

Abstract

Road traffic noise is a growing environmental concern that significantly affects public health, causing issues like stress, sleep disturbances, and hearing impairment. With urbanization and vehicle usage on the rise, especially in countries like India, addressing traffic noise has become a significant priority. This study attempts to develop a computer-based software for monitoring the traffic noise under heterogeneous traffic condition at the morning peak, off peak and evening peak periods of mid-block sections of a mid-sized city in India. Traffic noise dataset of 776 ($L_{Aeq,1h}$) were collected from 23 locations of Gorakhpur mid-sized city in state Uttar Pradesh in India. K-Nearest Neighbor algorithm was adopted for traffic noise prediction modeling. Moreover, Principal Component Analysis technique was used for the dimensionality reduction and to overcome the problem of multi-collinearity. The developed model exhibits R^2 value of 0.81, 0.78 and 0.77 in the morning, off and evening peak respectively for L_{eq} ; and a value of 0.86, 0.80 and 0.84 for L_{10} . The proposed model can predict more than 94% observations within an accuracy of $\pm 3\%$. Ultimately, a user-friendly noise level calculator named ‘Traffic Noise Prediction Calculator for Heterogeneous Traffic (TNPC-H)’ was developed for the benefit of field engineers and policy planners. Unlike homogeneous traffic conditions in many western countries, India's road traffic is highly heterogeneous, making it essential to develop models that reflect this diversity accurately.

Following this study, focus was also made on developing a vehicular source emission model along with emission curves for various vehicle types that captures the noise generated by different vehicle types commonly found on Indian roads, including 2-wheelers, 3-wheelers,

cars, buses, trucks, light commercial vehicles, tractors, and e-rickshaws. A comprehensive field dataset of 13,684 vehicles operating on bituminous surfaces under free-field propagation was collected, and the maximum sound level ($L_{AF,max}$) generated by each vehicle was measured at a standard distance of 7.5 meters from the roadway center. The study employs linear regression models to predict ($L_{AF,max}$) for each vehicle type. These models are grounded in the methodology of the Federal Highway Administration traffic noise model, widely used in the U.S. but adapted here to reflect Indian traffic dynamics. The use of emission curves allows for more precise predictions, considering factors such as vehicle speed and type, which are key determinants of noise emissions. The models provide vital data that can serve as basic inputs for more comprehensive traffic noise prediction models in India, aiding urban planners and policymakers in managing and mitigating road traffic noise.

Building on the existing study, the research advanced towards developing a modified highway traffic noise prediction model tailored to Indian conditions. The modification methodology was guided by the principles outlined in the Federal Highway Administration (FHWA) traffic noise model guidelines. To adapt the FHWA model for Indian highway traffic conditions, a key modification was made: the replacement of the standard FHWA noise emission curves with customized emission curves developed specifically for Indian traffic scenarios. These customized curves were constructed using an extensive dataset of 13,684 noise emission measurements recorded from individual vehicles operating under real-world conditions. The resulting equations, representing these curves, were referred to as the vehicular source emission models. Further refinement was achieved by incorporating adjustment factors for propagation conditions as prescribed by the FHWA model. These factors account for environmental influences such as ground effects, atmospheric absorption, and barriers,

ensuring the model's predictive capabilities align with Indian highway contexts. By combining these custom vehicular source emission models with the FHWA's propagation adjustment framework, the study successfully developed a robust noise prediction model, capable of accurately estimating highway traffic noise levels under Indian conditions. For development of this model, a comprehensive dataset of 142 ($L_{Aeq,1h}$) was collected from 4 different sites of 3 national highways. 106 ($L_{Aeq,1h}$) of data were utilized for model development. Remaining 36 ($L_{Aeq,1h}$) hours of data were reserved for model validation. The resulting L_{eq} model successfully explained 90% of the variability in the collected data, demonstrating its effectiveness in predicting noise emissions. The model exhibited a Mean Absolute Error (MAE) of 1.68 dB(A) and a Root Mean Square Error (RMSE) of 1.96 dB(A), indicating a high level of accuracy in its predictions. For further validation, the model was tested against data from the 4th site, which was distinct from the dataset used for model development. This validation process revealed that the model explained 81% of the variability in the new dataset. The validated model also achieved improved performance metrics, with a MAE of 0.77 dB(A) and an RMSE of 0.98 dB(A). These results confirm the model's reliability and applicability for predicting traffic noise in heterogeneous traffic scenarios, providing valuable insights for urban planners and policymakers in managing noise pollution on Indian highways. This model has significant potential applications in urban planning, highway design, and noise impact assessments in India.

Following the continuation of this study, the focus shifted to the measurement and prediction of road traffic noise at various floor levels of buildings in a mid-sized Indian city. It is widely accepted that residents of high-rise buildings located beside roads are inevitably exposed to significant levels of noise pollution due to traffic operation. This study aims to unveil crucial

insights into the dynamic fluctuations of noise levels within the vertical dimensions of high-rise buildings nestled amidst the bustling streets of mid-sized Indian cities where heterogeneous traffic is under operation. Two cycles of data were collected on all floors for hourly duration on the façade line for two high-rise buildings. Traffic volume, speed, distance of the building from centre of the carriageway and honking were used to develop models for predicting L_{eq} and L_{10} using Artificial Neural Network. The R^2 values obtained for L_{eq} and L_{10} were 0.93 and 0.90, respectively indicating the efficacy of the models in predicting noise level at all floors. Results show that the sound level rises to a certain height of the building and then begins to decrease. Floor level 3, 4, 5 and 6 (height approx. 8.4–21 meters) had the maximum noise level compared to the other floors, while the 1st and floor level above 10 were quieter floors. Frequency analysis reveals that buildings closer to roadways experience dominant honking noise, particularly at 3.15 kHz, whereas traffic noise prevails at frequencies up to 200 Hz. This work has the novelty of addressing the impact of heterogeneous traffic noise at various floor levels of Varanasi mid-sized city which has narrow carriageway. Such a traffic has prominence of honking which is modelled perhaps for the first time. The outcome of this research has importance in urban planning and formulating legislations.