A report on

MONITORING AND PREDICTION OF NOISE LEVEL IN URBAN AREA USING RLS-90 MODEL

Submitted in the partial fulfilment of the requirement for the award of degree of

MASTER OF TECHNOLOGY

(Environmental Engineering)

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(2K15/ENE/16)

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Acknowdegement

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AMIT SINGH

Declaration of Originality

I hereby undertake that AMIT SINGH, the sole author of this report. I undertake that this report neither infringes upon anyone neither's copyright nor violates any proprietary rights to the best of my knowledge. Any ideas, techniques, quotations, or any other material form of work of other people included in this report, published or otherwise, are fully acknowledged in accordance with the standard referencing practices.

I declare that this is the true copy of my report, including all revisions, as approved by my supervisor, and that this report has not been submitted for any other degree to any other University or Institution.

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List of Abbreviations

A weighting - A weighting audible frequencies taking as the standard ambient Noise Frequency.

A, B - Receiver point on both side of the road

$A_{barrier}$ - Screening in dB (A)

A_d - Distance attenuation in dB (A)

A_g - Ground effect

BIS - Bureau of Indian standards

C weight - C weight frequency

C_{ref} - Correction factor due to reflection dB (A)

C_d - Correction factor due to distance dB (A)

C_g - Ground attenuation dB (A)

Cgra - Correction due to gradient of the road

CL - Center line of the road

CoRTN - Calculation of road traffic noise

CPCB - Central pollution control board

C_r - reflection correction

C_{road} - Correction due to road surface type

CW - Carriageway width

d - Distance building from nearest adge of carriageway

D - Perpendicular distance from centerline of carriage way to receiver

D_o	- reference distance
D_g	- Geometric mean of road side section
Dn	- Distance from the observer to the centerline the near side roadway
E	- Acoustic Equivalence factor
g	- Gradient of the road
H	- Average height of propagation
Hz	- Unit of frequency in Hertz
INM	- Integrated Noise model
I	- Sound intensity
L_{10}	- Sound pressure level that is exceed 10% of the time in dB (A)
L_{90}	- Sound pressure level that is exceed 90% of the time in dB (A)
L_{AE}	- Sound Exposure level (SEL) with ‘A’ frequency
Leqi	- Equivalent noise level of one hour each class of vehicles
L_{eq}	- Equivalent noise level of continuous sound pressure level with ‘A’ frequency
LmE	- Source noise level emission
L_m	- Noise level due to propagation of sound
Ln	- Statistical analysis of noise level
M	- Mean hourly traffic volume
MW	- Median width
p	- % of the heavy vehicles

Pa - Pascal is the unit of sound pressure

Q - Hourly traffic flow (Veh/hour)

$Q_{bus/auto/car/truck/tw}$ – Hourly traffic flow for bus/auto/car/truck/tw

R - Position of the sound level meter (m)

R-O-W - Right of way

S - Mean speed of vehicles class

$S_{auto/car/bus/truck}$ - Mean speed of vehicles auto/car/bus/truck (Km / h)

S_E - Equivalent speed of traffic flow (Km / h)

S_n - Mean sped of traffic near side of roadway

SW - shoulder width

SLM - Sound level meter

SPL - Sound pressure level

T - Time period over which L_{eq} is computed

TNM - Traffic noise model

TNI - Traffic noise index

TNP - Traffic noise pollution

$V_{car/truck}$ - Speed of car/truck

$V_{n/f}$ - Traffic volume for near side /for side

Z - Z weight frequency is flat frequency response between 10Hz to 20 Hz

α - Ground cover absorption coefficient

Certificate

This is to certify that AMIT SINGH, M.Tech student in the Department of Environmental Engineering has submitted a project report on "MONITORING AND PREDICTION OF NOISE LEVELIN URBAN AREA USING RLS-90 model" in partial fulfilment of the requirement for award of degree of Master of technology in Environmental Engineering during the academic year 2015-2017.

It is a record of the student's research work prepared under my supervision and guidance.

DR. RAJEEV KUMAR MISHRA

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ABSTRACT

Noise pollution is the major environmental problem in developing countries as well as in developed country. Rapid industrialization, vehicle growth, urbanization and change in lifestyle of people has increased the noise level above the prescribed standard level. Traffic noise contribution in the total noise pollution is approximately 75%.

Delhi is the fourth noisiest city in the world and third noisiest city of the India. During this study, by keeping in mind the significance of the noise pollution in Delhi, ten locations have been selected to monitor the ambient noise level. These locations have been identified on the basis of different kind of land use pattern like residential, commercial and silence zone. The monitoring has been conducted during morning peak hour, off peak hour and evening peak hour. Sound level meter (Cesva SC 260) type two instrument has been used to monitor the ambient noise level at selected location.

Worldwide, various traffic noise model like FHWA, CORTN, Stop and Go and RLS -90 are available for the prediction of traffic noise in different condition. In this study RLS-90 Model has been used to predict the noise level at all the selected location. At the same time, this model used to forecast the traffic noise for the year of 2022, 2027 and 2032.

After data analysis, it was observed that the measured ambient noise level at all the locations were violated the permissible limits prescribed by CPCB. During monitoring, highest traffic noise level was observed at Ashram Chowk. This may be due to higher traffic volume as well as high traffic congestion at the particular location. The parentage error between monitored traffic noise level and predicted traffic noise level was found within the range of 0.5 % to 5.75% which indicates the suitability and applicability of the model in city like Delhi.

Keywords: Noise pollution, CORTN, FHWA, Prediction, RLS-90 model.

Contents

LIST OF FIGURES

LIST OF TABLE

CHAPTER-1

INTRODUCTION

"Noise" is derived from the Latin word “nausea” means unwanted sound which produces undesirable physiological and psychological effects on individual by interfering with one’s social activities like work, rest, recreation, sleep, etc. According to the 2011 census, the population of Dehli is approximately 11 million, which is the second highest population in India and this number will be expected to expaned by 40% in year 2021. Due to increasing the population in urban areas, traffic growth in the urban areas is increasing rapidly. The vehicular population in the Delhi, jumped by 135.59 % from 1999-2000 to 2011-12 and vehicle population became 7.4 million in year 2011, amid a similar period the quantity of vehicles per thousand populaces expanded from 253 to 436. Likewise it is notice that the road network system of the capital has expanded from 28,508 km (year 2001) to 32,663 km (year 2011) which is not sufficient, as the traffic density increases there is also increment in traffic noise level in same pattern.

A survey by the US Federal council of science and technology has revealed that noise is the technology generated problem and that the overall loudness of environmental noise doubles every ten years in pace with our social and industrial development. This geometric growth of ambient noise level could have serious consequences in view of the accelerating pace of technological growth.

The road traffic noise prediction model describes the procedure of theoretical estimation of the noise level at a selected locations under a specific sets of conditions and the prediction of the future traffic noise level is done on the basis of the present noise level and traffic conditions by using traffic noise prediction model. This will helps in the designing of the environmental noise barrier. There are different type of model used in different country for the prediction of noise level and designing of noise barrier like Federal highway administration (FHWA) model used in United State Of America, Calculation of road traffic noise (CORTN) model used in the united kingdom, Stop and Go model used in Bangkok and Richtlinien für den Lärmschutz an Straben (RLS-90) model used in Germany. RLS-90 is based on the point source method with spreading ground attenuation, screening and reflection. The forecasting of the traffic noise level at different year assumes that the only traffic volume is variable and another factor is constant.

1.1 Sound

Sound is the Vibration energy, because of the development of the particles that engenders as a regularly as a type of wave, of removal and pressure through a medium, for example, air or water. Medium is necessary for the transmission of the sound it affected all individuals in psychology and physiology, Sound waves with Frequencies between around 20 Hz and 20 kHz can be heard by humans. Sound underneath 20 Hz is infrasound or more 20 Hz is ultrasound wave. Different creatures have their distinctive Frequency extend for hearing sound wave.

A composite relationship between the pressure and thickness of the medium, It is influenced by temperature, decides the speed of sound inside the medium. In the event that the medium is moving, this development may increment or reductions the total speed of the sound wave contingent upon the heading of the development. For instance, sound traveling through breeze will have its speed of engendering expanded by the speed of the breeze if the sound and wind are moving a similar way. On the off chance that the sound and wind are moving in inverse ways, the speed of the sound wave will be diminished by the speed of the breeze.

The mechanical vibrations that can be interpreted as sound can travel through all forms of matter: gases, liquids, solids, and plasmas. The matter that supports the sound is called the medium. Sound cannot travel through a vacuum.

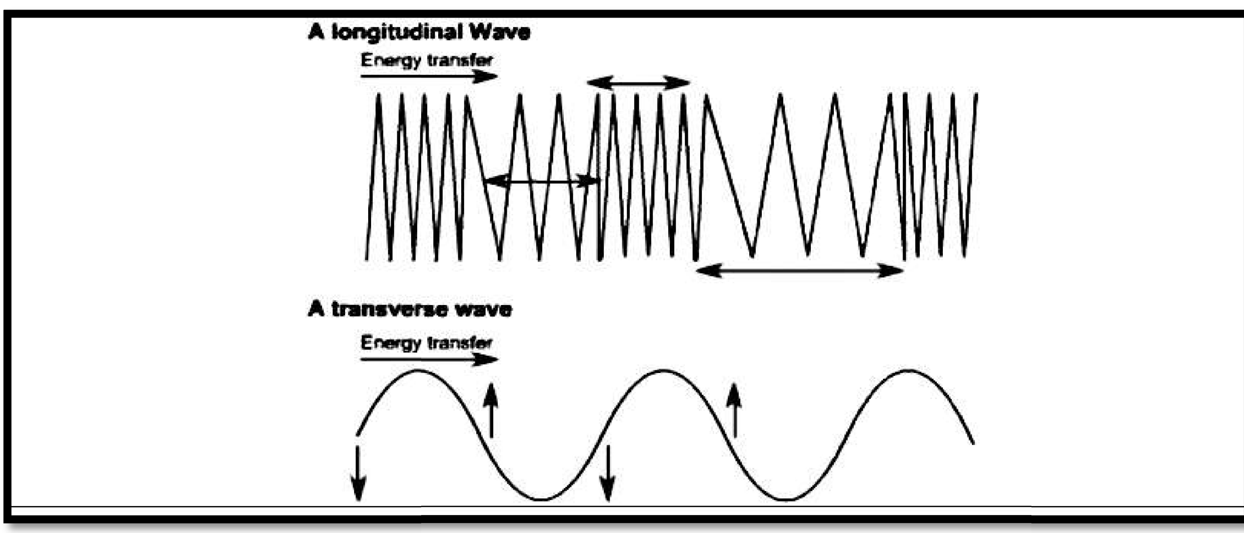


Fig 1.1: Longitudinal wave and Transverse wave

1.1.2 Sound Pressure level

Sound pressure level is the distinction, in a given medium, between normal neighborhood pressure and the pressure in the sound wave. A square of this distinction (i.e., a square of the deviation from the harmony pressure) is generally arrived at the midpoint of after some time as well as space, and a square base of this normal gives root mean square (RMS) esteem. For instance, 1 Pa RMS sound weight (94 dBSPL) in environmental air suggests that the genuine weight in the sound wave wavers between (1 ATM Pa) and (1 ATM Pa), that is in the vicinity of 101323.6 and 101326.4 Pa. As the human ear can identify sounds with an extensive variety of amplitudes, sound pressure is frequently measured as a level on a logarithmic decibel scale. The sound pressure level (SPL) or p is characterized as sound pressure or acoustic pressure is the neighborhood weight deviation of the encompassing (normal, or balance) air weight, caused by a sound wave. In air, sound pressure can be measured using a microphone, and in water with a hydrophone. The SI unit of sound weight is the Pascal (Pa). Sound weight level (SPL) or acoustic weight level is a logarithmic measure of the powerful weight of a sound with respect to reference esteem.

Sound pressure $p = p_{static} + p$

Where,

p = total sound pressure

P_{static} = static pressure

Sound pressure level, represented by p and measured in dB, is characterized by [4]

Sound pressure level $= 20\log_{10}$ (pressure measured / reference pressure)

$$SPL = 20 \log_{10} (p / p_o) \text{ dB}$$

Where,

p = root mean square sound pressure

p_o = reference sound pressure

Table 1.1: Health effect of high exposure of sound pressure

Effect	dB(A)
Hearing impairment	70-75
Hypertension	70
Heart disease	70
Performance	70
Annoyance	40
Disturbances in sleeping pattern	<60
Awakening	55
Sleeping quality	40
Mood to next day	60

The distance of the measuring microphone from a sound source is regularly discarded when SPL estimations are cited, making the information pointless. On account of encompassing ecological estimations of "background" noise, remove require not be cited as no single source is available, however, when measuring the noise level of a particular bit of gear the separation ought to dependably be expressed. A distance of one meter (1 m) from the source is an every now and again utilized standard separation. On account of the impacts of reflected noise inside a shut room, the utilization of an anechoic chamber considers sound to be equivalent to estimations made in a free field environment.

As per the inverse proportional law, when sound level p_1 is measured at a distance r_1, the sound level p_2 at the distance r_2 is:

$$P \ \alpha \ (1/r)$$

$$(P_2/p_1=r_1/r_2)$$

$$p_2 = p_1 + 20\log(r_1/r_2)\ \text{dB}.$$

Sound intensity

Sound intensity is the product of the sound pressure and velocity of the particle. It is represented I and unit is watts per square meter (W/m^2)

$$I=p*v$$

Average sound intensity in time t

$$I = 1/t \int_0^t p(t) * v(t) dt$$

Table 1.2 Sound pressure level for different sources

Source of sound	**Sound pressure**	**Sound pressure level**	**Loudness**
	Pascal	**dB re 20 µPa**	**sone**
threshold of pain	100	134	~ **676**
hearing damage during short-term effect	20	approx. 120	~ **256**
jet, 100 m away	6 ... 200	110 ... 140	~ **128 ... 1024**
jack hammer, 1 m away / nightclub	2	approx. 100	~ **64**

hearing damage during long-term effect	6×10^{-1}	approx. 90	**~ 32**
major road, 10 m away	2×10^{-1} ... 6×10^{-1}	80 ... 90	**~ 16 ... 32**
passenger car, 10 m away	2×10^{-2} ... 2×10^{-1}	60 ... 80	**~ 4 ... 16**
TV set at home level, 1 m away	2×10^{-2}	approx. 60	**~ 4**
normal talking, 1 m away	2×10^{-3} ... 2×10^{-2}	40 ... 60	**~ 1 ... 4**
very calm room	2×10^{-4} ... 6×10^{-4}	20 ... 30	**~ 0.15 ... 0.4**
leaves' noise, calm breathing	6×10^{-5}	10	**~ 0.02**
auditory threshold at 1 kHz	2×10^{-5}	0	**0**

1.1.3 Loudness

Loudness is the subjectively sensed attribute of the sound, which able to receiver to order the magnitude on a scale from soft to loud. Loudness is the sensation it does not directly measure for the same sound level, it is loud for older or unhealthy person and soft for young people. Sone is the unit of the loudness and it define as the loudness of 1000Hztone having SPL of 40 dB. Its nature is subjective scaling and has constituted in such a way loudness of the sound 2 sone is twice as the 40 dB reference sound of 1 sone and is linear nature, phon logarithmic nature it is also unit of the loudness. Loudness increases when the sound intensity increasing.

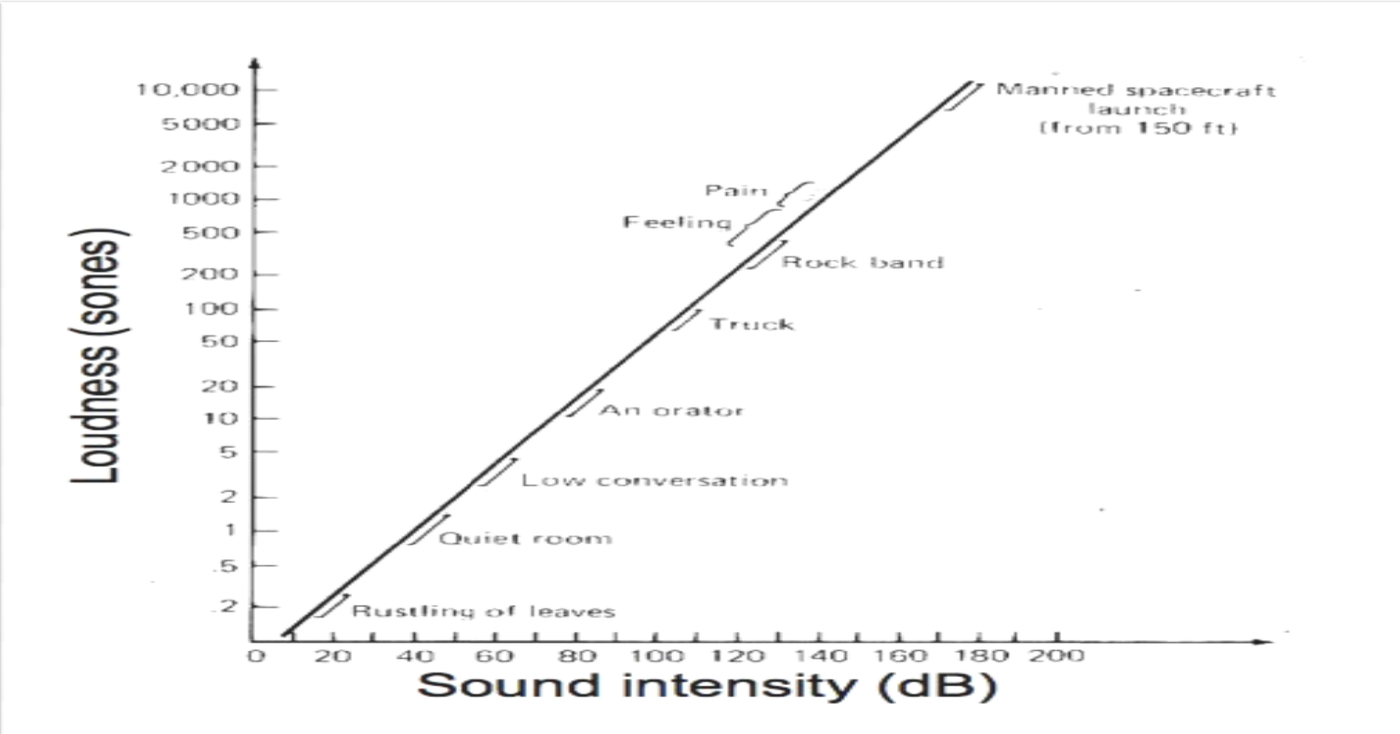


Fig.1.2 Relation between loudness and sound intensity

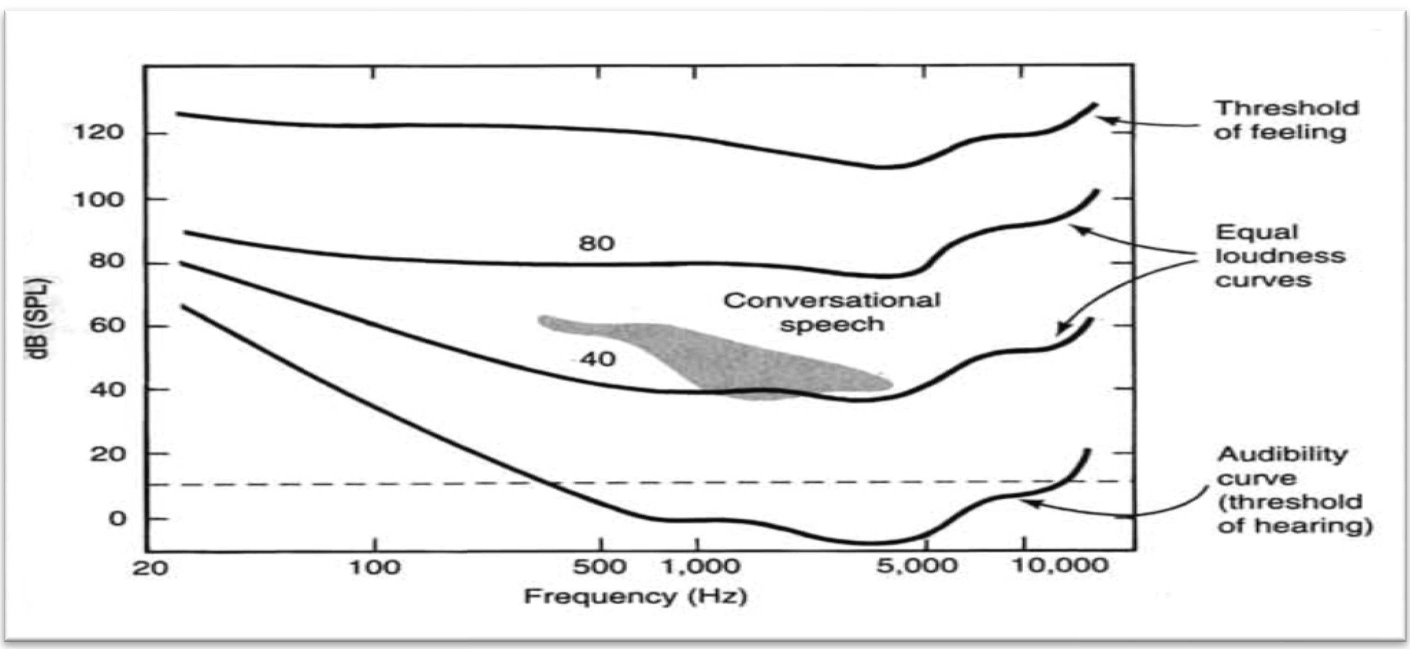


Fig 1.3 Equal contour line of loudness

1.1.4 Frequency

For cyclical processes, such as rotation, oscillations, or waves, frequency is defined as a number of cycles per unit time. In material science and designing controls, for example, optics, acoustics, and radio, frequency are typically meant by a Latin letter f or by the Greek letter or ν (nu) (see e.g. Planck's equation). For a basic symphonic movement, the connection between the recurrence and the period is given by

The SI unit of frequency is the hertz (Hz), named after the German physicist Heinrich Hertz; one hertz implies that an occasion rehearses once every second. A past name for this unit was cycling every second (cps). The SI unit for period is the second.

A conventional unit of measure utilized by turning mechanical gadgets is cycled every moment, contracted r/min or RPM. 60 RPM levels with one hertz. [3]

For intermittent waves in non dispersive media (that is, media in which the wave speed is free of recurrence), recurrence has a reverse relationship to the wavelength, λ (lambda).

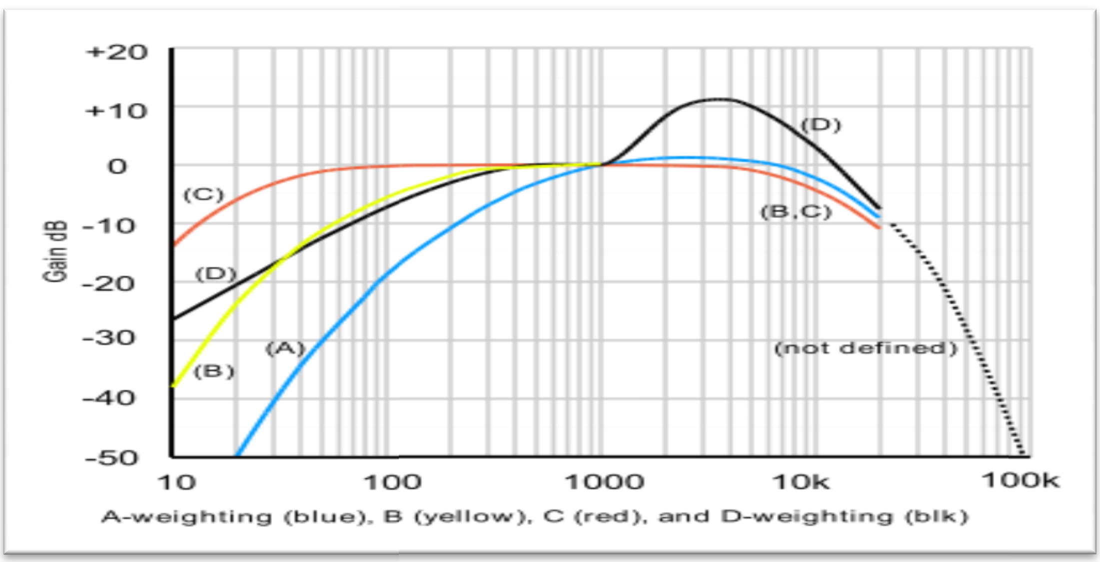


Fig 1.4 Frequency weighting curves

The A-weighting bend has been generally adopted for environmental noise estimation, and is standard in many sound level meters. The A-weighting system is utilized as a part of any estimation of natural noise (cases of which incorporate roadway noise level, rail noise, air ship noise).

A-weighted SPL estimations of noise level are progressively found in deals writing for household apparatuses, for example, refrigerators, freezers and computer fans. A noise level of more than 85 dB (A) every day builds the hazard figure for hearing harm. The reaction of the human ear shifts with the sound level. At more elevated amounts, 100 dB or more, the ear's reaction is complimentary, as appeared in the C-Weighted Response to one side. C-Weighting is generally utilized for Peak estimations and furthermore in some amusement clamor estimation, where the transmission of bass commotion can be an issue. C-weighted estimations are communicated as dB C or dB (C).

B-and D-frequency weightings are never again depicted with the body of the standard IEC 61672 : 2003, yet their frequency reactions can be found in the more seasoned IEC 60651, in spite of the fact that that has been formally pulled back by the International Electro-specialized Commission for IEC 61672 : 2003. The frequency weighting resistances in IEC 61672 have been fixed over those in the prior norms IEC 179 and IEC 60651 and in this way instruments agreeing to the prior details should never again be utilized for legitimately required estimations.

Z-or ZERO recurrence weighting was presented in the International Standard IEC 61672 of every 2003 and was expected to supplant the "Level" or "Straight" recurrence weighting regularly fitted by producers. Z-weighting is a level recurrence reaction of 10Hz to 20 kHz ±1.5dB. This reaction replaces the more established "Direct" or "Unweighted" reactions as these did not characterize the recurrence run over which the meter would be straight. Z-weighted estimations are communicated as DBZ or dB (Z).

1.2 Noise level in the form of (% exceeded) Lx

Lx is the noise level when it exceeded for x % in of the particular time period or monitoring time. It’s happened due to variation of the sound pressure with time.

L_{max}= maximum noise level at that time.

L_{1}, $L_{2,......}$ L_{9} = A singer of the highest noise level, 1%, 2%, 9% but these are neglecting up to 9%

L_{10} = A signifier maximum noise level, which is the 10% exceeded at the time.

L_{50} = the noise level 50% exceeded in time. It is represented as the midpoint of the noise level deviation

L_{90} = L_{90} normally represent background or ambient level of a noise environment L_{90} is the exceeded 90% of the time

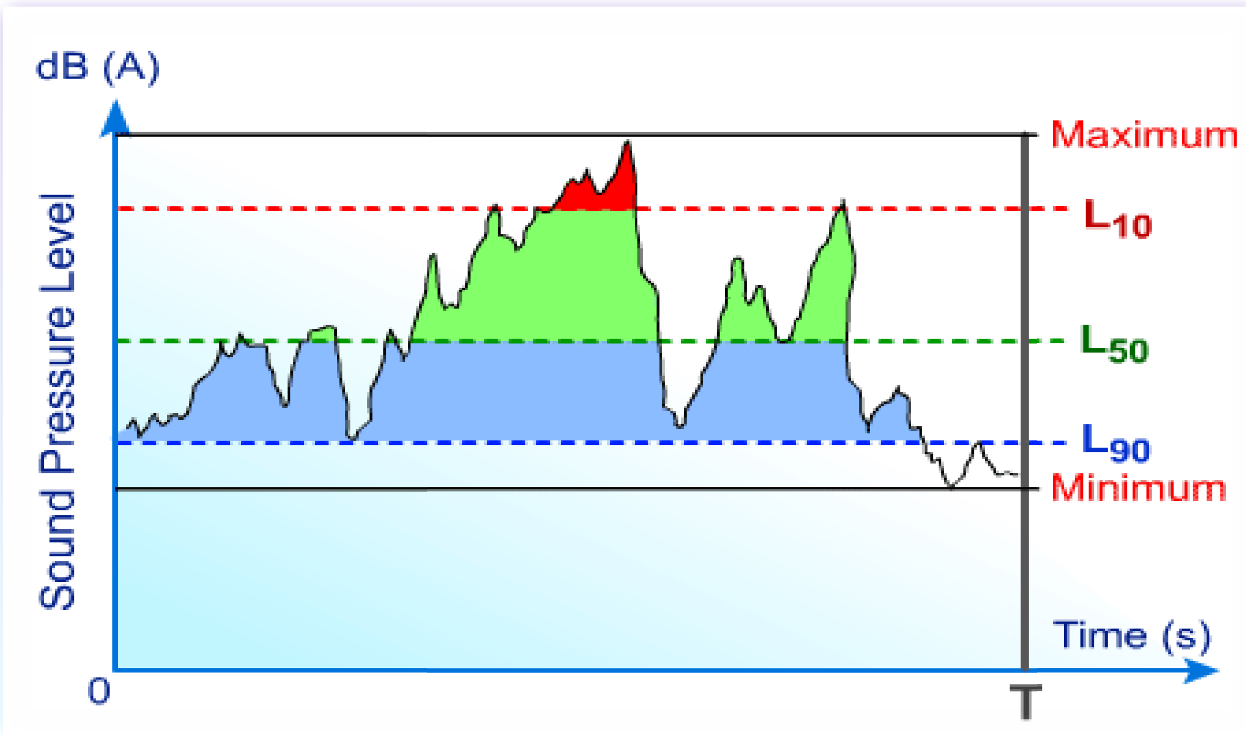


Fig 1.5 Statically distribution of noise level L_{10}>L_{50}>L_{90}

1.2.1 Leq Equivalent noise level

Equivalent noise level defined as the mean or the steady sound level, which retain the same amount of the acoustic energy level over the prescribed period of time .The monitoring time period is one hour, eight hours, sixteen hours and 24 hours.

$$Leq = 10 \log_{10} \int_0^T [\frac{p}{p0}]2$$

Where,

T = Total monitoring time

P = sound pressure or acoustic

P_0 = Reference pressure level 2×10^{-5} pa

$$\mathbf{Leq = L_{50} + (L_{10} - L_{90})^2 / 60}$$

1.2.2 Traffic noise index (TNI)

United Kingdom (UK) government was developing the traffic noise index for monitoring of motor vehicles annoyance. The traffic noise index is the sum of the climate noise, background noise and yield noise number depending on the nature of the sources.

$$\mathbf{TNI = 4\,(L_{10} - L_{90}) + L_{90} - 30\ dB\ (A)}$$

Where, Range of Climate noise= 4 $(L_{10}-L_{90})$

Background noise = L_{90}

Yield noise number =30 dB (A)

1.2.3 Noise pollution level (L_{NP})

Noise pollution is the sum of the equivalent noise level and the difference of L_{10} to L_{90}. It explains both traffic and aircraft noise condition.

$$\mathbf{L_{NP} = L_{eq} + (L_{10} - L_{90})}$$

Where,

L_{NP} = Noise pollution level

Leq = equivalent noise level

L_{10} = Noise level exceeding 10% in the monitoring time period

L_{90} = Noise level exceeding 90% in the monitoring time period

In urban area Industrial and commercial activity and transportation sector contribute 75% noise pollution. In transportation sector road traffic noise contributes 50 % and others all contribute 50 %, so that road traffic noise more affected the people. Residential area along the highway people more affected by the impairment, sleepiness, headache, and physiological disorder after that it can be used at the planning stage of the construction (road and fly over bridge) work in an urban area.

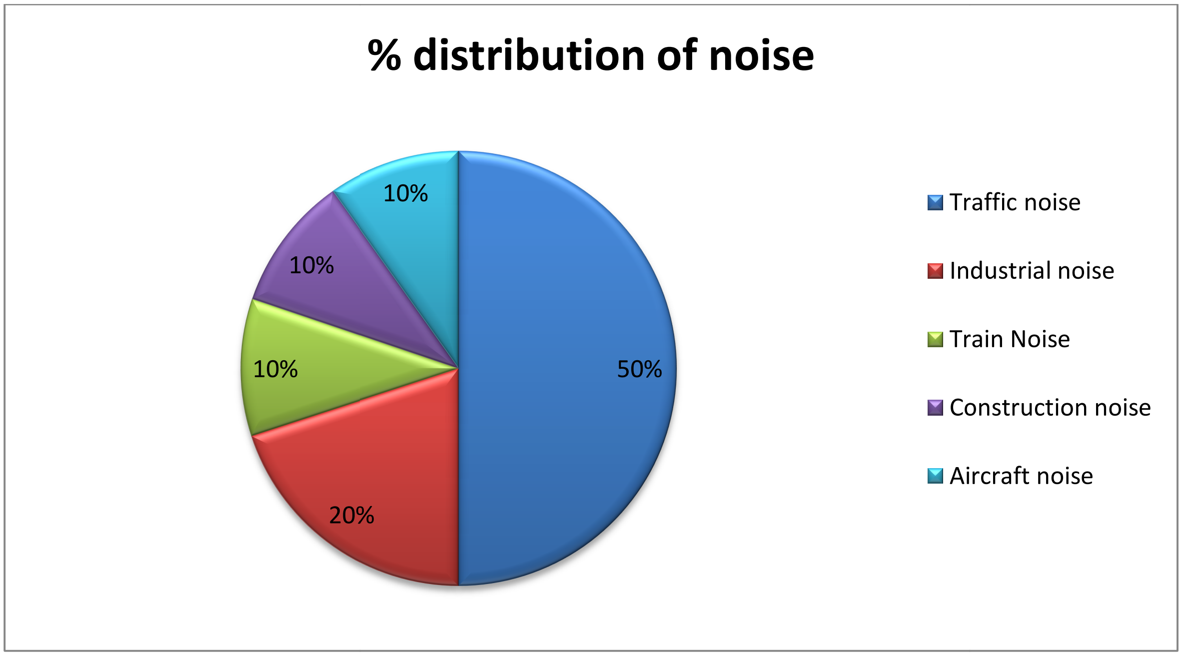


Fig 1.6 Percentage distribution of noise pollution in urban area

1.3 Objectives of the Study

- To investigate the traffic noise at various selected locations of Delhi.
- To develop the noise prediction model in urban areas of Delhi.
- To compare the monitored noise level with the predicted and permissible noise level
- To validated the noise prediction road model i.e. RLS-90 with the experimentally measured noise level in the urban areas.
- To forecast the traffic noise level for the year 2022, 2027 and 2032.

1.4 Organisation of thesis

There are six chapters in this thesis, Chapter 1 represents the introduction, Chapter 2 literature review, prediction Chapter 3,describes traffic noise prediction models and factor affecting the traffic noise level like traffic volume, traffic flow, road surface, gradient and meteorological condition. Chapter 4 methodology describes monitoring and analysis of traffic noise, procedure for noise prediction models, validation and development of the noise prediction model. Chapter 5 result and discussion, discussion present traffic noise level, validation of model and develop the prediction noise model. Chapter 6 Conclusion, describes the major finding of the study.

CHAPTER-2

LITERATURE REVIEW

An exhaustive survey of literature on traffic noise mention that the main objective of the various researchers in the following direction.

- Estimation of road traffic noise level
- Establishment of different parameters affecting traffic noise pollution
- Undertaking traffic noise surveys
- Formulation of mathematical models for noise prediction
- Compared with standard noise level

Our nation is the best example of the unity in diversity in the all sense climate, religions and people. India is a noise loving country, there are various festivals create more noise. A survey of noise level conduct by Lai (1984)

(Talukdar, 2001) examined the noise exposure from the material enterprises and demonstrated that a huge number of material specialists, particularly weavers experience the ill effects of modern hearing misfortune. He proposed, there ought to be considerable endeavors by the hardware makers, keeping the clamor discharge as low as could be expected under the circumstances while enhancing the speed of their machines.

Traffic noise modeling –Indian scenario

Sharma et al.(2014) equivalent traffic noise level calculated by the developmental model of equivalent traffic noise level based on four input variables, i.e. equivalent traffic flow (Q_e), equivalent speed of vehicles (S_e), distance (d) and honking (h). The study represented that honking has an important impact on traffic noise assessment. The discussed model performs well for traffic flow above 30 km/h while it needs further improvement where traffic is flowing at a creeping speed of less than 30 km/h. The study also shows that traffic parameters such as horn intensity, duration, driving pattern, and frequent gear changes, affect the sound level and need further investigation for better traffic noise prediction and noise pollution management.

Chakraborty et al.(1997) the studies carry out to measure of the traffic noise level at 24 locations in Calcutta. The A-weighted value of Leq (24), Ldn, L10, L90, L99, noise pollution level and total noise index has been determined. For every the site equivalent noise level (Leq) ranged from 81.3 dB (A) to 92.1 dB (A) and Ldn ranged from 84.7 to 95.4 dB (A). Which is significantly higher than the prescribe Central pollution control board standard.

Pandya and verma (1997) determined the noise levels in some commercial, residential, and sensitive areas in propinquity of major traffic road intersections in Nagpur and found that the Leq value in daytime (6.00 am to10. 00 pm) 58 to 75 dB (A) where as in night time (10.00 pm to 6.00am) is 48 to 66 dB(A)

Dev Swaroop Kafeel Ahmad and Ravinder Singh developed a RLS-90 model The prediction of noise levels, which gives better prediction values for Indian urban conditions and design of noise barrier to controlling of noise pollution in urban areas

Pathak et al. (2007) studied indicated that 85% of the person people had been disturbed by traffic noise and 90% of the people reported that traffic noise is the one of important reason of headache, high BP problem, fatigue and dizziness at Varanasi city. Marital status was found to be significantly affecting the annoyance level caused by traffic noise and people having higher education and income level are much aware of the health impact due to the traffic noise. Traffic noise was found to be interfering daily activities such as at resting, reading, communication etc.

Goswami Shreerup (2011) conducted noise monitoring at five places on the way from Vyasa Vihar Campus to Gyan Vigyan Vihar Campus of Fakir Mohan University, Balasore, Orissa. The contributions of different types of vehicles to environmental noise were found to range from 70.4-94.2, 79.0-96.1, 77.8-110.2, 70.8-90.3, 71.0-87.5, 71.1-84.4, 72.5-86.9 and 74.0-85.4 dB (A) by cargo carrying Trucks, Tractors, Dumpers, Town Buses, Motorcycles, Bolero/Trucker, Pick up and Tempo respectively was more than the road traffic noise-limit of 70 dB (A). The noise levels of all the five locations were found to be beyond permissible limit during the day time.

Due to increasing motorization, construction of flyovers and growth in transport network, the noise level has exceeded the prescribed limits in many Indian cities. The health implications of high noise levels are being identified as hypertension, sleeplessness, mental stress, etc. Due to this adverse effect of noise level, it is essential to assess the impact of traffic noise on residents and road users. (Mishra et al. (2010))

Mishra et al. (2012) Rapid motorization and urbanization can bring many environmental issues that can endanger the sustainability of cities. Like many big urban cities, the city of Delhi in India is also suffering from various environmental problems. Road traffic is considered as a primary source of air and noise pollution. Due to the high level of uncertainty regarding the future effect of existing condition, it is very challenging for policy makers to develop policies which result in an environmentally sustainable transport system.

Mishra et al. (2014) In Delhi, this need for public transport is served mainly by buses, auto rickshaws, a rapid transit system, taxis and suburban railways. Delhi has one of the highest road densities in India. Buses are the most popular means of transport catering to about 60% of the total demand. In order to meet the transport demand in Delhi, the State and the Union government started the construction of a mass rapid transit system, including the Delhi Metro.

Mishra et al. (2016) Noise is a global problem due to several factors: increase in demographic density and the number of per capita vehicles, appliances and vehicles capable of generating loud noise, and also the fact that society is getting used to higher noise levels.

Kumar Paras and S.P.Nigam (2014) developed two mathematical models to develop to predict, L_{10} noise level for Patiala city Punjab

Tripathi et al. (2012) is said the noise is viewed as a factor in its temperament and whenever for the activity in the street may depend speed of vehicles, volume of activity and street conditions so it progresses toward becoming important to distinguish the commotion levels by utilizing certain instrument. Hence, in perspective of the issue been related with era of noise, his works go for doing the alteration in the RTM and do near examination of this model with Calixto demonstrate for their information collection and give deductions on the premise of the investigation being led. He likewise demonstrates the allowable commotion level for the diverse zone, for example, Residential is up to 65dB (A) and Commercial is dependent upon 70dB (A).

Banerjee et al. (2008) studied the road traffic noise level Asansol, in India. He made noise maps for affect examination and detailing of Noise Risk Zones. Mean Leq esteem gone in the vicinity of 55.1

and 87.3 dB (A). Day time Leq level gone in the vicinity of 51.2 and 89.0 dB (A), where it extended in the vicinity of 43.5 and 81.9 dB (A) amid the night. The investigation uncovers that present clamor level in every one of the areas surpasses the utmost endorsed.

Akhtar et al. (2012) Increasing noise level due to road traffic is a major concern for the quality of life in urban areas. It can be reduced up to some extent by adopting mitigate measures such as providing noise barriers and suitable traffic management etc. This can be achieved using noise maps, which gives the visual representation of noise level of a certain area. Therefore, in the present study, an attempt has been made to prepare noise maps for various important locations of Delhi city using GIS and Predictor software. Critical locations have been identified in preliminary survey for noise level measurements. The noise levels in terms of L10, L50, L90, and Leq have been measured using digital Sound Level Meter (Larson and Davis, USA, Model –831). The equivalent noise levels measured at various locations have been ranging from 53 dB(A) to 83 dB(A).

Nirjar R.S. (2002) utilized a different set up models for prediction of the road traffic noise level for an urban zone. The information gathered at various destinations in Delhi has been investigated and contrasted and the qualities anticipated by each of three models. Likewise, a relapse show for expectation of noise level was produced from the information gathering in eight unique areas in Delhi

Singh et al., (2013) is available a recreation plan to reenact a versatile channel utilizing LMS (Least mean squares) versatile calculation for commotion cancelation. His principal objective behind this is to assess the commotion flag and to subtract it from unique info motion in addition to clamor flag to the cancelation of commotion and subsequently to get the clamor free flag. He likewise said in regards to the versatile commotion cancelation technique is there to assess a discourse flag which is debased by an added substance clamor or obstruction.

International scenario

Burgess M.A.(1977) proposed a traffic noise model for prediction of the traffic noise level in term of L_{10} and Leq where in assuming that the speed of the vehicles stand excluded. This model is used in the development of the noise pollution level prediction for L_{10} is valid for uninterrupted traffic condition and is used in Australian urban road condition.

Gilbert et.al.(1980) proposed a noise predictive model for prediction of noise level in term of L_{10} for interrupting flow condition. This model is suitable for urban street having traffic signal intersections and other features which affected the free flow characteristics.

Peng and Mayorga (2008) Hearing sensitivity decreases as the frequencies fall below 100Hz. In addition to Prebycusis, exposure to noise decreased hearing sensitivity. This sort of hearing loss is known as “Noise Induced Hearing Loss”. Exposure to noise is hazardous and can cause physical or psychological stress.

Claudio Guarnaccia et.al. (2011) Traffic Noise predictive Models (TNMs) are used in order to monitor and/or predict road traffic noise impact on the environment. Usually a statistical approach is followed in the most used model buildings and compiling. This model is used in Italy for measuring of noise level and is suitable of European climatic condition.

Habib K. (2016) the traffic noise pollution was predicted by using both MLP neural network and linear regression approaches. This process of modeling noise showed that linear regression and artificial neural networks could be used efficiently with the least number of parameters and be based mainly on traffic flow and its composition. Linear regression presents easy and simple models with reasonable accuracy, while MLP neural networks could be used to improve the accuracy, although, it seemed more complex.

Gilbert et.al. (1980) Road traffic noise modelling is usually performed with statistical models (e.g. Calculation of Road Traffic Noise “CORTN” algorithm) and calibrated based on experimental data related to standard conditions and assumptions, such as free flow constant-speed traffic with uniformly distributed vehicles. However, as the standard modelling approach does not take into account traffic dynamics, traffic noise emission from intersections are not always modelled correctly.

Pamanikabud P.(1987) studied the simulation of urban traffic noise along with a mathematical model of stop-and-go traffic noise for the road network in the city center is presented in this paper. The road network of the central part of Bangkok surrounded by the Cordon line of Rajchadapisek Ring Road was used as the study area.

Hankard M., Cerjan J. Leasure J. (2006) was analyse by three way first, noise levels predicted using TNM were compared to noise levels measured in various locations across the State. Second, each of TNM's input parameters was varied across its useful range, and the resulting changes in predicted noise level were analyzed. Third, noise levels predicted using TNM were compared to those predicted by other internationally recognized noise models.

Guarnaccia C. (2006) investigated that acoustical noise produced by vehicular traffic depends on many parameters, including the geometry and the general features of the road. The presence of a conflicting point, i.e. an intersection, strongly affects and modifies the simulation strategy of noise in urban environments, that is usually performed with statistical models tuned on experimental data related to standard condition (free flow traffic, intermediate vehicular volumes, etc.). In this paper, the author presents the analysis of an intersection case study in proximity of Salerno University, performed by means of experimental measurements and software simulations.

Noise scenario of Delhi

Noise pollution in Delhi last few decades, increasing due raising the population of the Delhi. According to CRRI report noise level in Ashram Chowk 83 dB (A), Patel Nagar 78 dB (A), Madhuban Chowk 77 dB (A), and Nehru Nagar 79 dB (A). High noise levels can result in cardiovascular effects and exposure to moderately high levels during a single eight-hour period causes a statistical rise in blood pressure of five to ten points and an increase in stress, and vasoconstriction leading to the increased blood pressure noted above, as well as to increased incidence of coronary artery disease. CPCB is also monitoring the noise level at the different place in Delhi, which is much above the standard noise level, ITO road intersection, East Arajun Nagar, civil lines, Anand Vihar, Shakti Nagar, Ashram Chowk, Nirman Vihar, NSIT and Sangam Vihar in these locations violation of the prescribed ambient noise level.

Today noise pollution is the important issue, especially for developing country like India, so that pollution control authority CPCB has monitored traffic noise level in 35 locations in 9 metropolitan communities (Mumbai (counting Navi Mumbai and Thane, Delhi, Kolkata, Chennai, Bangalore, Lucknow and Hyderabad (five stations in each)) in the first stage. Tarffic noise level in these places shown in fig2.3.

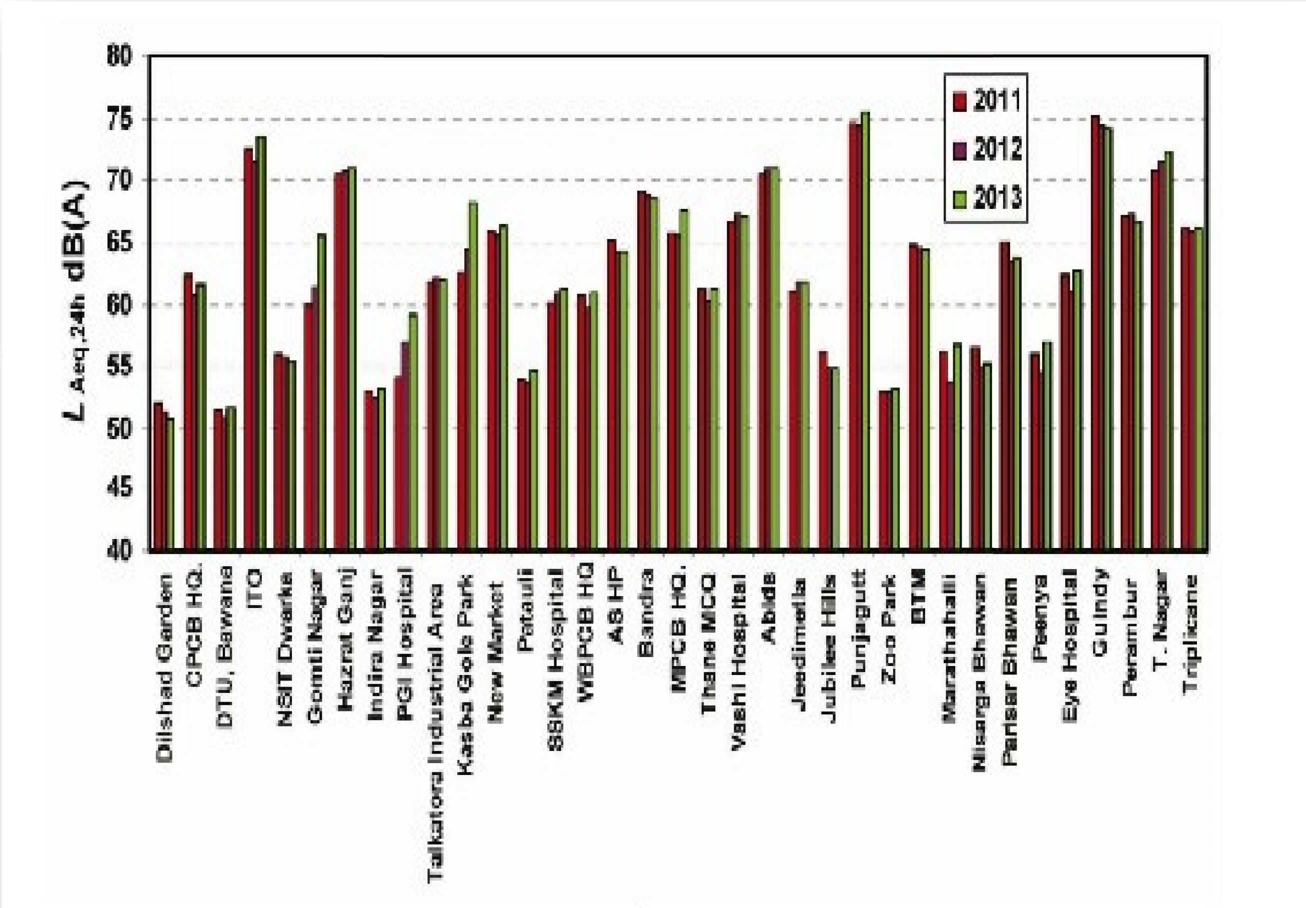


Fig 2.1 Previous years noise monitoring by CPCB at some important location

Chapter-3

TRAFFIC NOISE PREDICTION MODELS

There are some common input parameter use in traffic noise prediction model and these parameter affecting the traffic noise level like that traffic volume, vehicle speed, flow rate, type of vehicles, width of road, the surface of the road and age of vehicles.

3.1 Factors related to Traffic

3.1.1 Traffic volume

3.1.2 Type of vehicles

3.1.3 Speed of vehicles

3.2 Road characteristics

3.2.1 Traffic flow characteristics

3.2.2 Gradient

3.2.3 Road surface

3.3 Other characteristics

3.3.1 Observer distance

3.3.1 Observer height

3.3.3 Meteorological effect

3.1 Factors related to traffic

3.1.1 Traffic volume

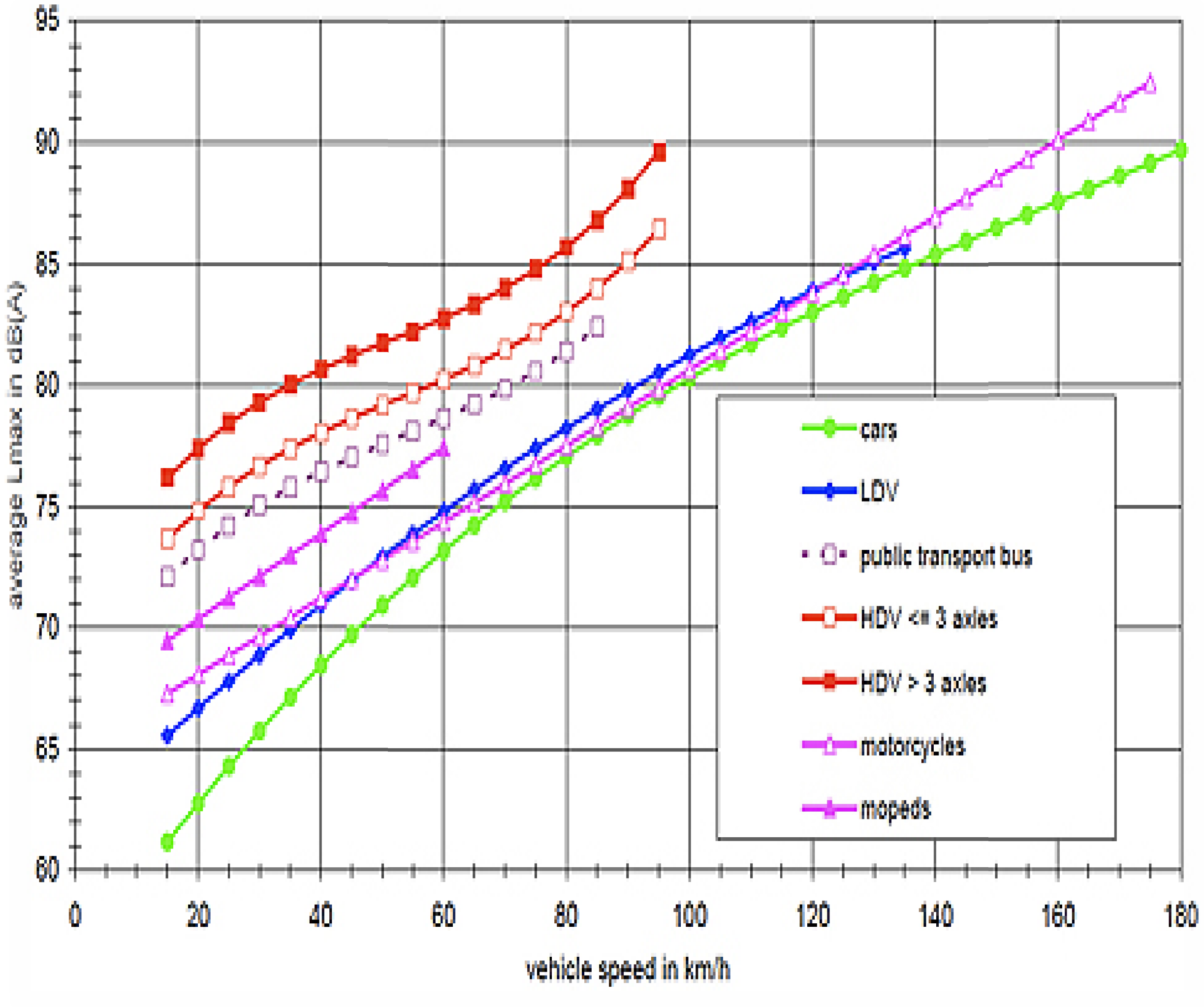
Traffic volume is the important input parameter of traffic noise level, it means a noise level directly depends on the number of vehicles. If the number of vehicles increasing or decreasing according the respective change occurring at the noise level. Traffic volume is defined as the total number of vehicles passing per hour through a particular section. In Indian condition traffic volume is may be divided according to the vehicle type and the converted in passenger car unit. Traffic volume count in the morning peak time (8.00 am to 12.00), off peak time (1.00pm to 3.00 pm) and evening peak time (4.30 pm to 7.30pm).

3.1.2 Type of vehicles

Vehicles are classified in three group passenger vehicles, good vehicles and slow moving vehicles in India. Passenger vehicles (two, three, four wheeler, minibus and bus), good vehicles (three wheeler, light carrying vehicle, heavy carrying vehicles) and their slow moving vehicles. Traffic is combined of both those groups so that a ratio is computed in the form of a percentage. If the traffic mix ratio is increasing road traffic noise level increasing.

3.1.3 Speed of the vehicles

In the urban area speed limit range decided for every vehicle, according to Indian traffic rule for car 40-50 km/hour and for heavy vehicles 35-40 km/hour. Speed of vehicles is directly affecting the noise level, it means the noise level increasing when the speed of the vehicle increasing. Interrupted traffic condition acceleration and deceleration process repeated so that vehicles producing more noise when speed is increased. From the fig (4.1) its show the variation of the noise level of each vehicle according to speed. In this fig speed range 40-60 km/hour the variation of the noise level graph is near about straight line nature.



(Source- Pamanikkabud research paper)

Fig.3.1 Variation of noise level (Lmax) according to speed of vehicles

3.2 Road characteristics

3.2.1 Traffic flow characteristics

Traffic noise level depended on the flow of traffic. If the flow is smooth noise level minimum, but in the Indian traffic flow pattern is interrupted flow due to this noise level increasing day by day. Traffic flow is defined as the number of vehicles passing in the unit hour.

Flow of traffic (no. Of vehicles/hour) = traffic density (vehicles/km) *speed of vehicle (km/hour)

In the interrupted traffic condition, there is no sufficient space availed for driving speed so that more number of vehicles move together in narrow space. Another word road traffic flow is directly proportional to traffic density. Noise level decreases 3 dB cover space with vehicles is double and increases 3dB if traffic density two times at given road length.

3.2.2 Slope of the road (Gradient)

The surface of the earth is not plain at some location rise and fall. Traffic noise level according to slope of the road is varied due load on the engine and fraction increase between wheels and the surface. Gradient play complex relation to raising the noise.For e.g. when up-gradation condition load on the vehicle's engine is that due to increasing noise level rising and down slope fraction between tire and surface increases and the result is the same.

3.2.3 Road surface

The texture of the road surface plays an important role to increment the traffic noise level. If the road the surface is the smoothly there is (3-5 dB) of the noise level vary according to FHWA. For the new road surface there is no adjustment needed. Where as if the old road surface or rough the noise level increasing up to 5 dB due fraction raising between tire and surface.

Traffic noise is also depend the type of road surface concrete, cement road surface, asphalt road surface and bituminous road surface, these have the different fraction index quality of the tire. From the fig. It's show the noise reduction for the different type of the asphalt concrete road surface condition for two vehicle car and truck.

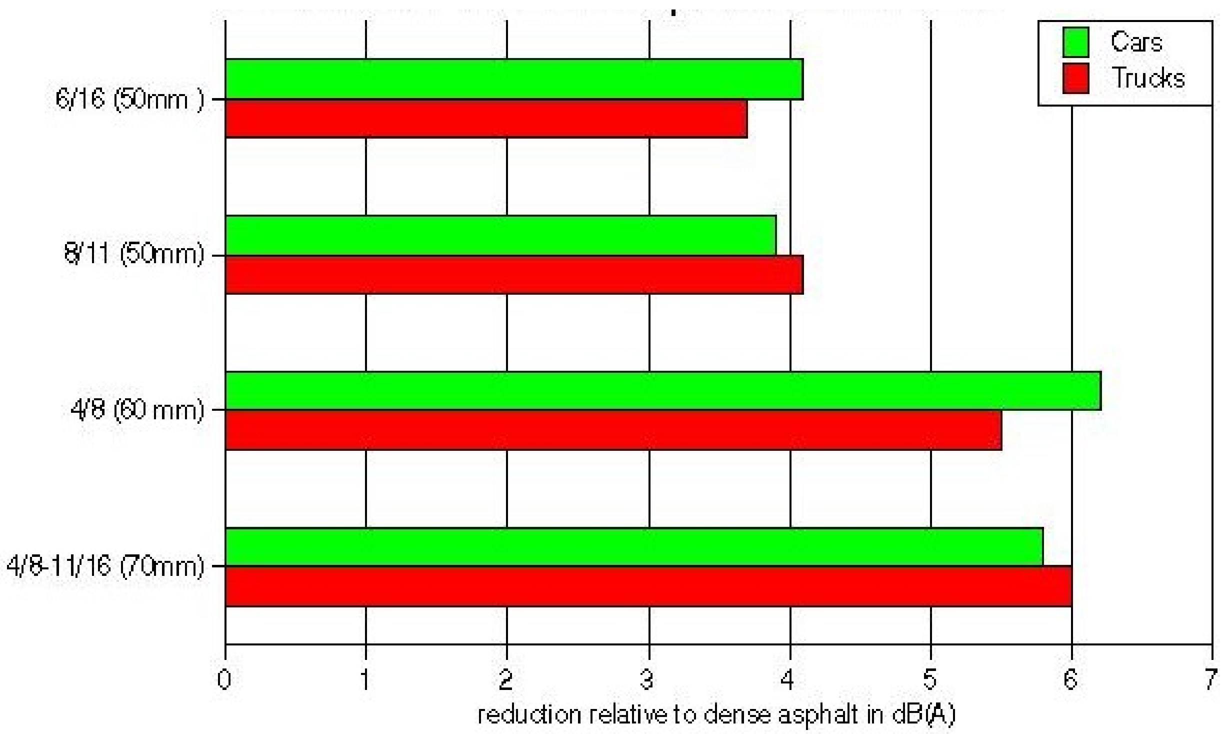


Fig.3.2 Noise variation according to the texture of the road surface

3.3 Other characteristics

3.3.1 Observer distance

Monitoring of the noise level and the prediction of the traffic noise model assume that traffic is located at the same distance (d). In real the distance of the highway and the road width is variable. Noise is the inversely propositional to distance. So that traffic noise level calculated by the single equivalent lane distance at

$$D_e = (d_n * d_f)^{1/2}$$

Where d_n=near lane distance from the observer

d_f= far lane distance from the observer

D_e =single equivalent lane distance

3.3.2 Observer height

For the traffic noise monitoring due to up gradation and down gradation, it is important that observer height should be sufficient of monitoring the right noise level. Height of the sound level meter, 1.5 meters above ground surface, for better prediction of the noise level

3.3.3 Meteorological effect

Traffic noise level affected by the meteorological condition, Such as temperature, humidity and direction of the wind. If humidity increases the fraction between tire and road surface rising, slightly increment the noise level.

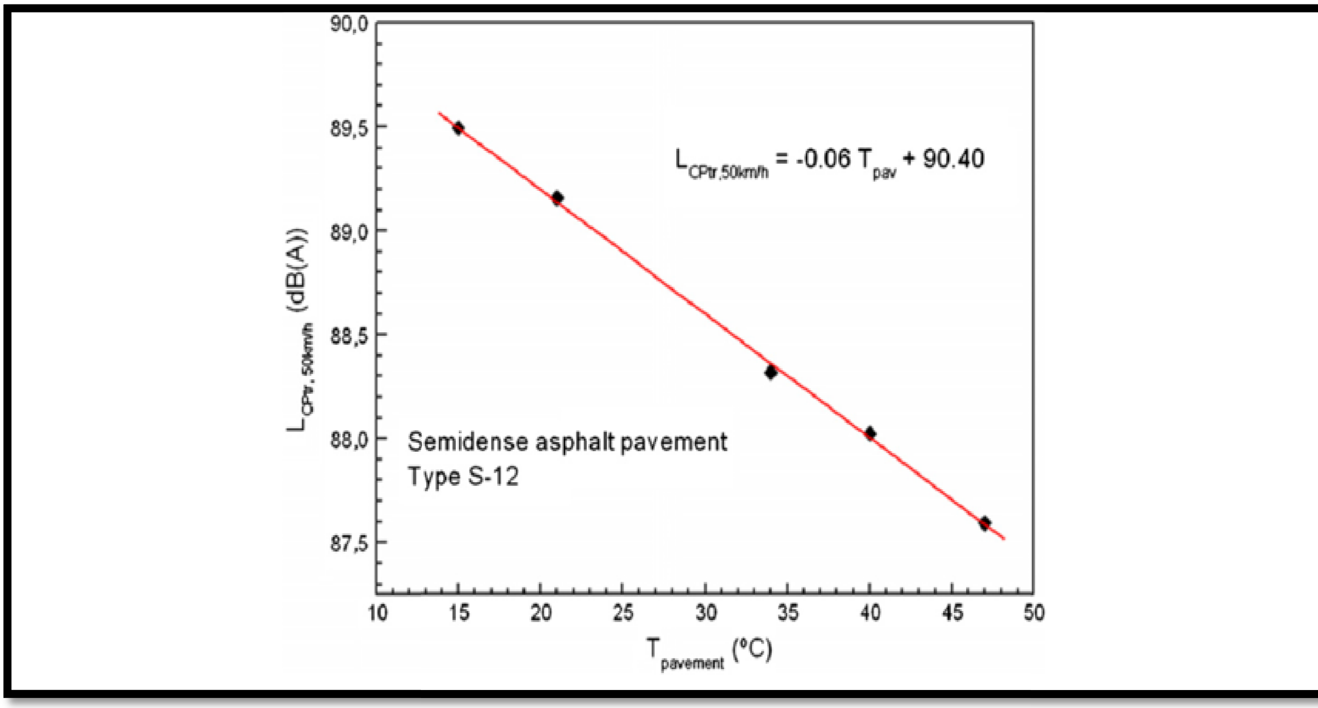


Fig 3.3 Relation between noise and temperature

3.4 FHWA-TNM MODEL

FHWA-TNM MODEL is used in the united states of America (U.S.A.) for measuring highway noise pollution. In this model vehicles are classified five types, including automobile, bikes, bus, medium truck and heavy truck. This mode is the use of the constant and non constant traffic flow condition. Traffic noise model (TNM) is affected by the pavement surface of the road surface and calculation of the noise the algorithm and one-third octave-band. FHWA-TNM model use in Indian climatic condition for hourly Leq of each type of vehicle .

$$\mathbf{Leqi = L_o + A_d + A_s + A_{vs}}$$

Where,

Leqi = Hourly equivalent noise level for each vehicle type

L0 = mean emission level at the reference point

Ad = correction due distance

$Ad=10\log (Do/D)^{1+\alpha}$

As = correction of ground cover

$As = 10\log(\psi_\alpha (\phi_1 \phi_2 /\pi))$

Avs = Volume and speed correction of noise

Calculation of equivalent noise level

Equivalent noise level is the sum of the logrthumic summation of L_{eqi} for each type of the vehicles

$$\mathbf{Leq = 10 \log (sum10^{Leqi/10})}$$

3.5 CORTN MODEL

Calculation of road traffic noise (CORTN) model is used in the United Kingdom to regulation and control of the noise pollution level. This model is the use of the road segment of road segment to prediction of the noise level. This is the fact that CORTN uses the perpendicular distance to the road segment in conjunction with the view angle correction. Where the observer is in front of the road segment, the CORTN model extends the road segment with an imaginary line to calculate the shortest perpendicular distance. L_{10} 18 hours are the sum of the L_{10} of the one in the road segment.

$$\mathbf{L}_{\mathbf{10\ (18\text{-}hourly)}} = \mathbf{1/18} \sum_{t=t1}^{t=t2} (\boldsymbol{L}\mathbf{10hourly})\mathbf{t}$$

$$\mathbf{L}_{\mathbf{10\ (hourly)\ t}} = \mathbf{C+E-A}$$

Where $L_{10\ (18\text{-hourly})}$ = when the sound pressure level exceeded 10 % for particular tim(One hour, 18 hour and 6 hours) in dB (A)

$L_{10\ (hourly)\ it}$ = when the sound pressure level exceeded 10 % for one hour in dB (A)

C=correction factor of the noise emission in dB (A)

E= emission of the noise at road or source in dB (A)

A=propagation of noise due to attenuation in dB (A)

Noise emission is depended on the no. of vehicles and the correction factors are calculated by the following formula:

C= speed correction + gradient correction + type road surface Correction

Correction due to attenuation:

$$A=A_{barrier}+A_{ground}+A_{distance}+C_{reflection}+C_{flow}+C_{angle}$$

Where;

$A_{barrier}$ = correction of the noise due screening effect in dB (A)

$A_{distance}$ = correction due to distance dB (A)

A_{ground} =correction of the noise due texture of ground dB (A)

$C_{reflection}$ = noise correction due to reflection dB (A)

C_{flow} = noise due to traffic flow condition dB (A)

C_{angle} = noise due to road segment angle view dB (A)

3.5 Stop and Go model

Stop and go model is developed for monitoring of the noise interrupted traffic flow condition. This is the firstly use in Bangkok city.In the urban area due traffic signal vehicles are not going uniform velocity, acceleration and deceleration process occur simntnniously so that this model is called stop and go model. The traffic noise level is calculated by the following:

A. Single equivalent lane model

B. Separate lane model

i. Acceleration lane model
ii. Deceleration lane model

Single equivalent lane model

The single model approach was applied to construct a single stop and go road traffic flow pattern model.This model can be connected to both sides of the road. Leq is calculated by this formula:

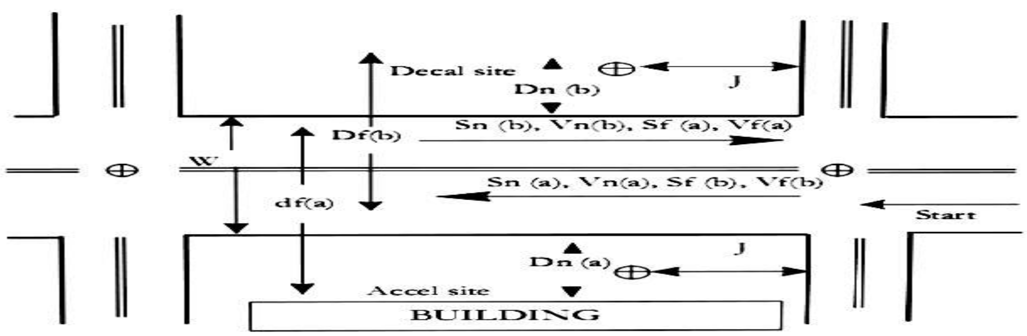


Fig 3.4: Position of sound level meter

$$\mathbf{Leq=71.05+ .10Sn + .04S_f + .95 \log (V_n) + .015 \log (V_f) -.111D_g}$$

Where,

Leq= equivalent road traffic noise level in dB (A)

Sn= near side mean speed of the traffic

S_f =far side mean speed of the traffic

V_n = traffic volume near side of the observer

V_f =traffic volume far side of the observer

D_g =geometric mean of the road secton

$Dg=\sqrt{(Dn*D_f)}$

B. Separate lane model

(i). Acceleration lane traffic noise model

At the intersection point when the traffic signal is green vehicle are in an accelerating mode at time noise level calculated by this model.

$$\mathbf{Leq= 56.91 + .09S_n + .04S_f +5.22 \log V_n +0.02 \log V_f -.006 D_g}$$

(ii). Deceleration lane traffic noise model

Deceleration is the opposite of the acceleration of the intersection point red signal vehicles goes slow down a fraction of the tire and surface increase. Noise level is predicted by the following equation:

$$\mathbf{Leq =72.12 + .07S_n +.08 S_f +.42\log V_n+ .44 \log V_f-0.061D_g}$$

3.6 RLS-90 model

RLS -90 model is best suitable for the noise map of the area and calculated the noise pollution of the area .With the help of the this data government authorities take the proper action to control the noise pollution of that location.

RLS -90 model is used in the German for the prediction of the noise pollution level in highway and parking place. RLS- 90 is two parts:

(I). Sources level emission model

(II). Propagation model

(I). Sources level emission model

Monitoring the noise level (LmE) at the 25 meter away from the road and above 1.5 m grund surface. In this model characteristic of the traffic flow, speed of the vehicles, type of the vehicles, according to its weight and texture of the road surface all these responsible factors of the L m E. Sources level emission calculated by the following formula:

$$L_M E = (Lm\ 25\ basic) + C_{speed} + C_{gradient} + C_{road\ surface} + C_{reflection}$$

Where,

Lm 25 basic =Lm is the standard noise at 25 m away from the roadside at the 100km /h speed of the car or 80km/h speed of the truck from non ground asphalt road surface which gradient less 5% and free field propagation condition.

$$Lam = 37.3 + 10*\log \{m* (1+.082p)\}$$

M=mean hourly traffic volume

P =% truck exceeding 2.8 tones

Correction factor

Speed correction

$$C_{speed} = L_{car} - 37.3 + 10*\log [100 + \{(10^{.1*c}) *p / (100+ 8.23*P)\}]$$

$$L_{car} = 27.8 + 10 *\log \{1+ (.002*V_{car})^{3\}}$$

$$L_{truck} = 23.1 + 12.5\log * (V_{car})$$

$$C = L_{truck} - L_{car}$$

V_{car} =speed of the car

V_{truck} = speed of the truck

(II). Propagation model

In this model noise level measured at the observation point noise is propagated energetic addition to the all contribution of the producing sources. Length of road and other meteorological factor affecting the noise level. Inverse relation between distance and sound, so that of the width of the road play important role.

$$Lm = Lm\ E + C\ section + C_{spreading} + C_{ground\ absorbent} + C_{screening} + C_{met}$$

$$C\ met = \exp\left[-1/200\sqrt{\{(A*B*direct\ distance/\ 2*extra\ path\ length)\}}\right]$$

RLS -90 model best suitable for the traffic noise prediction due to this model suitable for Indian traffic and climatic condition.

CHAPTER -4

METHODOLOGY

4.1 General

This chapter describes the details of the methodologies adopted in noise monitoring, modeling and validation. The noise monitoring procedure includes identification and selection of sampling locations, time duration for monitoring as well as the type of instrument used. The data analysis and steps involved in traffic noise prediction have been discussed in this chapter.

4.2 Site selection

All the locations are selected on the basis of their land use pattern. During site selection some of the locations are found under in residential or commercial and silence zone. Land use pattern like locations having high rise building on one side or both sides and locations under the flyover bridge is the most affecting factor for variation in the noise level at different locations. Selected sites with their characteristics are presented in table 4.1

4.3 Monitoring of traffic noise

Noise pollution is a major problem today in the world, but India like developing country give lower priority as compared to other problem. 120 million people suffering from hearing impairment problems in which traffic noise contributes more than other sources. Higher exposure of noise level affected more serious problem to all living beings. There is no suitable method for the monitoring of the noise level and modeling in India like developing nation but due to rising the issue on the noise pollution and its adverse effect, Grovnrment starts to work in this field.

Table 4.1 Selected site at the different location in Delhi

Serial no.	Location	Area	One side	Other side	Data used
1	Ashram Chowk	Mixed	Building	Building	Modeling
2	Lodhi road near Sai temple	Silence zone	Building	Open	Modeling
3	K.G& Tolstoy Marg	Silence zone	Building	Open	Modeling
4	Nirman Vihar	Commercial	Building	Building	Modeling
5	Pahrganj near police station	Commercial	Building	Building	Modeling
6	Peeragarhi Chowk	Commercial	Building	Open	Modeling
7	Patel Nagar Chowk	Mixed	Building	Open	Modeling
8	Shakti Nagar Chowk	Residential	Building	Building	Modeling
9	Kingsway Camp	Residential	Building	Building	Modeling
10	Badly mod near passport office	Mixed	Building	Open	Modeling

4.4 Noise measuring criteria

As per first criteria,sound level meter (SLM) is used to monitor traffic noise level and type 2 sound level meter are not in a position to give the best result . The microphone is the main part the sound level meter if possible, it may be an outdoor microphone for the best result. A second criterion is that SLM should be calibrated with a time cycle of 4 months for the better result. For monitoring of ambient noise (A-weighted) level code is used in international SLM.Shown in table 4.2

Table 4.2 International code of sound level meter

CODE	DISCRPITION
IEC-60804:1984	The international standard Integrating Averaging Sound level meter
IEC 61672:2002	The international standard for sound level meter and integrating average sound level meter superseded both IEC 60651 & IEC 60804
IEC 61260 :1995	The international standard for 1:1 Octave &1: 3 octave band filters

Height of the instrument from the road surface is 1.5 m.It is the average height of the ear all women, men and children and make a proper distance of sound level meter from the road edge for the purpose of the safety view. For the best result two sound level meter used on both sides of the road and take the mean values.

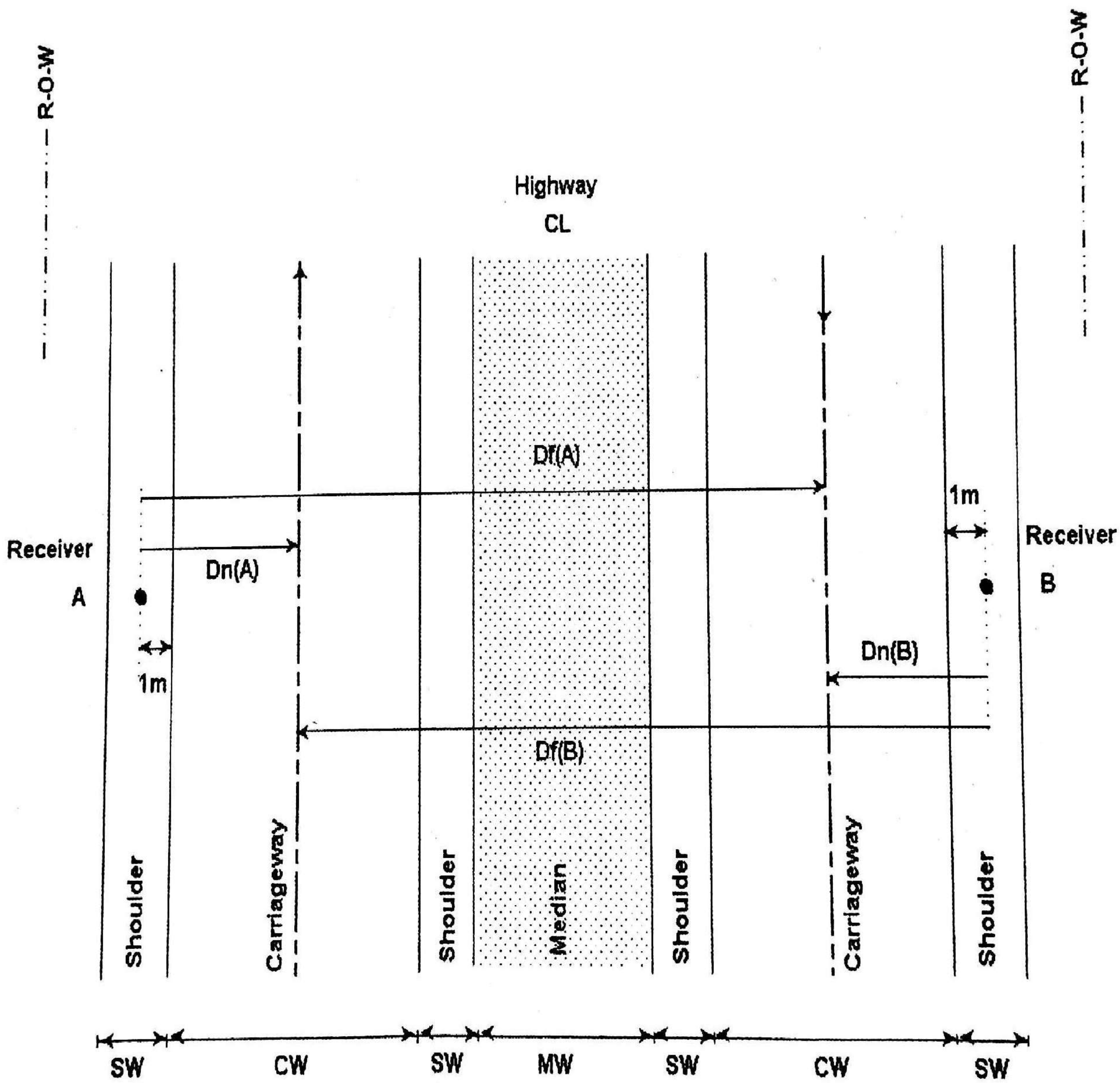


Fig. 4.1 Position of the sound level meter

4.4 INSTRUMENT

The traffic noise level has been monitored for the 1m away from the edge of the road and the height of the sound level meter is taken 1.5 m using CESVA SC 260 sound level meter. SC 260 is the type 2 instrument based on integrating averaging sound level meter and 1:1 and 1:3 octave band spectrum analyzers. It's monitored all frequencies (A- weight, C –weight and Z-weight) sound. Sound level meter calibrated before starting measuring of the traffic noise level.

Fig.4.2 Sound level meter

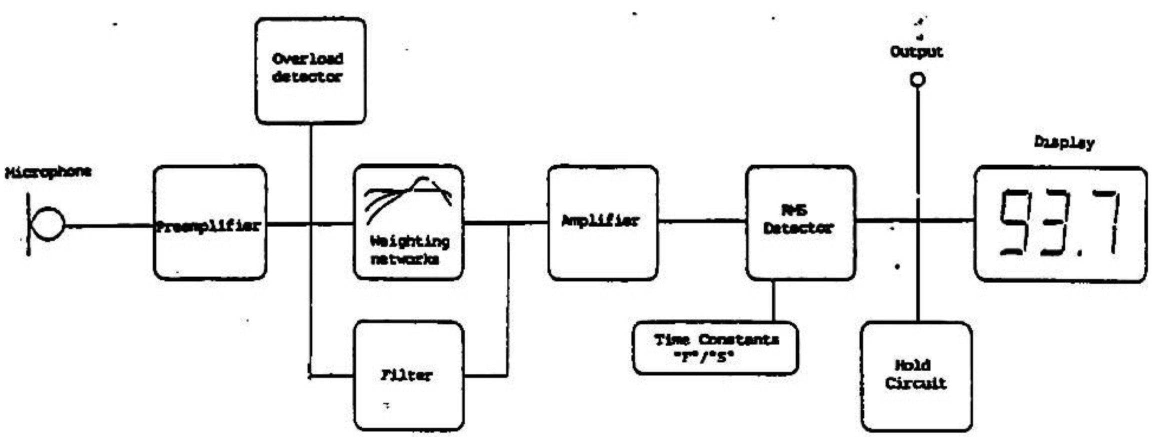


Fig 4.3 Functional diagram of sound level meter

4.5 Noise monitoring at different locations

4.5.1 Ashram Chowk

Ashram Chowk is situated at the intersection of the Mathura road and Mahatma Gandhi ring road and located at the southeast corner of the Delhi. The Land use pattern has mixed type with both sides high rise building. Ashram Chowk is the one of the busiest intersection because of link up between Utter pradesh and Haryana border.

Fig 4.4 Noise monitoring at Ashram Chowk during morning peak time

4.5.2 Lodhi Road

Lodhi road is the oldest road and it connects Nizamuddin (Ghiyathpur) village to Jor Bagh. Safdarjung's tomb and Humayun's tomb situated on western and eastern ends of the road respectively. The land use pattern of the location is silence and having one side building and the other side open. India Habitat Centre, Dayal inter college Air force Bal Bharati school and Indian social institute located there.

Fig. 4.5: Noise monitoring at Lodhi Road During evening peak time

4.5.3 Kasturba Gandhi & Tolstoy Marg

Curzon road was after independence known as the Kasturba Gandhi Marg, Who is the wife of the great social reformer and political person Mahatma Gandhi. Leo Tolstoy was the Great Russian philosopher and writer on the honor of that, Road is known as the Tolstoy Marg. Headquarter of the Indian railway (Baroda house), British Council Library, and headquarter of Hindustan times situated on this road. It is one of the roads to connect the Connaught Place. This location is one side to have tallest building and the other side is open and silence zone.

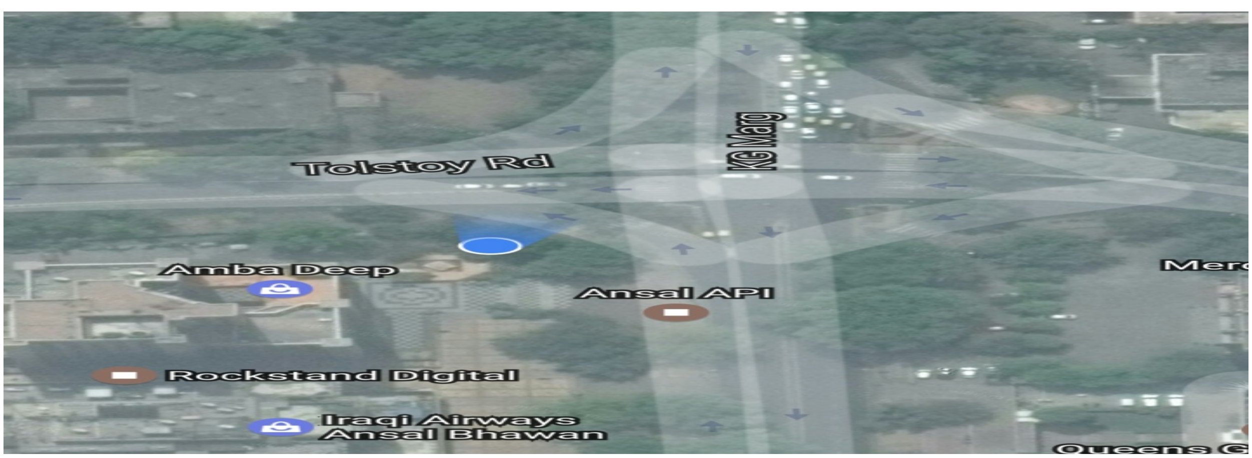


Fig 4.6 Satellite view of the location

4.5.4 Nirman Vihar

Nirman Vihar is located at the intersection of the Vikas Marg and Patparganj road in east Delhi. Nirman Vihar metro station on blue line there is no space available for parking facility near the metro station, due to this noise level more than the standard noise level. The land use pattern is commercial and both sides have covered by the building.

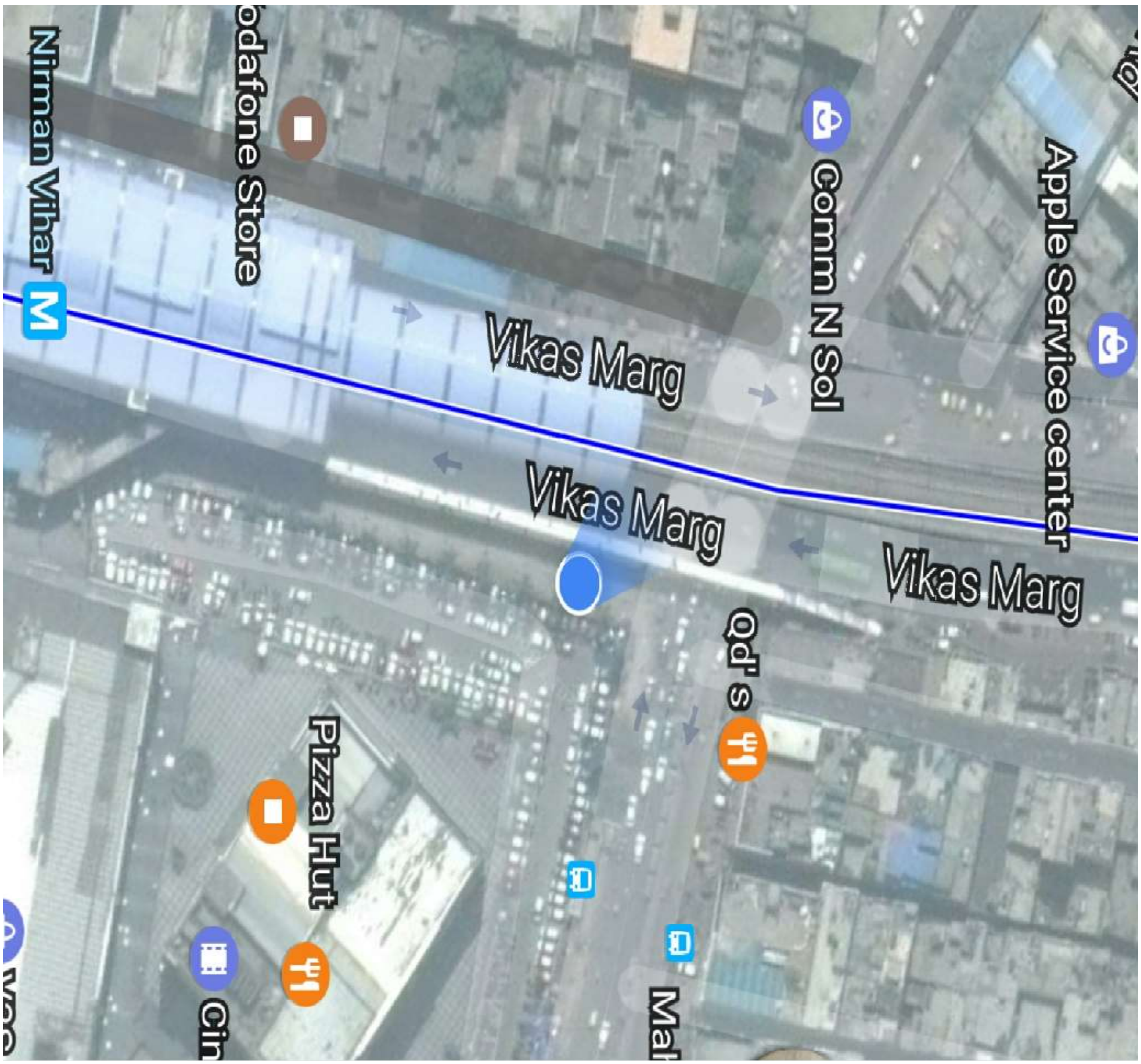


Fig 4.7 satellite view of location

4.5.5 Paharganj Chowk

Paharganj Chowk situated at the intersection of the Deshbandhu Gupta and Chitra Gupta road in (behind the New Delhi station) central Delhi. Sadar Bazar is the oldest and famous market for the household items, due to that busiest place. Paharganj become the hub of the foreign and domestictourist, near the New Delhi Railway station and easily available hotel and restaurant.

Fig 4.8 Prospective image of the Paharganj Chowk off peak time

4.5.6 Peeragarhi Chowk

Peeragarhi Chowk is located at the intersection of the Rohtak road and outer ring road in west Delhi zone. Peeragarhi is the transport hub (metro station, bus station and auto). This land use pattern of this area is mixed type and it is covered from one side and other side is open. Peeragarhi metro station is on the green line.

Fig.4.9 Monitoring of the noise level during the morning peak hour

4.5.7 Patel Nagar Chowk

Patel Nagar Chowk is the located at the intersection of the Shankar road and Pusa link road near the pasha harit Kranti park

4.5.8 Shakti Nagar Chowk

Shakti Nagar is located the main university of the Delhi and along with the grand trunk road in the north Delhi. It is the residential area and both sides have covered by the building. The narrow road width traffic noise level above the standard noise level. Shakti Nagar was the center of the political activity during British rule.

Fig 4.10 Prospective view of Shakti Nagar Chowk at morning peak time

4.5.9 Kingsway camp

Kingsway Camp is highly populated area. Kingsway camp has residential land use pattern and here large number of the students residence.

Fig 4.11 Monitoring of the noise level at Kingsway camp

Fig 4.12 Traffic flow pattern at evening time

4.5.10 Haiderpur Badli Mor

Haiderpur Badli Mor (near central Jail) Chowk 500 meters away from the metro station is located at the intersection of the outer ring road and Dr. MC Davar Marg. Both sides of the road are open and land use pattern is mixed type.

Fig.4.13 Noise monitoring during morning peak time

Fig.4.14: Traffic condition of Haiderpur Badly Mor

4.6 Process of traffic noise prediction model

The traffic noise prediction has been carried out by the following steps.

- Aggregation of the input data
- Monitoring Traffic noise level
- Substantiation of the mode

4.6.1 Aggregation of the input data

Collecting all information of the location like traffic flow, traffic volume, type of the vehicle, the speed of the vehicle, road texture, geographical information (industrial, residential, silent) and meteorological condition (wind flow pattern and temperature).

4.6.2 Monitoring of traffic noise level

Measuring traffic noise level of various locations during the morning peak time (9am to 12), off time (1 pm to 3 pm) and evening peak time (5 pm to 8 pm).computing noise level at different distance from the roadside to check out effect on noise level.

4.6.3 Validation of the model

In validation of traffic noise the model L_m has predicted by using the input parameter in term of mean traffic volume, type of the vehicles, the speed of the vehicles and other parameter. Predicted value Lm is compared with measuring traffic noise level. If their difference is 3dB (A) to 4 dB (A), the model is substantiated.

4.7 Traffic noise prediction model for urban area

Traffic flow pattern is a heterogeneous condition in India, so that developed a relationship between different types of the vehicles based on acoustic condition.

PCU Factors 1 0.5 2.2 1.4 2.2 1.4 1.4 2.2

Total equivalent traffic volume: it is delineated by V_e for 5% PCU

$$\mathbf{V_e = V_{CAR/VAN} + 0.5\, V_{TW} + 2.2\, V_{AUTO} + 1.4\, V_{MINI\ BUS} + 2.2 V_{BUS} + 1.4\, V_3\ 1.4\, V_{LCV} + 2.2\, V_{HCV}}$$

Where,

$V_{CAR/VAN}$ =Volume of the car/van

V_{TW} = Volume of the two wheeler

V_{AUTO} = Volume of the auto

V_{MB} = Volume of the mini bus

V_{BUS} = Volume of the bus

V_{LCV} = Volume of the light vehicle

V_{HCV} = Volume of the heavy vehicle

Total equivalent traffic flow: it is delineated by Q_e

$$\mathbf{Q_e = Q_{CAR/VAN} + Q_{truck} E_{truck} + Q_{bus} E_{bus} + Q_{LCV/MB} E_{LCV/MB} + Q_{AUTO} E_{AUTO} + Q_{TW} E_{TW}}$$

$$\mathbf{= Q_{CAR/VAN} + 7.8\ Q_{truck} + 7.8\ Q_{bus} + 2.93\ Q_{LCV} + 5.6\ Q_{AUTO} + 1.4\ Q_{TW}}$$

Where,

Q_e = Total equivalent traffic flow hourly

Q_{bus} = Traffic flow of bus hourly (vehicle/hour)

Q_{truck} = Traffic flow of truck hourly (vehicle/hour)

Q_{LCV} = Traffic flow of LCV hourly (vehicle/hour)

Q_{auto} = Traffic flow of auto hourly (vehicle/hour)

Q_{TW} = Traffic flow of two wheeler hourly (vehicle /hour)

Factor of equivalence:

As the reference vehicle taken a car /van

$$\mathbf{E_{vehi.} = 10^{(mean\ of\ the\ vehicle\ type-\ mean\ of\ reference\ vehicle)/10}}$$

$E_{truck} = 9.6$

The same formula is used for bus, auto, two and three wheeler and light vehicle.

$E_{bus} = 7.8$ $E_{bus} = 5.6$ $E_{LCV} = 2.39$ $E_{TW} = 1.4$

4.8 RLS-90 model

(I). **Sources level emission model**

Monitoring the noise level (LmE) at the 25 meter away from the road and above 1.5 m ground surface. In this model characteristic of the traffic flow, speed of the vehicles, type of the vehicles, according to its weight and texture of the road surface all these responsible factors of the L m E. Sources level emission calculated by the following formula:

$$L_M E = (Lm\ 25\ basic) + C_{speed} + C_{gradient} + C_{road\ surface} + C_{reflection}$$

Where,

$$Lm = 37.3 + 10*\log \{m* (1+.082p)\}$$

M=Mean hourly traffic volume

P =% truck exceeding 2.8 tones

- **Speed correction**

$$C_{speed} = L_{car} - 37.3 + 10*\log [100 + \{(10^{\cdot 1*c})*p / (100+ 8.23*P)\}]$$

$$L_{car} = 27.8 + 10 *\log \{1+ (.002*V_{car})^3 \}$$

$$L_{truck} = 23.1 + 12.5\log * (V_{car})$$

$$c = L_{truck} - L_{car}$$

Where,

V_{car} = Speed of the car

V_{truck} = Speed of the truck

(II). Propagation model

In this model noise level measured at the observation point noise is propagated energetic addition to the all contribution of the producing sources. Lengthy road and other meteorological factor affecting the noise level. Inverse relation between distance and sound, so that of the width of the road play important role.

$$\mathbf{Lm = Lm\ E + C_{section} + C_{spreading} + C_{ground\ absorbent} + C_{screening} + C_{met}}$$

Where,

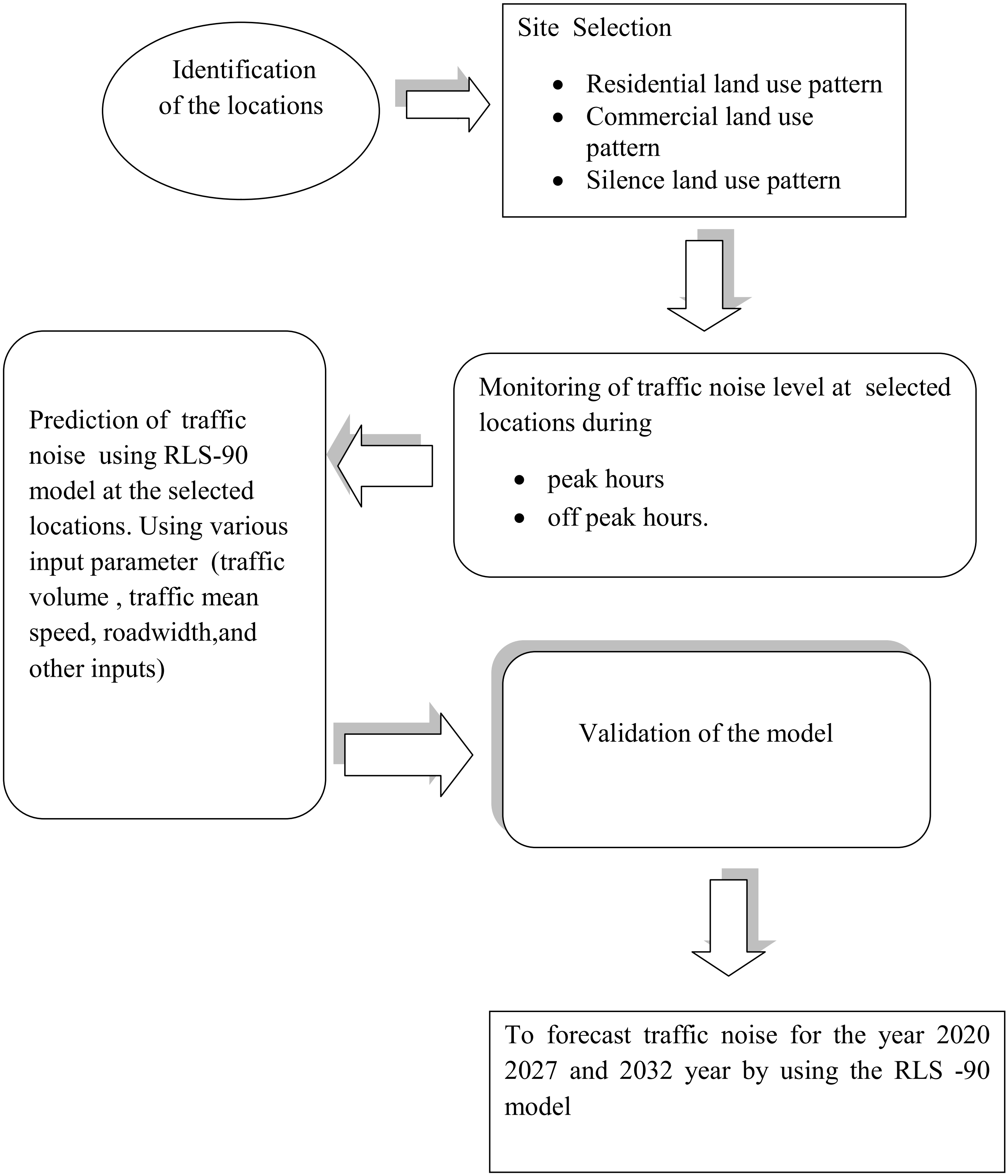
$C_{spreading}$ =Spreading correction factor

$C_{ground\ absorbent}$ =Absorbent correction factor

$C_{screening}$ = Screening correction factor

C_{met} = Meteorological correction factor

Flow chart



Identification of the locations
Site Selection
Residential land use pattern
Commercial land use pattern
Silence land use pattern
Monitoring of traffic noise level at selected locations during
peak hours
off peak hours.
Prediction of traffic noise using RLS-90 model at the selected locations. Using various input parameter (traffic volume , traffic mean speed, roadwidth,and other inputs)
Validation of the model
To forecast traffic noise for the year 2020 2027 and 2032 year by using the RLS -90 model

CHAPTER-5

RESULTS AND DISCUSSION

On the basis of the researcher's study it is assumed that in this model vehicles are adequately represented by the acoustic point sources, emission levels within vehicles groups (automobile, medium and heavy truck) are normally distributed and propagation losses are adequately represented by the distance effects because of its inverse relation with distance. Akhtar Nasim (2012) developed RLS-90 model where as Mishra et.al. (2010) developed FHWA and CORTN model for Indian traffic conditions. The predicted traffic noise level has been validated with observed noise and prediction of the traffic noise level for different period of years, taking 2017 as the base year with the help of new develop (calibrated) RLS-90 traffic noise prediction model.

5.1 Traffic noise monitoring at different locations

5.1.1 Variation of the average noise level during peak & off peak hours at Ashram Chowk:

At Ashram Chowk, average noise level vary from 76.6 dB (A) to 80.1 dB (A) and 78.3 to 84.4 dB (A) during morning and evening peak hours respectively, whereas during off peak hours it was found as 77.3 dB(A).Variation of the noise level with respect to traffic volume is shown in Fig.5.1. In residential area average traffic noise level is quite higher than the standard noise level (55 dB (A)) because of the heavy traffic flow condition and due to the high rising building on both sides of the road. At the evening peak hour traffic noise level is maximum due to high traffic density or jam condition and honking effects.

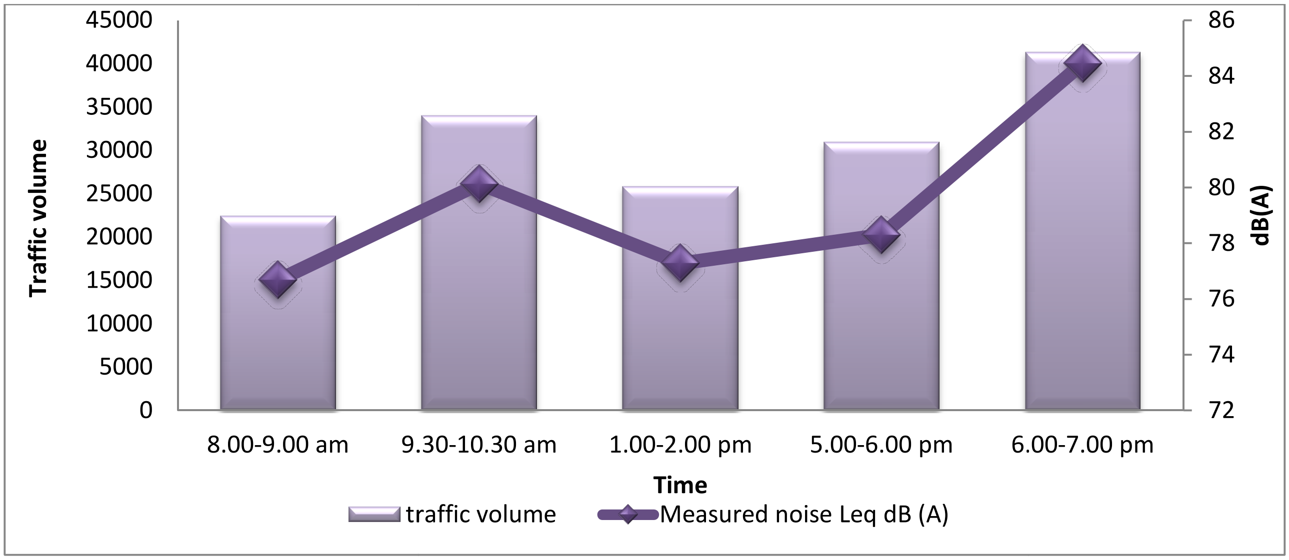


Fig 5.1 Variation of noise level during peak hours at Ashram Chowk

5.1.2 Variation of the average noise level during peak & off peak hours at Lodhi road

The traffic volume during peak hours vary from 6300 to 7340 vehicles per hour, whereas noise level vary from 70.2 to 74.8 dB (A). The Average noise level at Lodhi road vary from 74.3 to 74.8 dB (A) in morning peak hour, vary from 73.7 to 74.7 dB (A) in the evening peak hours, and off peak hours noise level is 70.2 dB (A). The average traffic noise level at Lodhi is quite higher than the standard noise because of the heavy traffic flow condition and due to the irregular movement of vehicles violating traffic signal.

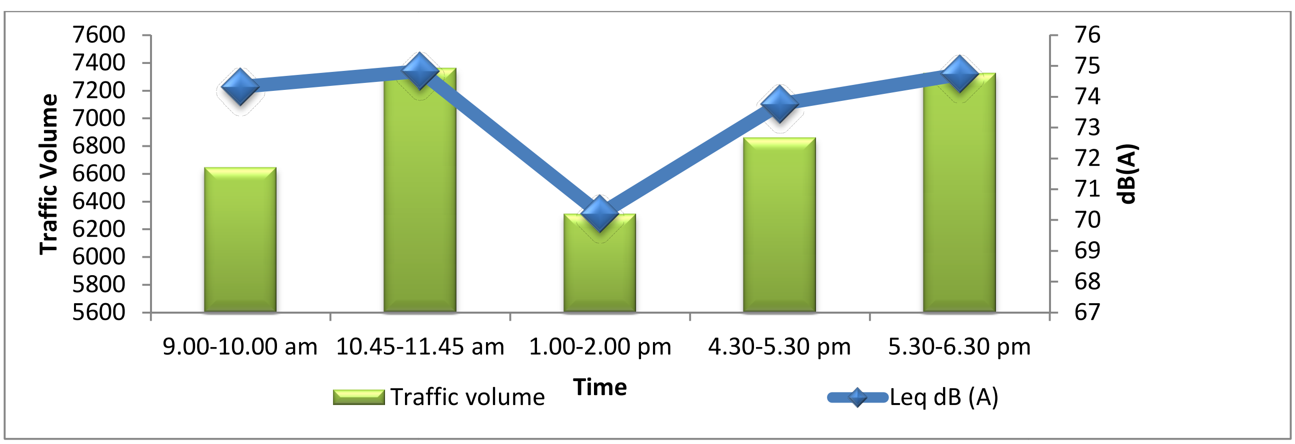


Fig 5.2 Variation of traffic noise level at Lodhi road

5.1.3 Variation of the average noise level during peak & off peak hours at K.G &Tolstoy Marg

At K.G & Tolstoy Marg average noise level vary from 72.8 to 74.7 dB (A) in the morning peak hours, in the evening peak hour vary from 71.9 to 73.7 dB (A) and during off peak hours noise level is 70.56 dB (A). The average traffic noise level at K.G & Tolstoy Marg is higher than the standard noise level (50 dB (A)).

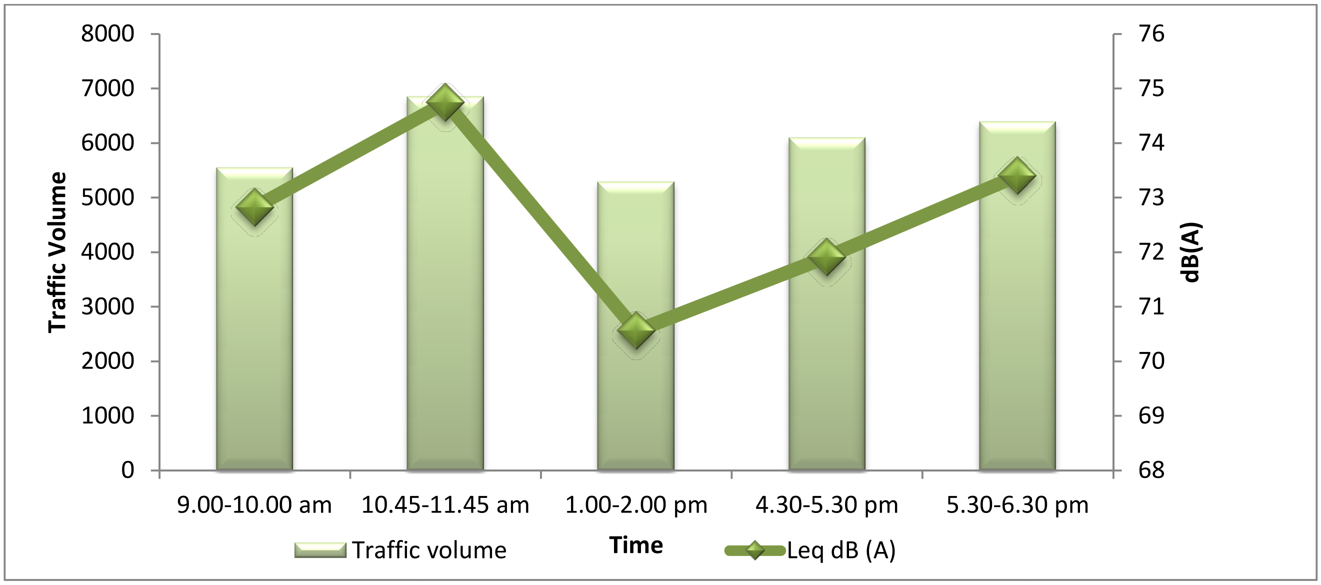


Fig5.3 Variation of traffic noise level during peak & off peak hours at K.G & Tolstoy Marg

5.1.4 Variation of the average noise level during peak & off peak hours at Nirman Vihar

The average noise level at Nirman Vihar in the morning peak hour, the evening peak hour is 75.6 to 78.4 dB (A) and 78.6 to 79.4 dB (A) respectively and off peak hour noise level is 76.3 dB(A) .The average traffic noise level at Nirman Vihar(commercial area) is higher than the standard noise level (65 dB (A)) because of Nirman Vihar metro station, there is no parking facilities result higher traffic density or congestion.

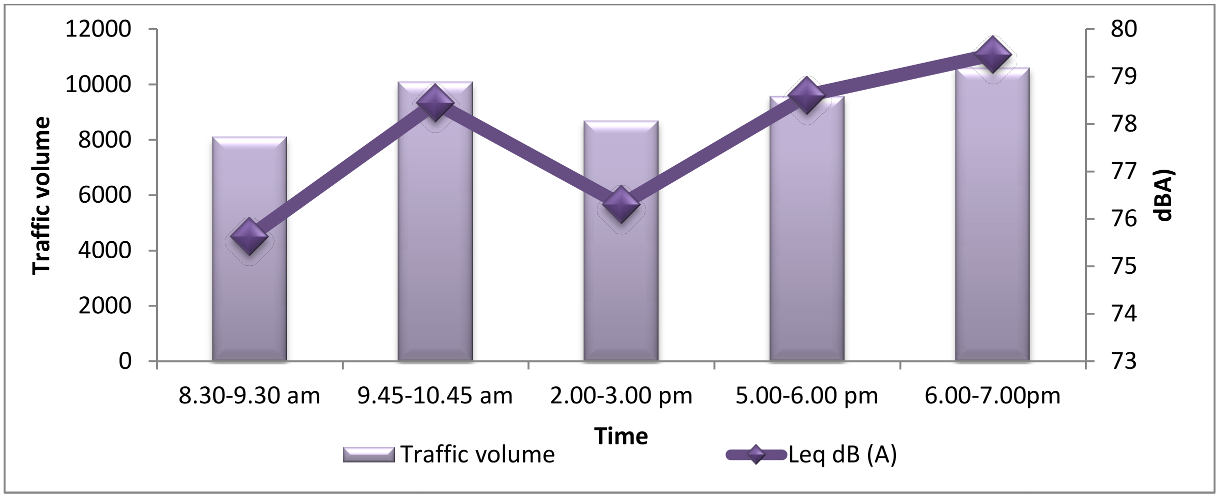


Fig 5.4 Variation of traffic noise level during peak & off peak hours at Nirman Vihar

5.1.5 Variation of the average noise level during peak & off peak hours at Paharganj Chowk

At Paharganj Chowk, average noise level was observed varying from 75.6 to 77.2 dB(A) in the morning peak hours, in the evening peak hours varied from 78.4 to 80.5 dB(A) and during off peak hours noise level was found as 76.3 dB(A). The average traffic noise level at Paharganj (commercial area) is quite higher than the standard noise level (65 dB(A)) because of the heavy traffic flow condition and high rising building on both sides of the road.

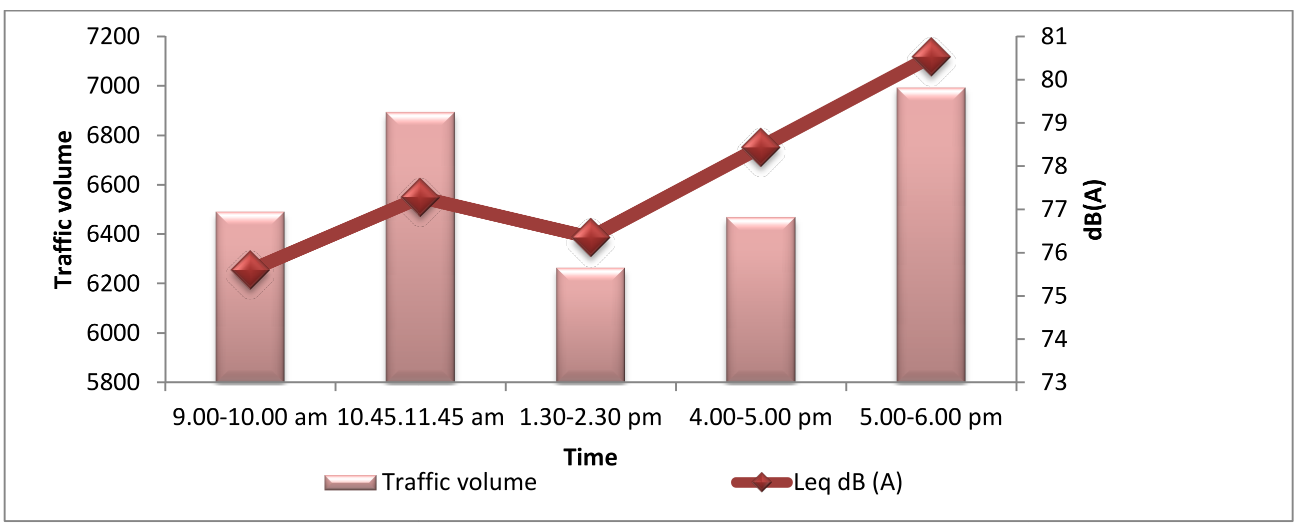


Fig 5.5 Variation of traffic noise level during peak & off peak hours at Paharganj Chowk

5.1.6 Variation of the average noise level During peak & off peak hours at Peeragarhi Chowk

The Average noise level at Peeragarhi vary from 75.1 to 80.7 dB (A) in the morning peak hours, in the evening peak hours vary from 77.6 to 79.1 dB (A), and during off peak hours noise level is 75.6 dB (A). The average traffic noise level at Peeragarhi Chowk (commercial area) is higher than the standard noise level (65 dB (A)) because of the area under the flyover bridge and heavy traffic flow condition.

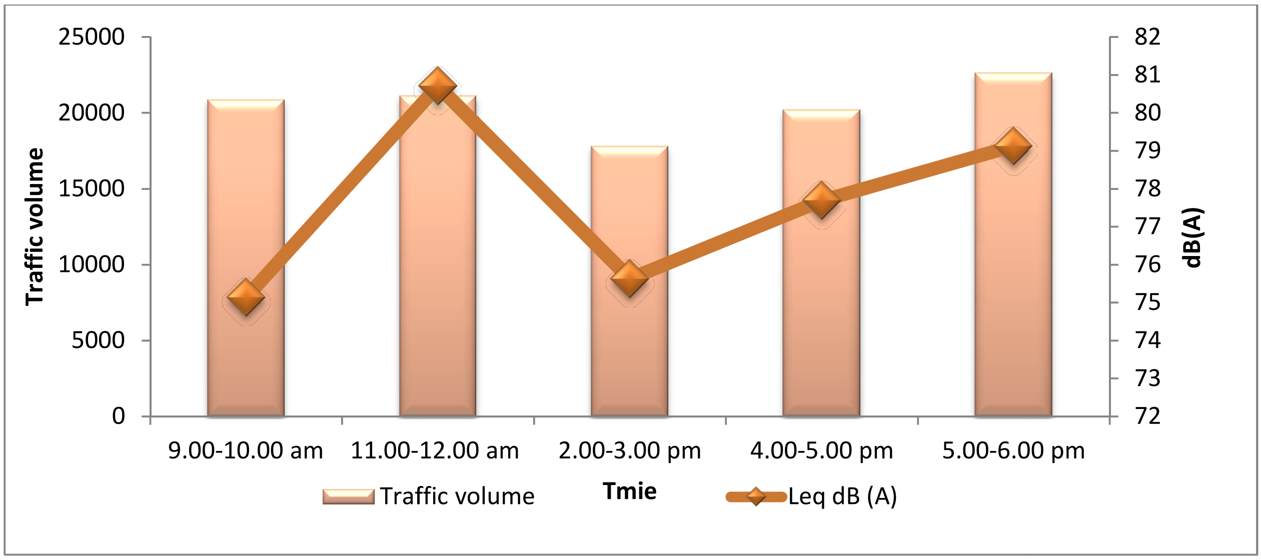


Fig 5.6 Variation of the traffic noise level during peak & off peak hours at Peeragarhi

5.1.7 Variation of the average noise level during peak & off peak hours at Patel Nagar Chowk

At Patel Nagar Chowk average noise level vary from 72.2 to 74.8 dB (A) in the morning peak hours, in the evening peak hours vary from 74.3 to 75.6 dB (A) and during off peak hours noise level is 73.7 dB (A). The average traffic noise level at Patel Nagar Chowk (residential area) is quite higher than the standard noise level (55 dB (A)) due to heavy traffic flow and interrupted traffic conditions during evening time.

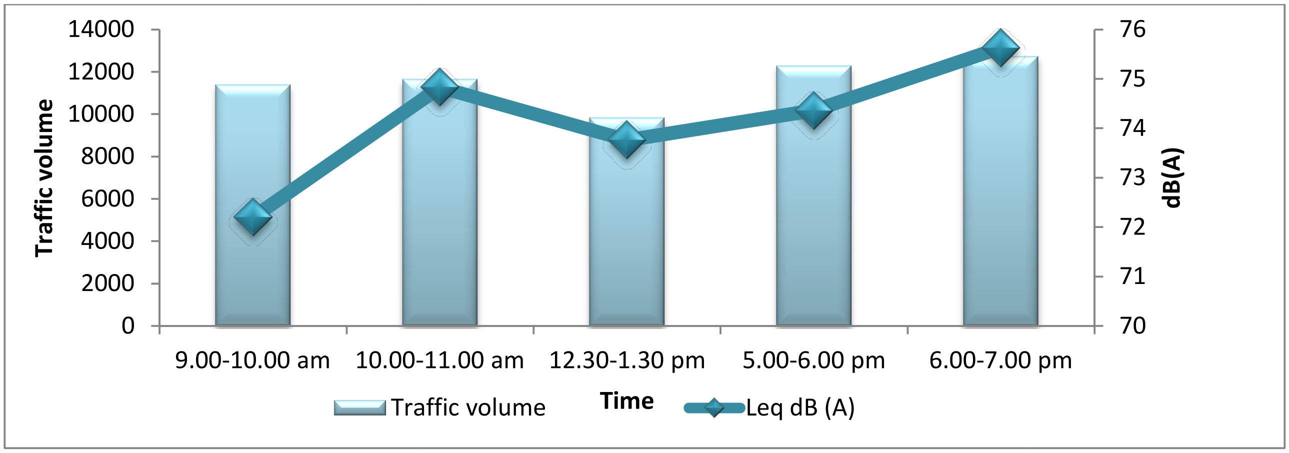


Fig 5.7 Variation of the traffic noise level during peak & off peak hours at Patel Nagar Chowk

5.1.8 Variation of the average noise level during peak & off peak hours at Shakti Nagar

The average traffic noise level at Shakti Nagar Chowk vary from 74.8 to 78.6 dB (A) in the morning peak hours, in the evening peak hours vary from 77.9 to 79.4 dB (A) and during off peak hours noise level is 74.1 dB (A). The traffic noise level in the evening peak hour is more than the morning peak hour because of high traffic density during evening time.

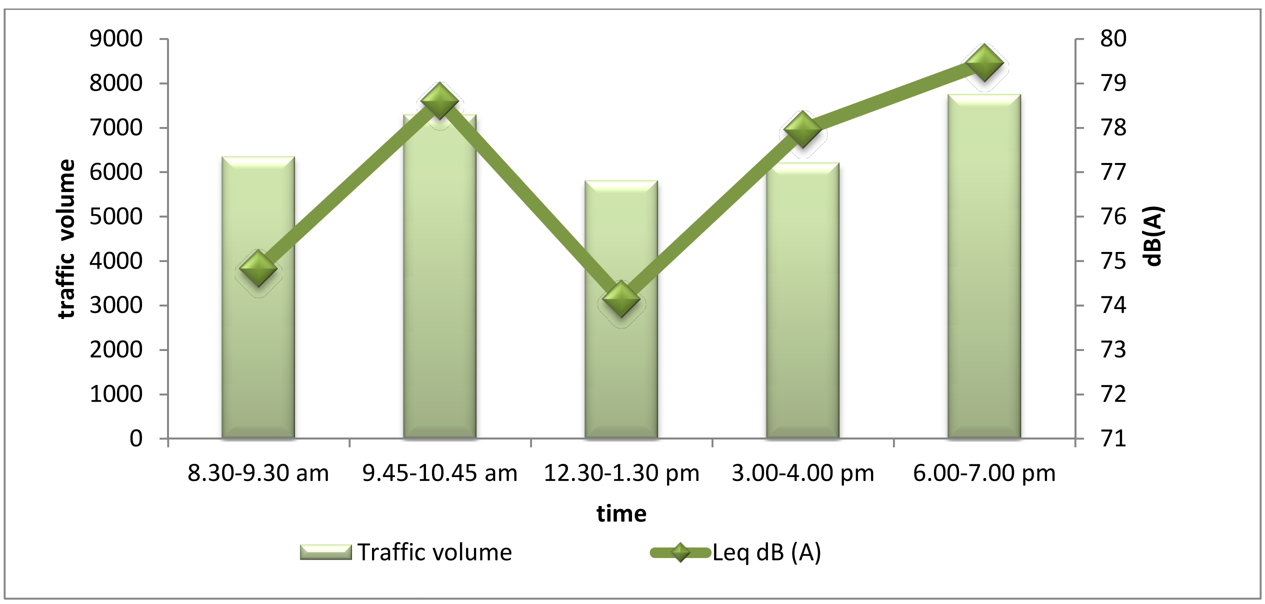


Fig 5.8 Variation of traffic noise level during peak & off peak hours at Shakti Nagar Chowk

5.1.9 Variation of the average noise level during peak & off peak hours at Kingsway Camp

At Kingsway camp, the average noise level vary from 71.9 to 75.4 dB (A) in the morning peak hours, in the evening peak hours vary from 73.4 to 73.6 dB (A) and during off peak hours noise level is 72.4 dB (A). Due to high traffic volume in the morning peak hours, the traffic noise level during morning peak hours is more than during evening time.

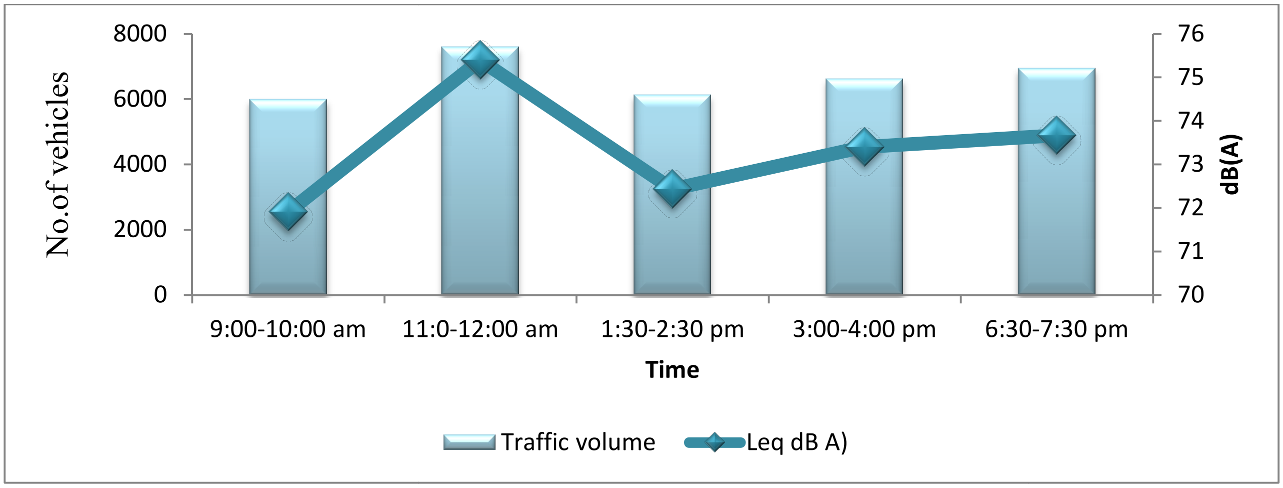


Fig 5.9 Variation of noise level during peak hours

5.1.10 Variation of the average noise level during peak & off peak hours at Haiderpur Badli

The average noise level at Haiderpur Badli vary from 76.3 to 77.2 dB (A) in the morning peak hours, vary from 74.7 to 78.4 dB (A) in the evening peak hours and off peak hours noise level is 74.28 dB (A).Due to high traffic volume during morning time the traffic noise level is more in morning evening time.

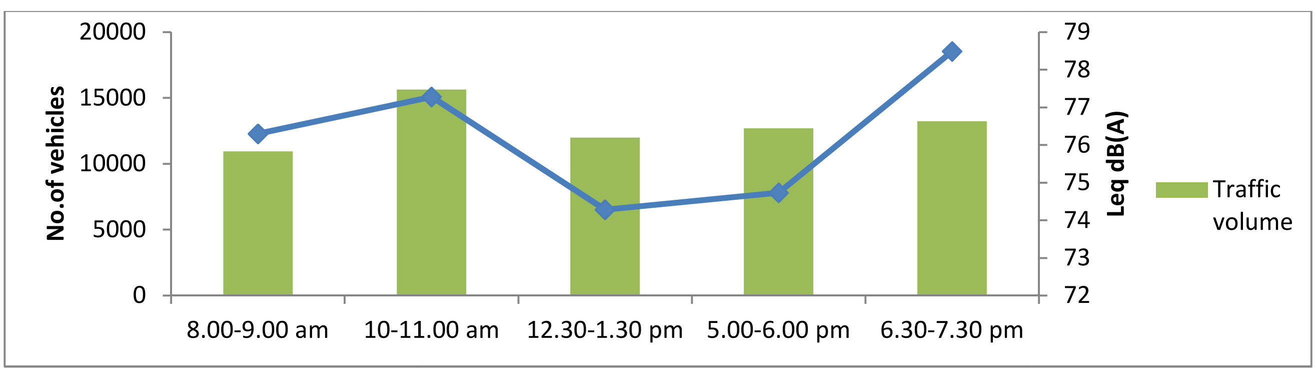


Fig 5.10 Variation of traffic noise in peak & off peak hours at Haiderpur badly mor

5.2 Validation of the noise prediction model

Average noise level Leq dB (A) measured by the sound level meter and calculation of the traffic noise level with the help of RLS -90 model, comparing these values if their difference is 5 to 6 dB(A) than these model uses for the forecasting of traffic noise level for different year.

5.2.1 Validation of the noise prediction model at Ashram Chowk

The difference between Observed and predicted traffic noise level in the morning peak hours, off peak hours and evening peak hours is found as 1.6,1.6 and 3.5 dB(A) respectively, and percentage difference between observed average traffic noise level and predicted traffic noise level in the morning peak hours, off peak hour and evening peak hours is found as 2.1%, 2.1% and 4.3% respectively. At evening peak hours due to traffic density higher than as compare to other time, the observed noise level sences to be higher than the predicted one.

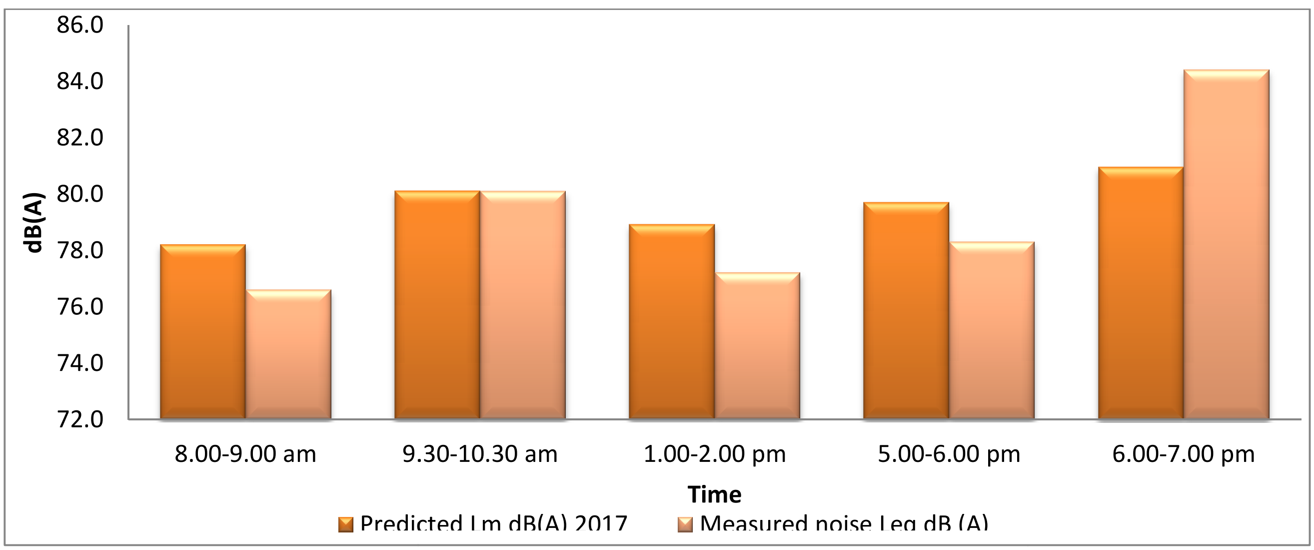


Fig 5.11 Validation of the noise prediction model at Ashram Chowk

5.2.2 Validation of the noise prediction model at Lodhi

The difference between average noise level and predicted traffic noise level in the morning peak hours, off peak hours and evening peak hours is 2.4, 1.2 and 2.3 dB (A) respectively, and percentage error between observed and predicted noise level is found as 3.30, 1.38 and 3.12 respectively. Predicted noise level vary from off peak hours to peak hours 71.2 to 72.4 dB (A) respectively.

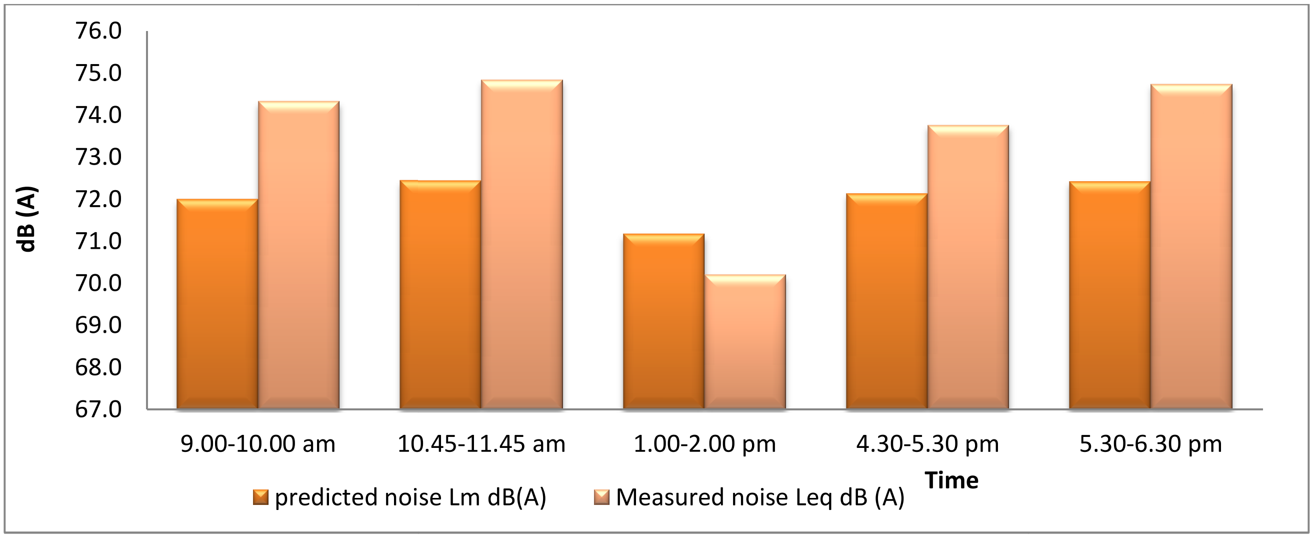


Fig 5.12 Validation of the noise prediction model at Lodhi road

5.2.3 Validation of the noise prediction model K.G &Tolstoy Marg intersection

Average noise level Leq vary from 70.2 dB (A) to 74.7 dB (A) during off peak hours to peak hours and predicted traffic noise level vary (Lm) dB (A) from 71.0 dB (A) to 72.8 dB (A). Their difference in the morning peak hours, off peak hours and in the evening peak hours is 2.5, 0.80 and 1.5 dB(A) respectively.

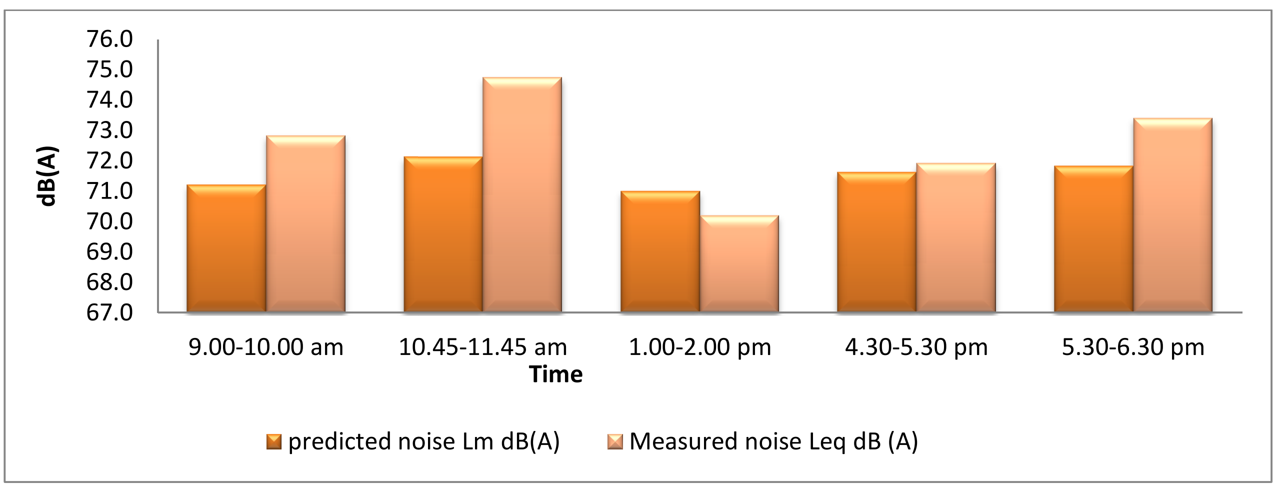


Fig 5.13: Validation of the noise prediction model at K.G &Tolstoy Marg intersection

5.2.4 Validation of the noise prediction model at Nirman Vihar

Average noise level Leq vary from 75.6 dB (A) to 79.4 dB (A) during off peak hours to peak hours and predicted traffic noise level vary from 77.9 dB (A) to 79.0 dB (A). Their difference in the morning peak hours, off peak hours and evening peak hours are 2.28, 1.91 and 0.4 dB(A) respectively, and percentage error between predicted traffic noise level is found 3, 2.5 and 0.5 % respectively

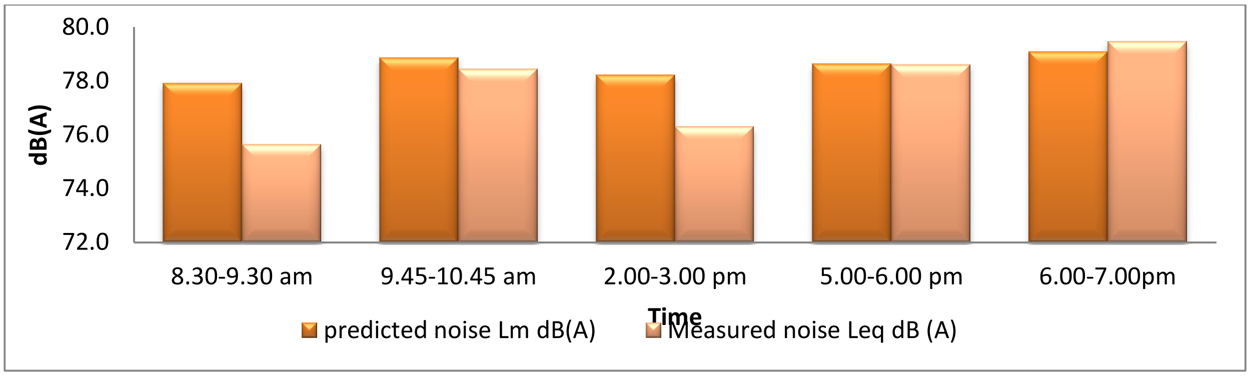


Fig 5.14: Validation of the noise prediction model at Nirman Vihar

5.2.5 Validation of the noise prediction model at Paharganj Chowk near the police

Average Traffic noise level (Leq) vary from 75.6 dB (A) to 80.5 dB (A) during off peak hours to peak hours and predicted traffic noise level vary from 77.0 dB (A) to 77.6 dB (A). Their difference in the morning peak hours, off peak hours and evening peak hours is 1.58, 0.65 and 2.96 dB(A) respectively.

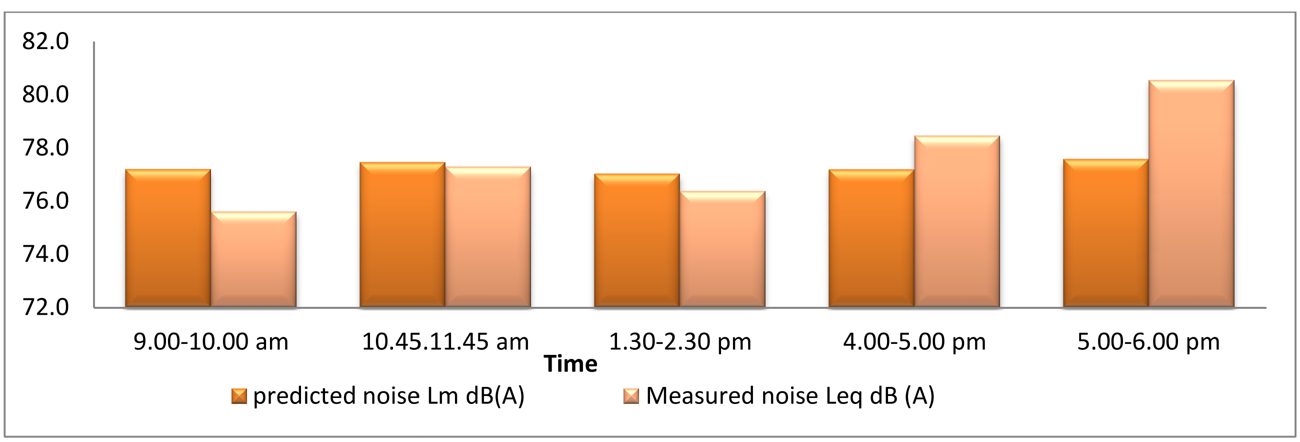


Fig 5.15 Validation of the noise prediction model at Paharganj

5.2.6 Validation of the noise prediction model at Peeragarhi Chowk

At this location the average noise level vary from 75.1 dB (A) to 79.1 dB (A) during off peak hours to peak hours and predicted traffic noise level vary from 78.56 dB(A) to 79.61 dB(A). Their percentage difference in the morning peak, off peak and even peak hours is 5.52, 3.87 and 1.84% respectively.

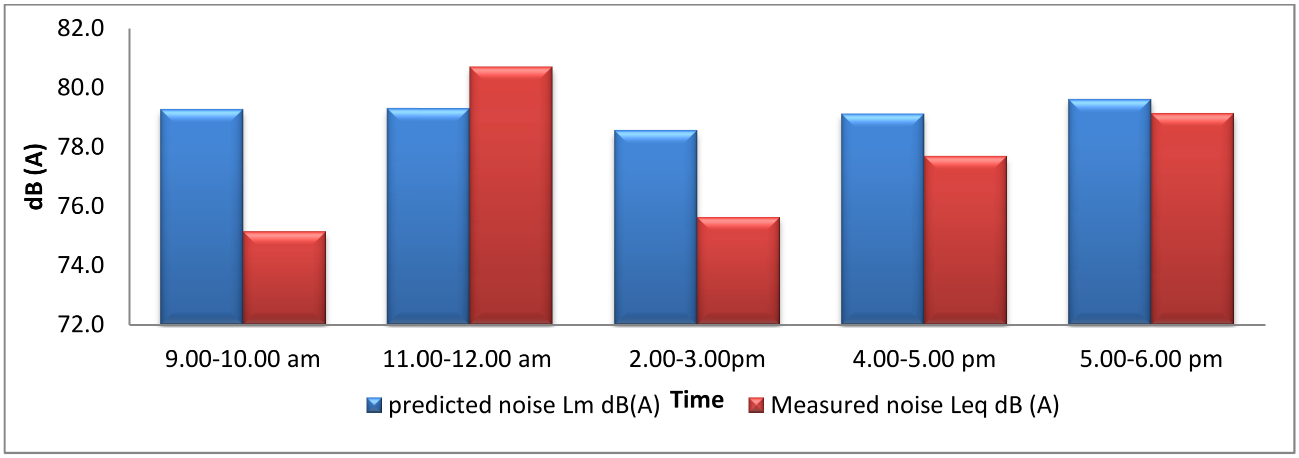


Fig 5.16 validation of the noise prediction model at Peeragarhi

5.2.7 Validation of the noise prediction model at Patel Nagar Chowk

Average noise level Leq vary from 72.2 dB (A) to 75.6 dB (A) during off peak hours to peak hours and modelled traffic noise level vary Lm dB (A) from 73.9 dB (A) to 75.1 dB (A). Their difference in the morning peak, off peak and even peak hours is 2.4, 0.3 and 0.6 dB (A)respectively.

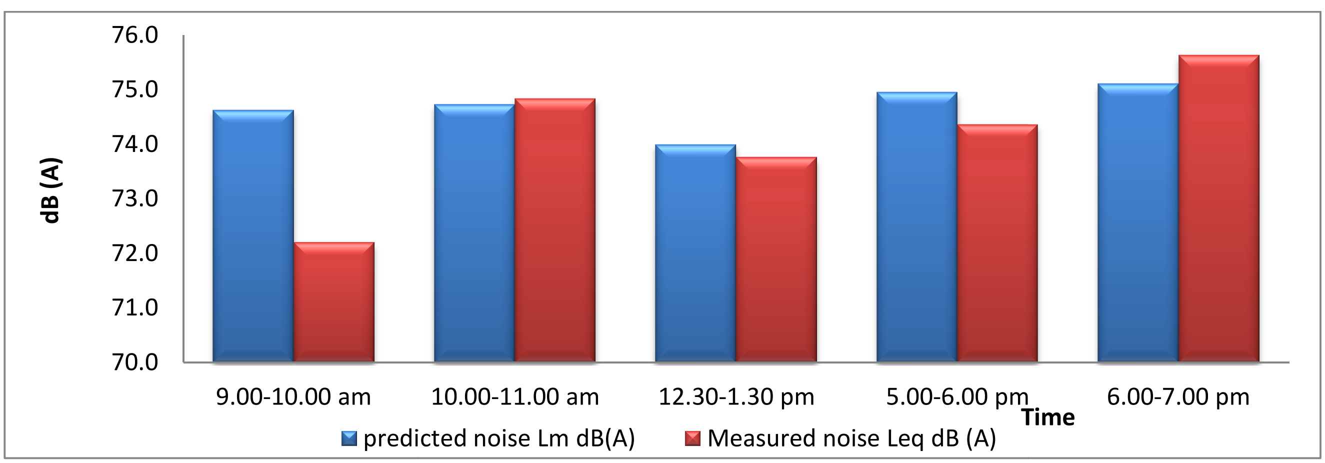


Fig 5.17 Validation of the noise prediction model at Patel Nagar Chowk

5.2.8 Validation of the noise prediction model at Shakti Nagar Chowk

Average noise level Leq vary from 74.14 dB (A) to 79.46 dB (A) during off peak hours to peak hours and predicted traffic noise level vary from 78.41 dB (A) to 79.66 dB (A). Their difference in the morning peak, off peak and evening peak hours is 3.97, 4.27 and 0.74dB (A) respectively, and percentage error of the predicted noise level and monitored noise level are 5.3, 5.57 and 1% respectively.

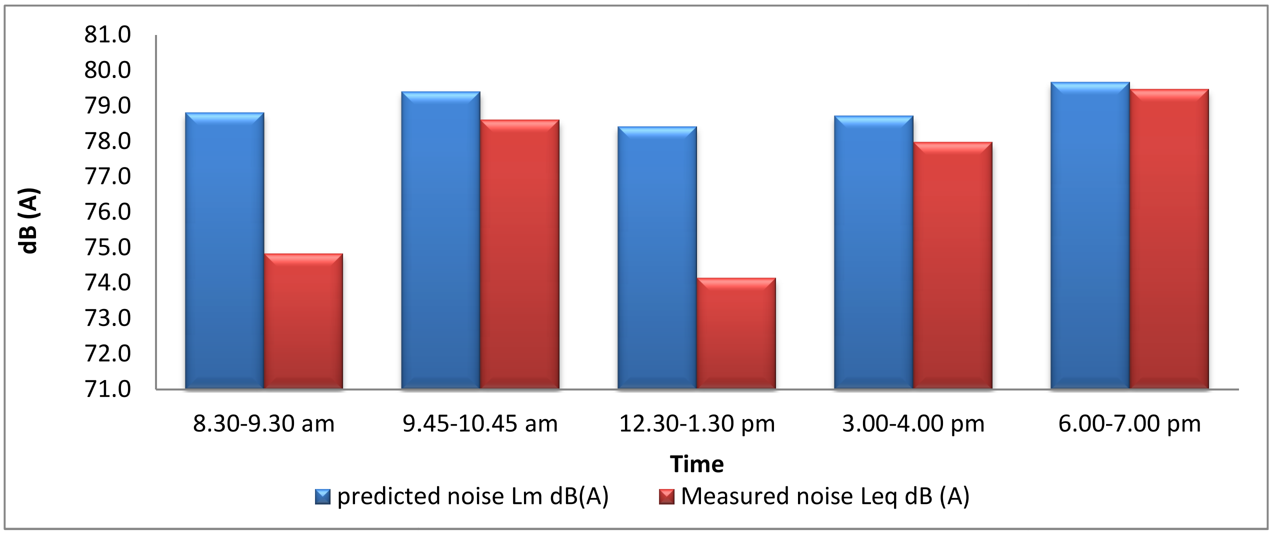


Fig5.18 Validation of the noise prediction model at Shakti Nagar Chowk

5.2.9 Validation of the noise prediction model of Kingsway Camp

At this particular location,the average noise level (Leq) vary from 71.9 dB (A) to 73.6 dB (A) during off peak hours to peak hours and modelled traffic noise level vary from 73.17 dB (A) to 74.20 dB (A). Their difference in the morning peak hours, off peak hours and even peak hours is 1.26, 0.83 and 0.20 dB(A) respectively, and percentage error of the predicted noise level and monitored noise level is found as 1.75, 1.14 and 0.54 % respectively.

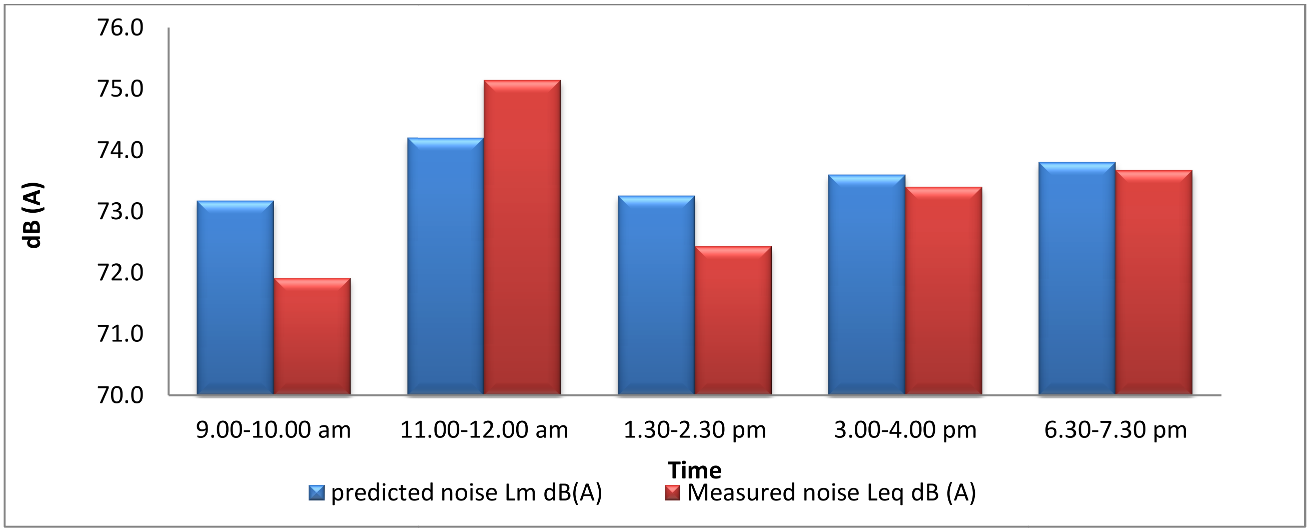


Fig 5.19 Validation of the noise prediction model at Kingsway Camp

5.2.10 Validation of the noise prediction model at Haiderpur Badly mor

The average equivalent noise level vary from 74.2 dB (A) to 78.4 dB (A) during off peak hours to peak hours and predicted traffic noise level vary from 75.7 dB (A) to 77.3 dB(A). The difference in the morning peak hours, off peak hours and even peak hours is 0.51, 1.91 and 1.70 dB(A) respectively, and percentage error between predicted noise level and observed noise level is found as 1.47, 1.38 and 2.35% respectively

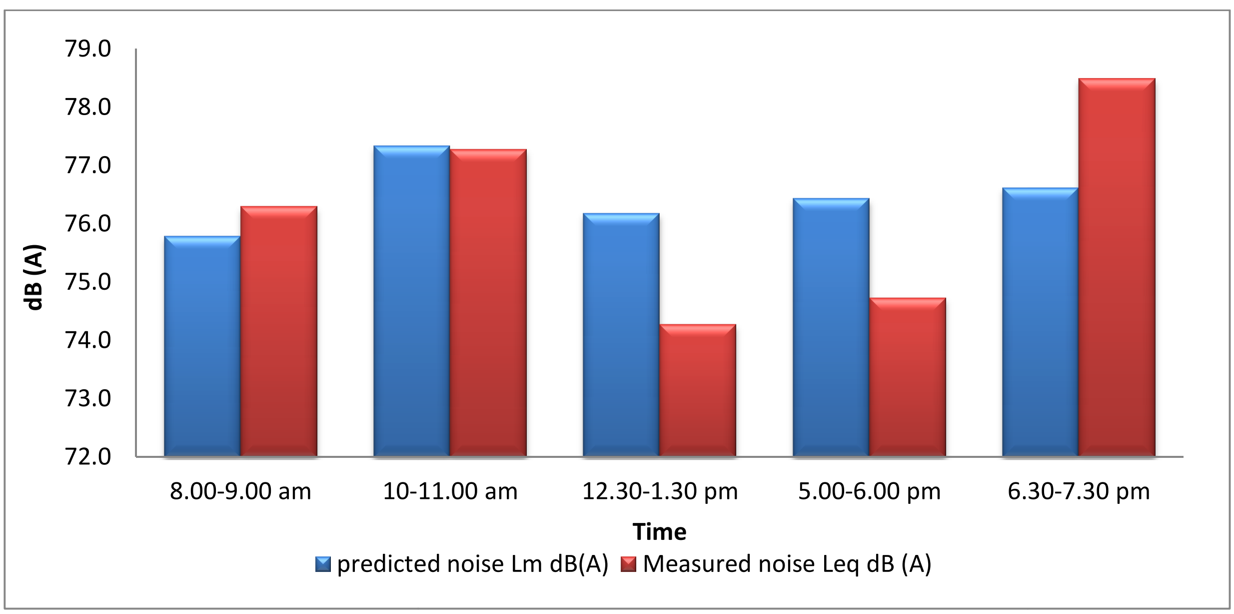


Fig 5.20 Validation of the noise prediction model at Haiderpur Badli Mor

On the basis of the comparative analysis between monitored and modelled traffic noise, at some locations the measured noise level is found a little bit higher than the predicted one, whereas at some locations the modelled noise level is found a little bit higher than the measured noise level. At each location the percentage error has also been calculated and overall range of the percentage difference is found from 0.5 to 5.75 %, which indicates the best suitability and applicability of this model in city like Delhi.

5.3 Forecasting of traffic noise level

Prediction of road traffic noise level by using RLS -90 model is found best suitable model in Indian hetrogeneous traffic conditions. The same model has been used to forecast the traffic noise level for the year 2022, 2027 and 2032.

Table 5.1 Forecasting of traffic noise level for different year

Year / locations	Predicted noise level in 2017 dB(A)	Predicted noise level in 2022 dB(A)	Predicted noise level in 2027 dB(A)	Predicted noise level in 2032 dB(A)
Ashram Chowk	81.0	81.6	82.0	82.5
Lodhi Road	72.4	73.0	73.6	74.0
K.G & Tolstoy Marg	71.8	72.4	73.0	73.4
Nirman Vihar	79.1	79.7	80.2	80.7
Paharganj Chowk	77.6	78.1	78.7	79.1
Peeragarhi Chowk	79.6	80.2	80.8	81.2
Patel Nagar Chowk	75.11	75.71	76.25	76.72
Shakti Nagar Chowk	79.7	80.3	80.8	81.3

Kingsway Camp	73.8	74.4	75.0	75.4
Haiderpur Badly	76.6	77.2	77.8	78.2

During this forecasting average annual vehicle growth rate is taken as 3% and other input parameters of the model assuming constant. Taking 2017 as the a base year, road traffic noise has been predicted for different year i.e. 2022, 2027 and 2032. The forecasting of the traffic noise level at Ashram Chowk varies from 81 dB (A) to 82.5 dB(A) in 2017 to 2032 year, predicted traffic noise level much above the prescribed level due to heavy traffic flow and covered by high rise building on both sides of roads. Prediction of the traffic noise level at Lodhi road and K.G & Tolstoy Marg are varies from 72.4 to 74 and 71.8 to 73.4 dB (A) respectively, both locations consider as silence zone by CPCB. At Nirman Vihar traffic noise level predicted 79.1 to 80.7 dB(A) in 2017 to 2032 year. Paharganj Chowk which is near the New Delhi railway station, the traffic noise level has been predicted 77.6 to 79.1 dB (A).

CHAPTER-6

CONCLUSIONS

After the analysis of the collected data, it is revealed that at each monitoring location, the traffic noise level was found more than the standard noise level as prescribed by CPCB. At Ashram Chowk, Nirman Vihar, Shakti Nagar and Peeragarhi Chowk the traffic noise level was observed much more during the evening time as compare to morning time. The reason behind this higher traffic noise may be due to high traffic density during the evening period. It was observed that the locations covered by both sides high rising buildings and under the flyover bridge, having higher traffic noise level than the open or plain area.

At silence zone area (Lodhi road and K.G. Marg), it was observed that the traffic noise level is more than prescribed standard noise level and some time its was found equivalent to residential and commercial noise level. The ambient noise standards have been violated at every locations in the peak hours as well as off peak hours. The developed model, i.e. RLS-90 gives very close results to the measured values as compared to other model. Percentage difference between predicted noise level and monitored noise level is found between 0.5 to 5.75%, which indicates the best suitability and applicability of this model in city like Delhi, where heterogeneous kind of traffic is found.

By keeping in mind the suitability of this model in Indian condition, the same model has also been used to forecast the traffic noise at all the selected locations.The forecasted noise level of the all the locations are found much more than the permissible noise level, which indicates the mitigating measure like noise barriers would be required at all the locations to curb the noise pollution and its associated adverse health problems.

Scope for the future Study

This study may be extended for monitoring and prediction for traffic noise level for other major locations of the Delhi as well as in other megacities so that it will also helped in the developement of multiple types of the noise barrier for the reduction of traffic noise level at various locations on the basis of exceed traffic noise. We can also develop noise map at every locations.

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