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Assessment of Traffic Scenario with Respect to Different Traffic Calming Measures in Urban Perspective

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Abstract: **Road safety is now about the major concern in India. The most frequent problems on the streets regarding motor vehicles are speed beyond their limits and disproportionate traffic volume. Also, traffic conflict between the vulnerable road users like pedestrians and vehicles is another problem on various intersections and zebra crossings. Speed is one of the main factors which affects road safety. In majority of cases, the vehicular speed is directly proportional to the accidental rate and accident severity. Hence speed control is most critical parameter towards road safety. Traffic calming measures are an effective and economic means to decrease speed and volume on any road section. Hence, number of accidents and severity of the accidents can be reduced by using traffic calming measures. The present study is carried out in the Satna city of Madhya Pradesh (India). This paper shows the effectiveness of different traffic calming measures which includes rubber speed hump, speed limit sign, rotary and speed bump. The study also deals with the estimation of traffic volume and speed at different sections taken. Ultimately, this study would help to understand the current traffic scenario and measures to improve the traffic in such city. The speed prediction models are also developed for selected calming measures.**

Keywords: Traffic volume, Traffic calming measures, speed hump, speed model etc.

1. INTRODUCTION

The traffic calming measures and traffic control devices are designed to reduce the vehicular speeds and traffic volumes in any area. Some of these strategies and devices used for this purpose are roundabouts, warning signs, speed humps, rumble strips, channelization islands, and special pavement marking. Speed is one of the main factors which affects road safety. Speed affects the accident rate, accident severity, chances of occurring the crashes, moreover more speed also creates many problems like noise nuisance, environment degradation and unpleasant living conditions [1][2][3].

High speed is one of the largest problems on highways worldwide and is a contributing factor in one-third of all crashes. In residential areas where the streets have a lesser width than the other urban roads require lower speed limits. Also in congested areas, accident prone areas or areas near to the schools, colleges and hospitals, lower vehicular speeds are requisite to lessen the noise nuisance and to improve the healthy living conditions. Therefore, vehicular speed control becomes an important parameter to road safety. Speed can be reduced using 3 E's, enforcement, engineering and education. There are mainly two principles which control vehicular speeds at a particular road section: visual measures and physical measures. The painted strips across the speed, various speed limit signs, pavement markings, etc. are common examples of providing visual measures. The various traffic calming measures & traffic control devices are an effective means to reduce speed and vehicular volume on the road section. They are reasonable and cost-effective too [4].

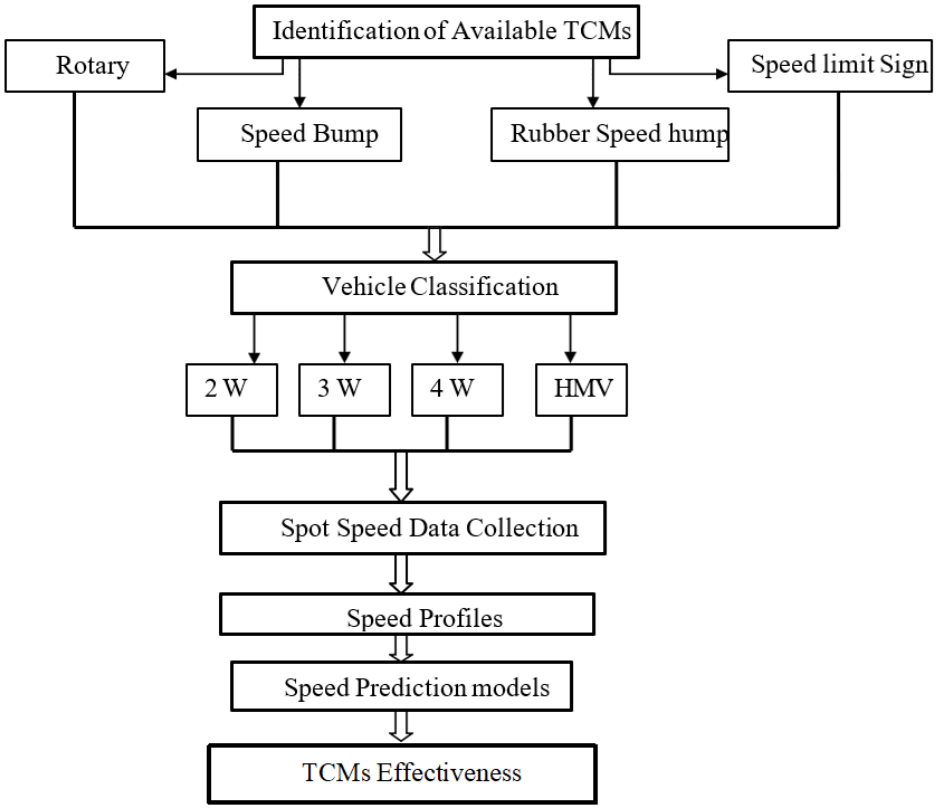
The development of road transport in India is increasing very fast. This is due to urbanization process, high population growth rate and economic development of the country. All these factors caused rapid increase in the vehicles on the roads. This has resulted in traffic volume also increasing and caused traffic problems and it is expected that in upcoming year's traffic volume will exceed the capacity of the roads. The total number of road accidents across India is about 4.5 lakh in the year 2019. It is estimated that about three to five percent of the GDP of the country was invested in road accidents each year. It is also estimated that, out of total accidents, 70 percent involved young people of the Indian population [5,6]. The accident rate of the country is rising greatly every year. Although India has less than 1% of the world's vehicles, the country accounts for 6% of total accident across the world and 10% of total road fatalities.

Natalia et al. [7] investigated the effectiveness in terms of speed reduction of three types of traffic calming measures: 1) speed table, 2) chicane, and 3) road narrowing. In this study, the speed analyses were done with respect to various traffic calming measures positioned in urban contexts of Catania Province (Italy). Experimental investigations were carried out into each of the traffic calming measures with the measurement of speed. This study concludes that the speed tables guarantee the greatest conditioning on speed. It is also found that also chicanes had a major impact on reducing speed, as well as the speed tables (average speed is reduced by up to 50%), while road narrowing allows maximum reductions in average speed of around 35%.

2. DATA COLLECTION AND METHODOLOGY

The first step in the study was identification of traffic calming measures and site selection: the site selection depends upon a few factors such as time constraints and economic constraints etc. The next step was to identify the parameters which can be used to show the performance of traffic control measures. The third step was identification and collection of data, such as spot speed, traffic peak hour volume, and type of traffic calming measures available at different sites [8]. After the collection of data required for this study, analysis of this data and interpretation of data was done to estimate the effectiveness of selected traffic calming measures (TCM's) and their comparison. The interpretation and assessment were based on data collected on selected roads sections of the Satna city in Madhya Pradesh (India).

The proposed methodology is also represented by a flow chart presented below:



The traffic volume data and spot speed data were collected at predetermined points on selected four road sections where different traffic calming measures were provided [9, 10]. The traffic data was collected during peak hours in the day and evening time. Four locations were chosen in the Satna city having different types of traffic calming measures. Table 1 shows the details of selected sites with the available traffic measure there. In this study, the speed profile assessment was done by measuring spot speed at different points on either side of traffic calming measures i.e. at a distance of 0m, 10m, 20m, 40m, 50m, and 100m.

Table 1: Selected Sites for Traffic volume and Spot Speed Study

S.No.	Location	Vehicular Movement Flow	Existing Traffic Calming Measures	Geometry Of Traffic Calming Measures	Street Classification
1	Satna Bus Stand To Circuit House	Towards Panna	Rubber Speed hump	Height: 50mm Width: 350 mm	Arterial Road
2	Civil Lines To Circuit House	Towards Rewa	Speed Limit Sign	Circular, Diameter: 600 mm	Arterial Road
3	Dhawari Indoor Stadium To Dhawari Chowk	Towards Dhawari	Rotary	Circular, Radius of central island 26 m	Arterial Road
4	Birla Hospital To Birla Cement Plant	Towards Simariya North	Speed Bump	Height: 55mm Width: 400 mm	Collector or Distributor or Road

In this research work, linear regression method is applied to obtain relationship between dependent and independent variables. The dependent variable is the spot speed at any point and independent variable is the distance of that point from the Traffic Calming measure. The upstream (before the Traffic Calming measure) and downstream (after the Traffic Calming measure) concept relates to the effect of a Traffic Calming measure associated with its position in the road [11]. For each traffic calming measure, speed prediction models are developed for the purpose of estimating speed on the approach to a traffic calming measure and speed after crossing the traffic calming measure using linear regression analysis method. The models that yielded the best curve fit properties were selected to represent the correlation between the variables studied. As speeds at different distances were regarded as the major output, it represents as Y intercept in linear regression and since the speed of any vehicle depends on the distance from the traffic calming measure, distance is taken as independent variable and represented by X intercept. Two models were developed for each type of traffic calming measure to represent the approach speed before the traffic calming measures on the upstream side and speed after crossing the traffic calming measures on downstream side. One model developed for the upstream side of Traffic Calming Measure describes the effect on the stretch of road which precedes the measure. Similarly, the effect on downstream side of measures is described from the other model. The regression models and their coefficients were tested for significance using p- statistic test and t- statistic test, respectively. The level of confidence was fixed at 95% (α =.05).

3. DATA ANALYSIS AND INTERPRETATION

The traffic volume data was collected at predetermined points on selected four road sections where different traffic calming measures were provided. The traffic data was collected during peak hours in the day and evening time. The locations of different sections in Satna city with the different vehicles class is given in table 2.

Table 2: Traffic volume (vehicles/hour) data at different location

S. No.	Location	Two Wheeler	Three Wheeler	Four Wheeler	Heavy Motor Vehicle
1	Satna Bus Stand To Circuit House	2760	210	730	39
2	Civil Lines To Circuit House	3270	245	810	44
3	Dhawari Indoor Stadium To Dhawari Chowk	2910	191	750	25
4	Birla Hospital To Birla Cement Plant	2130	144	732	34

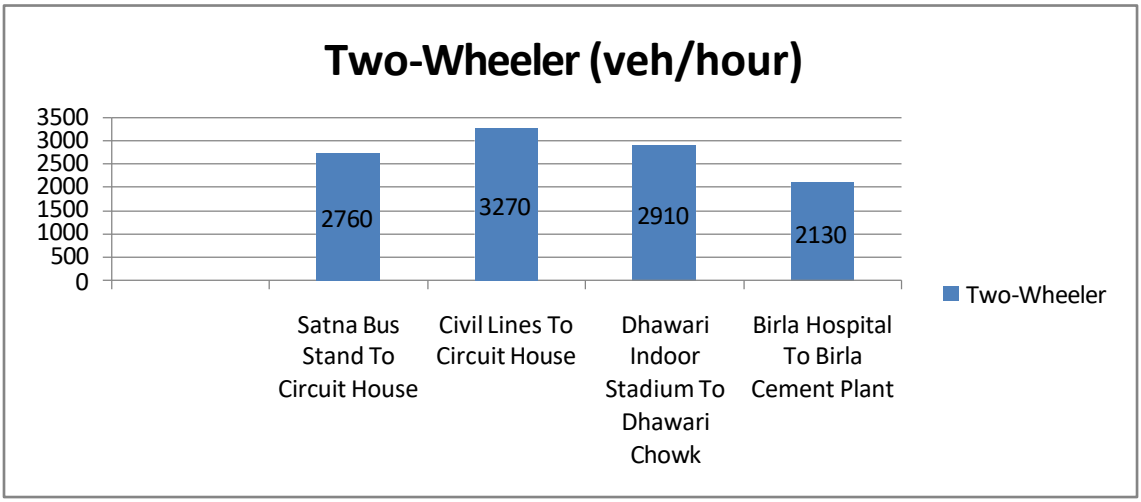


Figure 1: Traffic Volume of Two-Wheeler at Different Location

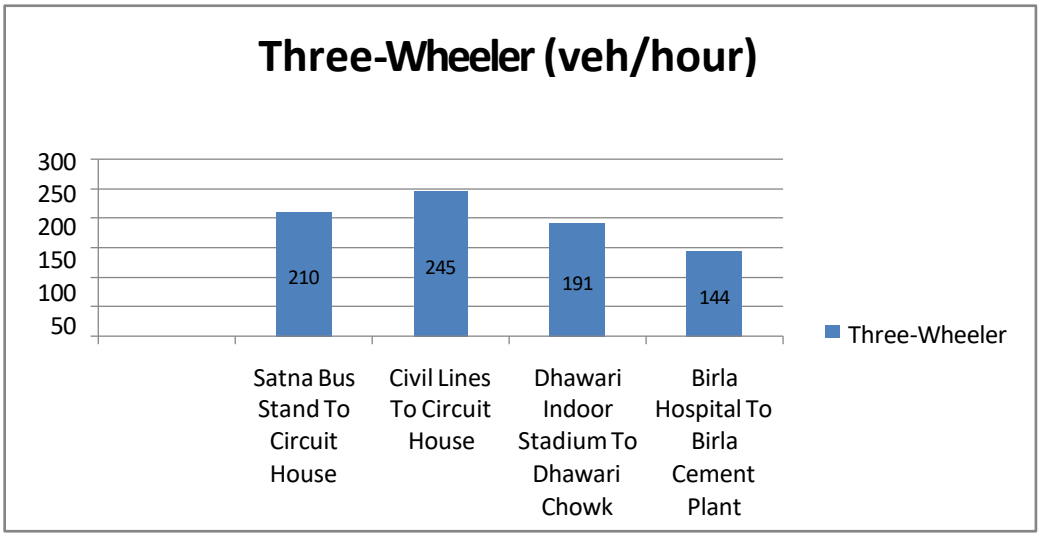


Figure 2: Traffic Volume of Three-Wheeler at Different Location

Speed Prediction Model on the Approach to TCM's

Linear regression was adopted for speed modeling. Microsoft Excel software was used for estimation of coefficients of correlation coefficients and regression equations. Since in the study different types of Traffic Calming measures: rubber speed hump, speed limit sign, rotary and speed bump were considered, different models were developed for the individual measure [12]. These developed models for upstream side of TCMs are given in following table 3. Vb 85 and Vb Mean represent the 85th percentile Speed in Kmph and mean speed in Kmph respectively when vehicle approaches the desired traffic calming measures.

Table 3: Models for Approach Speed at the Upstream Side of TCM's

S. No.	Traffic Calming Measures	Equation Representing 85th Percentile Speed in Kmph ($V_{b\,85}$)	Equation Representing Mean Speed in Kmph (V_b Mean)
1.	Rubber Speed hump	$V_{b\,85} = 26.63 - 0.37X$	$V_{b\,Mean} = 22.52 - 0.33X$
2.	Speed limit Sign	$V_{b\,85} = 29.37 - 0.26X$	$V_{b\,Mean} = 24.87 - 0.24X$
3.	Rotary	$V_{b\,85} = 25.75 - 0.43X$	$V_{b\,Mean} = 20.56 - 0.43X$
4.	Speed Bump	$V_{b\,85} = 26.77 - 0.37X$	$V_{b\,Mean} = 21.44 - 0.36X$

Speed Prediction Model after Crossing the TCM's

The following models were developed for estimating the 85th percentile speed ($V_{a\,85}$) of vehicle and the mean speed ($V_{a\,Mean}$) of vehicle after crossing the Traffic Calming Measure. These developed models for downstream side of Calming Measure are given in table 4.

Table 4: Models after Crossing the TCM's (at Downstream Side Road)

Sr. No.	Traffic Calming Measures	Equation Representing 85th Percentile Speed in Kmph ($V_{a\,85}$)	Equation Representing Mean Speed in Kmph (V_a Mean)
1.	Rubber Speed hump	$V_{a\,85} = 24.31 + 0.36X$	$V_{a\,Mean} = 20.41 - 0.32X$
2.	Speed limit Sign	$V_{a\,85} = 29.00 + 0.16X$	$V_{a\,Mean} = 24.34 - 0.10X$
3.	Rotary	$V_{a\,85} = 26.97 + 0.37X$	$V_{a\,Mean} = 17.26 - 0.37X$
4.	Speed Bump	$V_{a\,85} = 21.48 + 0.38X$	$V_{a\,Mean} = 16.71 - 0.39X$

Validation of models can be carried out by interpretation of the results found in a regression analysis. For validation of model, rejection of null hypothesis which states there is no relationship between the speed and the distance from TCMs is necessary. The results of regression analysis for approach speed at the speed bump are presented in Table 5.

Table 5: The Results of the Regression Analysis for Approach Speed at the Rubber Speed hump

Model summary (85th Percentile Speed of Rubber Speed hump) R- square: 0.99, Std Error: 0.61 ANOVA Significance f: 1.42E-07 **Coefficients**				
Constant	Coefficient	Std error	t-statistic	p value
a	26.6345	0.35	75.57	3.61E-10
b	-0.36602	0.01	-27.84	1.42E-07

Model summary (Mean Speed of Rubber Speed hump) R- square: 0.99, Std Error: 0.52 ANOVA Significance f: 1.06E-07 **Coefficients**				
Constant	Coefficient	Std error	t-statistic	p value
a	22.52	0.30	74.09	4.07E-10
b	-0.33	0.01	-29.24	1.06E-07

In this research work, all other speed models are developed by this approach. Statistical value tests overall significance of linear regression. At level of 5 % significance or in other words accept a 5

% of being wrong, the critical value is 1.85. If calculated F value is larger, null hypothesis would be rejected and the alternative hypothesis that a proposed regression model fits the data well could be accepted [13]. In all cases of regression analysis of spot speed data found at different Traffic Calming measures F value is higher than the critical value; hence, null hypothesis is rejected in each case. Significance F also supports hypothesis that a proposed regression model fits the data well. If the significance, f is less than 0.05(5%), a meaningful correlation exists between dependent variables and independent variables. In all cases of regression analysis significance, f was found to be less than 0.05.

Speed Reductions in each vehicle class due to presence of various traffic calming measures are presented in Table 6. The speed reduction for each vehicle groups two wheelers (2W), three wheelers (3W), four wheelers (4W) and heavy motor vehicles (HMV) are represented below.

Table 6: Speed Reduction for Each Vehicle Group due to Traffic Calming Measures

Speed Reduction in Percentage (%)				
	2W	3W	4W	HMV
Rubber Speed Hump	35	41	44	37
Speed Limit Sign	9	20	17	24
Rotary	62	52	59	71
Speed Bump	49	48	52	69

Based on effectiveness in speed reduction due to various traffic calming measures can be put into descending orders from the highest degree of effectiveness to lowest degree of effectiveness as shown in Table 7.

Table 7: Degree of Effectiveness of Traffic Calming Measures [14]

Vehicle Classification	**Degree of Effectiveness in descending order (from highest to lowest effective TCMs)**			
Two Wheelers	Rotary	Speed Bump	Rubber Speed Hump	Speed Limit Sign
Three Wheelers	Rotary	Speed Bump	Rubber Speed Hump	Speed Limit Sign
Four Wheelers	Rotary	Speed Bump	Rubber Speed Hump	Speed Limit Sign
Heavy Motor Vehicles	Rotary	Speed Bump	Rubber Speed Hump	Speed Limit Sign

4. CONCLUSION

The main objective of this study was to conduct the traffic volume study and to evaluate the effectiveness of different traffic calming measures. To achieve this goal, evaluation of traffic calming measures were done in terms of degree of effectiveness in speed reductions and speed reduction influence zone [8]. A case study was conducted at Satna city focusing on different traffic calming measures viz: rubber speed hump, speed limit sign, rotary and speed bump. It is seen that the traffic volume is maximum on Civil Lines to Circuit House Road section. Vehicle composition shows that most of the vehicles in the traffic stream were light vehicles. If all vehicles considered into one vehicle group and over all speed reductions are computed, then results show highest reduction in speed for rotary (61%) with slight difference from speed bump (54.5%). Rubber humps show moderate speed reduction (39.25%) and speed limit sign show lowest speed reduction (18%). Based on effectiveness in speed reduction due to various traffic calming measures [9], it is concluded that the rotary is the most effective traffic calming measures for all categories of vehicles whereas the speed limit sign is the least effective traffic calming measures. Results show that all vehicle groups cross the rotary with the lowest speed.

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