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Development of Road Traffic Noise Prediction Model for Major Urban Roads of Kota City

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Abstract: Kota a city situated near the bank of Chambal is also known as Education hub of India. Rapid urbanization of Kota leads to increase in the number of vehicles on the roads. With the increase in the number of vehicles on road, traffic noise has also been increased which is serious concern of the communities residing near the major urban roads of the Kota city. Road traffic noise levels can be reduced by predicting the noise level prior to its generation and it can be achieved by road traffic noise prediction model for Kota city. Present study deals with the development of dedicated road traffic noise prediction model for Kota city. For model generation total 10 major urban roads of the city were selected and study was performed. Based on the collected data and its analysis, the developed model has coefficient of determination value (R^2), 0.766.
Keywords: Road traffic noise, Road Traffic, Prediction Model

I. INTRODUCTION

Out of the categorised pollution i.e. air, land, water and noise pollution, noise pollution is considered to be list addressed issue. In the era of urbanization and modernization, number of vehicles have been increased drastically which is considered to be main source of road traffic noise. The trend of migration towards cities will increases more and more in the upcoming years. In the developed nations approximately half of the population resides in the cities and this will further enhance to two third population by 2050 [1]. Developing nations are also having similar kind of migration trend. Noise pollution are causing severe health issue such as annoyance and disturbance in sleep. Annoyance has broader meaning, it includes anger, disappointment, anxiety and depression. Disturbance in sleep during nights causes fatigue, depression and reduced work performance [2].

To reduce the traffic noise level several attempts has been made so far. Several countries have developed their road traffic noise prediction models. USA has developed FHWA model, the variable of FHWA models are flow of traffic, roadway distance from the receiver, finite length roadways, nature of ground cover, and effect of shielding [3]. Japan has developed ASJ-RTN model 2018 in which considered parameters are road type, traffic volume, running speed of vehicle, prediction range and meteorological conditions [4]. The stop and go model was developed by Urban Transport Department of Bangkok, they consider different class of vehicles and speed as model parameters [5]. Thailand has developed ERTC model, the parameters they considered are vehicle groups, traffic volume and average speed [6]. The RLS 90 model was developed for Germany. The RLS 90 model can incorporates traffic flow design data where the actual flow is not known [7].

Based on the literature survey: traffic volume, different class of vehicle and Noise level are selected as modelling parameters.

II. METHODOLOGY

The current section contains the methodology adopted for the study. Figure 1 represent the methodological flow chart used in the present study.

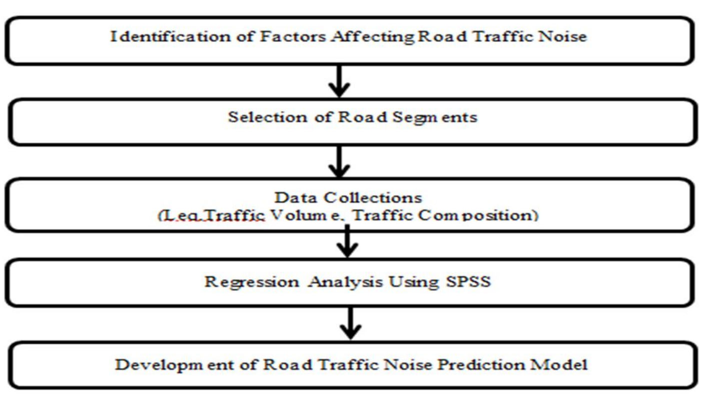

Figure 1: Methodology for Development of Road Traffic Noise Prediction Model

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Firstly, from the past research work carried out in this field, factors affecting the road traffic noise levels were identified then road segments having identical traffic behavioural characteristics were selected. Data were collected adopting standard procedures. After the data collection work multiple linear regression analysis was performed to develop the model. At last t-test was performed for model validation and significance.

III. DATA COLLECTION AND STUDY AREA

Peak hours duration was identified by the traffic experts of Kota city. Based on the traffic expert advice one hour in the morning i.e. 9 am to 10 am and one hour in the evening i.e. 5 pm to 6 pm timing slots were selected for the data collection work. Total 10 road segments were selected for the data collection. The road segments were selected such that they had similar traffic characteristics for consistent data. At each sampling site Digital Noise Level Meter was installed at a height of 1.5 above the ground. Road traffic were surveyed manually and recorded in standard format.

IV. DEVELOPMENT OF TRAFFIC NOISE PREDICTION MODEL

Road Traffic Noise Prediction model was developed by multiple linear regression analysis. SPSS software was used as a tool for multiple linear regression analysis and statistics. The equation developed for prediction of noise level is given by

$$L_{eq} = 48.171 + 0.002A + 0.039B + 0.018C + 0.175D + 0.069E$$

Where, L_{eq} is Equivalent Sound Pressure Level at section of road
A is percentage of two-wheeler at section of road
B is percentage of three-wheeler at section of road
C is percentage of four-wheeler at section of road
D is percentage of Heavy Vehicles at section of road
E is percentage of other vehicles at section of road

Variation of noise levels with different parameters are distinctly discussed below

A. SPL (Leq) with Percentage of Two-Wheeler (A)

Total 10 samples were taken to check the relationship between Sound Pressure level and traffic volume. Coefficient of determination (R square) was found to be 0.753 and the Variance ratio (F) Value was 24.332. Equation showing relation between SPL and percentage traffic volume is written below.

$$L_{eq} = 51.075 + 0.007A$$

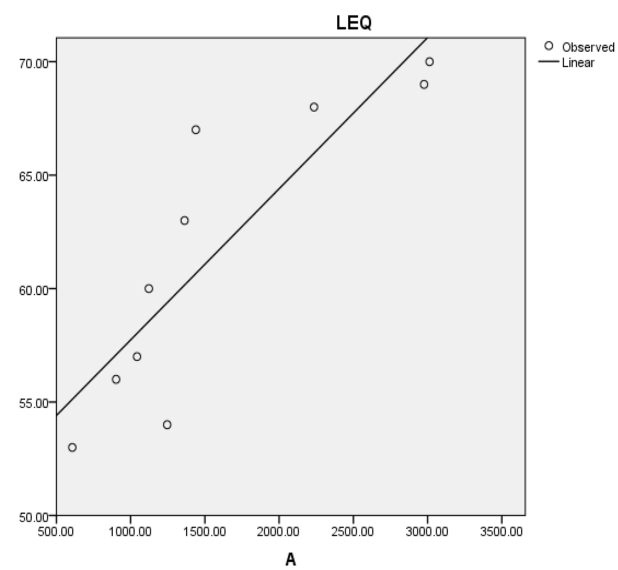

Figure 2: Graph between L_{eq} and Percentage of Two-Wheeler

B. SPL (L_{eq}) with Percentage of Three Wheeler (B)

Total 10 samples were taken to check the relationship between SPL and traffic volume. Coefficient of determination (R square) was found to be 0.744 and the Variance ratio (F) Value was 23.216. Equation showing relation between SPL and percentage traffic volume is written below.

$$L_{eq} = 53.655 + 0.101B$$

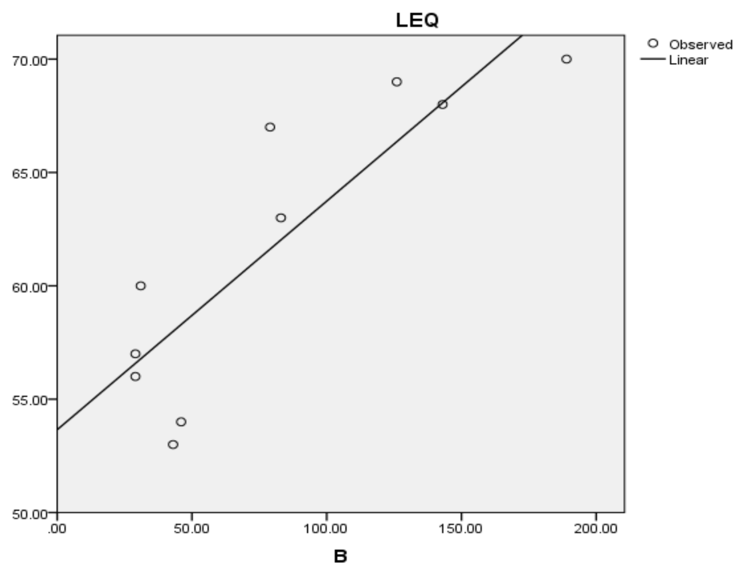

Figure 3: Graph between L_{eq} and Percentage of Three-Wheeler

C. SPL (Leq) with Percentage of Four Wheeler (C)

Total 10 samples were taken to check the relationship between SPL and traffic volume. Coefficient of determination (R square) was found to be .797 and the Variance ratio (F) Value was 31.343. Equation showing relation between SPL and percentage traffic volume is written below

$$L_{eq} = 49.381 + 0.024C$$

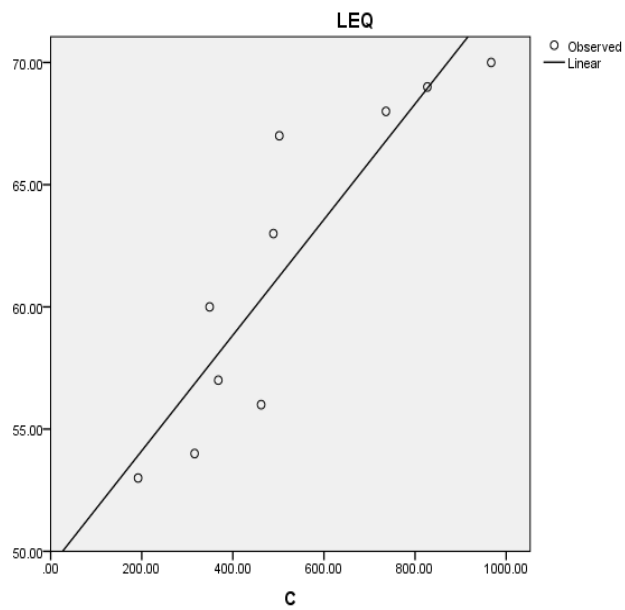

Figure 4: Graph between L_{eq} and Percentage of Four-Wheeler

D. SPL (L_{eq}) with Percentage of Heavy Vehicle (D)

Total 10 samples were taken to check the relationship between SPL and traffic volume. Coefficient of determination (R square) was found to be .366 and the Variance ratio (F) Value was 4.625. Equation showing relation between SPL and percentage traffic volume is written below

$$L_{eq} = 58.625 + 0.265D$$

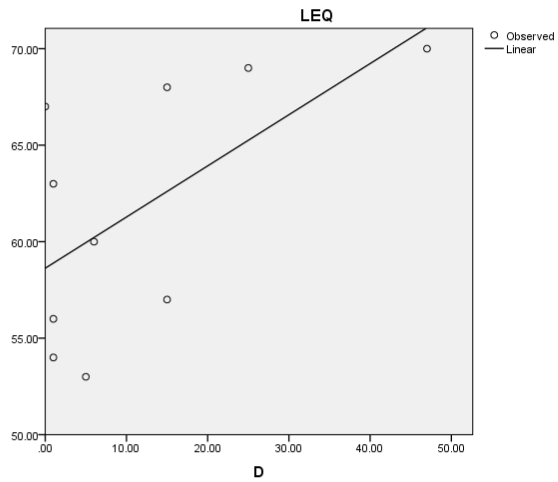

Figure 5: Graph between L_{eq} and Percentage of Heavy vehicle

E. SPL (Leq) with Percentage of Other Vehicle

Total 10 samples were taken to check the relationship between Sound Pressure level and traffic volume. Coefficient of determination (R square) was found to be .658 and the Variance ratio (F) Value was 15.391. Equation showing relation between SPL and percentage traffic volume is written below:

$$L_{eq} = 55.849 + 1.125E$$

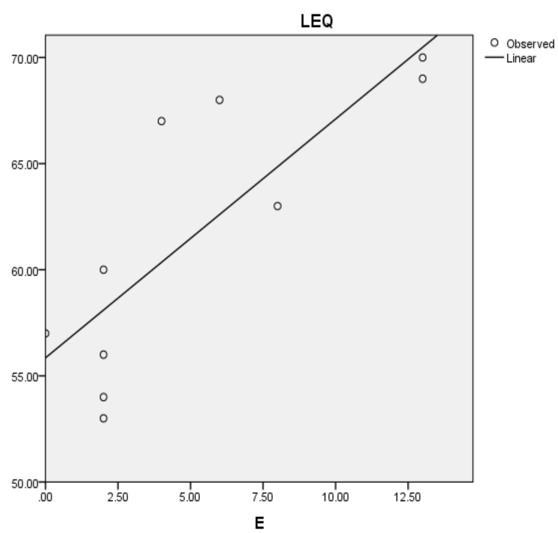

Figure 6: Graph between L_{eq} and Percentage of Other vehicle

V. MODEL VALIDATION AND SIGNIFICANCE

The linear model obtained from multiple linear regression analysis has the value of adjusted R^2 67.8 %. To check the goodness of fit, paired t-test was performed. Initially, for every class of vehicle t- test was performed there after a paired t-test was performed. t-test values fall less than the 5 percentage significant for all class of vehicle. From the t-test result, it can be concluded that generated sound pressure levels fit well with the monitored road traffic noise levels for every class of vehicles.

VI. CONCLUSION

Due to rapid urbanization, number of vehicles are increasing day by day on the roads which is responsible for increase in road traffic noise problem near the vicinity of road segments. The communities living near road segments are greatly affected by the road traffic noise and facing health issues. The current developed model is an infant step to deal with the noise problem of the concern communities. The developed model can be used during the road planning stage to predict noise levels which can be used to study environmental impact of traffic noise levels.

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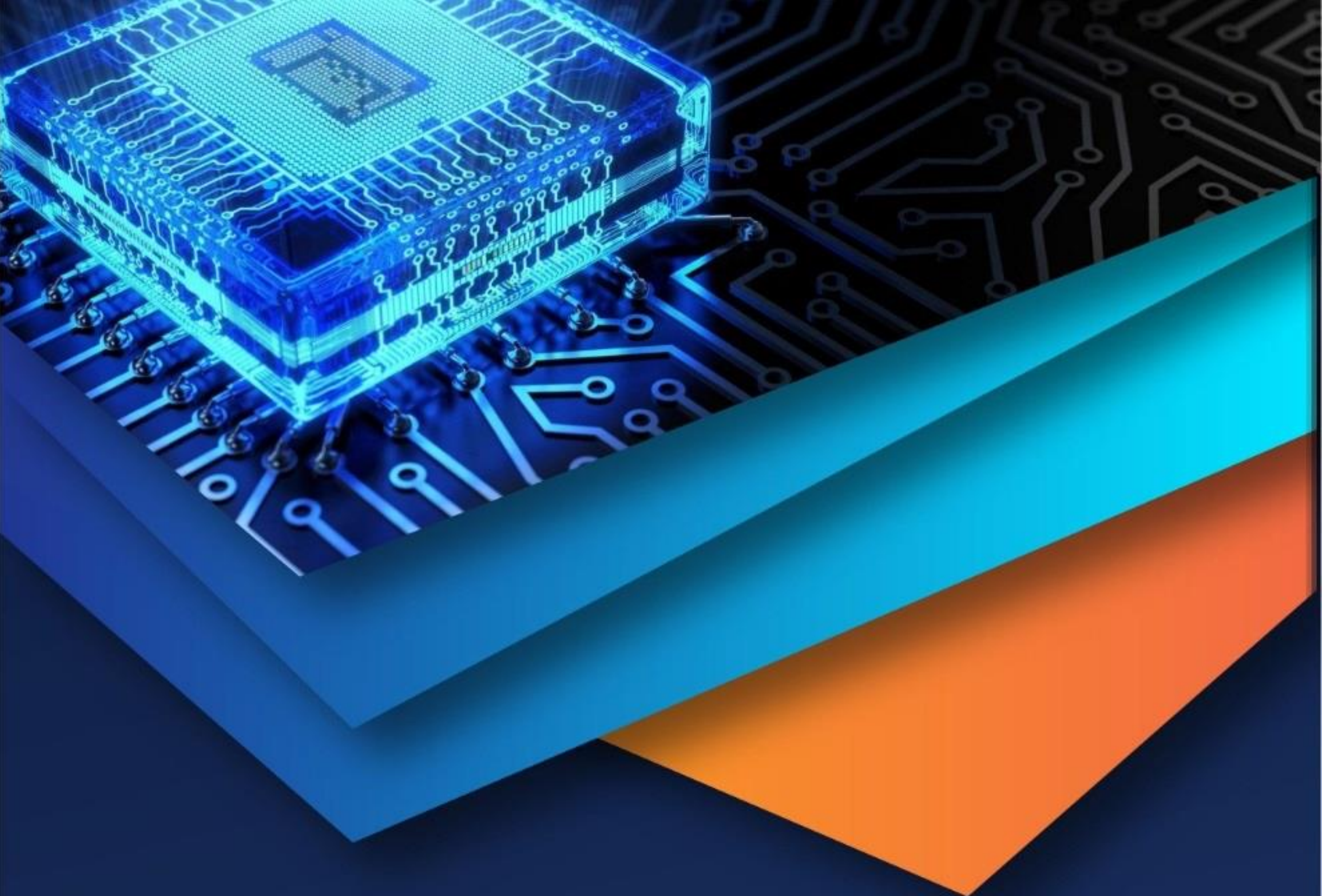

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