Recent Research in Science and Technology 2013, 5(5): 54-58
ISSN: 2076-5061
Available Online: http://recent-science.com/

A review paper on R&D efforts in assessing the traffic noise on highways

G.S.Vij[1] and M.L. Agrawal[2]

[1]Associate Professor, Deptt. of Civil Engg., CSIT, Durg, India.
[2]Principal, RITEE, Raipur, India.

Abstract
In rapidly urbanizing country like India, the transportation sector is growing in a fast pace and the number of vehicles on Indian roads is increasing at a rate of more than 7% per annum. This has led to over crowded roads and pollution. Transportation sector is one of the major contributors to noise in urban area, which contributes 55% of total noise on highway. In view of this, it is essential to study highway noise with respect to various causative factors. Hence, various noise prediction models have been developed, throughout the world to assess its impact on to the society and the human beings. These traffic noise prediction models differ in some respects, but the overall methodology is similar. All the noise prediction models consists of evaluating basic noise levels and making series of adjustments to take into account geometric, traffic flow, barrier data etc. In this paper, noise prediction models of U.S.A. and U.K. (FHWA and CORTON) along with the research efforts on noise in Indian context has been studied and discussed.

Keywords: FHWA model, CORTON model.

INTRODUCTION

Noise is one of the environmental pollutants that is encountered in daily life. The exposure to noise from highway, affects more people than noise from any other source [1]. It is not at all surprising that the adverse impact from highway noise is one of the major concern to planners, regulatory agencies, and effected individuals and communities. Several state agencies have implemented regulations that specify procedures to conduct noise studies.

These regulations led to the advancement of computerized method for predicting highway noise [2]. Surface transport noise is not a new problem. In the twentieth century, New York was reported to be the noisiest city of the world probably because of its elevated railways.

In 1929, a noise abatement commission was appointed to study the noise pollution in New York City . In Great Britain, a committee on noise for the operation of mechanically propelled vehicles was appointed in 1934 and recommended legislation to sound level limits for vehicles [3]. The well known Wilson committee report on noise drew attention to the serious problem of road traffic in Britain in 1936. In US quantitative limits for vehicle noise were first introduced by individual states beginning in the year 1965 with New York which sets a limit of 88 dBA measured at 15.56 m from the central of traffic lane. The study carried out by an OECD group of experts review the current state of the art and national experience with noise abatement techniques for new and existing roads [4].

LITERATURE REVIEW

J.K. Jain studied the impact of the constructions activities on existing highway SH-45 (now NH -58) by taking observations for volume, speed, noise level and suspended particulate matter. [5] Four stations were selected, two were on constructions sites, one away from constructions site and one at Roorkee. Noise level was found to be high at first and second construction sites.

Agrawal studied the environmental impacts of four lanes, such as noise and air pollution of the selected site on NH-2, out of which first was already four laned, second on the construction site where two lanes were blocked for the construction activities and the third on the two lane highway[6]. In all the three locations revealed that even the minimum noise level was also higher then the maximum recommended limit of 65dBA .The maximum noise level was observed at the construction site due to operation of equipments.

Reddy studied traffic related environmental factors such as noise and air pollution at some selected locations in Delhi metropolitan city. At about 12 busy intersections on NH -2 [7], the noise level and the traffic volume was recorded. Result shows that even minimum noise level limit was higher then the maximum recommended limit of 65 dBA.

Sheetal Agarwal and B.L. Swami [8] studied the annoyance among people created by motorized vehicles. Motorized road vehicles are the source of noise; always responsible for creating annoyance among people. The present study is aimed to investigated the correction between annoyance level and different noise indices and its impact on residents/community in terms of annoyance index. Noise and attitudinal response of local population were carried out at ten commercial road networks of the city. To define the noise annoyance quantatively, a new point scale [i.e. Mean Dissatisfaction Score(MDS)]has been used in the present study, a strong correlation was observed between percentage highly annoyed and various noise indices.

Gupta, Khanna and Gopal [9] developed a monogram for noise reductions in the year 1984. The above work was also one of the earliest published works in India on noise.

Sarin et al [10] evaluated the road traffic noise problem of residential scientist apartments near a very busy and important highway intersection in Delhi.

It was found that equivalent noise level was very high at all the floors (up to 7th floor) that the permissible noise level by Indian standard i.e. 65 dBA.

Shrivastava et al [11]developed a computer package TNAP(Traffic noise analysis package) in the year 1993. There are several options available. Using first option the various noise parameter like L_{10}, L_{15}, L_{90}, L_{eq} etc may be calculated. Second option is for predicting the noise (L_{eq}) L_{eq} predicated a given classified traffic volume per hour at a desired distance (in m) from center of traffic lane. The third option provides facility to obtain the combined noise level for a mixed traffic flow stream by giving their individual noise level as input data. The fourth option allows to exit the program.

Rao [12]studied two different locations at Vindhyachal project for estimating the vehicular noise pollution. Prediction of the ambient noise level L_{eq} the equivalent continuous noise level at a particular place can be expressed in the form of an equation.

$$L_{eq} = C + K\log_{10} N_x \quad \text{-----------------(2)}$$

Where C and K are the constant; and Nx, equivalent number of vehicles per hour of a particular category corresponding to the total mixed traffic density.

The ambient noise level Leq values for individual hour has been calculated using the equation:

$$L_{eq} = 40.60 + 9.5\log_{10} N_l \quad \text{----------------- (3)}$$
$$L_{eq} = 40.50 + 15.4\log_{10} N_h \quad \text{----------------- (4)}$$

Where Nl and Nh are respectively the equivalent number of light vehicles and equivalent numbers of heavy vehicles per hour obtained after conversion.

M. Parida et al [13], in their paper, a road traffic noise prediction model for Indian conditions is developed using regression analysis which is based on Calixto model. Data collected has been analyzed and compared with the values predicted by Calixto model. After comparison of results it was observed that Calixto Model could be satisfactorily applied for Indian conditions as they give accepted results with a good R^2 value.

Siddiramulu [14] developed a software package TNP-MM in 1998 for traffic noise prediction. This was developed based on the data collected in Delhi and SH-45 (now NH-58).

P Kumar [15] carried out individual vehicle noise level study for proper categorization of vehicles and developed basic noise level equations for each type. He further calibrated noise prediction model for traffic noise prediction for Indian conditions.

National highway authority of India (NHAI), ministry of surface transport (MOST) government of India has taken up the development of various national highway corridors where the intensity of traffic has increased considerably to provide safe, efficient and faster movement of traffic. NHAI has planned to widen the existing two lane Udaipur Gandhinagar section of NH-8 to partially access control 4/6 lane divided carriageway flanked by proper service road , wherever, required and improvement of road junctions with adequate mobility to local as well as trunk route through traffic. To carry out the widening project, noise studies were carried out at three different sections on the entire project section of NH-8 between Udaipur and Gandhinagar(km 278- km 495)as part of EIA study[16].

A research scheme T-1 [17] entitled 'development of comprehensive highway noise model and design of noise barrier' has been completed by Indian institute of technology, Roorkee sponsored by ministry of road transport and highways, government of India.

Padmanabha Murthy and Mishra (2000) have reported the effect of meteorological parameters, wind speed, direction, temperature and humidity in relation to noise levels in three different orientations along, opposite and perpendicular [18]. The measurement was made in Delhi during Nov. to March 1998, every hour from 6 am to 6 pm. It was observed that there was slight increase in the intensity of noise level along the wind direction, while there was no appreciable change in the noise level perpendicular to the wind direction. Increase in relative humidity and the existence of inversion conditions were observed to alternate the sound intensity.

Mohan and associates (2000, 2002) have also made noise level, vehicular speed, and traffic volume surveys under free flow conditions of traffic for more than 10 sites in Delhi [19]. Based on this data they have made an attempt to develop a model for prediction of road traffic noise as per Indian road conditions using the concept of CORTN (calculation of road traffic noise) model (Steele, 2001)[20].

D. Chakraborty (2002) carried out a comprehensive study on traffic noise level at twenty four pre selected road transaction of Calcutta metropolis [21]. Noise levels measured at each of twenty four sites, based on pre determined sampling interval and altogether 2880. Observations were generated by recording data continuously for 24 hours. The l_{eq} 24 excudence levels, LD, LN, LDN, LNP and TNI are determined. Traffic flow density as measured along with noise data recording were than compared for establishing relationship with noise level. Finally the clustering of the sites were made based on variable vif L_{eq} and traffic flow density.

Mittal et al (2002) and Kulshreshtha et al (2004) have made measurements of noise levels in six selected areas in Agra city, two each in residential, industrial and high traffic density areas [22]. Highest noise levels of 83.3 dBA, 80.7 dBA and 64.4 dBA were recorded in the evening hours. Through a response to the questionnaire by the residents of Agra city, they found physiological disturbances maximally linked to high traffic density areas, lack of concentration to industrial areas and annoyance to residential areas, as the effects of noise pollution.

Pand et al (2003) have made measurements of noise levels in the neighbourhood of manganese mines of Orissa. Day and night observations were carried out[23]. For siljora mines, the highest noise level was 120 dBA at a distance of about 300 meters from the blast site, while the ambient noise level in the area was 50-56 dBA. The guest house was the quietest at less than 40 dBA for both day and night. At Dubna mines, the noise level was 88-92 dBA, during the period the compressor was running road drilling made the noise level to read 88-96 dBA.

Noise Modeling in USA

Noise prediction for highway traffic has been tackled in a scientific manner in USA and a brief historical development is presented below.

NCHRP Report 78

When the noise produced by passenger car is described in terms of A scale noise level in dBA, then following emperically derived equation approximates the noise produced on typical pavements at various speed [24,25].

$$L_{car} = 16 - 10\log_{10} (d/50)^2 + 30 \log_{10} V$$
$$= 50 - 20 \log_{10} d + 30\log_{10} V \quad \text{------------------ (6)}$$

In which L_{car} is noise level of car in dBA , d, distance, in front , to car and v, speed in mph.

A simplified analytical form for the simulation model can be used for passenger cars on a level highway at traffic flows above about 1000 vehicles per hour.
The mean noise level in dBA is given by

$L=10\ Log_{10}\ q*100/d + 20\ log_{10}\ V$
$= 10\ log_{10}\ q-10log_{10}\ d+ 20\ log_{10}V+ 20$ ------------------ (7)

In which q is the traffic flow, in vehicle per hour, d, distance, infeet, to pseudo-lane, and v, average traffic speed, in miles per hour.

NCHRP Report 117

The first prediction model used extensively was that found in NCHRP report 117. The model has utilized a statistical approach in that Lx values (L_{50} and L_{10}) were the only descriptions found in the calculations. The noise source data based upon which the model was founded was quite small and did not adequately represent actual conditions. For example, the model assumed that all vehicles on a highway could be classified as either cars or trucks, with the following source emission levels.

$L_{car} = 16 + 30\ log\ S$ dBA -------------- (8)
$L_{truck}= 82$ dBA ---------------------------- (9)
S = speed in mph

NCHRP Report 174

This model was Leq based, but included only two types of vehicles: cars and trucks. The source emission levels in the TSC model were[26]:

$L_{car}=5+38\ log\ S$ dBA ------------------ (10)
$L_{truck}=87$ dBA --------------------------- (11)

In addition to Leq , the programme also computed L_{10}, L_{50},L_{90}. The model could accommodate the same multiple road & complex barrier configuration as NCHRP model, with addition to topography and ground surface acoustical properties. While the TSC model was perhaps more technically sound than the NCHRP117 model, it never gained wide acceptance by the state highway agencies because of its tendency to over predict the noise levels. It did, however, provide at least a part of the foundation for the new generation of models.

TRANSPORTATION SYSTEM L_{eq} CENTRE (TSC) MODEL

The research effort sponsored by the NCHRP produced Report 174 , a revised design guide(R.D.G.) which incorporated the medium truck concept, replaced the L_x initial description with L_{eq} and generally laid the foundation for the new generation of models. The significant change that is made to include three vehicle emission classes: cars, medium trucks and heavy trucks [27].

$L= 18 + 30\ log\ S$ dBA (car) --------------------------(12)
$L= 28 + 30\ log\ S$ dBA (medium trucks) -----------(13)
$L= 86$ dBA (heavy trucks) ----------------(14)

FHWA MODEL

In response to widely recognized short coming of NCHRP, TSC models, the FHWA (federal highway administration) developed an in house model [28]. The FHWA Model calculates noise level through a series of adjustment through a reference sound level. The reference sound level is the energy mean emission level, which is determined through field measurements of individual vehicle pass by for each vehicle type (cars, medium trucks, heavy trucks). Adjustments are then made to this level to account for traffic movement, varying distance of receivers from the roadways, finite length roadways and for shielding effects.

The basic emission and propagation equation for the FHWA model is mathematically stated as

$L_{eq(b)}i=(L_o)_{Ei}+10\ Log\ [(V_i\ \pi\ D_o) / (S_i\ T)] +10\ log\ [D_o/D]+\Delta G +\Delta B$ ----(15)

Where $L_{eq(h)i}$ is hourly equivalent sound level of the ith class of vehicles ;$(L_o)ei$, reference energy mean emission level of the ith class of vehicle ;V_i, vehicle volume for the ith class of the vehicle in passenger car unit per hour; S_i; average speed of the ith class of vehicle and is measured in km per hour ;D, perpendicular distance in meters ,from the edge of the pavement to the observer ; Do, reference distance from the centerline of road to the observer , 10 m; T, time period over which Leq is computed (one hour); ΔG, grade adjustment in dB A ; ΔB, barrier adjustment in dBA.

When sequentially added , these parameters produce an hourly L_{eq} value for ith vehicle class in practice, this means an L_{eq} value for case Leqc and leq value for medium trucks, L_{eqMT} ; and L_{eq} value for heavy trucks ,L_{eqHT} .The overall L_{eq} for the traffic mix , L_{eqTOT} is then obtained by decibel or logarithmic addition,

$L_{eqTOT} = \sum^{dB} L_{eq}(C+MT+HT)$ ---------------- (16)
$L_{eqTOT} = 10\ log\ (10\ Leqc/10 + 10\ LeqMT/10 +10\ LeqHT/10)$ ----- (17)

CORTN MODEL

It was developed in the UK in 1988 by the department of the environment and Welsh office[29]. First of all the basic noise level at a reference distance of 10m away from the nearside carriageway edges is obtained from the traffic flow, the speed of the traffic , the composition of the traffic , the gradient of the road and the road surface.

This model determines both the L_{10}(18 hour) (0600-2400) and L_{10}(1 hour) noise levels and takes into account traffic parameters such as volume, percentage of heavy vehicles speed, road surface and grade . Sound propagation factors include the distance of the noise surface, ground type, height of the noise surface shielding provided by barriers and reflections from facades .As with all such model, sites with particularly complex topography or traffic conditions require the traffic route to be split into segments in which each parameter is constant. Predictions are then made for each segment in turn and the total noise level combined logarithmically.

Vehicles are considered as being either passenger vehicles or heavy vehicles (unladen weight exceeding 1525 kg). A mean speed of all vehicles is used in calculation L_{10} noise level at a receiver point is calculated as follows.

$L_{10}=L_o + \Delta_f + \Delta_g + \Delta_p+ \Delta_d + \Delta_s+ \Delta_a+ \Delta_r$ ----------- (18)

Where L_o is base noise level measured at 10m from the edge of the pavement; Δ_f traffic flow adjustment; Δ_g gradient adjustment; Δ_d, distance adjustment; Δ_s, shielding adjustment ;

Δ_r, adjustment for reflection; Δ_p, pavement type adjustment; and Δ_a ,angle of view adjustment.

The base noise level L_o is calculated at a distance of 10m from the near side edge of closest traffic as follows.

L_{10} (18 h) = 29.1 +10 log $_Q$dBA ---------- (19)
L_{10} (1 h) = 42.2 +10 log $_q$ dBA -------- (20)

Where Q, total vehicle flow in the time period 0600 h to 2400 h and q, total vehicle flow within the hour considered.

NOISE ESTIMATION METHOD IN JAPAN

In Japan L50 is calculated by the following formula[30]:

$$L50 = L_w - 8 - 20 \log_{10} \ 1 + 10 \log_{10} (\pi(1/d) \tan h\ (21/d) + \alpha d + \alpha l \quad \text{-- (21)}$$

$$L_w = 86 + 0.2\ V + 10 \log_{10} (a_1 + 5a_2) \quad \text{---------- (22)}$$

Where L_{50} is central value of vehicle traffic noise (dBA); Lw average power level produce by one vehicle (dBA) gradient ; V ,average power travel speed (km/h); a, mix ratio of light duty vehicles; a_2, mix ratio of heavy duty vehicle;a_1+a_2 = 1.0; I, distance from sound source of sound receiving point (m); d, average vehicle interval (m) ,d = 1000 V/N; N, average traffic volume (units/h); αd, correction value according to detour reductions(dBA); and αl, correction value according to the various causes(dBA).

SUMMARY

The purpose of traffic study is to monitor and assess the traffic generated noise in its spatial temporal aspects on highways which matches with the regional and climatological conditions of the particular area on the basis of several parameters such as:

- Traffic flow/ volume of traffic
- Percentage of commercial vehicles
- Types of vehicles
- Speed of the traffic
- Road surface/pavement characteristics
- Physical characteristics of the road such as curves, hills, depression, elevation and grade.
- Measuring distance from the roadway.
- The effect of meteorological parameters eg. Wind speed & its direction, temperature & humidity.
- Height of the building around the road
- Geometric parameters.

A great deal of work regarding noise assessment , prediction & modeling has already been done in developed countries , where as a little could be done in developing country like India, particularly in setting the standards of noise levels for different land uses, public health & welfare.

RECOMMENDATIONS

- The possibility of including "Noise pollution under control" in PUC certificate as an abatement strategy to combat traffic generated noise pollution.
- Since traffic noise concerns with the health of the people i.e. related with society & quality of life , therefore , there is a need to establish "Noise abatement commission" to standardize the Norms & Regulate the noise emission Level well below the permissible values.
- There is a need to construct barriers at locations where noise level is exceeding acceptable limits and study the efficiency of barriers at variable heights, thickness and material type.
- Promoting traffic planning & management systems (low- speed traffic,Temporary bans on certain types of noise generating vehicles, systems which controls the excessive movement of number of vehicles.)
- Improvement & streamlining of roads & parking systems.
- Discouragement of high sound producing vehicles.

REFERENCES

[1] Siddiramulu D. 1998 "A study on urban Transport Environmental Interaction", M.E. Dissertation, COTE , Deptt. of civil Engg.,UOR,Roorkee.

[2] Jain S.S. and Parida M.1999 , Final Report on "Development of comprehensive Highway noise model and design of noise barrier", sponsored by MOST, Govt. of India, New Delhi.

[3] Sexton,B.H.1979, " Traffic noise", J.Trafficquaterly. "Road Noise Abatement", OECD Report(1995).

[4] W J Galloway,W E Clark and J S kerrick. 1969.'Highway Noise Measurement Simulation and Mixed Reactions'. National Co-operative Highway Research Programme Report, No.78, TRB, USA.

[5] S Agrawal.1995. "Traffic Flow and Environmental Impact of Four Laning of Selected Major Traffic Corridor." ME Thesis, Department of civil Engineering, UOR, Roorkee.

[6] C Reddy and V Bhaskar. 1993."Study of Traffic Flow and Related Environmental Factors at Identified highway locations." ME Thesis, Department of Civil Engineering, UOR, Roorkee.

[7] N L Gangil. 1979."Relationships between Vehicular Noise and Stream Flow Parameter." ME Thesis, Department of civil Engineering, UOR, Roorkee..

[8] Sheetal Agarwal and B.L. Swami.2009. " Noise annoyance under Interrupted Traffic Flow Condition for Jaipur City", Inernational Journal of Applied Science and Engineering, pp 159-168.

[9] S M Sarin.1990. "Evaluation of Road Traffic Noise Problem at Scientist Apartment – a Report." Environmental and Road Traffic safety Division, Central Road Research Institute (CRRI), New Delhi.

[10] J B Srivastava, 1994."Traffic Flow and Environmental Impact Analysis of a Highway Corridor." PhD Thesis, Department of Civil Engineering, UOR.Roorkee.

[11] P R Rao. 1997."Prediction of Road Traffic Noise." Indian Journal of Environmental Protection, vol 11, no 4, . pp 290-293.

[12] K Vimal. 1997."Analysis of Urban Traffic Noise." ME Thesis, Department of Civil Engineering, UOR, Roorkee,.

[13] M. Parida et al. 2011."Mathematical Modeling of Road Traffic Noise Prediction", international Journal of Applied Mat. And Mech. 7(4): pp 21-28.

[14] P Kumar. 2000."Traffic Noise Prediction for Rural Highway." ME Thesis, Department Civil Engineering, University of Roorkee.

[15] "Four/Six Laning of Udaipur-Ratanpur-Gandhinagar Section of NH-8; Draft Final Report: 2000.Volume IV-A: Environmental Assessment Report." National Highway Authority of India, Government of India.

[16] S S Jain and M Parida. 1999.State-of-the-Art Report on Research Scheme T-1 "Department of Comprehensive Highway Noise Model and Design of Noise Barrier." Sponsored by MOST, Government of India, New Delhi.

[17] S S Jain and M Parida. 2001.Final report of research scheme T-1 "Department of comprehensive Highway Noise Model and Design of Noise Barrier." Sponsored by MOST, Government of India, New Delhi.

[18] B. Padmanabhamurty and S.B. Mishra 2000. "Effects of some meteorological parameters on noise pollutionin Delhi." Ind. J.Environ. Protec.,Vol.20 No. 1, pp.27-30

[19] S. Mohan, N. Dutta and V.S. Batra.2002.." Prediction of road traffic noise for urban road stretches of Delhi under free flow conditions of traffic." Ind. J.Environ.Protec., Vol. 22, pp. 1367-1374..

[20] C. Steele.2001. "A critical review of some traffic noise prediction models." Appl. Acousst.,S Vol. 62, pp. 271-287.

[21] D. Chakraborty, S.C., Santra, A.L.Mukherjee, B. Roy and P.Das (2002). "Road traffic noise in Calcutta metropolis, India." Ind.J.Environ.Health, Vol. 3, pp. 173-180.

[22] N. Mitta, A. Kulshresstha, A. Abraham, A. Kumar and V. Sharma 2002. "Effects of noise pollution on human adaptability in Agra city." Ind.J.Environ.Protec., Vol 22, pp. 1379-1382.

[23] S.C. Panda, R.N. Kar, P.Patra, B. Das, J.K.Mohanty and M.Rout 2003. "Air Pollution and noise levels in two manganese mines of Orissa." Ind.J.Air Pollution Control, Vol. 3 No.1, pp. 11-14.

[24] C S Gordan, W J Glloway,BA Kugler and D L Nelson. 1971."Highway Noise: A Design Guide for Highway Engineers." National Co-operative Highway Research Program Report No.117, TRB, USA

[25] "Manual for Highway Noise Prediction". 1972.Transportation System Centre, US Department of Transportation, Washington DC

[26] WJ Galloway, B A Kugler and D E Commins. 1976."Highway Noise – a Design Guide for Prediction and Control". NCHRP Report No. 174 , TRB,USA.

[27] T M Barry and JA Reagan. 1978."FHWA Highway Traffic Noise Prediction Model." FHWA-RD-77-108, Washington, DC

[28] "Calculation of Road Traffic Noise.1988." Department of Transport, Welsh office, HMSO

[29] H Tachibana and S Minoru. 1994."ASJ Prediction Methods of Road Traffic Noise." Proceedings-inter-noise 94, vol I, Yokohoma(Japan)

[30] J K Jain. 1991."Study of Highway Noise of an Identified Highway Corridor." ME Thesis, Department of Civil Engineering, UOR, Roorkee