Development of Pedestrian Safety Index Models for Safety of Pedestrian Flow on Urban Roads Under Mixed Traffic Conditions

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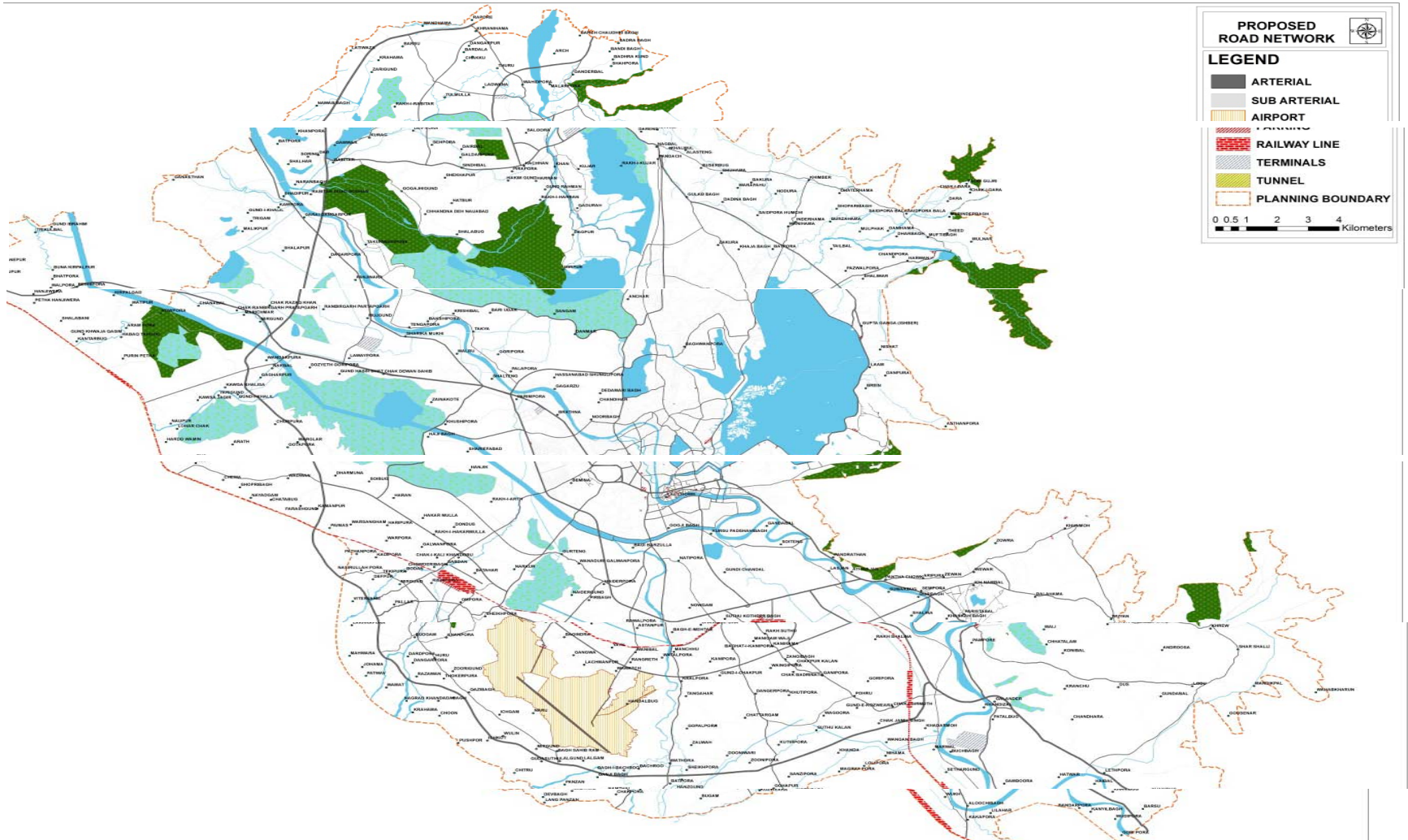
Need of the study:

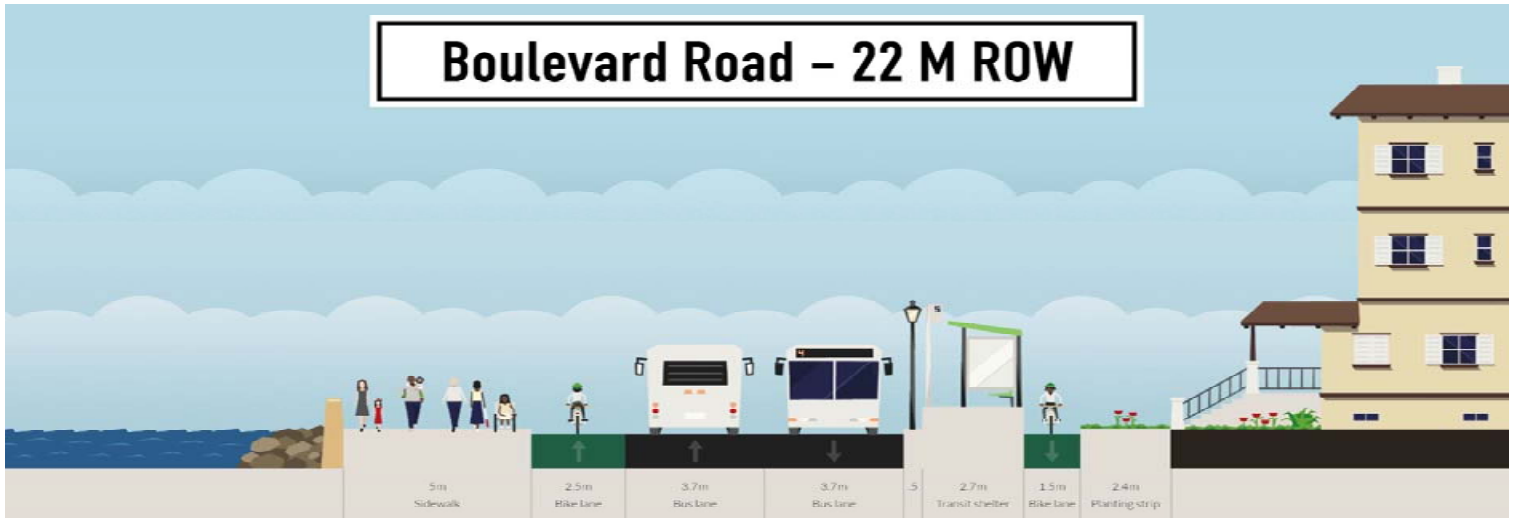
- On urban roads in India, there has been a rapid increase in the pedestrian volumes and traffic-pedestrian conflicts in last few decades. To enhance pedestrian safety under mixed traffic conditions, there is a need to improve the pedestrian facilities on the urban roads (signalized and unsignalized intersections).

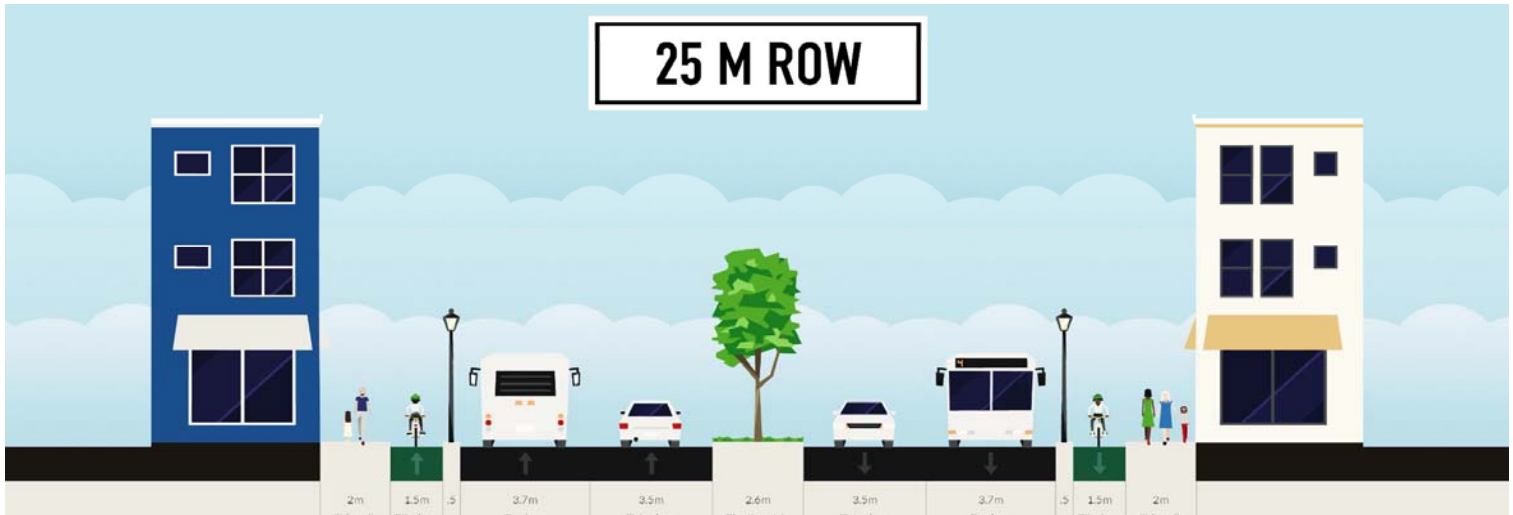
Proposed Road Network Plan 2035 , In Srinagar City

Source: Srinagar Development Authority (SDA Draft plan report,2017)

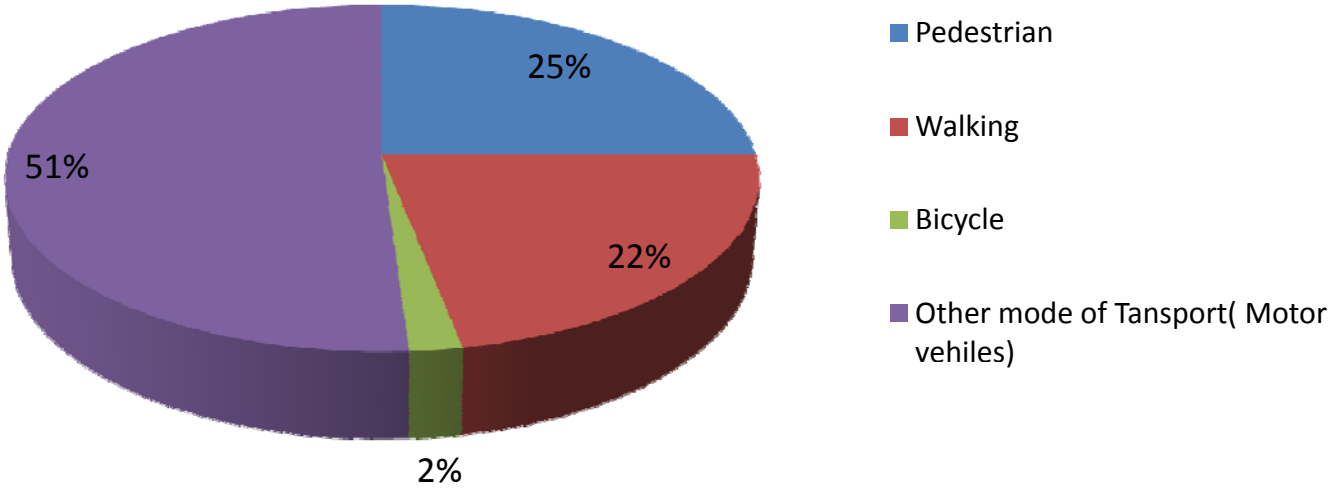


Proposed NMT Lane & Road Cross-Section
(Source : SDA Draft plan report, 2017)





NMT Modal share for Srinagar city



Source: SDA Draft Plan report 2017 & MoUD Report 2008

Objectives:

- The present study aims to develop pedestrian safety index models using variables like pedestrian volumes, crosswalk speed (m/sec), crosswalk markings, crosswalk length (m), and pedestrian safety ratings
- Data collection
- Formulation of Modal
- Validation and Calibration of Model
- Pedestrian Safety Index Model
- Model Results

Literature Review:

- The evaluation of pedestrian safety at intersections - Brian et al. 1995
- Modelling pedestrian delay and level of service at signalized intersections crosswalks under mixed traffic condition - Nagaraj, R., and vedagiri, P. (2013).
- Road safety in India - Mohan, D., Tiwari, G., Bhalla, K. (2015)
- Pedestrian and Bicyclist Intersection Safety Indices- Carter, Daniel L., William W. Hunter, Charles V. Zegeer, J. Richard Stewart, and Herman F. Huang, Federal Highway Administration, Washington, DC, Report FHWA-HRT-06-125, 2006.

Methodology:

Over view of Pedestrian Safety at Intersection

i. Selection of Study Locations
ii. Questionnaire Surveys Conducted on Selected Site Locations
iii. Data Collection
iv. Formulation of Model
v. Model Development for Pedestrian Safety Index
vi. Calibration and Validation of Model
vii. Results
viii. Conclusion

Data Collection:

(Questionnaire survey)

Location	Walking directions	L-A	L-B	L-C	L-D	L-E
Collected samples	right left	80 53	56 63	61 55	68 52	61 54
Gender	Classified pedestrian	male	Female	Young male	Young female	Senior citizens
Total	both	133	119	116	120	115

A:Kashmir university, L-B: Lal chowk, L-C:Dal gate, L-D:Pantha chowk, L-Sangarmal road

Pedestrian flow, time of survey, date of survey and Information of selected sites

destrian oss walk dentify ocation	Time of survey	Pedestrian flow (peds /hour)	Pedestrian c/w length(m)	Presences of crossing marking	Proper waiting area	Date of survey
L-A	5:00 to 6:00 pm	660	19.5	Yes- 1	No	28/06/17
L-B	5:00 to 6:00 pm	714	14.2	Yes -1	Yes	30/06/17
L-C	5:00 to 6:00 pm	459	7.6	Yes- 1	Yes	01/07/17
L-D	5:00 to 6:00 pm	745	14.3	No - 0	No	02/07/17
L-E	5:00 to 6:00 pm	421	14.3	Yes- 1	No	03/07/17

Pedestrian flow, time of survey, date of survey and Information of selected sites

edestrian oss walk ocation	Time of survey	Pedestrian flow (peds /hour)	Pedestrian c/w length(m)	Presences of crossing marking	Proper waiting area	Date of survey
L-A	8:00 to 9:00am	550	19.5	Yes- 1	No	28/06/17
L-B	8:00 to 9:00am	726	14.2	Yes -1	Yes	30/06/17
L-C	8:00 to 9:00am	419	7.6	Yes- 1	Yes	01/07/17
L-D	8:00 to 9:00am	624	14.3	No - 0	No	02/07/17
L-E	8:00 to 9:00am	611	14.3	Yes- 1	No	03/07/17

-A:Kashmir university, L-B:Lal chowk, L-C:Dal gate, L-D:Pantha chowk,
-E:Sangarmal road

Pedestrian flow, time of survey, date of survey and Information of selected sites

edestrian oss walk ocation	Time of survey	Pedestrian flow (peds/hour)	Pedestrian c/w length(m)	Presences of crossing marking	Proper waitin g area	Date of survey
L-A	9:00 to 10:00am	472	19.5	Yes- 1	No	28/06/17
L-B	9:00 to 10:00am	677	14.2	Yes -1	Yes	30/06/17
L-C	9:00 to 10:00am	452	7.6	Yes- 1	Yes	01/07/17
L-D	9:00 to 10:00am	610	14.3	No - 0	No	02/07/17
L-E	9:00 to 10:00am	593	14.3	Yes- 1	No	03/07/17

Average pedestrian volume (ped/hr)

S . No	Location name	Average pedestrian volume (ped/hr)
1	L-A = Kashmir university	561
2	L-B = Lal chowk	706
3	L-C= Dal Gate	444
4	L-D = Pantha chowk road	660
5	L-E = Sangarmal road crossing	542

Video Analysis

(a) Kashmir University

Classified Pedestrian volume, Average speed (m/sec) and Time of survey- 5:00- 6:00 pm

S. No	Children	Young male	Male	Female	Young female	Senior citizen
1	42	185	120	160	110	43
2	38	196	180	130	120	50
3	34	115	85	90	105	30
4	45	195	130	180	150	45
5	31	110	75	75	102	28
Total	190	801	590	635	587	196
Average flow (ped/hr)	38	161	118	127	118	40
Average speed	1.26	1.413	1.310	1.403	1.257	1.141

Classified Pedestrian volume, Average speed (m/sec) and Time of survey-9:00- 10:00 am

S. No	Children	Young male	Male	Female	Young female	Senior citizen
1	36	119	78	89	122	28
2	38	192	110	165	140	32
3	44	112	76	108	92	20
4	40	172	112	135	115	36
5	35	182	118	114	100	44
Total	193	777	494	611	569	160
verage flow ped/hr)	38	155	98	123	114	32
verage speed	1.271	1.453	1.322	1.60	1.278	1.165

Classified Pedestrian volume, Average speed (m/sec) and Time of survey 8:00- 9:00 am

S. No	Children	Young male	Male	Female	Young female	Senior citizen
1	36	189	110	80	100	35
2	40	192	128	175	145	46
3	35	108	72	82	98	24
4	41	175	110	140	120	38
5	33	186	120	116	108	48
Total	185	1039	540	593	571	191
Average flow (ped/hr)	41	208	108	119	115	38
Average speed (m/sec)	1.256	1.420	1.37	1.40	1.268	1.161

Pedestrian classified by their socioeconomic characteristics, behaviour, walking direction and Time of survey (5:00-6:00pm, 8:00-9:00am,9-10am)

Socio economic characteristics	Variables	Total Sample size(N)	Percentage of N (out of 100)
Gender	Male	4211	47.33
	Female	3566	40.103
Age groups	Child	568	0.0638
	Old	547	0.0615
Crossing speed (m/sec)	< 1	334	0.0375
	1.0-1.2	3802	42.735
	1.2- 1.4	3974	44.74
	1.4- 1.6	781	0.0878
Walking Directions	Upward direction flow	4490	48.826
	Downward	4402	49.48

Model development for pedestrian safety

- Formulation, Validation and Calibration of Model
- Details selected variables, Description and type of variables

Variables	Description (Rating)	Type of variables
PSSI:Pedestrian safety score index	1= Highly safe (excellent), 2= safe(normal) , 3= average ,4 = risk (danger), 5= high risk (high danger)	Discrete
PCWS	pedestrian crosswalk speed(m/sec)	Continuous
APV	Average pedestrian volume (ped/hr)	Continuous
CWM	1 for presence of pedestrian crosswalk marking and 0 for absent of pedestrian crosswalk marking	Discrete
CWL	Length of crosswalk (express as meter)	continuous

Pedestrian safety score index model

The primary Equation of the pedestrian safety score index model is expressed in the following mathematical expression,

$$PSSI_{Score} = \beta_o + \beta_1 (APV) + \beta_2 (PCWS) + \beta_3 (CWM) + \beta_4 (CWL)$$

Where, $PSSI_{Score}$ = Y = pedestrian safety score index through questionnaire survey (rating 1 to 5), X_1= PCWS = pedestrian cross walking speed (m/sec), X_2=APV= Average pedestrian volume (ped/hr), X_3=CWM = crosswalk marking, X_4 = CWL = crosswalk length (m).

Multiple Linear Regression Model

The stepwise regression technique was performed in SPSS 16.0 At 95 to 100% confidence interval and the results are shown in Table1. The R^2 value for proposed model is 1.00 (R^2 of 1 indicates that the regression line perfectly fits the data), which specifies that 100% of the variation in the predicted, dependent variable has been explained by explanatory variables and this denotes the perfect accuracy level of the proposed model prediction.

Dependent variable: PSSI (Pedestrian Safety Score Index)

From Table 1, the calculated t-values are ≥ the critical value and the p- values are less than the p- critical value (0.05).This represents that the model variables are significant at 95 to 100% confidence interval.

Table 1: Multiple Linear Regression Model

ariables	Model estimate	coefficients	Standard error	t value	sign	Unstandardized Coefficients
onstant	β_o	0.000	0.001	0.000	0.000	85.386
APV	β_1	2.800	0.042	0.030	0.020	.043
PCWS	β_2	-3.810	0.061	0.200	0.010	-65.396
CWM	β_3	-2.021	0.073	0.150	0.036	-7.145
CWL	β_4	-2.576	0.054	0.230	0.003	-.964

Pedestrian Safety Index Model (Ped ISI)

- The PED ISI model consists of one equation that determines the safety index score for a single pedestrian crossing. The model is presented in Table 2 below. A detailed description of the variables follows in the table 2.

Table 2 : Ped ISI model and variable descriptions

Ped ISI = 2.372—1.867SIGNAL—1.807STOP + 0.335THRULNS + 0.018SPEED+ 0.006(MAINADT*SIGNAL) + 0.238COMM

Source: FHWA, April 2017

Table 2 : Ped ISI model and variable descriptions

Ped ISI	Safety index value (pedestrian)	Descriptions.
SIGNAL	Signal-controlled crossing	0 = no 1 = yes
STOP	Stop-sign controlled crossing	0 = no 1 = yes
THRULNS	Number of through lanes on street being crossed (both directions)	1, 2, 3, …
SPEED	Eighty-fifth percentile speed of street being crossed	Speed in miles or Km per hour
MAINADT	Main street traffic volume	ADT in thousands
COMM	Predominant land use in surrounding area is commercial development (i.e., retail, restaurants)	0 = not predominantly commercial area 1 = predominantly commercial

Results: Pedestrian Safety Index Model at Nishat Garden

Ped ISI	Descriptions.	Number
SIGNAL	0 = no 1 = yes	0
STOP	0 = no 1 = yes	0
THRULNS	1, 2, 3, …	2
SPEED	Speed in miles or Km per hour	40
MAINADT	ADT in thousands	13336
COMM	0 = not predominantly commercial area 1 = predominantly commercial area	1

Results

- Using the Ped ISI model equation, the calculation is as follows:
- Ped ISI = 2.372-1.867* 0-1.807* 0 + 0.335* 2 + 0.018* 40 + 0.006(13336* 0) + 0.238* 1
- Ped ISI = 4.0 (At Nishat garden road – Risk condition)

Results

- By using pedestrian safety score index & safety index Model, the safety level rating is coded as given in the below table
- Details of Safety Level Rating

PSSI Rating	Description (at intersections)
1	Highly safe
2	Safe
3	Average
4	Risk
5 & 6	High risk & Least safe

Conclusion

- In Srinagar city, The Availability of pedestrian facilities As per Srinagar Development Authority is 24 to 25 % so there is a lack of pedestrian safety on urban roads.
- According to the PSSI rating and Ped ISI calculation, the Srinagar city comes under 3 equal to Average and 4 equal to Risk, as per above calculations. In Future there is a scope to Improve pedestrian safety at various locations in the city.
- 1 is safest, lowest priority for further evaluation and 6 is least safe, highest priority for further evaluation

References

- Nagaraj, R., and vedagiri, P. (2013). Modelling pedestrian delay and level of service at signalized intersections crosswalks under mixed traffic condition. Journal of the Transportation Research Board, Transportation Research Board, Washington,D.C,2394,70-76.
- Mohan, D., Tiwari, G., Bhalla, K. (2015). " Road safety in India. '' Transportation Research and Injury Prevention Programme (TRIPP), (New Delhi, India).
- Carter, Daniel L., William W. Hunter, Charles V. Zegeer, J. Richard Stewart, and Herman F. Huang, Pedestrian and Bicyclist Intersection Safety Indices: Final Report, Federal Highway Administration, Washington, DC, Report FHWA-HRT-06-125, 2006.
- Qi, Y., and Yuan, P.(2012). " Pedestrian safety at intersections under control of permissive Left –Turn signal". Transportation Research Record: Journal of the transportation Research Board, 2299, 91-99.

Thanking You