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Research Paper

A Study on Volume, Speed and Lane Distribution of Mixed Traffic Flow by using Video Graphic Technique

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Abstract

Lane Distribution Factor (LDF) is an integral part of load calculations on urban and rural highways. LDF describes the distribution of vehicular traffic across the roadway. It depends on the traffic composition, speed and volume, origin destination patterns of drivers etc. LDF is developed for transportation planners and highway engineers based on an estimation of macro level utilization of each lane by the total traffic volume. The above information is absolutely necessary to understand the fatigue behaviour of the pavements through number of probable applications of wheel loads on a portion of the pavement which also decides the required thickness. Accordingly, the IRC: 37 - 2012 suggested a set of Lane Distribution Factor for use in the design of flexible pavements. A Two lane road and an Intermediate lane road in urban environment are evaluated using Video Graphic technique. Analysis is carried out for the collected data and the results are also presented in detail for each category of vehicles. Lane distribution factors and Directional distribution factors are developed for both Two lane and Intermediate lane roads.

Keywords: *Lane Distribution, Mixed traffic flow, Traffic, Transportation, Video graphic*

1. Introduction

An understanding of vehicular traffic across the carriageway is very important to a highway transportation engineer for planning and designs of new highway and also for operational improvement of the existing facilities. The traffic on Indian roads is heterogeneous in nature, as it is composed of a number of vehicles categories. Vehicles with varying static and dynamics characteristics share the same road space. The peculiar mix of a wide variety of the vehicular types, each with its own distinct characteristics regarding the dimensions and speeds attained give rise to certain complex behaviour of distribution when the constituents interact with one another along the roadway, thereby resulting in lack of lane discipline [14].

The term 'placement of vehicles' indicates of the left wheel of a vehicle from the edge of the pavement when the vehicle is in motion [1]. Wheel load applications on the full carriageway width are generally non uniform distributed, and most trafficking is seen to occur along certain bands of smaller width, called wheel path. The characteristic of lateral placement of vehicles across the pavement width are important to know whether the traffic is channelized or distribution over the pavement deformation over the pavement width. It is the path of maximum repetitions that is distressed more and cracking and pavement deformations are confined mostly to the area having the maximum wheel load repetitions. In the simulation of mixed traffic flow, it is required to assign the position of vehicles within a lane when it enters the test section.

2. Need for the study

Analytical design of pavements requires selection of accurate design traffic volume for computation of the number of repetitions of standard axle loads during the design period. Knowledge of lateral placement characteristics of wheel of commercial vehicles across the pavement width is necessary to know whether the traffic is channelized or distributed over the pavement width. It is the path of the maximum repetitions that is distressed more and cracking and permanent deformation are confined mostly to the area having maximum wheel load repetitions. Location of the most stressed or path on the pavement enables the pavement designers to examine flexible pavements for failure against fatigue and rutting and the knowledge is also useful in conducting tests for evaluating the structural performance of pavement structures and also for evaluating functional performances of pavements. Hence from both point of view of design of flexible pavement and pavement maintenance management, Lane distribution of mixed traffic flow is utmost necessary [3]. This also will prove to be useful for better traffic management.

3. Selection of road stretch

The stretches of a two lane road and an intermediate lane road having earthen shoulders of varying widths of poor to fair conditions are selected for the present study.

The following criteria were adopted for the identification of sites on flexible pavements.

1. The stretch is to be on NH's, state highways or major district roads with a length of about 0.5 km.
2. The stretch should be straight and avoid any cross roads and major cross drainage works [4].

3. The height of embankment is to be limited to about 1.5m. Stretch with higher embankment may be considered only in exceptional cases and sections in cutting are to be avoided.
4. The section should be uniform longitudinally and transversely with regard to crest composition, sub grade, embankment height, drainage and surface condition.
5. Sections are to be selected on roads carrying different categories of traffic [5].
6. Sections should preferably beyond on plain terrain but gradient up to 4% max are acceptable.

By considering all the mentioned criteria both urban and rural highway sections are selected.
The details of selected stretches are as follows:

1. NH-9–Vijayawada(Vij) - Machilipatnam(Mtm) (Two lane Two way road)

MDR - Kamayyathopu(Kt) – Kanuru(Kn) (Intermediate lane road)

4. Data Collection Methods:

4.1 Video Recording procedure for a Two Lane road:

A two lane road of width 9.0m was selected for the field study. The selected road stretch was on a National Highway passage from Vijayawada to Machilipatnam. Location of the site was 1 Km from Penamaluru along the highway. The section was divided into 45 equal strips of 20 cm's width longitudinally along the pavement. A grid was prepared by dividing into equal strips. This grid of 2m x 9m is stickered along the road. The longitudinal strips are numbered from 1 to 45. In order not to influence the driver, the recording was done by an observer standing at an obscure place at a little distance away from the pavement. For same reason of not disturbing the general pattern of trafficking, observations restricted to day light hours [2]. Data collected in the morning and evening peaks for a period of 4 hours amounting up to 8 hours. The traffic movements in a chosen road section were recorded using a portable video camera with timer facility [8]. The camera was placed on the top of the two storied building and the camera was so positioned that all traffic movements are captured in the camera lens. Video recording procedure is shown in Figure 1.

Fig. 1: Video Recording procedure for Lateral Placement of vehicles

4.2 Video Recording procedure for Intermediate Lane road:

An intermediate lane road of 6.2m was selected for the field study. The selected road stretch was on a Major District road from Kanuru (Kn) – Kamayyathopu (Kt) main road [7]. Location of the site was 0.5 Km kamayyathopu along the MDR. The section was divided into 30 equal strips of 20cm width longitudinally along the pavement. A grid was prepared by dividing into equal strips. This grid was of 2m x 6.2m is stickered along the MDR.

The longitudinal strips are numbered from 0 to 30. Video recording was done in the same procedure as explained above for a two lane road.

4.3 Axle length measurements:

A sample survey to determine rear axle length of commercial vehicles was carried out [6]. The average of these axle lengths have been presented in Table 1. These values represent centre to centre distance of the rear axle wheels.

Table 1: Axle length of various Highway Vehicles

Vehicle Types	Axle Lengths
Auto	1.26m
Car	1.32m
Bus	1.96m
Truck	1.96m

5.1 Traffic volume studies

Volume is a measure to quantify the traffic flow. Volume or flow is expressed as the number of vehicles that pass across a given transverse line of the road during unit time. As the carriage width of road may vary, the traffic volume is generally expressed as number of vehicles per hour or per day, per traffic lane [9].

Data was collected for a period of 2 hr in the morning and evening peaks totaling up to 4 hrs. The Hourly variation of traffic Volume is shown in Figure 2 and 3. Analysis of the data is as follows:

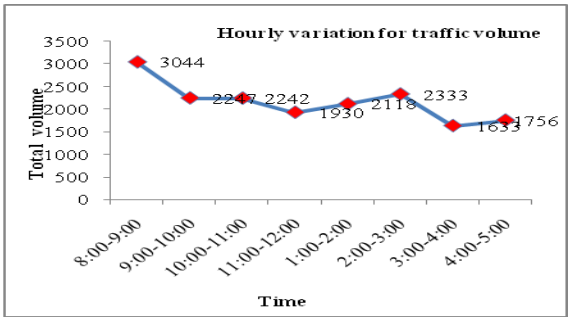


Figure 2: Hourly Variation of Traffic Volume for NH9

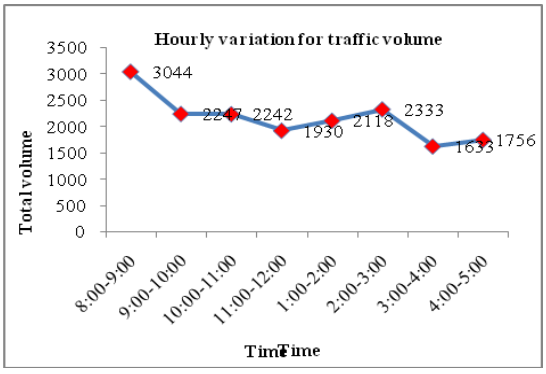


Figure 3: Hourly Variation of Traffic Volume for MDR

From the above results, it was observed that major portion of the road was occupied by two wheelers with 68% of total volume and the commercial traffic was observed to be around of 3% total volume.

5.2 Spot speed studies:

Spot speed is the instantaneous speed of a vehicle at a specified cross section or location. The spot speed of a vehicle fluctuates from place to place all along the route. These can be used to design the geometry of road like horizontal and vertical curves, su-

per elevation etc. location and size of signs, design of signals, safe speed, and speed zone determination require the spot speed data.

5.2.1 Mode wise Average speed for Vijayawada (VIJ) – Machilipatnam (MTM) road

From the video recording, was data collected to calculate the mode wise average speed of vehicles as shown in Figure 4.

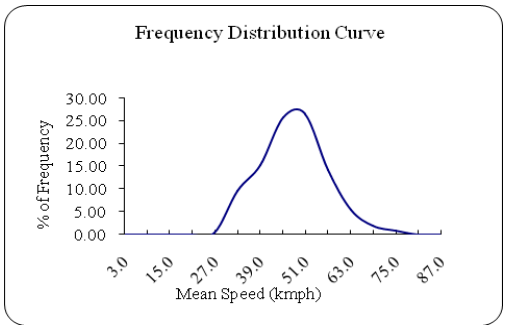
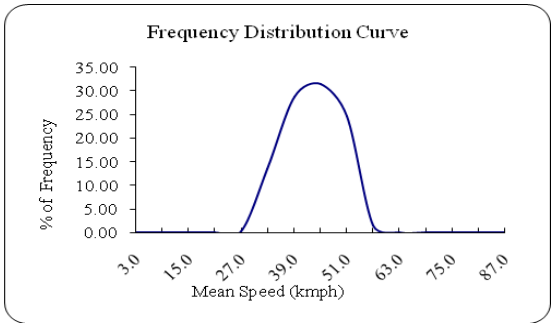


Figure 4: Frequency distribution curve for VIJ – MTM road

5.2.2 Mode wise Average speed KAMAYATHOPU – KANURU road

From the video recording data collected to calculate the mode wise average speed of vehicles as shown in Figure 5



6. Calculation of Maximum number of Wheel Repetitions

In the structural design of new highway pavements and the performance evaluation of in service pavements there is a need to identify the volume and wheel loads of commercial traffic by lane. The lane that carries the heaviest commercial traffic load, usually known as the design lane, governs the structural design of the pavement concerned [10]. The performance of the design lane is a major concern to highway engineers because it is likely to reach the end of its service life sooner than other lanes. Design Engineers are often given only the expected total traffic volume. They are required to estimate the total commercial traffic volume and wheel load distribution in the design lane. The idea of designing all lanes for same percentage of the total equivalent loading is identical to the idea of selecting the lane having the greatest loading as being the design lane and then designing companion lanes like it [11]. Maximum number of wheel load repetitions by commercial vehicles were calculated for both the two lane and intermediate lane roads.

6.1 Vijayawada – Machilipatnam Road

Total no of commercial vehicles on a two lane road are observed to be 2377. It is observed that path having maximum number of wheel repetitions is very close to the centre line of the pavement. Maximum number of wheel repetitions were observed to be 141, occurring in the 21th strip. Maximum number of wheel repetitions was found to occur at a distance of 4.2m from the pavement edge for the Vijayawada bound vehicles and at 4.8m from the opposing traffic as shown in Figure 6.

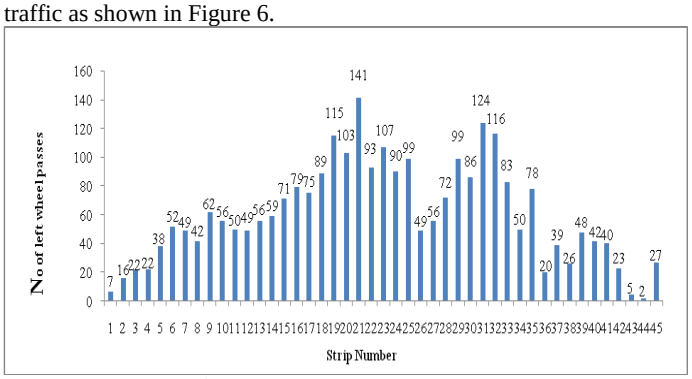


Figure 6: Number of Wheel Repetitions over a NH- 9 - Vijayawada – Machilipatnam (Two lane road)

Total number of commercial vehicles = 2377
Maximum number of wheel repetitions = 141 (in 21th strip)

6.2 Kanuru (Kn)– Kamayyathopu (Kt) Road

Total no of commercial vehicles on a two lane road are observed to be 598

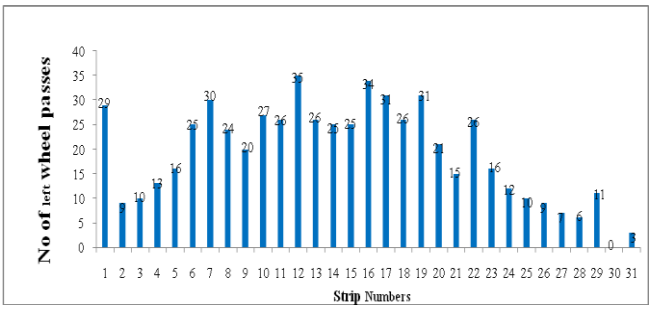


Figure 7: Number of Wheel Repetitions over a MDR - Kanuru - Kamayyathopu (intermediate lane road)

Total number of commercial vehicles = 598
Maximum number of wheel repetitions = 35 (in 11th strip)

7. Calculation of Lane Distribution Factors

Lane distribution factors are calculated from the data obtained through video graphic technique [12]. Consider a Two lane road for this purpose. Total number of vehicles travelling in one direction is calculated and the equation for this is given below;
LDF = (Total number of vehicles using a particular lane(D) / Total number of vehicles plying on that lane (P))

$$D = (A - B) + C \ldots\ldots \quad .(1)$$

Where
D = Total number of vehicles using a particular lane
A = Number of vehicles travelling in one direction
B = Number of vehicles overtaking the centre line of carriageway travelling in the same direction
C = Number of vehicles overtaking the centre line of carriageway travelling in the opposite direction

From the above mentioned equation, total number of vehicles using a particular lane was obtained. Total volume plying on the Two lane carriageways is also calculated from the data [13]. Lane distribution factors are obtained by dividing the total number of vehicles travelling in a particular lane with the total number of vehicles plying on that Two lane road. The lane distribution fac-

tors obtained for commercial vehicles for two roads are shown in Tables 2 and 3.

Table No 2: Lane Distribution Factors for Vijayawada(Vij) – Machilipatnam(Mtm) road

Mode	Towards Vijayawada		Towards Machilipatnam		Lateral Distribution Factor (towards Vijayawada)	1.12
Buses	286	286-12+64	71	71-64+12		
Trucks	227	227-12+21	73	73-7+8	Lateral Distribution Factor (towards Machilipatnam)	0.65
Total	P=513	D=574	P=144	D=93		

Table No 3: Lane Distribution Factor for Kanuru(Kn) Kamayyathopu(Kt) road

Mode	Towards Kanuru		Towards Kamayyathopu		Lateral Distribution Factor (towards Kanuru)	0.84
Buses	69	69-3+15	47	47-15+6		
Trucks	84	84-20+42	98	98-40+19	Lateral Distribution Factor (towards Kamayyathopu)	1.26
Total	P=153	D=183	P=145	D=115		

Thus a lane distribution factor for Two lane road is obtained as 0.89 (Vij - Mtm) and for an Intermediate lane is obtained as 1.05(Kn - Kt). Hence the study shows that the distribution factors for commercial traffic are presently quite different from those recommended by IRC: 37-2001.

8. Conclusions

The following conclusions are drawn from the present study,

1. The location of most frequented outer wheel path changes with pavement width, condition and width of shoulders, presence of centre line marking, and traffic volume, using always a constant value as suggested by IRC are not available.

2. The study shows that the distribution factors for commercial traffic for the design of flexible pavement are quite different from those recommended by IRC: 37-2012.

3. The study shows that maximum number of wheel repetitions occurred in the central portion of the Two lane carriageway.

4. Standard probability distributions are tried to fit lateral placement but the data collected did not follow any distribution.

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