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**A study on pedestrian behaviour in different
road traffic facilities in Indian traffic scenario**

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Introduction

- As per MoRTH (2021), 23.9% of crashes in India happened at intersections and 67.5% at straight mid-block sections.
- Out of the total deaths due to crashes in India, pedestrians are the second highest contributor with a share of 18.9% in 2021 (MoRTH, 2021)
- Earlier research did not examine how a countdown display (CDD) at a signalized intersection affects pedestrian speed.
- There is need of more study at midblock considering the effect of crosswalk on behaviour of pedestrian.
- A small number of studies have been conducted on pedestrian delays.

Objectives

- To study the behaviour of pedestrians in mid-block sections and intersections in mixed traffic scenarios.
- To estimate the speed and delay of pedestrians in different road traffic conditions.
- To develop speed prediction models for pedestrians in mid-block sections and signalized intersections.

Site Selection

- The signalized intersections were chosen from the winter capital of Maharashtra i.e. Nagpur city.
- The mid-block sections were chosen from New Delhi and Chandigarh.



(a) Rani Jhanshi Square, Nagpur



(b) Laxmi Bhavan Square, Nagpur

Site Selection



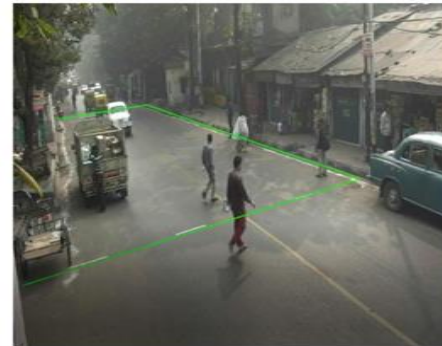
(c) RBI Square, Nagpur



(d) Alankar Square, Nagpur



(e) Palam Road, Chandigarh



(f) ISBT Road, Delhi

Data Collection

- To collect pedestrian data videographic survey was conducted.
- The data were collected for two hours in the morning peak period between 9:00 am to 11:00 am.

Signalized Intersection	Name of location	Approach width (m)
With countdown timer	RBI chowk	26.7
	Alankar chowk (IOE)	19.7
Without countdown timer	Jhansi rani chowk	28
	Laxmi Bhavan square dharampeth	20

Midblock section	Name of location	carriageway width (m)
Midblock without crosswalk	Palam Road	9.5
	ISBT Road	8.2

Estimation and Analysis of Speed and Delay of Pedestrians

For the extraction of required data, Kinovia software was used.

- $\text{Time} = \text{Difference in frame number} / \text{Number of frames per second}$
- $\text{Delay}(\text{sec}) = \text{Actual time of travel} - \text{Average time of travel}$
- $\text{Speed}(\text{m/sec}) = \text{Distance}(\text{m}) / \text{Time}(\text{s})$

Notation of Pedestrians Corresponding to the Age Group

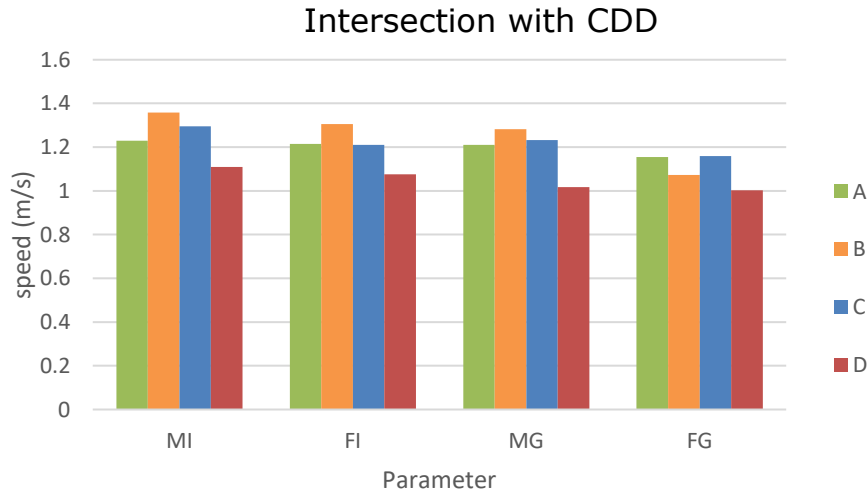
Age group	Notation
Age < 15	A
15 ≤ Age < 30	B
30 ≤ Age < 50	C
Age ≥ 50	D

Notation of Pedestrians Corresponding to their Movement

Parameter group	Abbreviation
Male Individual	MI
Female Individual	FI
Male in a group	MG
Female in a group	FG

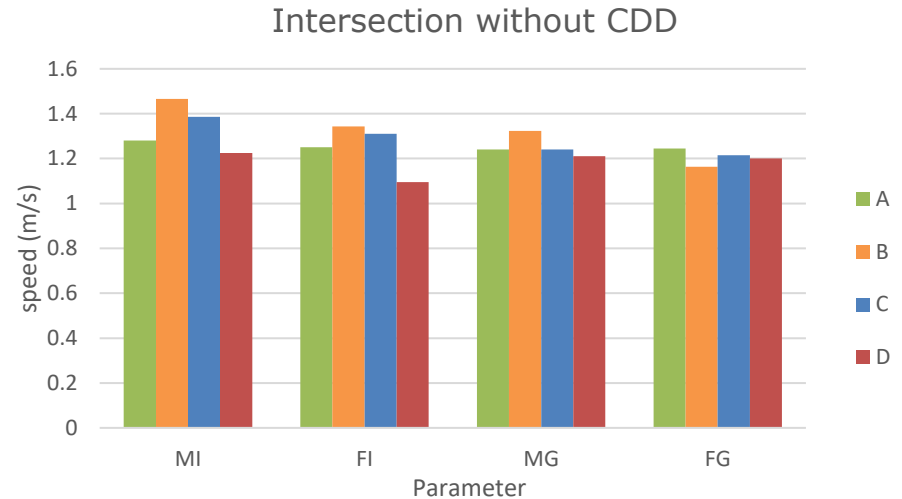
Estimation and Analysis of Speed and Delay of Pedestrians

- Variation of pedestrian speed at the signalised intersection with the presence and absence of CDD



MI= Male Individual
FI= Female individual

MG= Male in group
FG= Female in group

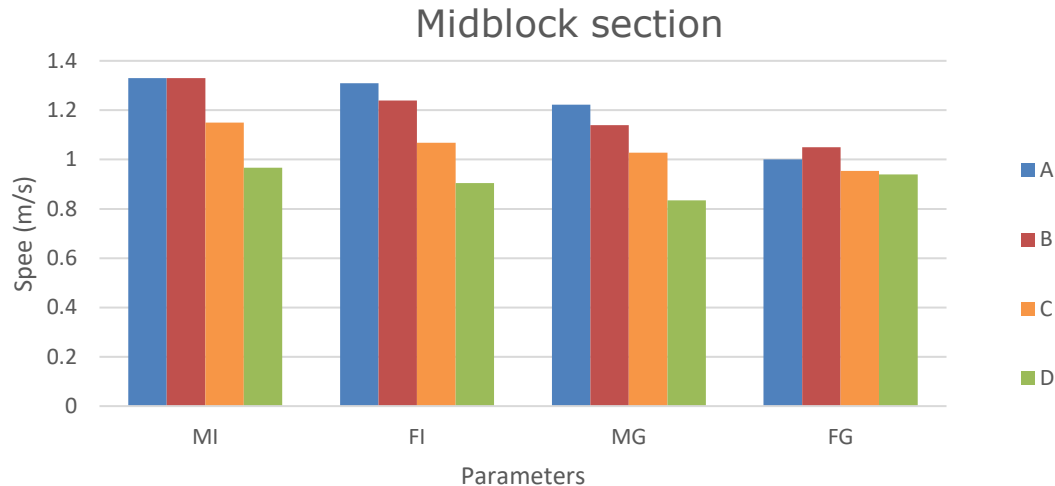


MI= Male Individual
FI= Female individual

MG= Male in group
FG= Female in group

Estimation and Analysis of Speed and Delay of Pedestrians

- Variation of pedestrian speed at the midblock section with the absence of a crosswalk

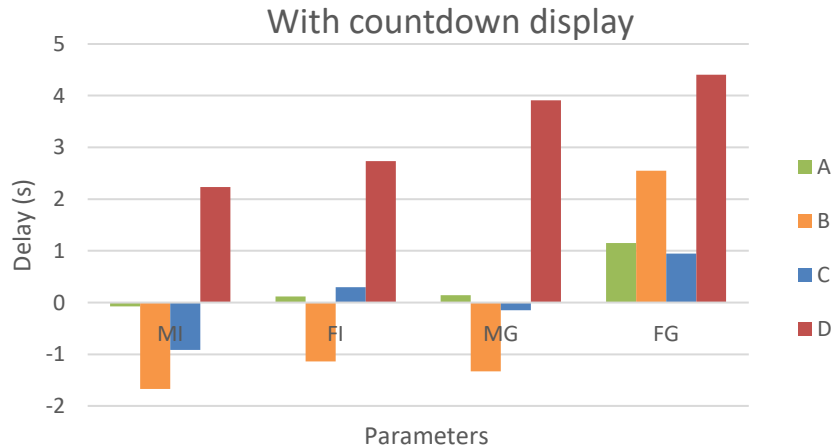


MI= male individual
FI= female individual

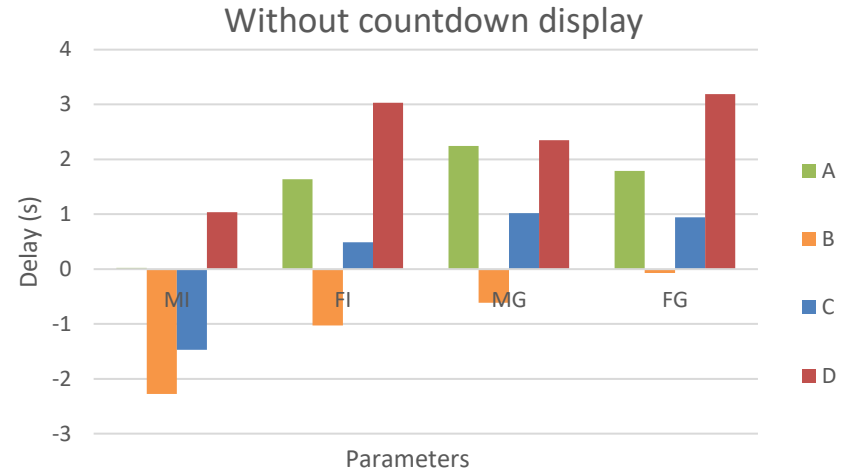
MG= male in group
FG= female in group

Estimation and Analysis of Speed and Delay of Pedestrians

- Variation of crossing delay of pedestrians at the signalized intersection with the presence and absence of CDD



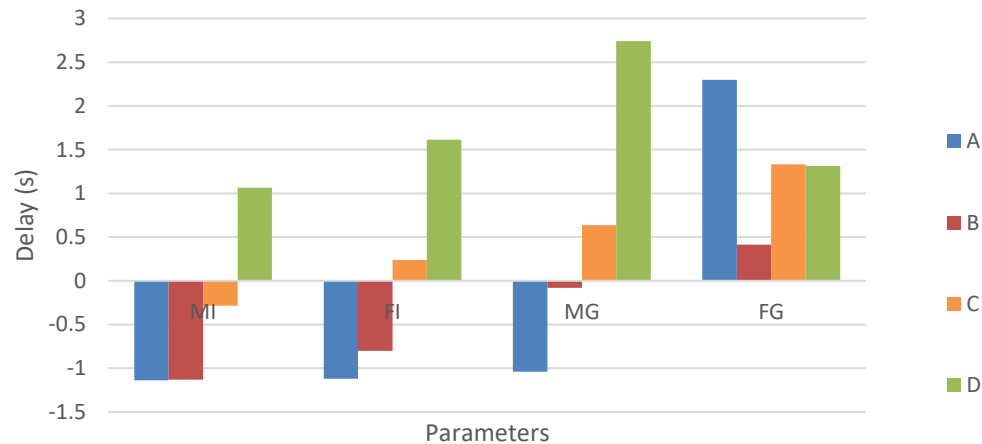
MI = Male Individual MG = Male in Group
 FI = Female Individual FG = Female in Group



MI = Male Individual MG = Male in Group
 FI = Female Individual FG = Female in Group

Estimation and Analysis of Speed and Delay of Pedestrians

- Variation of crossing delay of pedestrians at the midblock sections.



MI= male individual
FI= female individual

MG= male in group
FG= female in group

Development of Pedestrian Speed Prediction Model

▪ Selection of variables for Model Development

Parameters	Type of variable	Details	Code for SPSS
Speed	Numerical	-	Not required
Gender	Nominal	Male	1
		Female	0
Age	Ordinal	Age<15	0
		15≤age<30	1
		30≤Age<50	2
		Age≥50	3
Movement of Pedestrians	Nominal	Individual	1
		In Group	0
CDD	Nominal	Present	1
		Absent	0
Carriageway Width	Numerical	-	Not required

Development of Pedestrian Speed Prediction Model

▪ Pearson Correlation for Signalized Intersections

		I/G	Age of pedestrian	Gender	CDDP/CDDA	Approach Width(m)
Speed (m/s)	Pearson Correlation	0.253	0.17	0.211	0.267	0.214
	Sig (2-tailed)	<0.001	<0.001	<0.001	<0.001	<0.001

Development of Pedestrian Speed Prediction Model

- **Pearson Correlation for Mid-Block Sections**

		I/G	Age of pedestrian	Gender	Approach Width(m)
Speed (m/s)	Pearson Correlation	0.254	-0.404	0.227	-0.008
	Sig (2-tailed)	<0.001	<0.001	<0.001	0.436

Development of Pedestrian Speed Prediction Model

- **Selection of variables for Model Development**

For Signalized Intersection

Dependent Variable = Speed of pedestrian

Independent Variables = Age, Gender, I/G, Approach width, P/A of CDD.

For Midblock Section

Dependent Variable = Speed of pedestrian

Independent Variable = Age, Gender, I/G.

Development of Pedestrian Speed Prediction Model

- The below equation is the model equation for the speed prediction model in the signalized intersection.

Speed of Pedestrians =

$$\mathbf{0.999 - 0.073 * (age) + 0.122 * (I/G) + 0.111 * (gender) - 0.094 * (CDD P/A) + 0.012 * (approach width)}$$

- The below equation is the model equation for the speed prediction model in the signalized intersection.

Speed of Pedestrians =

$$\mathbf{1.201 - 0.14 * (age) + 0.148 * (I/G) + 0.073 * (gender)}$$

Model Validation

- Summary of the Regression Model Developed for Pedestrian Speed at Signalized Intersections

R	R Square	Adjusted R Square	Std. the error of the Estimate	F Change	df1	df2	Sig. F Change
0.872	0.76	0.752	0.188359	31.399	5	427	0<.001

- Summary of the Regression Model Developed for Pedestrian Speed at Mid – Block Section

R	R Square	Adjusted R Square	Std. the error of the Estimate	F Change	df1	df2	Sig. F Change
0.912	0.832	0.794	0.145832	83.507	3	448	0<.001

Model Validation

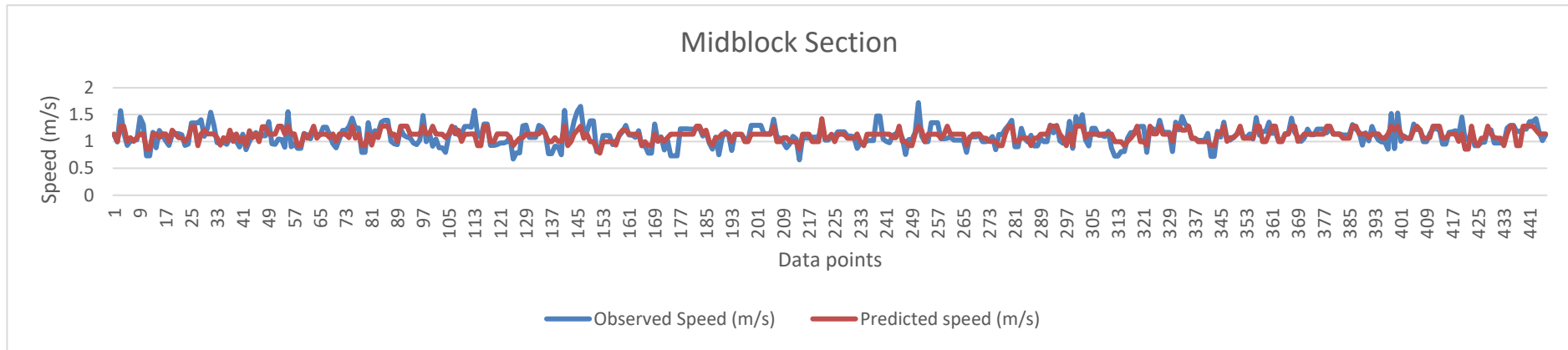
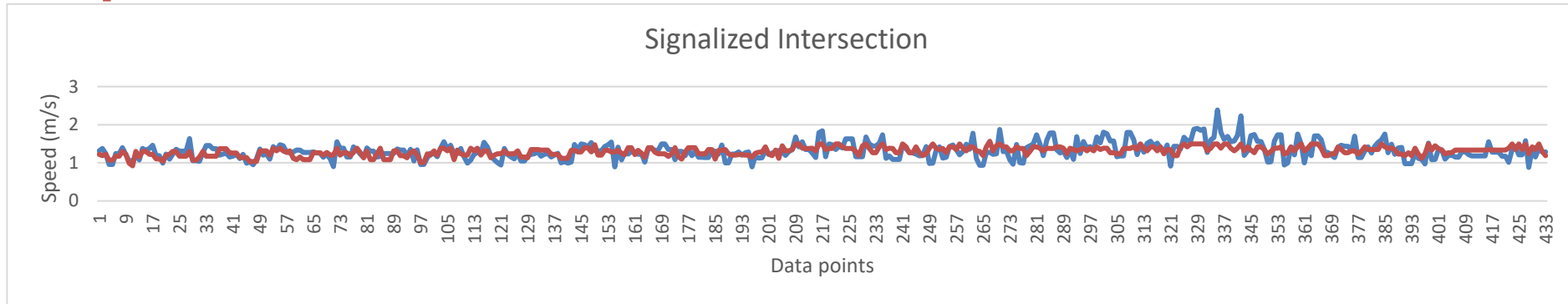
- For the development of the model 90% of extracted data was used while the remaining 10% of data was used for model validation.
- Mean absolute percentage error (MAPE) was used to validate the speed prediction model.
- For signalized intersection MAPE = 15.3%
- For midblock section MAPE = 6.08%

Table: Lewis's scale of model acceptance

MAPE Value	Conclusion
$\leq 10\%$	Highly accurate
11-20%	Good
21-50%	Moderate
$\geq 50\%$	Inaccurate

Model Validation

- Representation of Field Observed and Model Predicted Speed of Pedestrians



Conclusions

- Study analyzed pedestrian behavior at signalized intersections and mid-block sections in mixed traffic settings.
- Sites were categorized into signalized intersections with countdown displays, signalized intersections without countdown displays, and mid-block sections without crosswalks.
- Pedestrian speed and delay were significantly influenced by factors such as age, gender, movement individually or in a group, and the presence of countdown displays at the site.
- Linear regression models were developed to predict pedestrian speed at both signalized intersections and mid-block sections, showing highly accurate results.
- These models are valuable for facility design, policymaking, and enhancing pedestrian safety by considering crossing speed at specific locations.

Limitations

- Present study is based on pedestrian data from three cities in India, out of them signalized intersections are from the same city.
- Zonal characteristics were not considered in site selection.
- The outcome of the study is limited to the development of speed prediction models only, delay estimation models are not included in the scope.
- These models are valuable for facility design, policymaking, and enhancing pedestrian safety by considering crossing speed at specific locations.

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Thank You
