INSERSION LOSS STUDY DUE TO NOISE BARRIERS CONSTRUCTED ALONG FLYOVERS IN THE CITY OF LUCKNOW

Amol Gupta [a], A. K Shukla [b], Apoorva Shukla [c]

[a] *Student, Department of Civil Engineering, Institute of Engineering and Technology, Lucknow -226016, India*

[b] *Professor, Department of Civil Engineering, Institute of Engineering and Technology, Lucknow -226016, India*

[c] *Guest Faculty, Department of Civil Engineering, Lucknow University, Lucknow -226025, India*

ABSTRACT

Residents living near urban roads and major highwayshave become concerned about noise pollution. It has become essential to construct noise barriers along traffic roads in order to decrease the intensity of noise to an acceptable level in nearby residential areas. There are different zones in Lucknow city based on itsland use in order to study the noise levels due to vehicle movement. The noise data analysis also takes other factors into account, including terrain, traffic speed, cross sections, and traffic composition. This paper highlights the noise levels at the fly over situated on Talkatora road(D1), Tulsi Das Marg(D2) and Nirala Nagar(D3) (Lucknow, UP, India) are selected for the study and the heights of the noise barrierinstalled were 1.35m ,0.62m, and 1.22m (with edge 0.24m) respectively. Barrier height, type of traffic, ground equivalence, height of measuring instrument and barrier material are taken into consideration. The readings were taken at one side of barrier panel at the time when no traffic was present and only a single noise source was chosen. The pavement material is same and instrument has been kept 1.5m behind the barrier and then 1 m above the barrier on all the three sites. Due to the presence of noise barrier the reduction in noise as insertion losses with respect to presence ofbarrier were found to be upto 8.4 dBA at site D1(barrier height = 1.35 m), upto 5.3 dbA at site D2 (barrier height =0.62m),) and upto 12.3 dbA at D3(barrier height = 1.22m with edge 0.24m). Also, it was inferred that due to presence of edge on site D3, there is less diffraction of sound waves from the top edge of barrier. This result was compared with CPCB and all the three barriers have proved to be efficient asthey are reducing the noise of more than 5 decibel.

Keywords: *Noise barrier, efficiency with respect to height, Insertion Loss, Flyover noise.*

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1. Introduction

Cities are being increasingly crowded and the noise level has exceeded permissible limits as a result of the increase in vehicles and rapid urbanization. Several portions of the road network may need noise barriers to reduce noise levels (Mohan et al., 2002). A highway's visual environment and its surroundings can be adversely affected by noise barriers. It is usually made by a combination of materials, and it is a long continuous structure that is more than 15 feet high. Asa means to reduce noise levels on roads, noise barriersare highly sought by neighborhoods.

1.1. Noise Standards

Table 1 (Source: CPCB, 1991) presents the ambientnoise standards for different types zones

Sl. No	Category	Leq dbA	
		Day Time	NightTime
1.	Industrial	75	70
2.	Commercial	65	55
3.	Residential	55	45
4.	Silence	50	40

Table 2 (Source: CPCB, 1991) for residential areas.

Sl. No	Location	Acceptable Noise Level indB (A)
1.	Rural area	25 to 35
2.	Suburban area	30 to 40
3.	Residential area	36 to 45
4.	Urban area (Residential and Business)	40 to 45
5.	City	45 to 50

1.2 Factors Considered in Traffic Noise

There are following factors on which the traffic noisedepends (Attenborough, 1982):

- Traffic speed
- Traffic Volume;
- Heavy vehicles in the traffic stream.

Traffic noise is louder when there is a large volume oftraffic, a high speed of traffic, and a large number of heavy vehicles on the road. Noise produced by an automobile is a result of the combination of noises created by its engine, exhaust, and tires. It has also been found that defective mufflers or other equipment on vehicles also contribute to increased traffic noise levels. It is also a sign of traffic noise when a situationcauses the engines of motor vehicles to work harder. Natural and man-made obstacles, terrain, vegetation, and distance affect traffic noise levels. In most cases, noise does not pose a serious problem for people who live over 150 m away from heavily traveled freeways or over 30 to 60 m away from roadswith a moderate level of traffic. The most common traffic noise descriptors are L10, L50, L90 and Leq. Inspite of it being substantially less than the occasional peak, L10 indicates the top end of the level range. Noise levels L90 correspond to background noise when there are no nearby sources of noise (no nearby sources of noise). As the actual time varying sound level varies over time, a constant sound level has the same amount of sound energy over time (Harris, 1979).

1.3 Characteristics of Noise Barrier

Issues which need to be addressed in the designing ofnoise barrier include:

• Aesthetic: The purpose of this noise barrier is to provide an attractive noise barrier that complements the surrounding community and improves the urban image of the area;

• Cost: Provide a barrier that can be built and maintained at a reasonable cost;

• Effectiveness: The purpose of this study is to estimate the effectiveness of noise barriers in reducingnoise levels;

• Maintenance: As much as possible, we would like to minimize the cost of maintaining our barrier and plant materials, as well as potential legal.

• Acceptability: It is imperative to create barriers that attract a wide range of political decision-making groups in addition to the enthusiastic support of the surrounding community.

1.4 Barrier Height Design

The Barrier attenuations is a function of Fresnelnumber, Eq. (1):

$$N = 2.\frac{A + B - C}{\lambda} \qquad (1)$$

Where:
N is the Fresnel number
A+B is the Path length over the panel
C is the Path length through the noise barrier
l is sound source wavelength given by Eq. (2):

$$\lambda = c\ .T \qquad (2)$$

$$C = 20{,}04 \cdot (T^{*} + 273{,}16) \cdot 0{,}5 = 20{,}04 \cdot (20 + 273{,}16) \cdot 0{,}5 = 343\ m/s \quad (3)$$

where,
c is the sound speed in m/s and
T is the time period in seconds (1/*f*) ,*f* is the frequency in Hz.
Three parameters A, B and C are described in Figure 1 and 550 Hz is used for all vehicles as an effective frequency. At 20 ^{o}C, the sound speed C is given by Eq. (3) and the sound wavelength at *f*=500 Hz is, Eq. (4): Λ = c/f = 343/550 = 0.624 m (4)

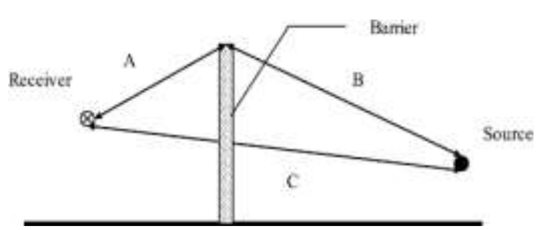

Fig 1. Geometry of Barrier, Source andReceiver for Establishing the Attenuations.

thus for f=550 Hz, we have Eq. (5):

$$N=2.(A+B-C)/0.624=\delta.3.21 \qquad (5)$$

δ =.(A+B-C) - a particular source-barrier-receivergeometry determines path length difference.
Freestanding barriers have positive Fresnel number, the barrier attenuation is given by Eq. (6) and Eq. (7):

$$D = 10\ log\left[\left(\frac{1}{\phi_R - \phi_L}\right)\left(\frac{1}{\sqrt{10}}\right)\int_{\phi_R}^{\phi_L} \frac{tanh^2\sqrt{2\pi N cos\phi}}{\pi N cos\phi}\, d\phi\right]$$

$$\text{for } 0 \le N\cos\phi < 5.03 \qquad (6)$$

$$D=20 \text{ for } N\cos\phi > 5.03 \qquad (7)$$

$$\Delta_{barrier} = \begin{cases} 0 & \text{for} \quad N\cos\phi < -0.1916 \\ 10\ log\left[\left(\frac{1}{\phi_R - \phi_L}\right)\left(\frac{1}{\sqrt{10}}\right)\int_{\phi_L}^{\phi_R} \frac{tan^2\sqrt{2\pi|N\cos\phi|}}{2\pi|N\cos\phi|}d\phi\right] & \text{for} -0.1916 \le N\cos\phi < 0 \\ 10\ log\left[\left(\frac{1}{\phi - \phi}\right)\left(\frac{1}{\sqrt{10}}\right)\int_{\phi_L}^{\phi_R} \frac{tanh^2\sqrt{2\pi N\cos\phi}}{\pi N\cos\phi}d\phi\right] & \text{for} \quad 0 \le N\cos\phi < 5.03 \\ 20 & \text{for} \quad N\cos\phi > 5.03 \end{cases}$$

where,
Δbarrier - Barrier Adjustment
ΦL – Angle (in radians) measured towards the leftfrom the perpendicular;
ΦR - Angle (in radians) measured towards the rightfrom the perpendicular;

1.5 Equivalent noise level measurement

Equivalent Continuous Sound Level (Leq) isthe average sound level which over a given period of time has the same total energy as the fluctuating noise. Leq has been measured of particular sites respectively from all the total eight samples obtained during different days. The formula which has been used to calculate Leq is as follows:

$$Leq = 10\ log(10^{Li/10})ti$$

Where summation is done upto nth and n is the total no of samples, Li is the level in dBA if the i sample, and ti is thefraction of total sample time. (Here ti = 1)

1.6 Site Details

(A) TALKATORA MARG FLYOVER (D1)

The locality Talkatora falls in Lucknow district situated in Uttar Pradesh state having area is of 1.53 km^2 and contains a population of 11523(in 2020) with population density of 7551 people per km^2. It is of two lane and constructed on Vikram cotton mill marg. Thecoordinates are latitude 26°49'09.5"N and longitude 80°53'53.9"E.

Figure 2. Talkatora Road Flyover

B) TULSIDAS MARG FLYOVER (D2)

Lucknow Chowk falls in Lucknow district situated in Uttar Pradesh state, with a population 300749 (in 2020). Population Density of 7743 people per km^2

Figure 3. Tulsi Das Marg Flyover

C) FLYOVER AT NIRALANAGAR (D3)

The locality Nirala Nagar falls in Lucknow district situated in Uttar Pradesh state, with a population 23290(in 2020). The size of the area is about 1.9 square kilometer with population density of 12262 people per km2. The coordinates are latitude 27°45' and longitude 81°57'

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Figure 4. Nirala Nagar Road Flyover

2. Methodology

2.1 Readings obtained at sites

Two identical sound measuring instrument (SL-1352)were used. The measured sound barrier is located in the section of at the end of the flyover bridge and readings were obtained only from one side of noise barrier panel as the study only focuses on efficiencyof panel and not on noise environment in that area. First SLM instrument was placed before the starting ofbarrier which represent no barrier condition and the other instrument was placed behind the barrier (1 m away from the panel). Both instruments were kept at same height from the ground level. Eight samples were obtained during different days and measurement was done for 2 minutes as mentioned in ISO 10847. Therewas no traffic during measurement time as it was doneearly in the morning and pavement material is same inall the three sites. Mostly these bridge structures havethese kinds of barriers. Each measurement was conducted using a regulated artificial noise source, i.e., for measurements without and with a barrier. This source was omnidirectional with pink noise and was simple and omnidirectional, installed in the middle of the road at the time of measurement. Noise barrier insertion loss was calculated using the acoustic average.

2.2 Results and discussion

Talkatora Flyover (D1) : Barrier Height = 1.35m, Tulsidas Marg Flyover (D2): Barrier height = 0.62m

Nirala Nagar Flyover (D2) : Barrier Height = 1.22m,Edge =0.24m

Table 3. Measurements taken at all the three sites inthe presence of Barrier

Date	25 May	26 May	27 May	28 May	29 May	30 May	31 May	1 June
D1	76.3	79.8	73.5	73.1	75.8	77.6	75.2	76.9
D2	82.5	86.2	79.8	80.4	84.6	81.2	83.9	84.5
D3	76.9	79.1	76.8	74.6	75.2	77.8	76.4	78.7

Table 4. Measurements taken at all the three sites inthe absence of Barrier

Date	25 May	26 May	27 May	28 May	29 May	30 May	31 May	1 June
D1	84.2	86.9	81.6	82.5	84.5	83.7	85.2	87.6
D2	87.5	89.6	84.2	86.8	90.5	86.7	89.6	91.2
D3	89.6	91.5	87.6	88.7	87.4	90.5	87.8	90.8

Table 5. Atmospheric conditions during sampling days.

Date	25-May-22	26-May-22	27-May-22	28-May-22	29-May-22	30-May-22	31-May-22	01-Jun-22
Temperature of Air	27-29	27-29	27-29	27-29	27-29	27-29	27-29	27-29
Speed of Win d (m/s)	3.1	2.7	2.5	2.7	6.3	6.5	4.7	3.8
Direction of wind	Variable-N	Variable-E	Variable-S	Variable-S	Variable-E	Variable-E	Variable-E	Variable-E
Humidity in the air	76	65	56	29.1	29.1	29.1	29.1	29.1
Pressure	29.2	29.2	29.2	56	65	69	70	68

3. Conclusion

There are three sites having different height of noise barriers have been chosen, so the purpose was to study the insertion loss variation with respect to height. The environment is considered to be in free field i.e. no other obstruction was there during the measurement and only a single noise source of frequency 550 hz waspresent as the measurements were taken during early morning when no traffic was running on the flyovers. The noise levels are considered to be same at every point within the overall width of pavement and reflected waves are considered as equally strong as the direct waves. The Insertion losses are greatly influenced by frequencies. IC engines and horn soundin vehicles with large frequencies tends to have greaterinsertion loss and those with low frequencies, theinsertion losses are less. It was found that the barrier located at sight D1 is more efficient than barrier at siteD2 because height of the barrier at D1 is more (1.35m) than barrier at location D2 (0.62m). Further, barrier at site D3 (1.22m, edge = 0.24m) is most efficient despite of its height is less than barrier at site D1 (1.35m) because of the presence of edge on top of thebarrier as it reduces diffracted sound waves from the top. Insertion losses are accordingly:

- Site D1 (1.35mm) =8.4 dbA
- Site D2 (0.62m) = 5.3 dbA
- Site D3 (1.22m with diffractingedge of 0.24m) =12.3 dbA

Table 6 . Loudness Equivalent of average soundlevels.

Site	Without barrier(dB) (equivalent level)	With Barrier(dB) (equivalent Level)	Insertion loss(dB)
D1 (Ht=1.35m)	93.97	85.54	8.42
D2 (Ht=0.62m)	97.8	92.42	5.38
D3 (Ht=1.22m) , ,edge 0.24m	98.52	86.21	12.31

3.1 Graphical comparison of results

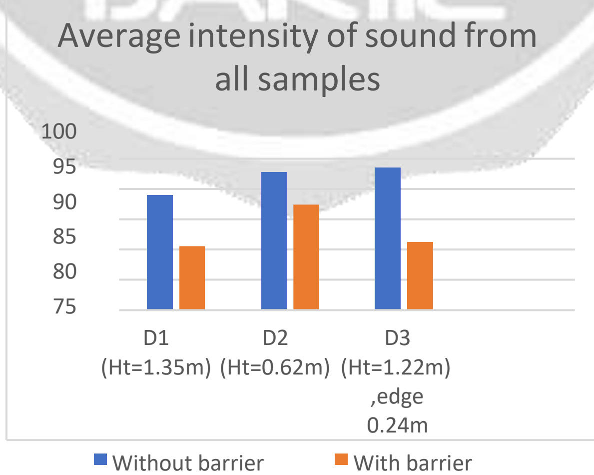

Fig. 5. Graph showing an average intensity of noisemeasured during presence and absence of barrier atsites D1, D2, D3 respectively

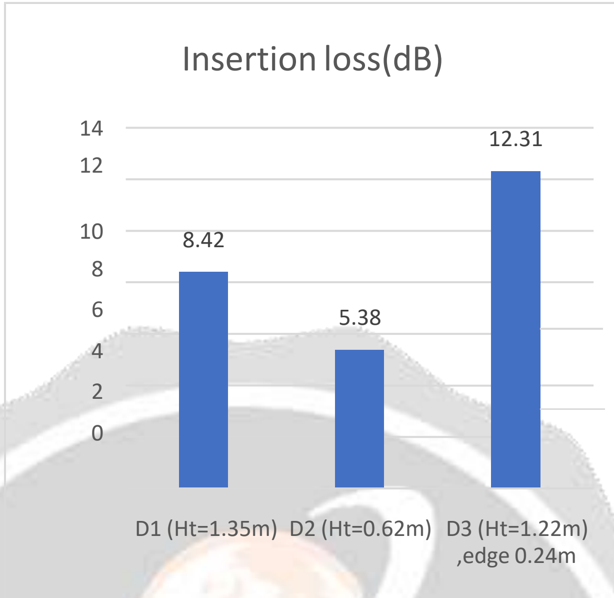

Fig. 6. Graph showing intensity of an averageinsertion loss measured at sites D1, D2, D3 respectively

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