10th URBAN MOBILITY INDIA & CODATU XVII CONFERENCE
INTELLIGENT, INCLUSIVE AND SUSTAINABLE MOBILITY

On-Road Parking

A New Approach to Quantify the Side Friction Regarding Road Width Reduction

Suvin P V[a] and Mallikarjuna C[b]

[a] *Research Scholar, Civil Engineering Department, Indian Institute of Technology Guwahati*

[b] *Associate Professor, Civil Engineering Department, Indian Institute of Technology Guwahati*

Indian Institute of Technology Guwahati
Guwahati – 781039, India

Outline

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Motivation

Linear assumptions of traffic flow are invalid

- Road width reduction
- Capacity Drop
- Speed Drop
- Congestion
- Delay
- Accidents

Can We Apply Existing Simulation Models to This Traffic?

Introduction

- One of the major urban challenges for both the policymakers and the designers
- Significant reduction in the road space → Capacity & Speed drop
- Parked vehicles act as a frictional element to the through traffic
- Due to the psychological reasons, the drivers are forced to move at lower speeds

OBJECTIVE

To quantify the friction resulting from the parked vehicles

Introduction

- Friction is quantified in terms of the road width reduction
- Total width reduction is considered as

  Physical width reduction+Psychological width reduction

- Speed variation across the road width is analysed to quantify the psychological width reduction
- A fluid dynamic model, "The Law of the Wall" is considered to model the speed variation

Background

Effect of lane width-reduction on the traffic behaviour

Author & Year	Findings
Leong (1968)	0.95m reduction in the road width leads to a capacity drop of 28%
Kadiyali & Viswanathan (1993)	Proposed a factor of 0.64 to scale the capacity when the lane width drops from 3.5m to 2.75m
HCM, (2000)	The capacity of roadway decreases by 3% for a lane drop from 12ft. (3.7m) to 11ft. (3.4 m) and by 7% for 10-ft. (3.0 m).
Chandra (2004)	Capacity reduces almost by 12% for every 0.3m (1-ft) drop in lane width
HCM (2010)	Capacity reduction occurs only when the drop in the lane width is 10-ft. (3.0 m) or more

Background

Effect of the parking operations on the traffic stream behaviour

Author & Year	Findings
Cao, Yang, & Zuo (2017)	The capacity of a road section with on-street parking should be estimated according to the available transverse width at the parking zone. They have estimated a 22% capacity drop as a consequence of the on-street parking.
Wijayaratna (2015)	The on-street parking manoeuvres resulted in a 17% reduction in the theoretical capacity of the traffic lane
Guo, Wang, & Guo (2012)	On-street parking manoeuvres result in a capacity reduction of about 35%

Parking is an important aspect to be considered in various traffic flow analyses

Data Collection

Site Selection

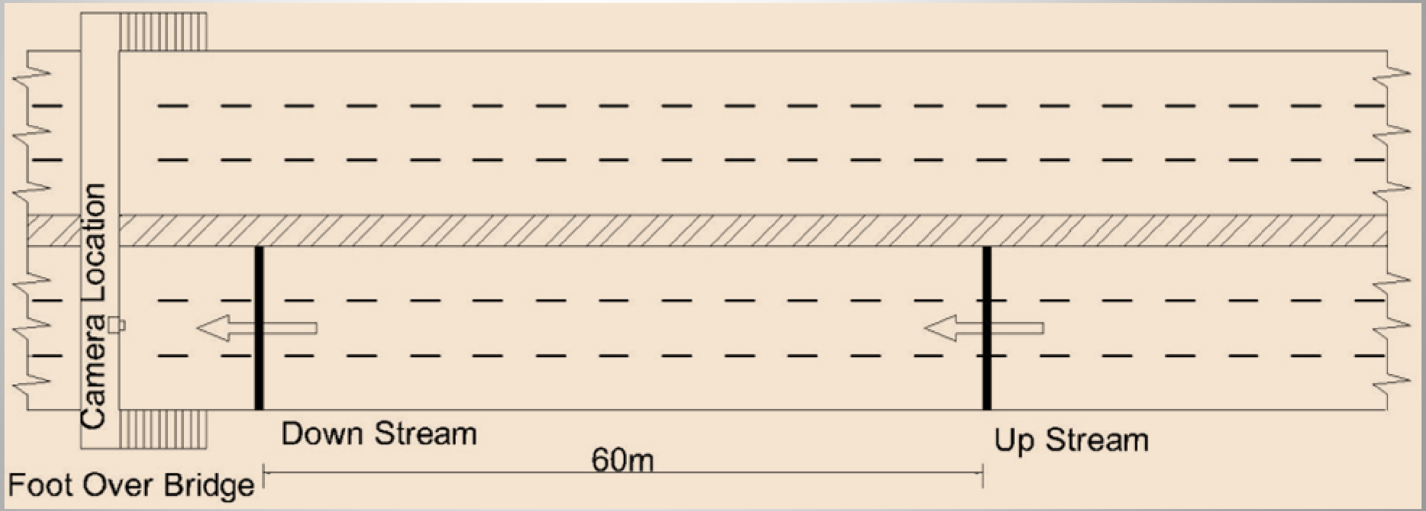
The following criteria were applied,

- The influence of the other factors on traffic stream is minimal
- The site has a nearby vantage point to place the camera
- The width of the road is constant within the section
- The road is straight and the terrain is flat.

Data Collection

Data Collection

- Video graphic data collected from an urban arterial located in Dispur, Assam
- The video was covering a 60m road stretch for a duration of 2 hours



Data Collection

Data Extraction & Post Processing

- Trajectory data is extracted using Traffic Data Extractor (TDE) dveloped by *Ronald Munigety, Vicraman, & Mathew, (2013)*
- The observed trajectories are reconstructed using LWPR method based on the methodology proposed by *Suvin & Mallikarjuna (2017)*
- The instantaneous speed of all the vehicles, at each 0.2-second interval, was extracted

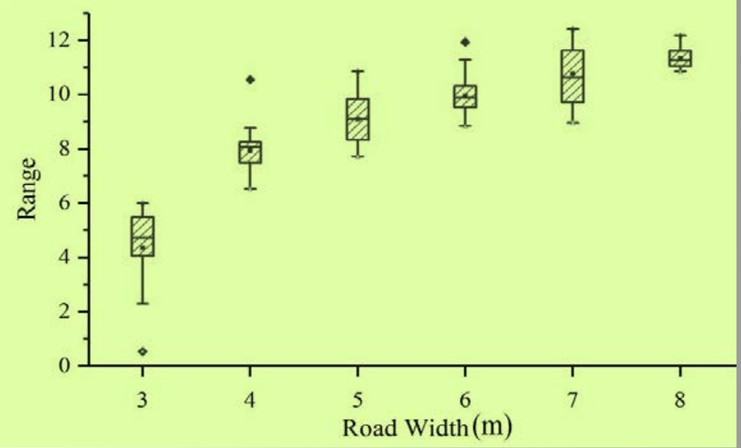
Data Analysis

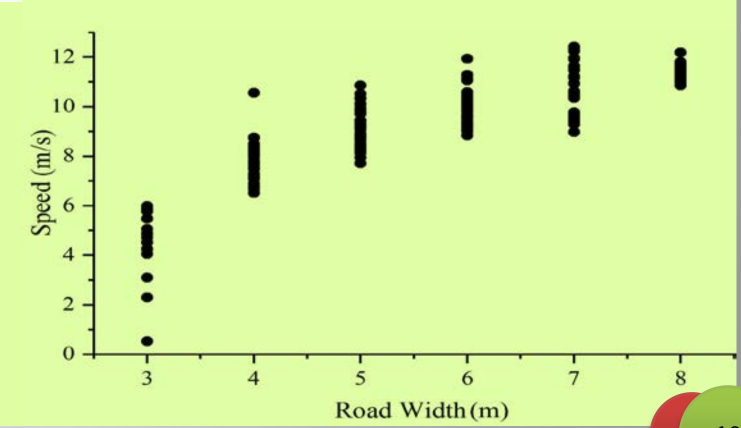
Estimation of time-space averaged speed

- Speed data were averaged spatiotemporally across all the vehicles
- Outliers in the speed data were removed before averaging the speed data using **Quartile Analysis**

$$Speed^{+} = \max_{v_i}\{v_i \mid v_i < Q_3 + 1.5 \times IQR\}$$

$$Speed^{-} = \min_{v_i}\{v_i \mid v_i > Q_1 - 1.5 \times IQR\}$$





Methodology

Log law of the wall

The average velocity of the turbulent fluid flow at any point away from the wall is proportional to the logarithm of the distance from the wall.

Th. Von Karman, in 1930

$$v \propto \ln(\mathrm{w} - \mathrm{w}_{phy})$$

$$v = \frac{1}{k}\ln(w - w_{phy}) + c$$

v = Average speed of traffic at location away from the parked vehicles

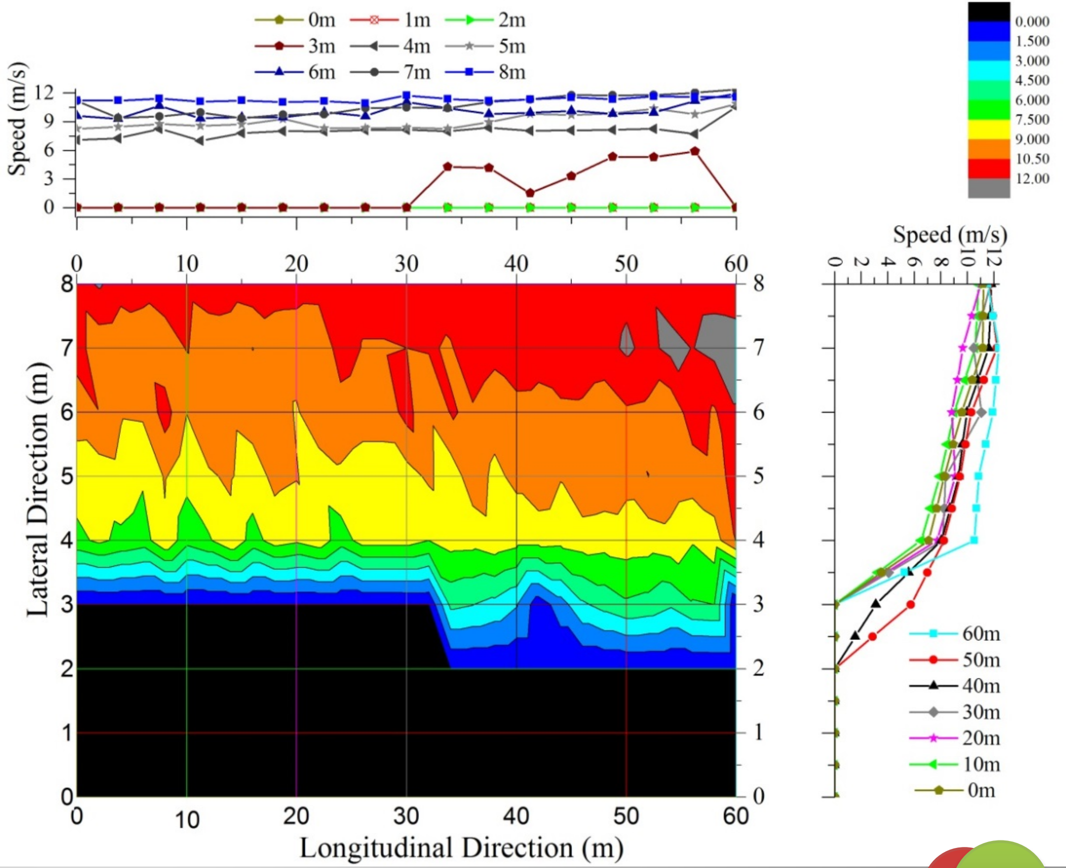
w = Distance from the parked vehicles (distance from $\mathrm{w}_{\mathrm{phy}}$)

w_{phy} = Physical road width reduction

k & c = Constants

Methodology

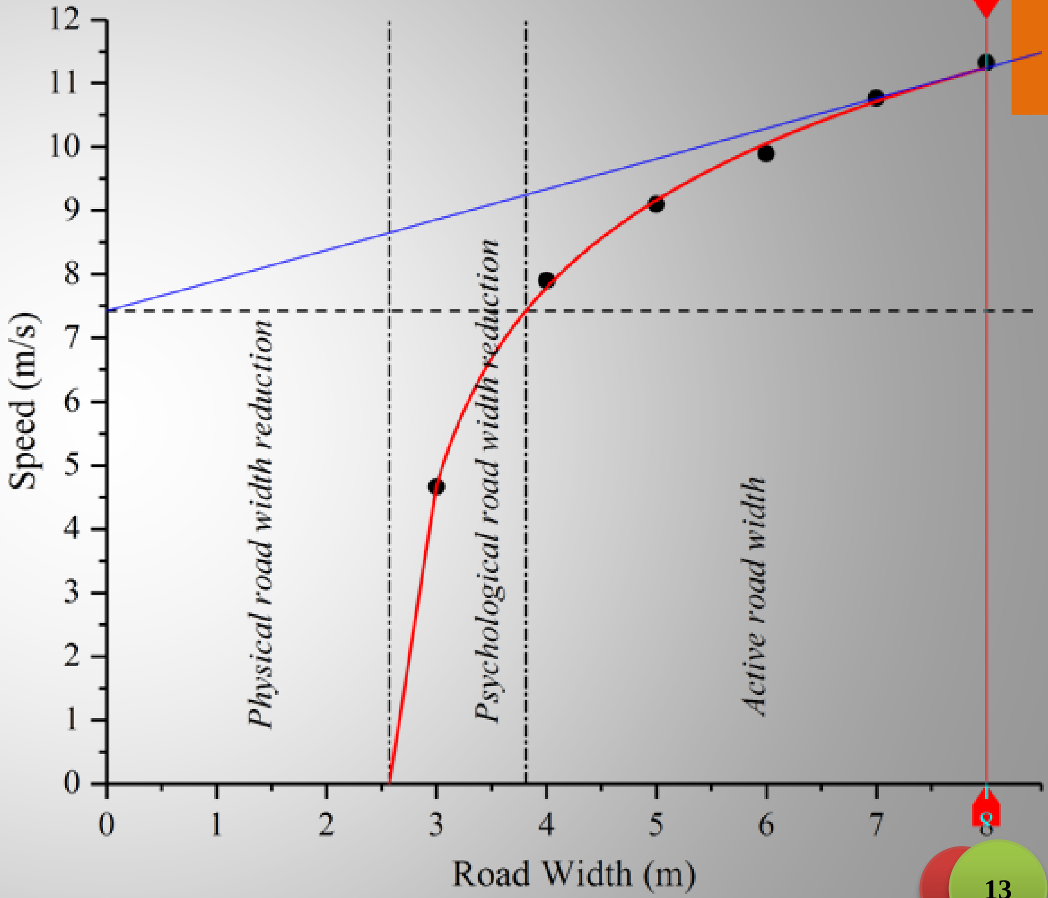
- It was hypothesized that the law of the wall is valid for the traffic stream with on-street parking
- The viscous effect is a result of the friction drag of the parked vehicles on the nearby moving traffic



Methodology

The entire road width is divided into 3 zones

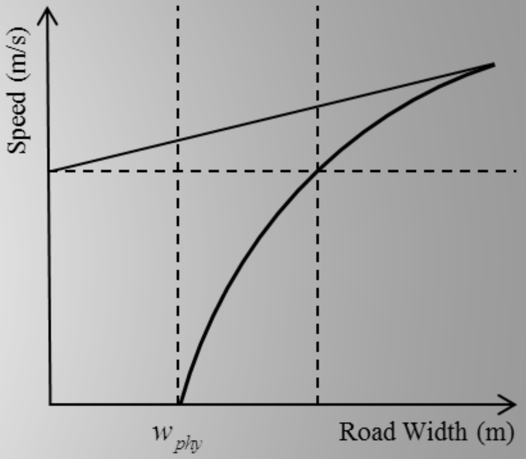
- ➢ Physical width reduction
- ➢ Psychological width reduction
- ➢ Active road width



Methodology

Estimation of Physical and Psychological road width reduction

$$v = \frac{1}{k}\ln(w - w_{phy}) + c \quad (1)$$



The gradient of the tangent at the maximum speed level is provided by

$$\left.\frac{dv}{dw}\right|_{w=W} = \frac{1}{k}\left(\frac{1}{W - w_{phy}}\right) \quad (2)$$

From the gradient and a coordinate, the equation of the tangent is derived as follows

$$y - \frac{1}{k}\ln\left(W - w_{phy}\right) + c = \frac{1}{k}\left(\frac{1}{W - w_{phy}}\right)\left(x - W\right) \quad (3)$$

Methodology

Estimation of Physical and Psychological road width reduction

Rearranging the equation

$$y = \frac{x}{k\left(W - w_{phy}\right)} + \frac{1}{k}\left\{\ln\left(W - w_{phy}\right) - \frac{W}{W - w_{phy}}\right\} \quad (4)$$

The psychological width reduction is assumed to be the width corresponding to the intercept speed value in the equation 1

Methodology

Estimation of Physical and Psychological road width reduction

By substituting the intercept to the equation 2

$$\frac{1}{k}\left(\ln\left(W-w_{phy}\right)-\frac{W}{W-w_{phy}}\right)=\frac{1}{k}\ln\left(w-w_{phy}\right)+c$$

Rearranging the equation

$$w=w_{phy}+\frac{W-w_{phy}}{\exp\left\{\frac{W}{W-w_{phy}}+kc\right\}}$$

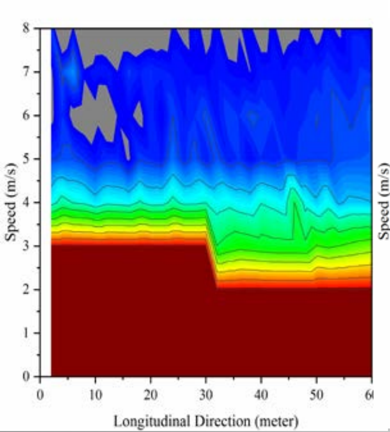
Physical width reduction + ***Psychological width reduction***

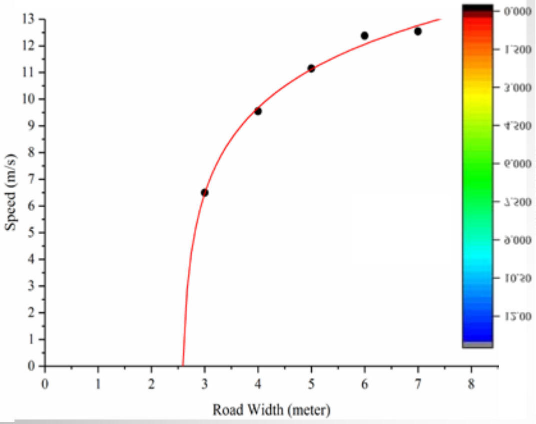
Results & Discussion

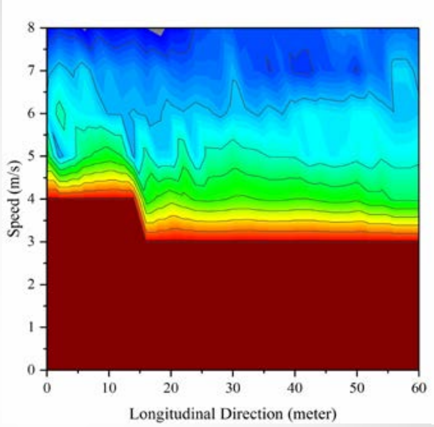
Model	*Lateral Speed Variation Model*		
Equation	$v = \frac{1}{k}\ln(w - w_{phy}) + c$		
Reduced Chi-Sqr	*0.0176*		
Adj. R-Square	*0.997*		
		Value	Std. Error
Parameters	k	*0.386*	*0.31*
	w_{phy}	*2.57*	*0.09*
	C	*6.86*	*0.33*

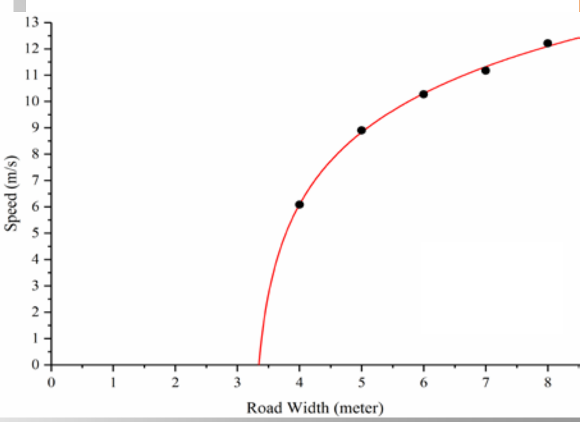
It is clear from the table that the model perfectly characterizes the speed variation of the traffic stream across the width of the road

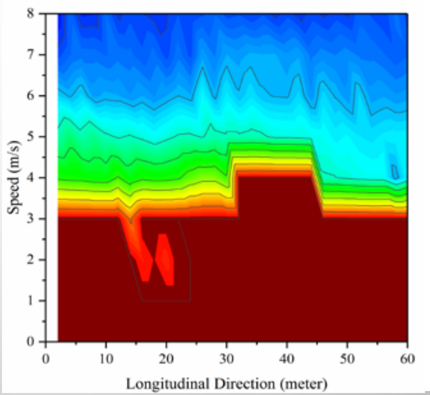
Results & Discussion

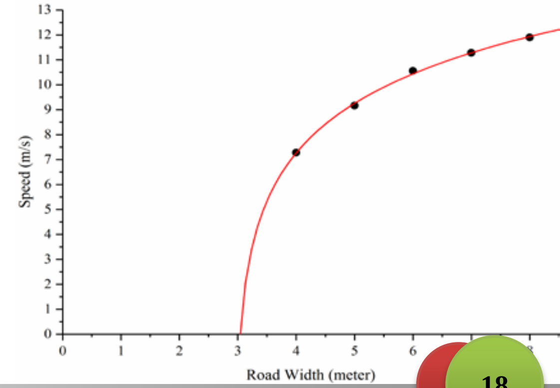












Model is validated against various parking intensity and configuration

For all the situations $R^2 \geq 0.95$

Conclusion

- The road width reduction resulted from the on-street parking can be represented as a sum of the physical and the psychological width reduction.
- The proposed model describes the variation of the speed of the traffic stream across the road width.
- The speed variation across the width of the road follows the log law of the wall

Conclusion

- This variation of the speed should be incorporated into the existing microscopic simulation models as well as in macroscopic models for more realistic representation of the heterogeneous traffic stream.
- The average width reduction can be directly inputted to estimate the practical capacity of the traffic stream

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Thank You!

Suvin P V & Mallikarjuna C