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MULTILANE HIGHWAY CAPACITY ESTIMATION BY MICRO-SIMULATION TECHNIQUE USING CALIBRATED VEHICLE FOLLOWING MODEL

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Introduction

- The nature of the traffic condition in India is highly heterogeneous without proper lane discipline.
- The most significant issue in highway planning and management is to determine the roadway capacity.
- The detailed study of vehicular movement is important to estimate the practical capacity of road links.
- Multimodal simulation software VISSIM is applied in the present work for assessment of complex vehicular interactions .

Objective of the Study

- To estimate the capacity of an eight lane divided expressway in India with the help of traditional method.
- To develop a simulation model for estimation of capacity of an eight lane divided expressway.
- To calibrate driver behavior model parameters of the simulation software VISSIM in order to imitate mixed traffic conditions of a multilane expressway.

Literature Review

- Gipps (1981) developed a behavioral based car following model to be used in computer simulation.
- Wiedemann and Reiter (1992) defined that the response of a subsequent vehicle behind a vehicle moving in front depends on the relative speed between the two vehicles.
- Menneni (2008) has done calibration of a vehicle following model at microscopic and macroscopic level.
- Durrani, Lee and Maoh (2016) used varied pair of vehicle interactions to calibrate the Wiedemann's vehicle-following model.

Analysis of Field Data

- The section chosen for the present study is Nehru Outer Ring Road at chainage 20+200 (Towards Gacchibowli).
- It is an inter urban eight lane divided expressway encircling the city of Hyderabad with each 3.5m wide lane having a curved section.
- The prevalent weather condition for data extraction was sunny without any rainfall.
- The speed-volume data has been mainly collected with the help of a video camera.

Details of traffic volume and composition of the eight lane divided expressway

Highway Type	Time period	Directional Volume (veh/hr)	Traffic Composition (%)					
			SC	BC	LCV	HCV	MAV	BUS
Nehru Outer Ring Road (ch. 20+200)	09 – 10 AM	805	36.77	42.36	8.2	7.45	3.23	1.99
	10 – 11 AM	831	36.34	42.5	7.7	6.25	5.65	1.56
	04 – 05 PM	873	33.44	42.5	9.51	7.78	4.6	2.17
	05 – 06 PM	1041	36.41	42.93	9.42	5.86	4.04	1.34

Methodology

- Selection of study section and data collection of free flow mixed traffic by video graphic techniques.
- Extensive analysis of collected data to get the traffic characteristics of the study section.
- Calculation of time headway, space headway, relative distance and relative speed of individual vehicles.
- Hysteresis plots has been done with relative speed (X-axis) against relative distance (Y-axis) for each vehicle category.

Methodology

- The values of relative velocity and relative distance are taken for the vehicles maintaining a time headway within 4.5 sec.
- From the hysteresis plots, the coefficient of correlation (CC) parameters used in the micro-simulation software VISSIM has been calculated.
- With the changed CC parameters than the default values, the simulation was run.
- The results for both the calibrated parameter values and default values has been analyzed.

Micro-simulation Model

- In microscopic simulation, each entity of reality (car, train, person) is simulated individually.
- It can model individual vehicles of roadway traffic in a large area considering all possible lane change behavior even under heterogeneous traffic conditions.
- The model can assign specific driver behavior characteristics to each vehicles on network and simulate the ‘driver-vehicle-unit’ as single entity at every small time step.

Wiedemann74 model

- The Wiedemann 74 car following model is one of the two implementations of car following models available in VISSIM.
- This model is suggested for use in urban traffic. The driver behavior modeling in car following is based on perception thresholds.
- The formulation can be best explained using a relative velocity vs. relative distance graph.

Wiedemann 99 model

• The parameters representing car-following behavior of drivers are as follows:

•CC0: It defines the desired front bumper-to-front bumper distance in a standstill condition.

$$AX = CC0$$

•CC1: It defines the time (in seconds) the following driver wishes to keep.

$$ABX = \text{Lead Vehicle Length} + CC0 + CC1 * V_{slower}$$

Wiedemann 99 model

•CC2: It defines how much more distance than the desired safety distance (ABX) before the driver intentionally moves closer.

$$SDX = ABX + CC2$$

•CC3: It defines the start (in seconds) of the deceleration process; i.e., the time in seconds, when the driver recognizes a slower moving preceding vehicle, and starts to decelerate.

$$SDV = CC3$$

Wiedemann 99 model

- CC4 and CC5: They define the speed difference (in m/s) during the following process. CC4 controls speed differences during closing process, and CC5 controls speed differences in an opening process.
- CC6: It defines the influence of distance on speed oscillation during following condition.
- CC7: It defines actual acceleration during oscillation in a following process.

Wiedemann 99 model

- CC8: It defines the desired acceleration when starting from a standstill.
- CC9: It defines the desired acceleration when at 80km/hr. However, it is limited by maximum acceleration for the vehicle type.

Wiedemann Car Following Logic

1.AX: It is the minimum distance headway (front-bumper to front-bumper distance) in a standstill condition

2.ABX: It is the minimum desired following distance to avoid collision

3.SDX: It is the maximum desired following distance to avoid collision

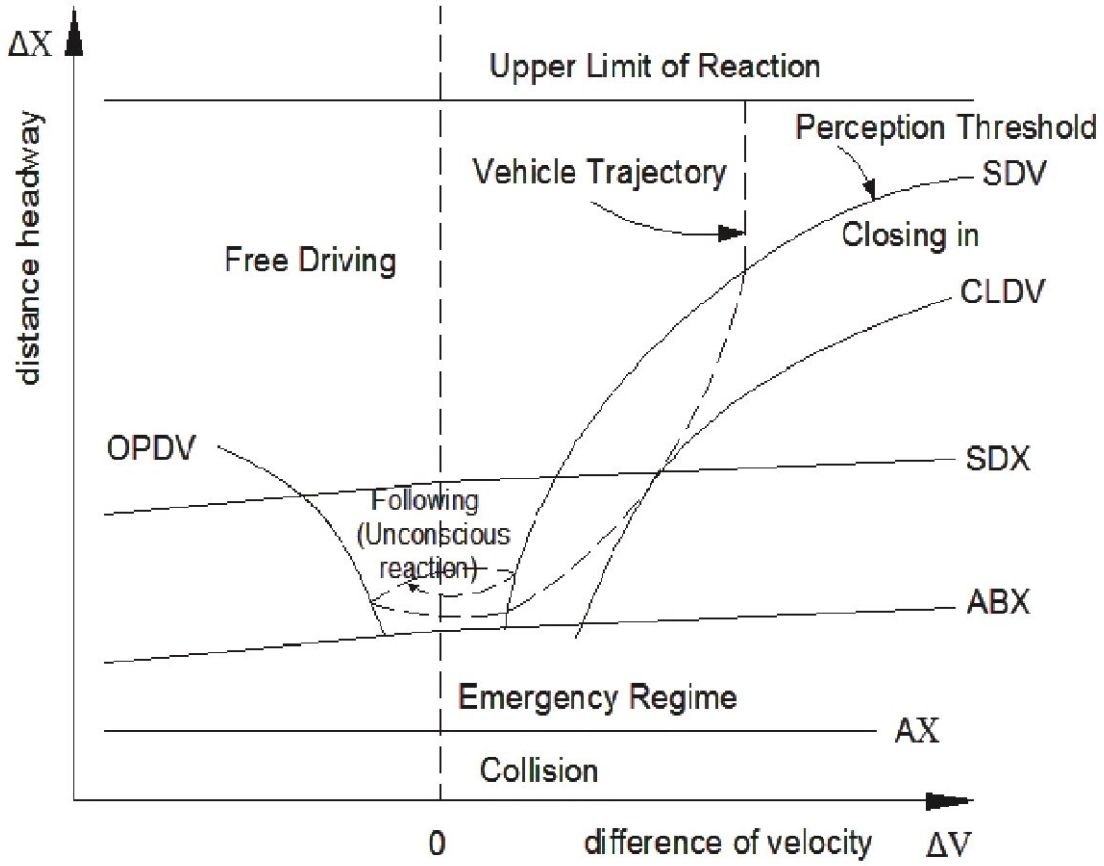
4.SDV: It is the threshold at which driver recognizes that he is approaching a slower vehicle

5.OPDV: It is the threshold for speed difference in an opening process during a following condition

6.CLDV: It is the threshold for speed difference in a closing process during a following condition

Wiedemann Car Following Logic

• The diagram of the Psycho-Physical car following model logic as illustrated by Wiedemann is represented below.



Parameters of wiedemann99 in present study

1.	CC0	Taken from calibrated wiedemann74
2.	CC1	Based on optimization
3.	CC2	From 25th percentile value of relative distances
4.	CC3	Taken as a slope value
5.	CC4	25th percentile of speeds on negative side
6.	CC5	25th percentile of speeds on positive side
7.	CC6	Default value is adopted
8.	CC7	Default value is adopted
9.	CC8	Default value is adopted
10.	CC9	Default value is adopted

Wiedemann 99 model parameters listed with changed values in VISSIM for Outer Ring Road

Parameter	Default Value	BC	SC	LCV	HCV	MAV	BUS
CC0	1.5	1.31	1.26	1.29	1.74	1.83	1.88
CC1	0.9	0.44	0.62	0.604	0.99	0.78	0.59
CC2	4	3.3	3.58	2.82	3.98	1.63	2.58
CC3	-8	-8.93	-7.63	-11.29	-6.16	-12.72	-9.57
CC4	-0.35	-1.98	-1.74	-1.57	-1.19	-1.17	-1.84
CC5	0.35	1.59	1.68	1.49	1.77	1.98	2.22
CC6	11.44	11.44	11.44	11.44	11.44	11.44	11.44
CC7	0.25	0.25	0.25	0.25	0.25	0.25	0.25
CC8	3.5	3.5	3.5	3.5	3.5	3.5	3.5
CC9	1.5	1.5	1.5	1.5	1.5	1.5	1.5

Validation of the Driver's Following Behavior Parameters

- The sensitivity of driver's following behavior parameters is done by two-way analysis of variance (ANNOVA).
- The sequential validity of the simulation model has been checked by a comparison of the observed and simulation flow value at 5 minutes interval of traffic flow.
- A statistical validation has been done through the paired t-test.

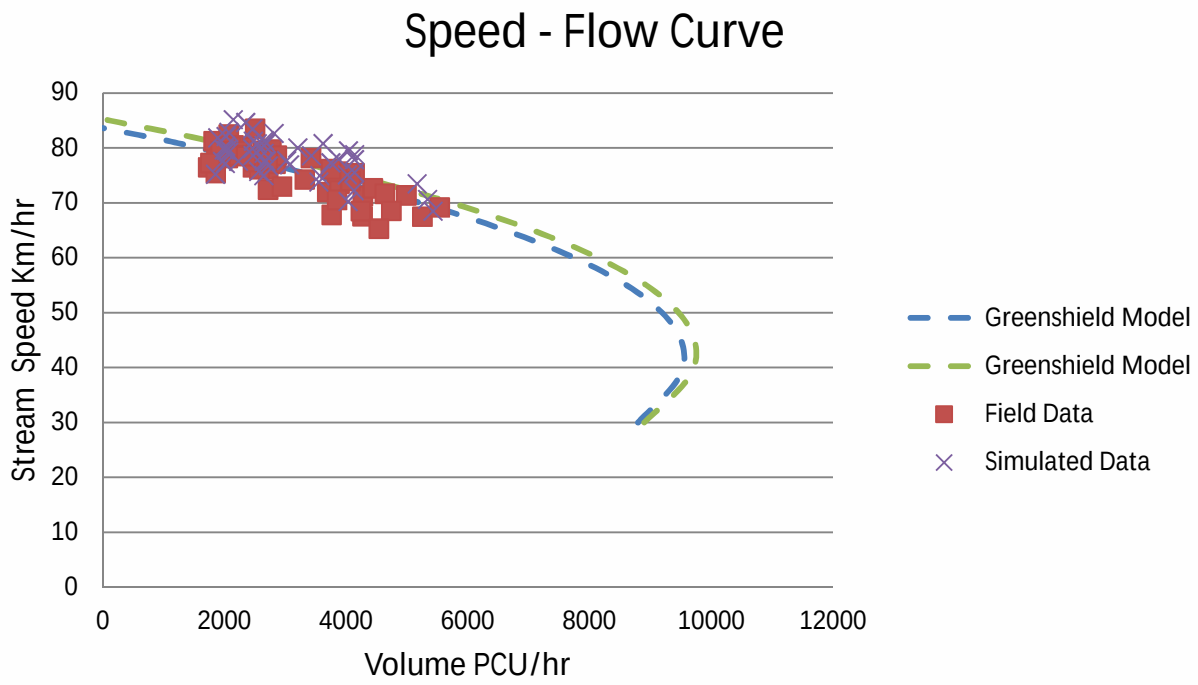
Validation of the Driver's Following Behavior Parameters

- The estimated t-statistic, p-value and t-critical values obtained for 95% confidence level, along with their respective degrees of freedom.
- The estimated t-statistic (-1.6861) is lesser than the t-critical (2.0117) values for t-test and the p-value (0.098) is more that the 5% level of significance.

Estimation of Capacity

- The traffic parameters of the study section has been extracted from the video graphic data.
- The heterogeneous traffic volume measured at every five minutes interval were converted to traffic flow values.
- The extracted traffic data were used as basic parameters for Greenshield's linear model and also as input parameters in VISSIM software.

Plot of Speed Versus Flow for Outer Ring Road



Results of Estimation of Capacity

- The capacity estimated by traditional method (Greenshield's Model) has been found to be 9542 PCU/hr/direction.
- While, the simulated capacity estimated for the expressway has been found to be 9721 PCU/hr/direction.
- Thus the simulated capacity varies with the traditional capacity by 1.87% that lies well within 5% value.
- It can be inferred from the result that the simulation model produces realistic capacity estimate with changed co-efficient of correlation (CC) parameters.

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THANK YOU