*Asian Journal of Water, Environment and Pollution*, Vol. 4, No. 2, pp. 65-74.

# Development of the Traffic Noise Prediction Model

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*Received April 12, 2005; revised and accepted January 10, 2007*

**Abstract:** The high traffic density in urban areas is one of the main sources of noise that degrade the general environment. As the traffic noise is more fluctuating than the industry noise, it inflicts more serious damage to the health of human beings and lowers their labour productivity. Therefore, the control of traffic noise has become a matter of major concern for communities trying to maintain a satisfactory environment in which to live and work. To ensure a high quality environment, methods for prediction of the noise emission of motor vehicles are necessary tools. In order to model traffic noise and select corresponding noise control measures, it is necessary to know functional relationships between noise emission and traffic volume of the various categories of vehicles. This paper attempts to establish the traffic noise predictions with the traffic volume of different categories of vehicles based on their established weights.

**Key words:** Noise, model, vehicle, density.

## Introduction

Traffic noise is the most pervasive and most acutely perceived negative impact of transportation on the quality of life for residents living next to our highways. Our roads are the most intensively used in the nation. As our state continues to develop and as we strive to maximize the efficiency of our existing highways, there will be an ever-increasing noise impact on the quality of life for our residential neighbours. Therefore, the department must adopt a realistic, comprehensive policy, which recognizes that noise impacts of traffic growth cannot be eliminated. However, just as we strive to make incremental improvements in the safety and efficiency of our highway network, traffic noise must be managed through a similar incremental, comprehensive approach, to reduce its pervasive impacts on our state's residents.

The motor vehicles in particular are the passenger and utility vehicles. While the passenger vehicles are limited to the vehicles of a certain weight, the notion utility vehicles have a wide canvas encompassing all types of motor trucks, buses and off-road vehicles. Even today, the driving units of road vehicles are mainly the internal combustion engines. The traffic noise of motor vehicles is the most important type of noise to which people are exposed in their everyday life. Not only those who are in the vehicles, but particularly those who are in the vicinity of roads on which the vehicles move are exposed to that noise irrespective of the fact whether they are inside or outside rooms.

The spread of motor vehicles has led to serious problems in urban areas including the noise pollution. Therefore, the prediction of traffic noise of motor vehicles has become a matter of major concern for communities trying to maintain a satisfactory environment in which they live and work.

A number of research works have been carried out to assess and predict the noise level but most of the predictions were location sensitive. Burgress (1977) had developed a prediction model for noise level in urban traffic conditions in Sydney Metropolitan area. Brasch (1967) had predicted the same near a highway. Johnson and Saunders (1968) attempted the prediction of noise level from freely flowing road traffic. Langdon's (1968)

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contribution in this area is a bit remarkable. He has contributed a lot in evaluating noise nuisance caused by road traffic in residential areas in London city. Row (1990) had developed a model regarding the subjective response to the changes in the road traffic noise. Rao (1990) carried out a social survey in Visakhapatnam city to quantify the subjective response along the objective measurements at various locations. Pal et al. (1997) studied the noise situation along national highway 2 (NH-2) and selected state highways, and indicated that the noise levels were considered higher in both the cases. These elevated noise levels were due to the high frequency of the total volume of vehicles and the higher number of heavy vehicles in particular. Abdullahi et al. (1998), based on the results from an eight-city noise survey in Nigeria, showed that the inter-city traffic was characteristically different from the intra-city traffic noise, though in many cases, they had comparable day-night levels. Horoshenkov et al. (1999) used scale modelling to study sound propagation in city street canyons and showed that although the effects produced by complex noise abatement schemes are significant, they cannot be predicted by the simple addition of the effects from the individual components of the scheme. Singh (1995), based on a noise study in the city of Calcutta, showed that the noise variation at a place had got a definite characteristics pattern and suggested a methodology for characterizing the noise environment.

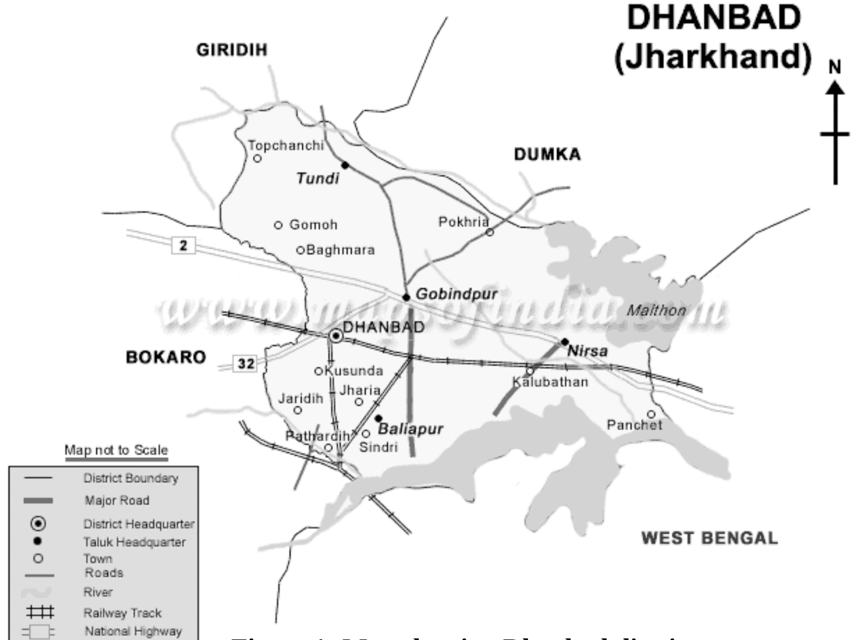


**Figure 1: Map showing Dhanbad district.**

## Study Area

The mining town of Dhanbad is internationally famous for its rich coalfields. It is located in the state of Jharkhand and is 171 kms from Jamshedpur. This industrial and commercial town in Chotanagpur Plateau has the distinction of lying in the heart of India's richest coalfields at Jharia. The collieries, various technical institutions and research centre of high order, attractive neighbourhood and the landscape are the attractions of this city. The township is located 250 kms NW-ward from Kolkata, West Bengal. Dhanbad, an important town from mining standpoint, is affected environmentally by coal mining around and other industrial activities. Coal mining in Jharia coalfield, a part of Dhanbad district, commenced in 1894. The other industries around the town are: steel plant, thermal power plant, fertilizer plant, coke ovens, chemical plants, zinc smelter, cement plant etc. The area of Dhanbad is 24 sq.km and lies at an altitude of 840 ft above the sea level. The population of Dhanbad district is around 43 lakhs approximately with a population density of approximately 1167 persons per sq.km. The climate of the area is dry to moist tropical with defined summer from April to June, rainy season from July to September, winter from October to February. The temperature rises to a maximum of 22 °C and drops to a minimum of 8 °C in winter. In summer, the temperature rises to 44 °C and drops to a minimum of 22 °C. The average rainfall is 1418 mm.

### Noise Monitoring Locations

In order to study the overall traffic noise situation in Dhanbad town, following seven strategic noise-monitoring locations/stations were selected (Figure 2).

1. Bank More—It is basically the very busy commercial area situated in Dhanbad Jharia road.
2. Court More—It is just outside of Civil Court and Civil Hospital. Though a sensitive area, it is one of the busiest places of traffic and public during the daytime.
3. Shramik Chowk—It is near the Railway Station and is a very busy commercial place.
4. Bartand—It is just outside of Bus Stand. This place is becoming a commercial place.
5. Steel Gate—This is situated on the Dhanbad-Govindpur District Board Road. Koyla Bhawan, the head quarters of Bharat Coking Coal Limited (BCCL)

is situated close to this locality. The residential complex of CCWO is adjacent to this locality.

6. ISM Gate—This monitoring location is just outside the gate of Indian School of Mines campus, an educational institute.

In order to assess the variability of noise situations, the following noise descriptors were monitored.

MaxP = The maximum sound level with ‘A’ Frequency weighting and Fast Time weighting.

MaxL = The maximum RMS sound level with ‘A’ Frequency weighting and Fast Time weighting.

MinL = The minimum RMS sound level with ‘A’ Frequency weighting and Fast Time weighting.

$L_{eq}$ = Equivalent continuous sound pressure level which would have same total acoustic energy as the real fluctuating noise over the same time period.

The vehicles moving on the highways were categorised as

Heavy vehicles: These are defined as transport vehicles with gross vehicle weight more than 4536 kg and include buses, heavy trucks, dumpers, etc.

Automobiles: These are defined as transport vehicles with gross vehicle weight less than 4536 kg and include cars, jeeps, trekkers and three wheelers.

Two wheelers: These include scooters and motorcycles.

## Methodology

Systematic noise monitoring was done during November-December 2004 using Modular Precision Sound Level Meter, Type 2231 and Modular Sound Analyzer, Type 2260 as per the guidelines given in IS:3028 (1998). The microphone of the sound level meter was set at a distance of 7.5 m from the centre of the road and 1.2 m above the ground. The locations, which are being monitored, are Shramik Chowk, Bank More, Bartand, Court More, Steel Gate and ISM Gate as shown in Figure 2.

Discontinuous monitoring was done at all the six stations from 6.00 A.M to 10.00 P.M. Based on these observations Max P, Max L, Min L, Leq levels were determined for each monitored location. Besides noise monitoring, traffic density of heavy vehicles, automobiles and two wheelers counts were undertaken simultaneously. The observed values are shown in Tables 1, 2, 3, 4, 5 and 6.

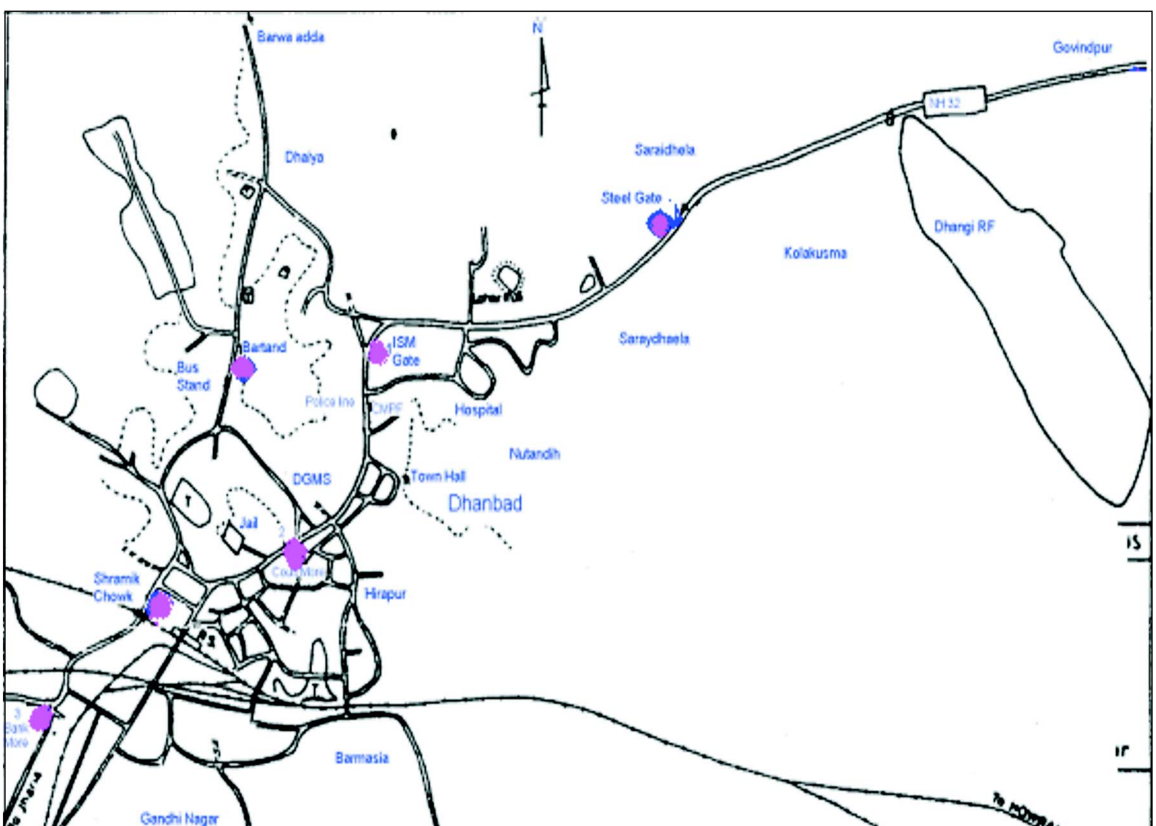


**Figure 2: Traffic noise monitoring stations in the Dhanbad town.**

## Results and Discussions

Tables 1 to 6 display summarised results of monitored noise parameters as well as vehicular frequency on an hourly basis for all the monitoring stations. The fluctuation of the number of vehicles per hour at various locations varied. Generally, the vehicle density increases as the day passes and the number of heavy vehicles in the traffic stream decreases. The heavy vehicle percentages are higher in the morning and in the late evening. The associated Leq levels were observed to be at maximum during that period which registered movement of either maximum number of total vehicles or maximum number of heavy vehicles.

The Leq level found at Bartand was in the range of 75.7 dB(A) to 80.3 dB(A). The Leq level was found maximum during 6.00 AM-7.00 AM due to the high speed of the heavy vehicles. The vehicle density was found maximum during 9.00-10.00 AM period.

The Leq level found at Court More was in the range of 75.9 dB(A) to 77.9 dB(A). The Leq level found was maximum during 9.00-10.00 PM due to the maximum number of heavy vehicles whereas the number of vehicle pass was found maximum during 5.00-6.00 PM.

At Steel Gate the density of heavy vehicle was observed to be maximum during 6.00 to 7.00 AM and Leq levels were observed attaining peak levels during this period.

At Shramik Chowk total vehicular movement was registered to the peak level during 10.00 to 11.00 AM but the density of heavy vehicle was maximum in the period of 9.00-10.00 PM. The Leq level was also maximum during 9.00 to 10.00 pm and that was due to the number of heavy vehicles.

At ISM Main Gate, the maximum vehicular movement was registered during 5.00 to 6.00 PM. whereas the heavy vehicular density was found maximum during the period 6.00-7.00 AM. The Leq level also has higher values in morning period 6.00-7.00 AM.

At Bank More, maximum vehicular density was observed during 5.00 to 6.00 pm. But the Leq level was found maximum during 6.00 to 7.00 AM due to the maximum heavy vehicle density.

**Table 1: Sound level parameters at Bartand**

| *Sl. No.* | *Monitoring time* | *MaxP dB(A)* | *MaxL dB(A)* | *Min L dB(A)* | *LAeq dB(A)* | *Heavy vehicles* | *Automobiles* | *Two wheelers* | *Total vehicles* |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 6.00-7.00 AM | 115.3 | 93.6 | 59.2 | 80.3 | 101 | 422 | 402 | 925 |
| 2. | 9.00-10.00 AM | 110.1 | 91.7 | 56.5 | 77.9 | 102 | 754 | 1056 | 1912 |
| 3. | I0.00-11.00 AM | 111.1 | 95.6 | 58.0 | 77.3 | 50 | 374 | 722 | 1146 |
| 4. | 11.00-12.00 noon | 111.3 | 95.5 | 58.6 | 77.0 | 41 | 327 | 612 | 980 |
| 5. | 2.00-3.00 PM | 109.6 | 95.0 | 54.0 | 76.9 | 47 | 454 | 835 | 1336 |
| 6. | 3.00-4.00 PM | 114.9 | 99.8 | 54.4 | 77.2 | 54 | 419 | 785 | 1258 |
| 7. | 4.00-5.00 PM | 110.1 | 93.5 | 55.1 | 77.5 | 68 | 582 | 747 | 1397 |
| 8. | 5.00-6.00 PM | 113.7 | 95.3 | 55.3 | 76.3 | 38 | 822 | 764 | 1624 |
| 9. | 6.00-7.00 PM | 111.5 | 93.2 | 54.8 | 75.7 | 31 | 814 | 822 | 1667 |
| 10. | 9.00-10.00 PM | 110.8 | 94.5 | 56.7 | 76.1 | 38 | 681 | 663 | 1382 |

**Table 2: Sound level parameters at Court More**

| *Sl. No.* | *Monitoring time* | *MaxP dB(A)* | *MaxL dB(A)* | *Min L dB(A)* | *LAeq dB(A)* | *Heavy vehicles* | *Automobiles* | *Two wheelers* | *Total vehicles* |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 6.00-7.00 AM | 110.6 | 92.3 | 61.2 | 77.7 | 22 | 386 | 672 | 1080 |
| 2. | 9.00-10.00 AM | 106.8 | 92.6 | 60.1 | 77.0 | 21 | 721 | 1462 | 2204 |
| 3. | I0.00-11.00 AM | 109.4 | 92.7 | 60.8 | 76.9 | 18 | 732 | 1236 | 1986 |
| 4. | 11.00-12.00 noon | 115.3 | 95.7 | 60.0 | 76.8 | 18 | 622 | 1298 | 1938 |
| 5. | 2.00-3.00 PM | 115.3 | 98.4 | 61.6 | 77.3 | 26 | 658 | 1308 | 1992 |
| 6. | 3.00-4.00 PM | 105.6 | 90.1 | 61.5 | 77.5 | 28 | 477 | 1120 | 1625 |
| 7. | 4.00-5.00 PM | 109.0 | 93.3 | 60.8 | 76.4 | 17 | 523 | 1223 | 1763 |
| 8. | 5.00-6.00 PM | 108.3 | 92.5 | 61.6 | 75.9 | 21 | 779 | 1563 | 2363 |
| 9. | 6.00-7.00 PM | 109.7 | 94.8 | 62.8 | 77.2 | 28 | 813 | 1408 | 2249 |
| 10. | 9.00-10.00 PM | 106.5 | 95.1 | 60.5 | 77.9 | 34 | 630 | 852 | 1516 |

**Table 3: Sound level parameters at Steel Gate**

| *Sl. No.* | *Monitoring time* | *MaxP dB(A)* | *MaxL dB(A)* | *Min L dB(A)* | *LAeq dB(A)* | *Heavy vehicles* | *Automobiles* | *Two wheelers* | *Total vehicles* |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 6.00-7.00 AM | 119.8 | 98.6 | 64.6 | 84.1 | 101 | 321 | 212 | 634 |
| 2. | 9.00-10.00 AM | 13.3 | 95 | 64 | 77.8 | 52 | 562 | 394 | 1008 |
| 3. | I0.00-11.00 AM | 110.6 | 95.6 | 61.2 | 75.4 | 43 | 618 | 724 | 1385 |
| 4. | 11.00-12.00 noon | 111.8 | 98 | 62.9 | 75.6 | 41 | 598 | 656 | 1295 |
| 5. | 2.00-3.00 PM | 114.7 | 97.2 | 62.3 | 76.0 | 33 | 329 | 544 | 906 |
| 6. | 3.00-4.00 PM | 112.5 | 98.2 | 64.1 | 77.7 | 45 | 467 | 482 | 994 |
| 7. | 4.00-5.00 PM | 114.3 | 98.6 | 64.7 | 77.2 | 52 | 602 | 669 | 1323 |
| 8. | 5.00-6.00 PM | 117.4 | 97.7 | 63.8 | 76.9 | 38 | 582 | 887 | 1507 |
| 9. | 6.00-7.00 PM | 115.8 | 96.9 | 64.1 | 77.3 | 42 | 612 | 952 | 1606 |
| 10. | 9.00-10.00 PM | 117.6 | 97.5 | 64.3 | 77.8 | 39 | 571 | 423 | 1033 |

**Table 4: Sound level parameters at Shramik Chowk**

| *Sl. No.* | *Monitoring time* | *MaxP dB(A)* | *MaxL dB(A)* | *Min L dB(A)* | *LAeq dB(A)* | *Heavy vehicles* | *Automobiles* | *Two wheelers* | *Total vehicles* |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 6.00-7.00 AM | 109.6 | 96.4 | 64.7 | 81.2 | 110 | 452 | 396 | 958 |
| 2. | 9.00-10.00 AM | 112.2 | 97.6 | 60.4 | 76.9 | 51 | 734 | 1612 | 2397 |
| 3. | I0.00-11.00 AM | 108.6 | 91.9 | 58.7 | 77.1 | 59 | 680 | 1932 | 2671 |
| 4. | 11.00-12.00 noon | 110.5 | 95.8 | 64.8 | 76.7 | 61 | 672 | 1918 | 2651 |
| 5. | 2.00-3.00 PM | 109.2 | 95.6 | 63.9 | 77.6 | 69 | 698 | 1271 | 2038 |
| 6. | 3.00-4.00 PM | 111.4 | 96.5 | 62.6 | 78.1 | 92 | 722 | 1324 | 2138 |
| 7. | 4.00-5.00 PM | 110.8 | 96.2 | 61.9 | 77.8 | 87 | 746 | 1236 | 2069 |
| 8. | 5.00-6.00 PM | 108.8 | 96.7 | 61.2 | 77.9 | 74 | 813 | 1427 | 2314 |
| 9. | 6.00-7.00 PM | 110.5 | 97.3 | 62.4 | 78.6 | 68 | 724 | 1196 | 1988 |
| 10. | 9.00-10.00 PM | 111.7 | 97.2 | 63.4 | 84.3 | 134 | 411 | 296 | 841 |

**Table 5: Sound level parameters at ISM Gate**

| *Sl. No.* | *Monitoring time* | *MaxP dB(A)* | *MaxL dB(A)* | *Min L dB(A)* | *LAeq dB(A)* | *Heavy vehicles* | *Automobiles* | *Two wheelers* | *Total vehicles* |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 6.00-7.00 AM | 110.8 | 94.3 | 61.6 | 80.4 | 43 | 204 | 148 | 395 |
| 2. | 9.00-10.00 AM | 112.4 | 96.3 | 63.6 | 77.2 | 23 | 644 | 418 | 1085 |
| 3. | I0.00-11.00 AM | 113.6 | 94.7 | 60.1 | 77.5 | 35 | 594 | 507 | 1136 |
| 4. | 11.00-12.00 noon | 115.9 | 98.2 | 64.7 | 77.3 | 29 | 614 | 642 | 1285 |
| 5. | 2.00-3.00 PM | 110.3 | 96.8 | 64.8 | 77.5 | 19 | 321 | 484 | 824 |
| 6. | 3.00-4.00 PM | 111.8 | 98.1 | 66.5 | 77.2 | 18 | 497 | 521 | 1036 |
| 7. | 4.00-5.00 PM | 114.3 | 98.5 | 64.1 | 76.9 | 21 | 711 | 735 | 1467 |
| 8. | 5.00-6.00 PM | 113.5 | 97.2 | 63.8 | 77.0 | 23 | 834 | 747 | 1604 |
| 9. | 6.00-7.00 PM | 112.9 | 96.4 | 64.6 | 77.6 | 32 | 764 | 628 | 1424 |
| 10. | 9.00-10.00 PM | 111.9 | 97.6 | 62.2 | 78.5 | 47 | 512 | 345 | 904 |

**Table 6: Sound level parameters at Bank More**

| *Sl. No.* | *Monitoring time* | *MaxP dB(A)* | *MaxL dB(A)* | *Min L dB(A)* | *LAeq dB(A)* | *Heavy vehicles* | *Automobiles* | *Two wheelers* | *Total vehicles* |
|---|---|---|---|---|---|---|---|---|---|
| 1. | 6.00-7.00 AM | 112.6 | 94.7 | 61.4 | 81.1 | 114 | 482 | 394 | 990 |
| 2. | 9.00-10.00 AM | 113.4 | 95.8 | 62.5 | 76.4 | 32 | 866 | 723 | 1621 |
| 3. | I0.00-11.00 AM | 111.6 | 97.6 | 62.7 | 77.1 | 38 | 1042 | 773 | 1853 |
| 4. | 11.00-12.00 noon | 113.8 | 96.4 | 63.2 | 76.1 | 24 | 891 | 689 | 1604 |
| 5. | 2.00-3.00 PM | 114.2 | 94.3 | 60.9 | 76.0 | 19 | 753 | 541 | 1313 |
| 6. | 3.00-4.00 PM | 110.7 | 94.1 | 61.2 | 77.6 | 29 | 560 | 419 | 1008 |
| 7. | 4.00-5.00 PM | 111.5 | 95.7 | 63.4 | 77.3 | 41 | 865 | 775 | 1681 |
| 8. | 5.00-6.00 PM | 110.4 | 96.8 | 62.4 | 76.9 | 39 | 985 | 864 | 1888 |
| 9. | 6.00-7.00 PM | 109.8 | 93.2 | 61.8 | 76.4 | 18 | 910 | 763 | 1691 |
| 10. | 9.00-10.00 PM | 112.3 | 93.8 | 60.5 | 77.4 | 57 | 668 | 451 | 1176 |

Since there are number of variables like MaxP, MaxL, MinL, Leq, heavy vehicle, automobile, two wheelers, attempts was taken to establish the relationship to predict the noise level with the help of number and type of vehicle. The relationship was best found simultaneously and individually for the different locations among the parameters Leq, total number of vehicles and percentage of heavy vehicles over the total vehicles. In the mathematical model following relationship was drawn to predict the equivalent noise level (Leq) with the help of two variables viz. total vehicle pass ($Q$) and percentage of heavy vehicle over total vehicle ($P$), through multivariate regression analysis using SYSTAT Package. The statistical analyses of the data are shown in Annexure I. The relationship for the different locations and the overall equation for all the observed parameters are shown in Table 7. The co-relation coefficient for all the monitoring stations were found good except in the Court More. This was due to other parameters like community noise played the role to effect the noise level. Thus this equation was not significant to predict the noise level.

The predictive values against each observed values were calculated from the different equations as shown in Table 8. The predictive values obtained from the different equation except equations for Court More showed the maximum deviation (Ä$L$) from the observed value in the order of ±1.5 dB(A) for all the locations.

**Table 7: Prediction equation for the different locations**

| *Locations* | *Prediction equation* | *Co-relation coefficient* |
|---|---|---|
| Bank More (1) | Leq = 0.84 log $Q$ + 0.47 $P$ + 73.00 | 0.93 |
| Bartand (2) | Leq = 0.78 log $Q$ + 0.51 $P$ + 72.50 | 0.98 |
| Court More (3) | Leq = –0.69 log $Q$ + 0.94 $P$ + 77.58 | 0.56 |
| ISM Gate (4) | Leq = –0.23 log $Q$ + 0.34 $P$ + 77.30 | 0.98 |
| Steel Gate (5) | Leq = 2.61 log $Q$ + 0.65 $P$ + 66.46 | 0.91 |
| Shramik Chowk (6) | Leq = –0.05 log $Q$ + 0.49 $P$ + 76.16 | 0.96 |
| Overall (7) | Leq = 0.86 log $Q$ + 0.50 $P$ + 72.90 | 0.85 |

**Table 8: Validation of the predictive equation**

| *Equation used* | *Observed value* | *Predictive value from equation 1* | *Predictive value from equation 2* | *Predictive value from equation 3* | *Predictive value from equation 4* | *Predictive value from equation 5* | *Predictive value from equation 6* | *Predictive value from equation 7* |
|---|---|---|---|---|---|---|---|---|
| **Bank More** | 81.1 | 80.93 | 80.71 | 86.34 | 80.53 | 81.76 | 81.65 | 81.23 |
| | 76.4 | 76.62 | 76.01 | 77.22 | 77.23 | 76.12 | 76.97 | 76.65 |
| | 77.1 | 76.71 | 76.09 | 77.25 | 77.25 | 76.32 | 77.00 | 76.74 |
| | 76.1 | 76.40 | 75.76 | 76.77 | 77.07 | 75.80 | 76.73 | 76.40 |
| | 76.0 | 76.30 | 75.67 | 76.79 | 77.07 | 75.54 | 76.71 | 76.31 |
| | 77.6 | 76.88 | 76.31 | 78.21 | 77.59 | 76.17 | 77.42 | 76.92 |
| | 77.3 | 76.86 | 76.26 | 77.65 | 77.39 | 76.46 | 77.19 | 76.89 |
| | 76.9 | 76.72 | 76.11 | 77.26 | 77.25 | 76.35 | 77.01 | 76.75 |
| | 76.4 | 76.21 | 75.56 | 76.35 | 76.92 | 75.58 | 76.52 | 76.21 |
| | 77.4 | 77.86 | 77.37 | 80.02 | 78.24 | 77.62 | 78.38 | 77.96 |
| **Bartand** | 80.3 | 80.62 | 80.38 | 85.80 | 80.33 | 81.30 | 81.36 | 80.38 |
| | 77.9 | 78.26 | 77.78 | 80.33 | 78.36 | 78.49 | 78.61 | 77.78 |
| | 77.3 | 77.62 | 77.11 | 79.57 | 78.08 | 77.28 | 78.14 | 77.11 |
| | 77.0 | 77.48 | 76.97 | 79.45 | 78.03 | 76.99 | 78.06 | 76.97 |
| | 76.9 | 77.28 | 76.73 | 78.73 | 77.78 | 76.91 | 77.73 | 76.73 |
| | 77.2 | 77.62 | 77.11 | 79.48 | 78.05 | 77.34 | 78.11 | 77.11 |
| | 77.5 | 77.93 | 77.44 | 79.99 | 78.23 | 77.83 | 78.39 | 77.44 |
| | 76.3 | 76.80 | 76.20 | 77.56 | 77.36 | 76.36 | 77.15 | 76.20 |
| | 75.7 | 76.58 | 75.96 | 77.10 | 77.19 | 76.08 | 76.91 | 75.96 |
| | 76.1 | 76.93 | 76.35 | 78.00 | 77.51 | 76.44 | 77.35 | 76.35 |
| **Court More** | 77.7 | 76.51 | 75.90 | 77.40 | 77.29 | 75.70 | 77.01 | 76.53 |
| | 77.0 | 76.26 | 75.59 | 76.17 | 76.86 | 75.81 | 76.46 | 76.25 |
| | 76.9 | 76.20 | 75.53 | 76.16 | 76.85 | 75.66 | 76.44 | 76.19 |
| | 76.8 | 76.20 | 75.54 | 76.18 | 76.86 | 75.64 | 76.45 | 76.19 |
| | 77.3 | 76.38 | 75.74 | 76.53 | 76.98 | 75.92 | 76.63 | 76.39 |
| | 77.5 | 76.51 | 75.88 | 76.98 | 77.15 | 75.96 | 76.84 | 76.52 |
| | 76.4 | 76.18 | 75.52 | 76.25 | 76.88 | 75.56 | 76.47 | 76.17 |
| | 75.9 | 76.25 | 75.58 | 76.09 | 76.83 | 75.84 | 76.43 | 76.25 |
| | 77.2 | 76.40 | 75.75 | 76.44 | 76.95 | 76.02 | 76.60 | 76.41 |
| | 77.9 | 76.73 | 76.12 | 77.49 | 77.33 | 76.22 | 77.10 | 76.76 |
| **Steel Gate** | 84.1 | 82.84 | 82.81 | 90.62 | 82.07 | 84.13 | 83.83 | 83.28 |
| | 77.8 | 77.95 | 77.47 | 80.36 | 78.36 | 77.65 | 78.54 | 78.06 |
| | 75.4 | 77.10 | 76.53 | 78.33 | 77.63 | 76.68 | 77.52 | 77.15 |
| | 75.6 | 77.10 | 76.54 | 78.41 | 77.66 | 76.64 | 77.56 | 77.16 |
| | 76.0 | 77.20 | 76.66 | 78.96 | 77.86 | 76.55 | 77.80 | 77.26 |
| | 77.7 | 77.65 | 77.15 | 79.77 | 78.15 | 77.23 | 78.23 | 77.74 |
| | 77.2 | 77.47 | 76.94 | 79.12 | 77.92 | 77.16 | 77.93 | 77.55 |
| | 76.9 | 76.85 | 76.26 | 77.76 | 77.43 | 76.39 | 77.24 | 76.89 |
| | 77.3 | 76.92 | 76.33 | 77.83 | 77.45 | 76.53 | 77.28 | 76.96 |
| | 77.8 | 77.31 | 76.78 | 79.05 | 77.89 | 76.78 | 77.86 | 77.38 |
| **Shramik Chowk** | | | | | | | | |
| | 81.2 | 80.90 | 80.68 | 86.32 | 80.52 | 81.70 | 81.64 | 81.21 |
| | 76.9 | 76.84 | 76.22 | 77.25 | 77.25 | 76.66 | 77.03 | 76.87 |
| | 77.1 | 76.92 | 76.30 | 77.29 | 77.26 | 76.84 | 77.07 | 76.95 |
| | 76.7 | 76.96 | 76.34 | 77.38 | 77.29 | 76.89 | 77.12 | 76.99 |

(contd.)

**Table 8** (contd.)

| *Equation used* | *Observed value* | *Predictive value from equation 1* | *Predictive value from equation 2* | *Predictive value from equation 3* | *Predictive value from equation 4* | *Predictive value from equation 5* | *Predictive value from equation 6* | *Predictive value from equation 7* |
|---|---|---|---|---|---|---|---|---|
| | 77.6 | 77.37 | 76.81 | 78.48 | 77.69 | 77.30 | 77.65 | 77.44 |
| | 78.1 | 77.82 | 77.29 | 79.33 | 78.00 | 77.95 | 78.10 | 77.92 |
| | 77.8 | 77.76 | 77.23 | 79.24 | 77.97 | 77.85 | 78.05 | 77.85 |
| | 77.9 | 77.33 | 76.76 | 78.26 | 77.61 | 77.32 | 77.56 | 77.39 |
| | 78.6 | 77.38 | 76.82 | 78.52 | 77.70 | 77.29 | 77.67 | 77.45 |
| | 84.3 | 82.95 | 82.91 | 90.54 | 82.04 | 84.45 | 83.82 | 83.38 |
| **ISM Gate** | 80.4 | 80.30 | 80.08 | 86.02 | 80.40 | 80.31 | 81.36 | 80.58 |
| | 77.2 | 76.55 | 75.95 | 77.48 | 77.32 | 75.76 | 77.05 | 76.57 |
| | 77.5 | 77.01 | 76.45 | 78.37 | 77.64 | 76.44 | 77.52 | 77.07 |
| | 77.3 | 76.67 | 76.08 | 77.56 | 77.35 | 76.04 | 77.11 | 76.70 |
| | 77.5 | 76.53 | 75.95 | 77.74 | 77.41 | 75.57 | 77.14 | 76.56 |
| | 77.2 | 76.35 | 75.74 | 77.13 | 77.20 | 75.46 | 76.86 | 76.36 |
| | 76.9 | 76.33 | 75.70 | 76.74 | 77.06 | 75.65 | 76.70 | 76.34 |
| | 77.0 | 76.37 | 75.73 | 76.72 | 77.05 | 75.76 | 76.70 | 76.37 |
| | 77.6 | 76.71 | 76.11 | 77.52 | 77.34 | 76.15 | 77.10 | 76.74 |
| | 78.5 | 77.93 | 77.46 | 80.43 | 78.39 | 77.56 | 78.56 | 78.04 |

## Conclusion

The heavy vehicle percentage was found high during morning and late evening. The associated Leq levels were found to be high during the period of movement of maximum number of total vehicles or heavy vehicles. In most of the monitoring locations within the Dhanbad town maximum Leq levels were found either in early morning or late night due to the maximum number of heavy vehicles.

Statistical models/relationship between the noise parameters and total traffic volume per hour ($Q$) and percentage of heavy vehicles over total number of vehicles ($P$) were developed. These relationships were found to have good statistical significance for all the monitoring stations except one due to the existence of the other types of noise sources. The deviation of the observed value and predicted value from each equation except equation for Court More (3) has the deviation in the order of ±1.5 dB(A). Thus any of the above equations except 3 can be used to predict the equivalent noise level.

## References

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# Annexure I

**Bank More**

Raw *R*-square (1-Residual/Total) = 0.99
Mean corrected *R*-square (1-Residual/Corrected) = 0.93
*R* (observed vs predicted) square = 0.93

| *Parameter* | *Estimate* | *A.S.E* | *Parameter/ASE* | *Confidence Interval (95%)* | |
|---|---|---|---|---|---|
| | | | | *Lower* | *Upper* |
| A | 0.84 | 1.86 | 0.45 | –3.56 | 5.26 |
| B | 0.47 | 0.06 | 7.50 | 0.32 | 0.62 |
| C | 73.0 | 6.03 | 12.09 | 58.77 | 87.32 |

**Bartand**

Raw *R*-square (1-Residual/Total) = 1.00
Mean corrected *R*-square (1-Residual/Corrected) = 0.98
*R* (observed vs predicted) square = 0.98

| *Parameter* | *Estimate* | *A.S.E* | *Parameter/ASE* | *Confidence Interval (95%)* | |
|---|---|---|---|---|---|
| | | | | *Lower* | *Upper* |
| A | 0.78 | 0.74 | 1.05 | –0.98 | 2.54 |
| B | 0.51 | 0.30 | 17.55 | 0.45 | 0.58 |
| C | 72.5 | 2.40 | 30.17 | 66.80 | 78.16 |

**Court More**

Raw *R*-square (1-Residual/Total) = 0.99
Mean corrected *R*-square (1-Residual/Corrected) = 0.56
*R* (observed vs predicted) square = 0.56

| *Parameter* | *Estimate* | *A.S.E* | *Parameter/ASE* | *Confidence Interval (95%)* | |
|---|---|---|---|---|---|
| | | | | *Lower* | *Upper* |
| A | –0.64 | 2.85 | –0.22 | –7.38 | 6.10 |
| B | 0.94 | 0.57 | 1.65 | –0.40 | 2.30 |
| C | 77.58 | 9.91 | 7.82 | 54.13 | 101.01 |

**ISM Gate**

Raw *R*-square (1-Residual/Total) = 1.00
Mean corrected *R*-square (1-Residual/Corrected) = 0.98
*R* (observed vs predicted) square = 0.98

| *Parameter* | *Estimate* | *A.S.E* | *Parameter/ASE* | *Confidence Interval (95%)* | |
|---|---|---|---|---|---|
| | | | | *Lower* | *Upper* |
| A | –0.23 | 0.63 | –0.36 | –1.73 | 1.27 |
| B | 0.34 | 0.04 | 8.94 | 0.25 | 0.44 |
| C | 77.3 | 2.04 | 37.92 | 72.45 | 82.1 |

**Steel Gate**

Raw *R*-square (1-Residual/Total) = 0.99
Mean corrected *R*-square (1-Residual/Corrected) = 0.90
*R* (observed vs predicted) square = 0.91

| *Parameter* | *Estimate* | *A.S.E* | *Parameter/ASE* | *Confidence Interval (95%)* | |
|---|---|---|---|---|---|
| | | | | *Lower* | *Upper* |
| A | 2.61 | 4.04 | 0.65 | –6.96 | 12.18 |
| B | 0.65 | 0.12 | 5.24 | 0.36 | 0.95 |
| C | 66.46 | 12.85 | 5.17 | 36.06 | 96.85 |

**Shramik Chowk**

Raw *R*-square (1-Residual/Total) = 0.99
Mean corrected *R*-square (1-Residual/Corrected) = 0.96
*R* (observed vs predicted) square = 0.96

| *Parameter* | *Estimate* | *A.S.E* | *Parameter/ASE* | *Confidence Interval (95%)* | |
|---|---|---|---|---|---|
| | | | | *Lower* | *Upper* |
| A | –0.05 | 4.22 | –0.01 | –10.03 | 9.93 |
| B | 0.49 | 0.16 | 3.11 | 0.12 | 0.88 |
| C | 76.16 | 14.66 | 5.19 | 41.50 | 110.82 |

**Overall prediction equation**

Raw *R*-square (1-Residual/Total) = 1.00
Mean corrected *R*-square (1-Residual/Corrected) = 0.86
*R* (observed vs predicted) square = 0.86

| *Parameter* | *Estimate* | *A.S.E* | *Parameter/ASE* | *Confidence Interval (95%)* | |
|---|---|---|---|---|---|
| | | | | *Lower* | *Upper* |
| A | 0.86 | 0.68 | 1.26 | –0.50 | 2.23 |
| B | 0.50 | 0.03 | 15.20 | 0.43 | 0.56 |
| C | 72.9 | 2.23 | 32.61 | 68.47 | 77.42 |