigation measures such as providing double glazed windows, repairing of broken glasses of existing windows, servicing and repairing of ceiling fans, acoustic treatment of walls and providing wooden flooring may be good abatement tools also.

V. ACKNOWLEDGEMENTS

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