

# Study of Pedestrian Safety on Urban Roads under Mixed Traffic Conditions

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**Abstract:** *In developing country like India, there has been a rapid increase in the pedestrian volumes and traffic-pedestrian conflicts in last few decades. The pedestrian facilities have been improper as far as the safety, adequacy and usability is concerned. To enhance pedestrian safety under mixed traffic conditions, there is a need to improve the pedestrian facilities on the urban roads (Un-signalized intersections). The present methodology aims to study on a total of 1526 pedestrian. Data was collected through the manual survey at various selected locations through opinion and questionnaire surveys. The data were collected at different locations in the CBD area of the city where high pedestrian flow was observed. At these selected locations, pedestrian volume count and pedestrian average speeds (m/sec) were observed during peak hours. Pedestrians have been categorized on the basis of different age groups with different gender. Flows are categorized based on crossing speed and direction. The final results were obtained from the analysis questionnaire and opinion survey data collected at various locations. The study will also be helpful to improve the existing pedestrian facilities, pedestrian flows (Ped/hour) and also to provide pedestrian safety measures on urban roads.*

**Keywords:** *Pedestrians, Pedestrian variables, pedestrian respondent survey,*

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## 1. Introduction

In India less number of studies conducted survey at un-signalized intersections. So the evaluation of pedestrian safety at un-signalized intersections can be divided into major categories: pedestrian conflict method and level of the service model. Pedestrian accident rate method is the most refereed method to evaluate pedestrian safety level, however, it has some limitations, such as, it requires larger data set, needs secondary data of long periods in accidents statistics, and it produces lesser evaluations and results findings (Brian et al. 1995). Pedestrian conflict method is simple to follow and the model has been developed by considering the interaction between pedestrians and vehicles on crosswalks. Various factors were considered in model development such as traffic volume, vehicle type, suitable gap, lane, crosswalk length, and speed. However, the accuracy levels of developed models fail to produce accurate pedestrian safety level at un-signalized intersections (Wang and Abdel Aty 2008; Wang and Aty 2008). Most of the studies addressed the pedestrian safety by developing the level of service models (Zhang and provedores 2000). Previous researchers have developed pedestrian safety models based on conventional linear regression methods such as linear or multiple linear or stepwise or generalized models ( Leden 2002; Qi and Yuan 2012 ). Linear regression is simple to develop and is most widely used. Linear regression model generally based on the following two assumptions: (i) the observations follow the normal distribution, and (ii) means are

varying with respect to independent variables. Cumulative logistic regression method is more suitable and is also a useful technique to develop regression models when the observations are in ordered and qualitative data type. Very few studies adopted cumulative logistic regression method for modeling level of service and there are no studies for pedestrian safety level modeling and there were limited studies at un-signalized intersections for Indian conditions.

## 2. Research objectives

**The research objectives are as under:**

- i) Identification of the pedestrian safety issues on urban roads.
- ii) To develop a questionnaire and opinion survey of pedestrian safety facilities in urban roads under mixed traffic conditions.
- iii) To Determine peak hour and average pedestrian volume from collected data of pedestrian safety variables like gender, age groups, pedestrian volumes, crosswalk speed (m/sec) and crosswalk markings.
- iv) Development of pedestrian safety index model for pedestrians on urban roads.
- v) To suggest improvements in pedestrian safety measures for existing urban roads.

## 3. Literature review

In India, the review of literature was very less and we were studied the evaluation of pedestrian safety at un-signalized intersection under mixed traffic conditions (Harsh shah, P.Vedagiri). The pedestrian safety facilities in urban roads is very poor. there were around 5 lakh road accidents, during the year 2010, which resulted in the deaths of 134,513 people with pedestrians and others (bicyclists and two wheelers), comprising of the most unprotected road users, accounting for around 40% of all fatalities and out of the total 5 lakh road accident victims, 53.1% were in the age group of 25 to 65 years (Pawan 2014).

Keegan and O'Mahony (2003) studied the impact of the pedestrian waiting for countdown timer on pedestrian behavior based on an attitude survey and video survey. Researcher workers and engineers in the traffic safety field are actively interested in pedestrian to vehicle collision incidents now. Every year, many unprotected road users are fatally injured in road traffic accidents. In the European Union (EU), for example, 8000 unprotected bicyclists and pedestrians die, while 300,000 are injured severely and as much as 1.4 million are slightly injured (CARE, 2008), and 3000 pedestrian fatalities in Japan. In the United States, approximately 5000 pedestrian fatalities occur each year (2003-2012) (Yong Peng, 2012). The insights drawn from studies using cross-sectional and longitudinal designs remain useful but can only offer correlational evidence between risk factors and pedestrian safety. Good examples of quasi-experimental research on pedestrian safety include LaScala, Johnson, and Gruenewald (2001) and Ewing, Chen, and Chen (2013).

Previous studies were related to the pedestrian safety treatments in urban roads: These

studies move researchers and practitioners closer to understanding the causality between risk factors, safety treatments, and pedestrian safety. We also suggest that qualitative methodologies have much to offer the understanding of pedestrian safety and the built environment. Like quasi-experimental research, qualitative research is well suited to answer research questions that ask why? The majority of studies reviewed are purely quantitative (i.e., Clifton and Kreamer-Fults 2007; Petch and Henson 2000; Changcheng et al. 2010). We observed that some of the best studies we reviewed used mixed methods, employing both quantitative and qualitative research (Hijar, Vasquez-Vela, and Arreola-Risa 2003; LaScala, Johnson, and Gruenewald 2001). These studies moved beyond descriptions and summaries to answer why did a pedestrian injury occur? Employing mixed methodologies would further researcher and practitioner understanding of pedestrian safety.

Hamed (2000) developed models for waiting time at the curbside and number of crossing attempts using proportional hazard and Poisson regression models for both divided and undivided mid-block roads. It was found that gender, age, number of children in the household, crossing frequency, number of people in the group attempting to cross were of the most significant predictors from the model.

#### **4. Methodology**

The present methodology aims to developing questionnaire survey and opinion survey of pedestrian safety facilities on urban roads and using pedestrian variables like pedestrian volume, crosswalk speed (m/sec), crosswalk marking, crosswalk length (m), and pedestrian safety rating. The data were collected at different locations in the CBD area of the city where high pedestrian flow was observed. At these selected locations, pedestrian volume count and pedestrian average speeds (m/sec) were observed during peak hours. Pedestrians were categorized based on different age groups and gender. Flows were categorized based on crossing speed and direction. We were developed pedestrian safety index model for urban roads under heterogeneous traffic conditions.

#### **5. Selection of study locations**

After defining the problem, site selection has to be done. Some of the sites which we have selected in the Srinagar city are:

**Location: Dal Gate:**



**Figure 1:** Plan of a site for a selected un-signalized intersection  
Source: Google Earth

**Location : Near Mallinson Girls School:**



**Figure 2:** Plan of a site for the selected un-signalized intersection  
Source: Google Earth

**Location: Kashmir University:**



**Figure 3:** Plan of a site for the selected un-signalized intersection

Source: Google Earth

## 6. Development of a Questionnaire and Opinion survey

### Questionnaire survey and opinion survey format

This is the survey in which questions were asked to the pedestrians and drivers at the study location. These were asked to get some basic idea about the problems of the location.

**Some of the questions which we have prepared are:**

1. Do you face a problem because of the wide lanes provided while crossing the road?
  - Yes
  - no
  
2. Who according to you faces the maximum problem while road crossing?
  - Children
  - Teenagers
  - Middle aged man
  - Middle aged woman
  - Old man
  - Old women
  
3. What should be provided over here to make it easier for you to cross the road?
  
4. Do you think that installation of pedestrian light will help you?
  - Yes
  - No

5. In which direction do you find it most difficult to cross the road and why?

6. At what time is the traffic usually maximum?

- Morning
- Evening
- Afternoon
- Night

7. In which direction is the traffic usually maximum?

8. Does U-turn cause any problem to the pedestrians?

- Yes
- No
- Don't know

9. Is there proper lighting on the footpath?

- Yes
- No

10. How do you find the material of the footpath?

- Very poor
- Poor
- Average
- Good
- Very good
- Can't say

11. Do animals in this area cause any problem to the pedestrians?

- No
- Yes

12. How many mints do you usually travel by walking in a day?

- <30 mints
- 30 mints – 1hr
- >1hr

13. Do you prefer to walk in all the seasons?

- yes
- no
- only during

14. At what time of the day do you prefer to walk?

- morning
- afternoon
- evening
- night

15. Do you think that provision of rotary would help pedestrians?

- Yes
- No
- Can't say

16. Do you face any special problem during the winter season because of snow?

- Yes
- No

17. Should speed breaker be provided over here?

- Yes
- No

18. Should zebra crossing be provided over here?

- Yes
- No

19. Do you think that traffic police can help in increasing the safety of pedestrians?

- Yes
- No
- Don't know

20. Which type of vehicles causes the maximum problem?

- 4 wheeler <
- 4 wheelers
- 2 wheelers

21. Rate the driving skills of the people

- Very poor
- Poor
- Average
- Good
- Very good

22. Do obstructions such as trees, light poles and other hurdles cause any problem to you while walking on the footpath?

- Yes
- No

23. How frequently do you drive on and around this area for travel other than commuting to/from this area?

- Never
- 1 to 2 days per week
- 3 to 4 days per week
- 5 to 6 days per week
- Everyday

24. Would you stop or yield for crossing pedestrians?

- Yes, all the time
- Yes, but only if they are crossing on the marked crosswalk
- Sometimes, it depends
- Never

## 7. Data collection

After determination of study locations, we have collected data from the selected locations are given below.

**Location : Dal gate**

socio economic characteristics	variables	Total Sample size(N=1526)	Percentage of N (out of 100)
Gender	Male	520	34.076
	Female	500	32.765
Age groups	Child	256	16.77
	Old	250	16.338
Crossing speed(m/sec)	< 1	334	21.882
	1.0-1.2	380	24.901
	1.2- 1.4	597	39.121
	1.4- 1.6	215	14.089
Walking Directions	Up word direction flow	793	51.96
	Down word direction flow	733	48.034

**Table 1:** Pedestrian classified by their socioeconomic characteristics, gender, age group, Crossing speed (m/sec) and walking directions.



Pedestrian crosswalk location	Time of survey	Pedestrian flow (Ped/hr)	Presences of crossing marking	Proper waiting area	Date of survey
<b>Dal gate</b>	5 to 6 pm	620	Yes-1	No YesYes	10/02/18
	9 to10 am	450	No-o		12/02/18
	10 to11 am	430	Yes-1		14/02/18

**Table 2:** Details of Pedestrian crosswalk location, Time of a survey, Pedestrian flow and date of survey.

**Location : Near Mallinson Girls School**

.Pedestrian crosswalk location	Time of survey	Pedestrian flow (Ped/hr)	Presences of crossing marking	Proper waiting area	Date of survey
Near Mallinson Girls School	5 to 6 pm	580	Yes-1	No	10/02/18
	9 to10 am	480	No-o	Yes	12/02/18
	10 to11 am	421	Yes-1	Yes	14/02/18

**Table 3:** details of Pedestrian crosswalk location, Time of a survey, Pedestrian flow and date of survey

**Location : Kashmir University**

Pedestrian crosswalk location	Time of survey	Pedestrian flow (Ped/hr)	Presences of crossing marking	Proper waiting area	Date of survey
Kashmir University	5 to 6 pm	647	Yes-1	Yes	10/02/18
	9 to10 am	505	Yes-1	Yes	12/02/18
	10 to11 am	453	Yes-1	No	14/02/18

**Table 4:** Details of Pedestrian crosswalk location, Time of the survey, Pedestrian flow and date of survey.

S.No	Location name	Average pedestrian volume (Ped/hr)
1	L-C= Kashmir University	535
2	L-B= Near Mallinson Girls School	493
3	L-A= Dal Gate	500

**Table 5:** details of Location names and Average pedestrian volume (Ped/hr).

### 7.1 Development of a pedestrian safety index model

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

$$PSSI_{score} = \beta_0 + \beta_1(APV) + \beta_2(PCWS) + \beta_3(CWM) + \beta_4(CWL) + \beta_5(W.C)$$

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),  $X_5 = W.C$  = Weather condition .The stepwise regression technique was performed in SPSS 16.0 At 95 to 100% confidence interval and the results are shown in Table 6. 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.

Variables	Model estimate	coefficients	Standard error	t value	sign	Un-standardized Coefficients
Constant	$\beta_0$	1.050	0.025	0.001	0.0028	85.386
APV	$\beta_1$	2.800	0.014	0.020	0.0031	.043
PCWS	$\beta_2$	-3.810	0.023	0.018	0.0026	-65.396
CWM	$\beta_3$	-2.021	0.015	0.036	0.0041	-7.145
CWL	$\beta_4$	-2.576	0.0029	0.0012	0.0020	-.964
WC	$\beta_5$	-3.276	0.0016	0.00011	0.0014	-.564

**Table 6:** Multiple Linear Regression Model.

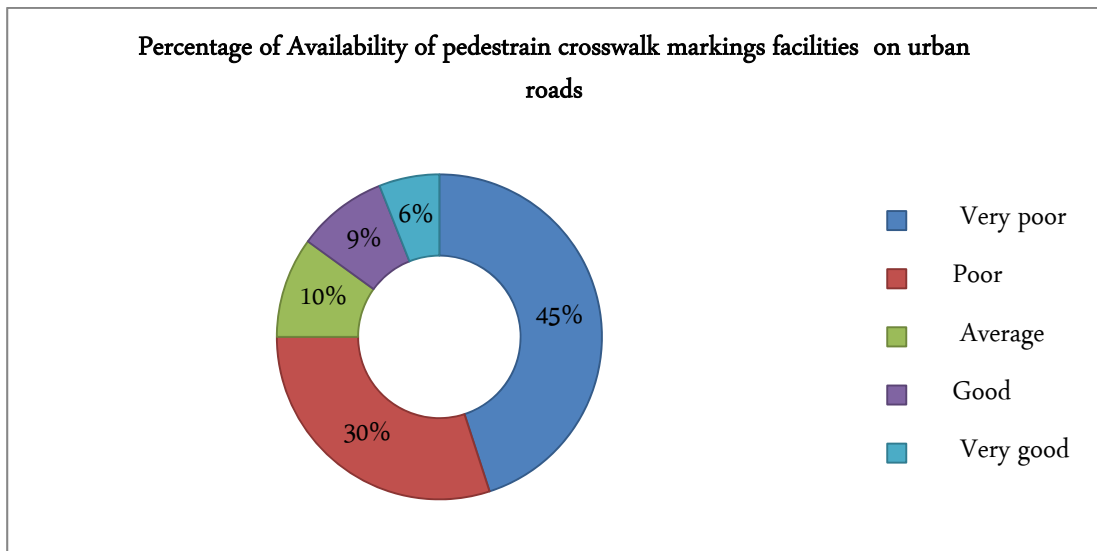
- a. Dependent variable: PSSI

From Table 6, the calculated t-values are  $\geq$  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.

## 8. Analysis of results from questionnaire and opinion survey

The final results obtained from the data collected through questionnaire and opinion surveys have been analyzed to assess the existing pedestrian facilities and pedestrian movement scenario in the study areas and to identify the inefficiency in the pedestrian safe infrastructure facilities for urban roads. The summary of the analysis of the following surveys is included in this section and as shown in figure 4.

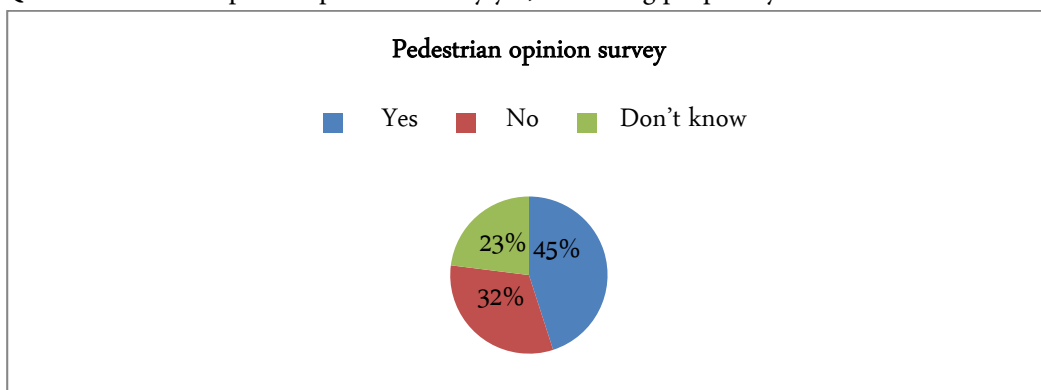
The pie chart its shows results of pedestrian questionnaire survey from respondent peoples



**Figure 4:** The pie chart its shows Percentage of Availability of pedestrian crosswalk markings facilities for urban roads.

**Question:** Do you think that traffic police can help in increasing the safety of pedestrians?

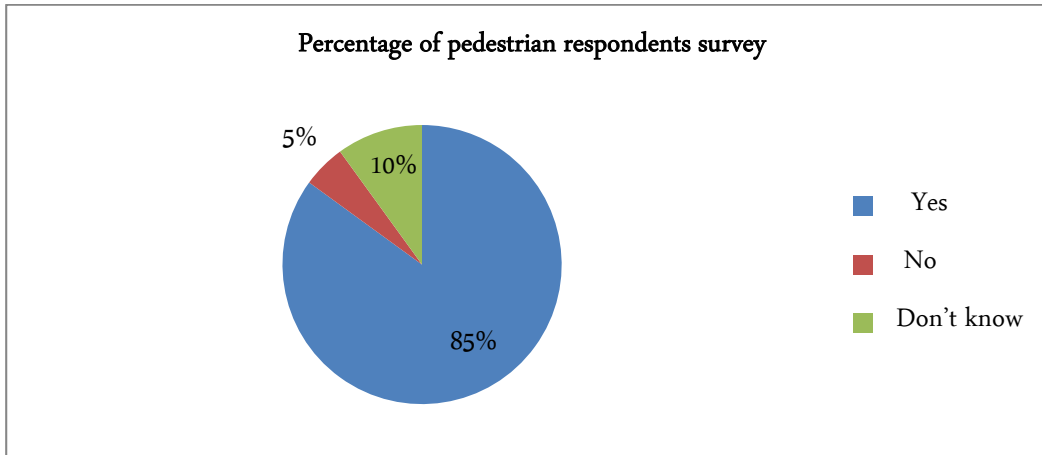
**Question result:** 45 percent pedestrians say yes, remaining people says No and don't know



**Figure 5:** The pie chart its shows pedestrian opinion survey results.

**Question:** Do you face any special problem during the winter season because of snow?

**Question result:** 85 percent pedestrians say yes and remaining people says No and don't know



**Figure 6:** The pie chart its shows Percentage of pedestrian respondents' survey results.

### 9. Results and Discussions:

The study results obtained from questionnaire and opinion survey of pedestrian safety on urban roads under mixed traffic conditions.

Pedestrian Safety Questions	Results From Respondent Survey (%)	Remarks
Do you face a problem because of the wide lanes provided while crossing the road?	Yes - 85% No- 15%	No separate lanes for urban roads
Who according to you faces the maximum problem while road crossing?	Children -10% Teenagers -25% Middle aged man -30% Middle aged woman-15% Old man- 15% Old women -5%	No pedestrian cross marking facilities
What should be provided over here to make it easier for you to cross the road?	To provide Zebra crossing facilities for urban roads	Lack of pedestrian facilities

Do you think that installation of pedestrian light will help you?	Yes -85% No-15%	
In which direction do you find it most difficult to cross the road and why?	Along width of road	No lane marking facilities
At what time is the traffic usually maximum?	Morning -30% Evening -40 Afternoon -20 Night-10	Security problem
In which direction is the traffic usually maximum?	longitudinal direction of road	No rules & regulation for urban roads
Does U-turn cause any problem to the pedestrians?	Yes -50% No-30% Don't know-20%	No safety facilities for urban roads
Is there proper lighting on the footpath?	Yes -20% No-80%	No lighting facilities for footpath
How do you find the material of the footpath?	Very poor-30% Poor-15% Average-10% Good-15% Very good-25% Can't say-5%	Quality of material very less (mud pumping, pot holes...etc)
Do animals in this area cause any problem to the pedestrians?	No -40% Yes -50%	Creates Congestion problems on urban roads
How many minutes do you usually travel by walking in a day?	<30 mints - 40% 30 mints – 1hr -30% >1hr- 30%	Safety problem
Do you prefer to walk in all the seasons?	yes -40% no-25%	Safety & security

	only during – 35%	problem
At what time of the day do you prefer to walk?	morning -50% afternoon-15% evening-35% night- nill	Safety & security, weather problems
Do you think that provision of rotary would help pedestrians?	Yes No Can't say	
Do you face any special problem during the winter season because of snow?  Should speed breaker be provided over here?  Should zebra crossing be provided over here?	Yes -85% No-15%  Yes -20% No-80%  Yes -25% No-75%	Weather problems Single lane roads No facilities pedestrian
Do you think that traffic police can help in increasing the safety of pedestrians?  Which type of vehicles causes the maximum problem?  Rate the driving skills of the people	Yes -55% No -40% Don't know-5% 4 wheeler < -30 4 wheelers-45% 2 wheelers -25%  Very poor -20% Poor-15% Average-20% Good -20% Very good-25%	Lack of Co- ordination problems No-separate Lanes for urban roads
Do obstructions such as trees, light poles and other hurdles cause any problem to you while walking on the footpath?	Yes-80% No-20%	Major footpath problems on urban roads.

How frequently do you drive on and around this area for travel other than commuting to/from this area?	Never-2% 1 to 2 days per week-15% 3 to 4 days per week-30% 5 to 6 days per week-35% Everyday-18%	Lack of pedestrian safety facilities on urban roads
Would you stop or yield for crossing pedestrians?	Yes, all the time-20% Yes, but only if they are crossing on the marked crosswalk-30% Sometimes, it depends-30% Never-20%	

**Table 7:** Respondent survey results.

## 10. Conclusion:

In Srinagar city, the pedestrian safety facilities in urban roads are not adequate which has made people to use carriageway for crossing anytime. We were developed questionnaire and opinion survey of pedestrians. From the above survey we were concluded that 75% of pedestrians said that there was a lack of safety facilities at un-signalized junctions on urban roads. A real lasting change in their pedestrian behavioral pattern would be possible only when proper pedestrian facilities are provided all over the city. At the same time vehicle users also need to be disciplined and should respect the rights of pedestrians. The following pedestrian safety issue on urban areas are given below.

**Safety issues, safety measures asked from questionnaire and opinion survey of pedestrians on urban roads and as we discussed given below:**

### a. Infrastructure related problems on urban roads

i) Proper pedestrian refuges not provided suitably on the crossing path where pedestrians can stand safely and cross the road in stages – especially important for wider roads of more than 2 lanes each way. ii) Faded zebra marking not clearly visible and hence crossing becomes unsafe for pedestrians – in such cases, enforcement by Traffic police is also not possible even if vehicles encroach on the crossing path. iii) Access to zebra crossing from footpath blocked by parked vehicles. iv) No proper same level connectivity to a footpath in case of a raised crossing. v) Approaching vehicles not visible to the pedestrians before they begin to cross the road. vi) Vehicles approach mid-block crossings at high speeds endangering lives of pedestrians. vii) Pot holes dislocated/damaged chamber covers, uneven road surface on the crossing path, pedestrians (especially senior citizens) may stumble and get injured while crossing the road. Also, crossing time increased. viii)

Inadequate Street lighting and its absence at road crossings – hazardous for pedestrians to walk and also pedestrians are not clearly visible to vehicle drivers when it is dark, thus increasing the possibility of accidents.

#### **b. Signal related problems on urban roads**

The problems related to signal in urban roads of Srinagar city is as follows:

- i) There is inadequacy of pedestrian crossing phase time period in the traffic signal cycle.
- ii) Where provided, pedestrian signals are not suitably aligned as far as the walking path and pedestrian viewing zone is concerned which makes them not clearly visible to the pedestrians thereby defeating the purpose.
- iii) Even if the road is wide at the junction which would be crossed in stages, pedestrian signals are provided only on footpaths at the edges of the road and not on intermediate pedestrian refuges. Thus pedestrians do not get information regarding when it is safe to cross each road segment.
- iv) No provision in the signal system for the visually impaired.
- v) Pedestrian signals have been provided at some intermediate crossings between junctions. However, these signals do not serve the desired purpose as vehicles never honor such intermediate signals in the absence of enforcement.

### **11. Future scope and need of pedestrian safety policy**

According to the Srinagar Development Authority (SDA), the availability of the pedestrian facilities on urban roads is merely 25%. Therefore, there is a lack of pedestrian marking facilities which includes safe usable footpaths, safe pedestrian road crossings, adequate pedestrian phase in traffic signal cycle, adequate enforcement to ensure safe passage for pedestrians, proper maintenance of footpaths and pedestrian road crossings. Hence in future, there will be a scope to implement pedestrian safety policies on urban roads in Srinagar city.

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