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Traffic Noise Levels at Different Locations in Dhaka City and Noise Modelling for Construction Equipments

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ABSTRACT

Development of a suitable infrastructure is a sine-que-non for rapid economic growth in a developing country like Bangladesh. Noise emission is one of the major concerns for a mega city like Dhaka. A large civil-structured project is being implemented in Dhaka, which is known as Jatrabari-Gulistan flyover. Main focus of this research was concentrated to record and analyze noise levels in major intersections located at the study area as well as key entities, such as hospitals, educational institutions; religious institutions etc. for both day and night and seven days of a week. Average noise level was found 92.7 dBA at Jatrabari intersection during construction period and 86.6 dBA during normal period. To compare the noise level during operation phase and construction phase two other similar civil structured projects, Khilgaon and Kuril flyover were selected and same operation was carried out. In this regard, noise related parameters such as L_{eq}, L_{10}, L_{50}, and L_{90} have been estimated from field observations of noise levels. It was observed that at all locations; noise level remained far above the acceptable limit. Comparisons have been made considering various factors of noise level and contour, vector and wireframe diagram was prepared for the intersections and along the route in the study area. Noise modelling was done for generator and wheel loader used in the construction site of flyover.

KEY WORDS - Average noise level, Comparison of noise levels, Noise contour, Noise modelling.

I. INTRODUCTION

Due to rapid population growth and urbanization, noise pollution is becoming a potential nuisance in urban life in most of the countries in the world. Among different sources of city noise, traffic noise is generally the most omnipresent. Though exposure to noise emanating from many different sources can be avoided, traffic induced noise is the most obvious source that we confront. DCC (Dhaka City Corporation) has taken a major initiative for construction of Gulistan-Jatrabari flyover**.** This is aimed at achieving easy and trouble free connection with Dhaka city to Chittagong and Sylhet divisions, other two major divisions in Bangladesh. This is expected to cause significant reduction in vehicle operating cost, huge reduction in travel time, improvement to environmental quality by reducing air pollution, smooth and safer journey on the flyover through improved traffic circulation and management.

The other two similar civil structured projects are Kuril flyover and Khilgaon flyover. Though, these three projects are located at different areas in but generated a huge number of traffic because all of these projects located at the entrance of Dhaka city.

Noise pollution in the urban area is a serious threat to the environmental quality. In order to identify any potential impact on and any potential change to the natural and socio- economic environment, this research is carried out following novel ways:

1) Reconnaissance survey was done to identify the key entities in the study areas.
2) Secondary data were collected from BBS (Bangladesh Bureau of Statistics), DoE (Department of Environment), DCC.
3) Noise level data were collected in and analysed for 41 locations at Jatrabari- Gulistan area, 7 locations at Kuril area and 12 locations at Khilgaon area using sound level meter.
4) Noise modelling was done for generator and Wheel loader used in Gulistan-Jatrabari flyover construction site.

Noise level was measured both for day and night and every day of a week. Data were recorded not continuously in a week but were recorded for different days in different week to gather total overview of noise level data of a whole week. Day time was considered from 8:00 am to 6:00 pm and night time was considered from 6:01 pm to 11:59 pm. Data were taken at one minute interval spread over fifteen minutes. To calculate different statistical parameters of noise level data; such as L_{10}, L_{50}, L_{90} etc. samples were classified randomly in a range by using SPSS. Latitude and longitude of each and every data collection point was recorded using a GPS.

Once the noise levels have been measured, computation of Leq was done. Leq of a number of discrete A-weighted noise levels for a specified time period. After analysing all the statistical parameters comparison among different properties, comparison among different locations, and comparison between different times were done. At the end of comparison contour diagram, vector diagram and wireframe diagram was prepared for the major intersections located at the study areas.

Noise modelling was done for the sound emanating from construction equipment e.g. generator following NYSDEC (New York State Department of Environmental Conservation) screening level noise analyses.

II. INTRODUCTION TO NOISE

Noise can be defined as the level of sound which exceeds the acceptable level and creates annoyance. Frequent exposure to high level of noise causes severe stress on the auditory and nervous system. Extended exposure to excessive sound has been proved physical and psychological damage. Because of its annoyance and disturbance implications, noise adds to mental stress and hence affects the general well-being of those exposed to it. Noise is a major source of friction among individuals [1]. The major sources of noise are Industrial noise, traffic noise & community noise Out of above three parameters, the source that affects the most is traffic noise. In traffic noise, almost 70% of noise is contributing by vehicle noise. Vehicle noise is created by engine and exhaust system of vehicles, aerodynamic friction, interaction between the vehicle and road system, and by the interaction among vehicles. The major concern is to study and development of a road traffic noise model [2].

2.1 NOISE MEASUREMENT TECHNIQUES AND INSTRUMENTS

An instrument for the measurement of sound levels, whose characteristics are specified by the American National Standards Institute; the instrument includes a microphone, amplifier, an output meter, and two electrical networks (called weighting network A and C) which weight different frequency components differently. Sound level meters measure sound pressure level and are commonly used in noise pollution studies for the quantification of almost any noise, but especially for industrial, environmental and aircraft noise [3]. To locate the point of noise data collection through latitude and longitude a GPS was used. GPS machine uses the satellite and locate the position of the machine in terms of degrees, minutes and seconds. There are many sound level meter and GPS out there; specifically the following two machines were used (Fig. 1).

2.2 ACCEPTABLE LEVELS OF NOISE

Various standards are being used in different countries regarding the acceptable levels of noise depending on the situation. Limits of acceptable noise level established by different organizations are given in Table 1.

TABLE 1. ACCEPTABLE NOISE LEVEL FOR VARIOUS AREAS

Description of Area	Noise Level dBA		
	DOE	FHA	AASHTO
Sensitive Areas such as parks, schools, hospitals and mosques	45	60	55-60
Residential Area	50	70 (Interior max. 55)	70 Exterior 55 Interior
Mixed Area	60	70	70
Commercial Area	70	75	75
Industrial Area	75	75	75

FIG. 1. SOUND LEVEL METER AND GPS.

III. RESEARCH INVESTIGATIONS – PROBLEM IDENTIFICATION & NOISE ANALYSIS

Noise pollution in the urban area is a serious threat to the environmental quality. High intensity sound especially traffic oriented in the highways is creating disturbance to the road users and the nearby dwellers. Where at around 50dB sound it creates discomfort to the people, there average 80dB is quite common in urban area and in some points it is more than 90 dB sound during construction period. To get the overview of noise level, noise related parameters such as L_{eq}, L_{10}, L_{50}, and L_{90} have been estimated from field observations of noise levels. A survey of the area revealed that the major contribution to the noise is from traffic with substantially high percentage of heavy vehicles, and high noise level was found at different intersections; inter district bus stands, level crossings etc.

3.1 STUDY AREA

To compare the noise levels for different stages of large infrastructure projects three areas have been selected. Our main focus was to record the noise levels at different locations of Jatrabari-Gulistan flyover project, which is the largest among the other two. Noise level data were collected in and analysed for 41 locations at Jatrabari- Gulistan area before its construction phase (Fig. 2). With a view to making our research more useful and policy oriented, another location was chosen for the study which is Kuril Flyover Project. The reason for selecting this project is that though both are similar civil structure project, Kuril flyover project is located in a more open space than Jatrabari-Gulistan flyover and data were recorded during construction phase. Sound level data were collected at 7 locations in Kuril area. The last location of our research was Khilgaon flyover project. This was selected to see noise level during operation phase and to compare it before construction and during contraction time also with a view to comparing at grade and grade separated noise level. Noise level data were recorded at 12 locations in Khilgaon area.

FIG. 2. AERIAL VIEW OF DATA COLLECTION POINTS AT JATRABARI-GULISTAN AREA

3.2 NOISE MEASUREMENT

For traffic noise problems it is important to know the different statistical parameters. The constant sound pressure level which would have produced the same total energy as the actual sound level over the given time is denoted as L_{eq} and the sound levels exceeding 10%, 50% and 90% of the total time intervals during a particular period are designated as L_{10}, L_{50} and L_{90} respectively. All these parameters can be estimated by sound level meter but in this research it was estimated manually. Such information was obtained using a sound level meter (SL-4001, Lutron made). The sound level meter was suitably calibrated before taking the measurements. The sound level meter was placed on a stand at a height of about 1.2 m above the existing road level and at a distance of 1.5 to 2.0 m from the edge of the roads. During the measurement period, the irregular noise events such as low-flying planes, dogs barking, passing of ambulances, fire service and VIP vehicles, etc. were measured and marked in different colour for easy identification of them.

3.2.1 Calculation of L_{10}, L_{50}, L_{90}

To calculate different statistical parameters of noise level data; samples were classified randomly in a range by using SPSS (version14.0). To analyse the data two assumptions have been made:

1) For ease of calculation class interval of these ranges were taken randomly

2) Numbers of samples were uniform for each data collecting locations for both day and night.

Considering these factors, frequency distribution (Fig. 3) of noise level data was done for day and night and for all locations in three study areas.

3.2.2 Calculation of L_{eq}

Once the noise levels have been measured, computation of Leq was done. Leq of a number of discrete A-weighted noise levels for a specified time period is given by:

$$Leq = 10\,log10\left[\frac{1}{n}\sum_{i=1}^{n} f * antilog\,(Li/10)\right]$$

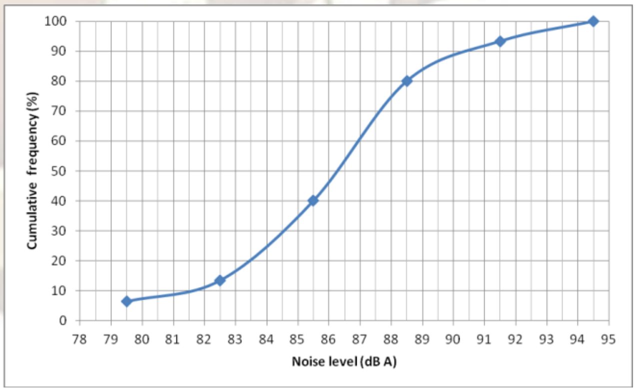

FIG. 3. FREQUENCY DISTRIBUTION CURVE OF SOUND LEVEL DATA AT JATRABARI INTERSECTION

Where, L_i = Instantaneous noise level for sample for sample i

n = Number of samples in the sampling period

f = Frequency of each range

L_i was taken the median integral value of each range for frequency distribution of the data.

IV. RESULTS AND DISCUSSION

4.1 NOISE LEVEL AT DIFFERENT LOCATIONS

From the study it is observed that average noise level at every location varies within the range of 80-90 dB(A) which far exceeds the acceptable limit of 60 dB(A) set by DoE, Bangladesh considering the road side as mixed area. In most places minimum sound level also exceeds the acceptable limit. Table 2 shows the average noise levels of some important locations in Jatrabari-Gulistan area.

TABLE 2. AVERAGE NOISE LEVEL (L_{eq}) IN JATRABARI-GULISTAN AREA DURING WEEKDAYS

Locations	Day	Night
Jatrabari Intersection	85.9	83.7
Saidabad Intersection	88.5	87.1
Saidabad Bus Terminal	90.7	91.4
Jatrabari Ideal High School	83.5	83.9
Islamia General Hospital	80.5	80.2
Baitul Mamur Mosque	84.1	82.8

Noise levels measured at different places in Kuril area have been compared to see the relative status of environment with regard to ambient noise levels at these locations. Maximum average noise level is being observed at Armed Forces Medical College for both day (Fig. 4) and night (Fig. 5) over the entire week. Two expected drop of noise level is being observed at gate no.-1 and gate no.-2 of Nikunja residential area because this two entrance is around 30 m away from the edge of the road. Two peaks are also observed at Kuril intersection and Khilkhet intersection. Noise level at these intersection is higher because of high volume of traffic as well as these intersections are located just beside of a busy level crossing.

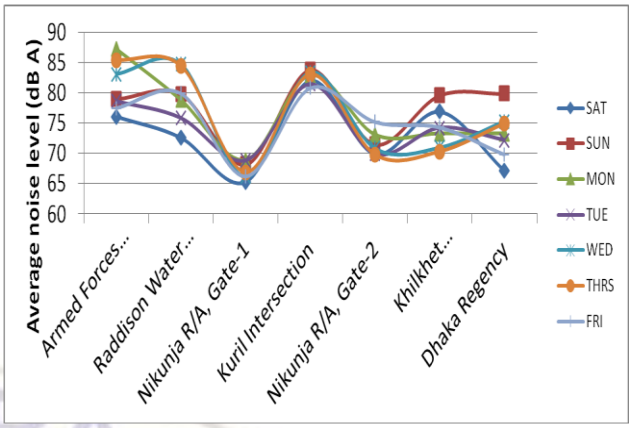

FIG. 4. AVERAGE NOISE LEVEL VARIATION (DAY) ALONG THE ROUTE IN KURIL AREA

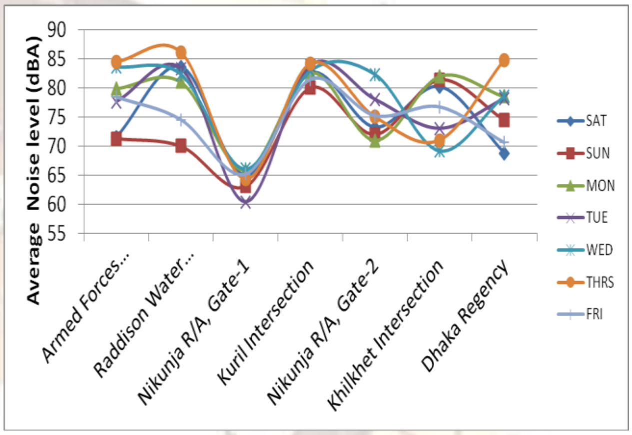

FIG. 5. AVERAGE NOISE LEVEL VARIATION (NIGHT) ALONG THE ROUTE IN KURIL AREA

4.1.1 Variation in at grade and grade separated noise level

A significant variation in at grade noise level and noise level on flyover is being observed in Khilgaon flyover project area. This helps us to predict the noise condition at operational level of a flyover. Also this variation is not distinctive for every location; it varies from place to place and time to time.

At grade noise level and noise level on flyover largely depends on location. Almost every day higher value of average noise level is being observed for at grade noise level than that of noise level on flyover because public transports use roads at grade to pick the passenger up. Khilgaon level crossing is another reason for higher value of at grade noise level at Khilgaon intersection (Fig. 6). Besides, road side grocery shops and standing non motorized vehicles directly contribute to the at grade sound level. But in front of Rosewood apartment (Fig. 7) at grade noise level is lower because most of the private cars and other motorized vehicles use flyover and this apartment is being located just in front of an upward ramp of this flyover. Another reason for high sound level is being of high speed. Vehicles move at a higher speed on flyover than that of at grade.

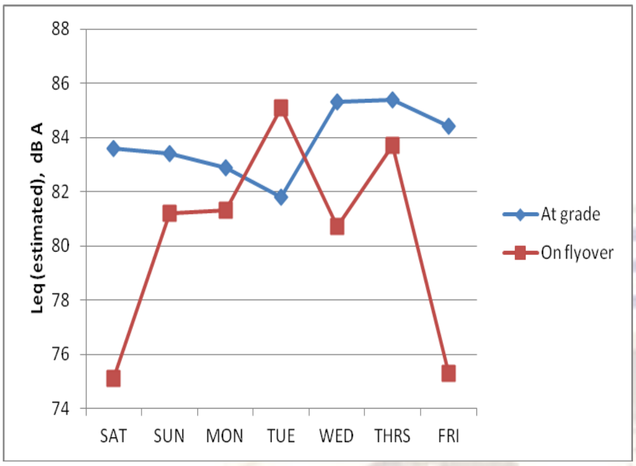

FIG. 6. SOUND LEVEL (DAY) AT KHILGAON INTERSECTION

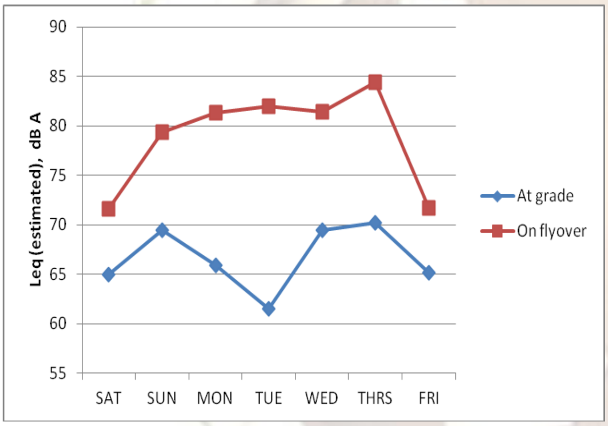

FIG. 7. SOUND LEVEL (DAY) AT ROSEWOOD APPARTMENT COMPLEX

4.1.2 Comparison among three study areas

After analysing sound level data in different locations of three study areas, five major intersections is being observed with high value of sound level. Nonetheless similar type of project is carried out both at Jatrabari and Kuril but these two areas are having completely different environmental characteristics. Again Khilgaon flyover is already a completed project so we can predict the noise level in operation phase of other two flyovers. Average noise level during day time is always higher at Jatrabari intersection and always lower at Khilkhet intersection throughout the week (Fig. 8). Noise level of these intersections varies from 80-85 dBA. Noise level also varies within the same range during night (Fig. 9). A significant drop in noise level is being observed on Wednesday. But for other days average sound level is almost similar for these intersections.

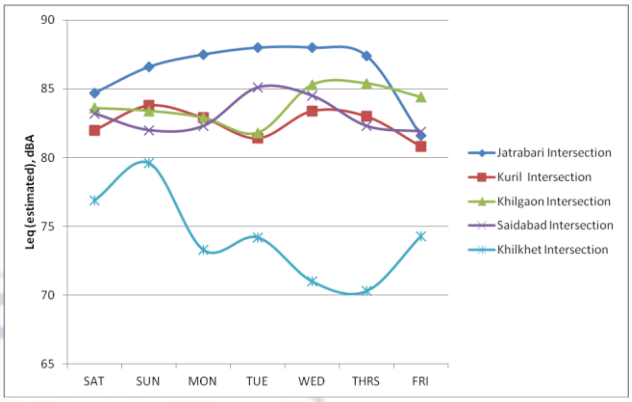

FIG. 8. COMPARISON OF SOUND LEVEL (DAY) AMONG FIVE INTERSECTIONS THROUGHOUT A WEEK

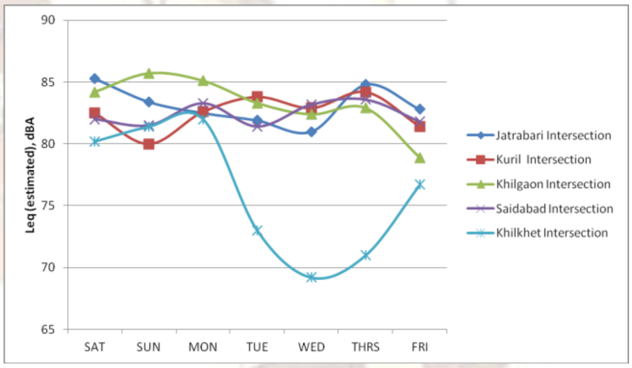

FIG. 9. COMPARISON OF SOUND LEVEL (NIGHT) AMONG FIVE INTERSECTIONS THROUGHOUT A WEEK

4.2 NOISE PARAMETERS AT DIFFERENT LOCATIONS

It is observed that typical values of noise parameter described earlier is always higher at Saidabad bus terminal. It is obvious because of the constant movement of buses at this location. At Khilkhet intersection values of noise parameters were observed lower than that of the other intersections because it is located in an open area. Values of different noise parameters at different locations are listed in Table 3.

TABLE 3. TYPICAL NOISE PARAMETERS AT DIFFERENT LOCATION

Noise Parameters	DAY				NIGHT			
	L_{eq}	L_{10}	L_{50}	L_{90}	L_{eq}	L_{10}	L_{50}	L_{90}
Jatrabari Intersection	85.9	88.9	84.5	79.8	83.7	87.1	81.5	77
Saidabad Intersection	88.5	87	80.8	71.9	87.1	87.5	79.6	76.5
Saidabad Bus Terminal	90.7	99.7	88	83	91.4	87.9	88.5	81.5
Kuril Intersection	85.6	86.7	80.5	74.9	86.4	87.4	80.7	75.3
Khilkhet Intersection	78.3	78.6	70.1	63.3	77.1	81.7	74.6	68.1
Khilgaon Intersection	87.4	93	83	79	82.4	91	82	74

4.3 NOISE CONTOUR, VECTOR AND WIREFRAME DIAGRAM

Noise contour was drawn for three different intersections and two different routes. The intersections are:

a) Contour for Jatrabari intersection
b) Contour for Saidabad intersection
c) Contour for Kuril intersection

And the routes are:

a) Contour from Shanir Akhra to Swamibag
b) Contour form Khilkhet to Armed Forces Medical College

In order to draw the noise contour map, vector diagram and wireframe diagram of the intersection was divided into grid and noise was measured at each corner of it. Depending on the dimensions of the intersection size of the grid and number of data varied. Some of the grids have to be compromised as they have already been occupied by noise sources. The noise level at those points was assumed. SURFER (version 9.0) had been used to develop noise contour, vector and wireframe diagram. The contour diagram was found as expected, the larger noise at the mid section and the lower intensity at the outmost edge of the road. These procedures were followed for all the contour map operations.
Geometric measurement of Jatrabari intersection (Fig. 10) is:
Length = 100 m and Width = 50 m

For both X and Y axis of the contour map and vector diagram 0.5 unit represents 5 m in real. Intensity of noise (dBA) is represented by different lines of the contour map (Fig. 11). For vector diagram (Fig. 13), converging characteristics indicates noise converge into a particular point from difference and diverging pattern indicates the diverging propagation of noise from a source. Wireframe diagram represents the intensity of noise along Z –axis (Fig. 12).

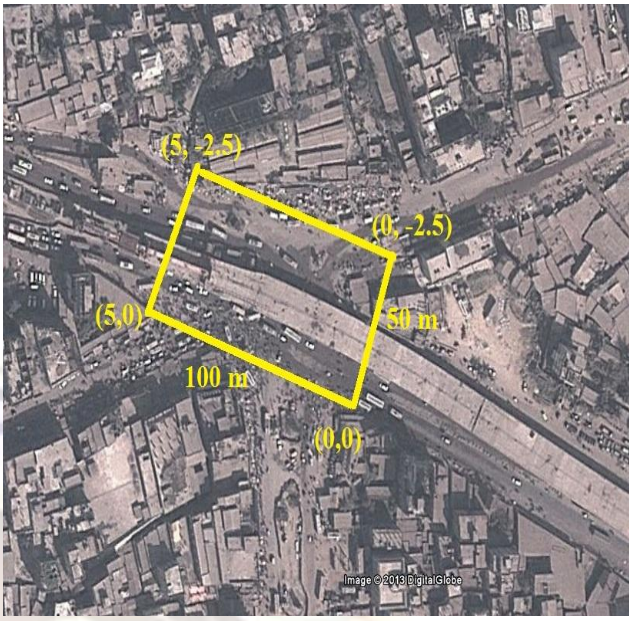

FIG. 10. AREIAL VIEW OF GEOMETRIC DIMENSIONS OF JATRABARI INTERSECTION

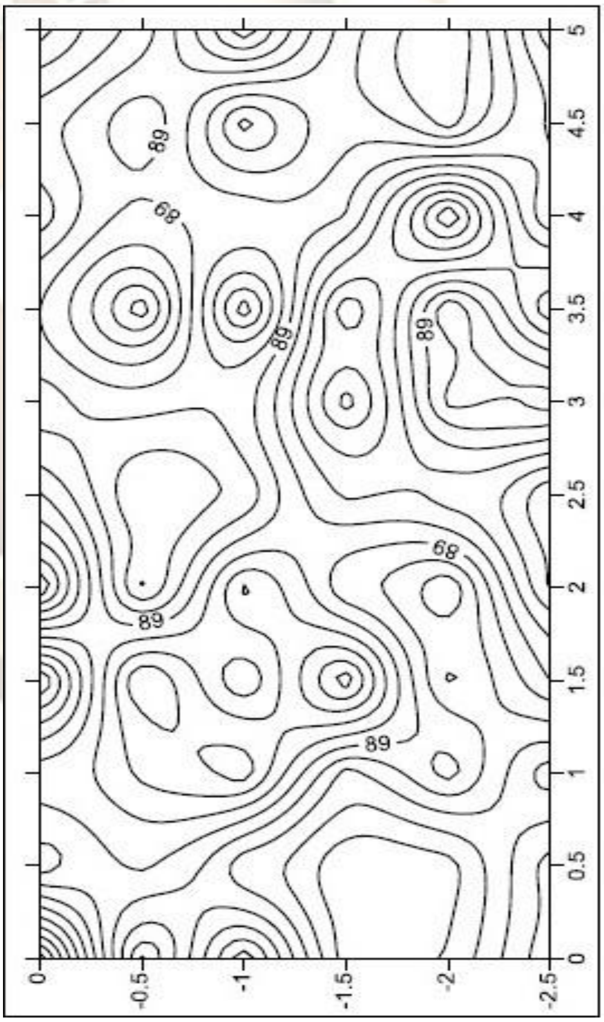

FIG. 11. CONTOUR DIAGRAM AT JATRABARI INTERSECTION

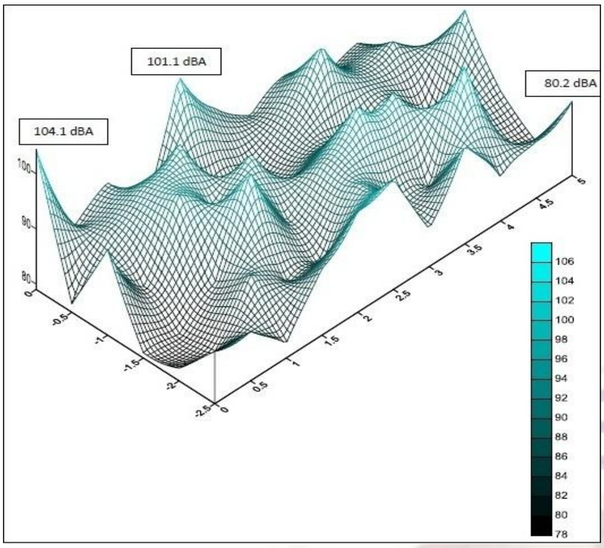

FIG. 12. WIREFRAME DIAGRAM AT JATRABARI INTERSECTION

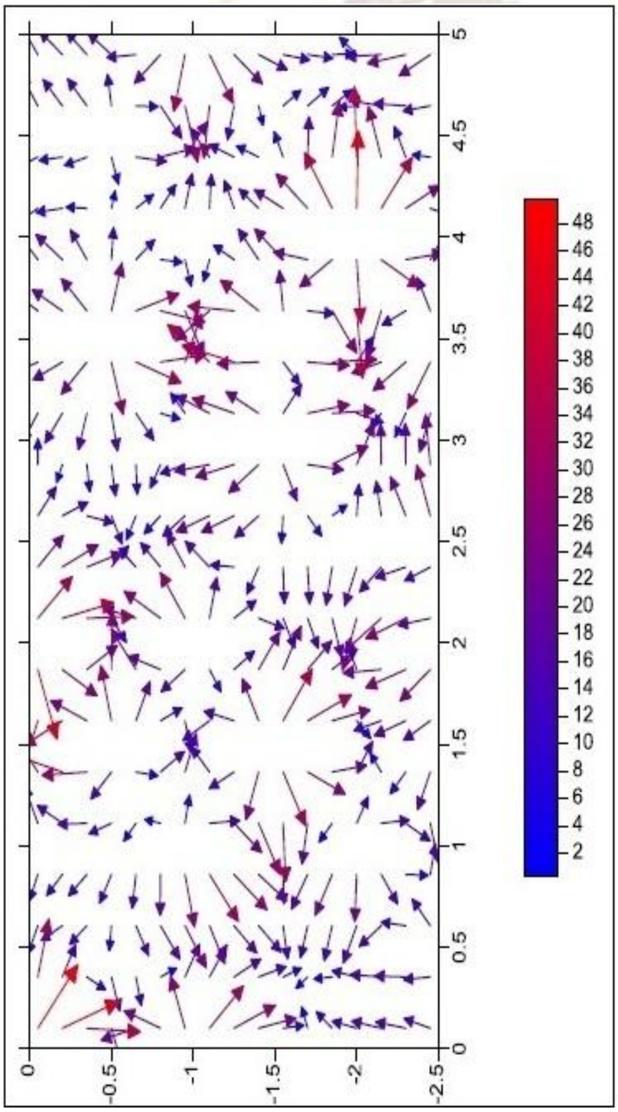

FIG. 13. VECTOR DIAGRAM AT JATRABARI INTERSECTION

4.4 NOISE MODELLING FOR CONSTRUCTION EQUIPMENTS

Two types of construction equipment were observed at Jatrabari-Gulistan flyover project site. These are

a) Gen Power Generator
b) Wheel Loader

During construction data were collected in two days due to time constraints. Maximum and minimum noise level was found 101.2 dBA and 76.9 dBA respectively for generator. A screening model was used to predict sound levels as a function of distance from the construction operations. The screening modelling was based on sound level reduction over distance only. Given the relatively short distances between the construction operations and receptors (households, offices, etc.), this is a reasonable assumption. The noise assessment was made following the New York State Department of Environmental Conservation (NYSDEC) screening level noise analyses [6]. This methodology uses the principle of hemispherical spreading of sound waves so that every doubling of distance produces a 6 dBA reduction of sound for a point source. Thus, the sound level was calculated using equation below:

$$L_{eq}\,(h) = L_{max} + E.F. + 10 \log U.F. - 20 \log (D/Do)$$

Where, L_{eq} (h) = A-weighted, equivalent sound level at a receptor resulting from operation of a piece of equipment over a 1-hr time period

L_{max} = Maximum noise emission level of equipment based on its work cycle at distance Do

E.F. = Equivalency Factor, which accounts for the difference between the maximum and minimum sound levels in the equipment work cycle and the percent of time spent at the maximum level; Table 7.2 in the U.S. DOT reference provides E.F.s based on these differences. For example, an E.F. of 0 applies to a steady-state noise source, while an E.F of -9 applies to sources that is quite visible and is at the maximum sound level for a short time during the work cycle

U.F. = Usage Factor, which accounts for the percent of time the equipment, is in use over the time period of interest (1 hour). For example, a U.F of 1 applies for equipment in use over 1 entire hour, while a U.F of 0.33 applies for equipment use for 20 minutes per hour

D = Distance from the equipment to the receptor of the interest; and

Do = Reference distance at which the Leq was measured for the piece of equipment of interest.

Sound level reduces in an exponential way unless any noise reducing barrier is used for generator (Fig. 14). Noise level was estimated around 57 dBA and 52 dBA at distance of 100 m and 200 m away respectively from the source. Most of the residential areas are located within this range of 200m in this area. So it can be concluded that noise level is just exceeds the acceptable limit set by DoE for residential areas. For wheel loader (Fig. 15) predicted noise is lower than the limit set by DoE at 200m away from wheel loader.

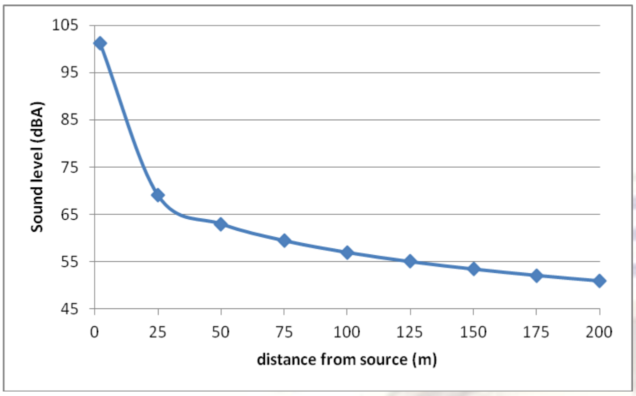

FIG. 14. MODEL PREDICTION OF SOUND LEVEL FOR GENERATOR

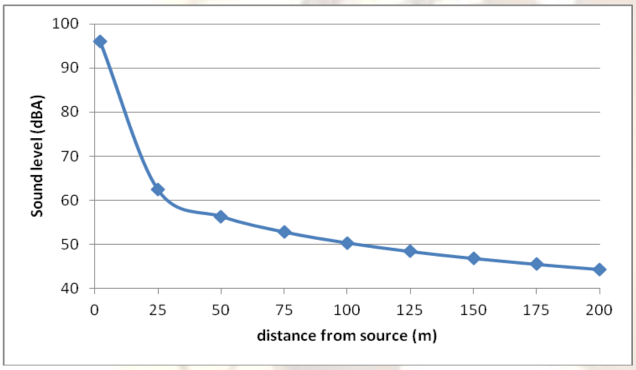

FIG. 15. MODEL PREDICTION OF SOUND LEVEL FOR WHEEL LOADER

V. CONCLUSION

As in recent years, traffic noise - the unpleasant, unwanted sounds generated on our nation's streets and highways has been of increasing concern both to the public and to local and government officials. At the same time, modern acoustical technology has been providing better ways to lessen its intensity and the adverse impacts of traffic noise, but its implementation in Bangladesh is poor. Highway and road traffic noise is never constant. It always changes with volume and speed. After the completion of the proposed Gulistan-Jatrabari flyover project the increased traffic volume will get a free flow condition, and with increasing speed the environmental quality of that area may be deteriorated specially the noise. So the proposed project is supposed to alleviate the problem regarding congestion but at the same time the noise problem must be taken into account.

From this study it is clear that all three study areas are not in a sustainable condition. The scenarios of the study area in fact are extreme threat to human health especially for the elderly people and children. Analysed data show that the level of noise pollution in Dhaka city far exceeds the acceptable limits set by the Department of Environment, Bangladesh. Even in the residential areas and vulnerable institutions like schools, hospitals, religious institutions, noise level is higher than the acceptable limit.

From the noise prediction of noise for different construction equipments it is clear that noise level is within the limit at a distance far away from source but it is really high in the nearby areas.

It is also observed that noise level is closely related to the volume of traffic, traffic flow condition, speed, tyre and pavement types, and characteristics of vehicles and so on.

Immediate measures should be taken to control the level of noise pollution. Several measures can be implemented which include road side tree plantation, banning hydraulic horn, maintenance of vehicles and pavements, construction of sound barrier where needed, installing noise insulation for the construction of road side buildings, provision of buffer zone etc.

VI. SCOPE FOR FUTURE RESEARCH

1. In this work, intermittent noise level meter was used and L_{eq} has been calculated manually. Accuracy of data may be improved by using continuous noise level meter.
2. Vehicle speed, traffic volume, tyre types, characteristics of vehicles, weather conditions were not considered in this work. Results may be improved if these factors are also considered.
3. In this study only two construction equipments is considered for modelling. The noise predicting model for different equipments may be more practical.
4. This study is done for uninterrupted free flow traffic. But the nature of noise level may vary in different traffic flow condition. Therefore traffic flow condition may be considered in future study.
5. This study was carried in flexible pavement. The characteristics of noise will be totally different in rigid pavements. Hence it is wide open to explore the level of noise in rigid pavements [2].
6. Data can be analysed using advanced softwares to present the noise pollution intensity into chloropletth maps for the whole study area. Chloropleth maps show a continuous variation of a feature across space which is more realistic.

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