Analysis of Pedestrian Behaviour in Urban Areas

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Abstract:- Pedestrian crossing behaviour is analysed for the provision of proper pedestrian facilities at desired locations, as well as to improve their safety while crossing the road. This paper presents the analysis of pedestrian crossing behaviour from a study conducted at Jaipur city (Rajasthan state in India). The effect of pedestrian characteristics like age, gender, carrying baggage and luggage as well as their crossing patterns were analysed on pedestrian flow characteristics like crossing speed and waiting time. Pedestrian safety was also analyzed with respect to gaps accepted by pedestrian in traffic flow. Crossing time was recorded for different age group and gender.

Keywords-Pedestrian crossing behaviour, crossing pattern, waiting time, crossing time and gaps accepted.

I. INTRODUCTION

Due to the increase in economic growth of the country, there has been rapid urbanization and increase in traffic growing in Indian roads. It has result in increase in urban spread and further resulted in increase in the use of public transportation trips. Public transportation stagger are usually connected to walk trips either origin or destination or both and occasionally at mode transfer points. A pedestrian may need to cross the road for many reasons.

The traffic on the roads of Indian cities is highly divergent in nature encompassing vehicles with a wide range of static and influential characteristics. There are more than ten different type of vehicles present in the traffic on major roads of Indian cities. All these different type of vehicles move on the same road space occupying any position on the road depending on availability of free space at a given instant of time without complying to any lane authority. This diversity in traffic and jaywalking behaviour of pedestrian leads to severe conflicts with motorized vehicles and results in a decline of pedestrian safety. This convolution of interactions between pedestrian and vehicular traffic increases mostly at signalised intersections.

Jaipur city continues to remain on top in terms of road accident and deaths in state and mishaps are also reported in other cities like kota and jodhpur A Ministry of Urban Development (MOUD) study found that pedestrian share in road accidents is 12.8% in Jaipur (MOUD, 2015). Another recent Indian study found that 54% accidents are related to the road crossing activity[1]. All these study statistics clearly shows that pedestrian safety is a main issue for transport planners, traffic engineers and policy makers. Hence, it is worth studying the road crossing behaviour of pedestrians in mixed traffic condition at uncontrolled intersection.

II. BACKGROUND

More studies provide significant facts about pedestrian demographic characteristics such as (age, gender) and these characteristics affect road crossing behaviour. Such studies have focused on detailed experiments to find out the effect of age on road crossing decisions with effect of vehicle distance or speed of vehicle. Most of these studies have been carried out in a effective environment. Road crossing behaviour with respect to gender has also been observed in various studies. Males have a tendency to show more hazardous road crossing behaviour than females due to less waiting time. Few studies have also explored the importance of the pedestrian speed at different location, such as the zebra crossing location and signalized intersections .these studies suggest that males walk significantly faster than females while crossing the roads Studies had identified the importance of the environmental characteristics, such as type of crossing facility, traffic volume and pavement geometry on road crossing behaviour. Some studies have also explored the pedestrian road crossing behaviour before and after construction of traffic facility. Gap can be defined as the time difference between leader vehicle and lag vehicle and it is an important term in pedestrian road crossing behaviour. Some studies have also explored the pedestrian gap acceptance behaviour with behavioural and statistical analysis. Numerous studies have explored the pedestrian safety issues at different locations. Studies had focused on the safety impacts of marked and unmarked crosswalks for pedestrian and driver in rural and recreational areas. Some studies explored the pedestrian road crossing behaviour and safety issues at unmarked location. Studies have also explored pedestrian behavior in narrow urban roadway with mixed traffic condition and a new concept for level-of-service standards has been developed. Researchers have also explored the pedestrian road crossing behavior with effect of pedestrian demographic as well as gap acceptance criteria. However, no studies are available for pedestrian behavioral characteristics which is more important than demographic as well other environmental characteristics in mixed traffic conditions. Research on pedestrian vehicle interaction and pedestrian road crossing behavior at an uncontrolled intersection location in urban environments are more important to identify danger locations for pedestrians. In this paper, the main objective of this study is to describe

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the road crossing behaviour of pedestrian at un-controlled intersection location.

2.1. Needs for modeling pedestrian:

Despite recent pedestrian-oriented trends in urban planning, the methods used in the planning processes are inadequate and insufficient to predict patterns of pedestrians' spatial movement. "Research or detailed investigation on behaviour of pedestrians has been neglected in transport management". This is because that most transport modelling until recently exclusively focused on motorised transport as urban transport system has been highly dependent on vehicular traffic. Urban planners who want to implement walking-friendly urban environment schemes need new tools to help them with understanding present situations of pedestrians in town centers by measuring flows, analyzing their patterns, and identifying the functioning of movement systems. One of the key requirements for these tools is to provide accurate estimations of the impact of proposed plans on pedestrian behaviour.

III. METHODOLOGY

The major steps involved in this study are Selection of suitable site for field survey, Field data collection and extraction and Analysis of pedestrian characteristics and pedestrian behavioural aspects.

3.1. Selection of suitable site for field survey:

The selected site is an uncontrolled intersection location and two lanes per direction two way road in Jaipur, India. It has an adequate volume of pedestrians as well as vehicular traffic to allow for collection of logical behavioural data using video graphic survey/direct observation method.

I. India Gate Intersection
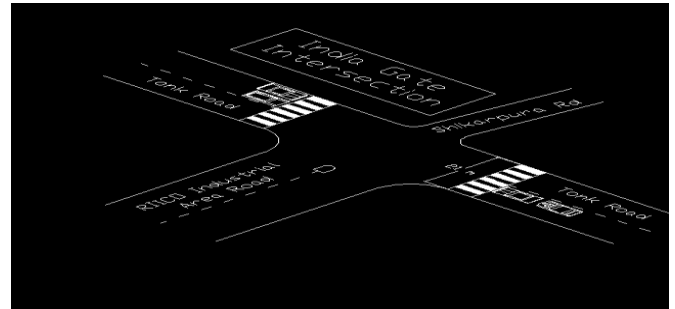
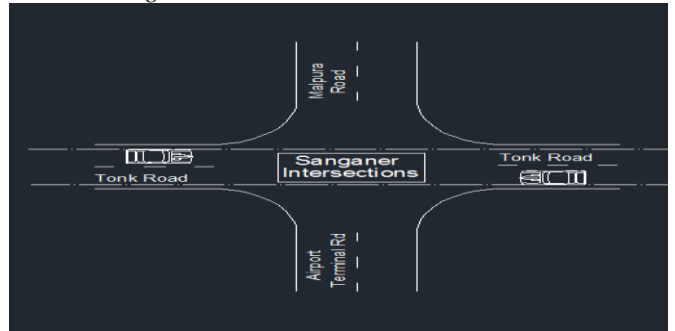#### II. Sanganer Intersection

Fig 1. Sanganer Intersection

3.2. Field data collection and extraction:

TABLE-1. PEDESTRIAN CROSSING PATTERN

Crossing Pattern	Percentage of Pedestrians (%)	
	One Step Crossing	Two Step Crossing
Perpendicular Crossing	44.66	20.6
Oblique Crossing	21.09	13.65
Overall	65.75	34.25

It represents the percentage of pedestrian crossing patterns, two major crossing patterns are observed classified as one step or two step, perpendicular or oblique. Percentage overall one step crossing is more than two step crossing

TABLE-2 VARIATION WITH RESPECT TO PEDESTRIAN CROSSING PATTERN

Location	Crossing Patterns	Perpendicular Crossing		Oblique Crossing	
		Waiting Time (Sec)	Crossing Time (Sec)	Waiting Time (Sec)	Crossing Time (Sec)
India Gate	One Step	8.74	19.04	7.1	20.49
Intersection	Two Step	13.44	28.96	10.93	28.814
Sanganer Thana	One Step	8.97	32.02	10.84	35.544
Intersection	Two Step	14.8	37.51	12.72	39.22
Overall	One Step	8.855	25.53	8.97	28.017
	Two Step	14.12	33.235	11.825	34.017

crossing pattern classified as one step or two step, perpendicular or oblique crossing in table no2. Perpendicular crossing and oblique crossing with respect to crossing pattern intersection. This table also shows overall waiting time and crossing time.

TABLE-3. PEDESTRIAN AVERAGE CROSSING SPEED AT STUDY LOCATION

Location	Crossing Patterns	Avg Pedestrian Crossing Speed (m/sec)	
		Perpendicular	Oblique Crossing
India Gate	One Step	1.102	1.024
Intersection	Two Step	1.353	1.174
Sanganer Thana	One Step	1.171	1.093
Intersection	Two Step	1.189	1.019

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This data is recorded on two different locations to find out the average pedestrian crossing speed for different crossing pattern in table-3.perpendicular avg pedestrian crossing speed are estimated and also oblique avg pedestrian crossing speed are estimated at two different locations. Also find crossing speed in one step and two step crossing.

TABLE-4 VARIATION OF TIME WITH RESPECT TO GENDER OF PEDESTRIAN

Location	Male		Female	
	Waiting Time (Sec)	Crossing Time (Sec)	Waiting Time (Sec)	Crossing Time (Sec)
India Gate Intersection	15.83	14.57	15.5	15.67
Sanganer Thana Intersection	12.85	23.84	13.23	24.55

Data shows variation in waiting time and crossing time with respect to gender of pedestrian at different studied locations. Waiting time and crossing time of male and female are estimated. It has been found that males have less crossing time as compare to females.

TABLE-5 VARIATION WITH HANDLING OR WITHOUT HANDLING BAGGAGE

Location	With Baggage		Without Baggage	
	Waiting Time (Sec)	Crossing Time (Sec)	Waiting Time (Sec)	Crossing Time (Sec)
India Gate Intersection	10	17.12	8.5	15.34
Sanganer Thana Intersection	9.5	26.51	8.54	23.88

Variation in waiting time and crossing time with respect to Handling and Without Handling Baggage pedestrians are recorded in table no 5 waiting time and crossing with baggage are estimated and also waiting time and crossing time without baggage are estimated at two different locations. It has been found that with baggage pedestrian takes more crossing and waiting time

TABLE-6 VARIATION OF TIME WITH RESPECT TO AGE OF PEDESTRIAN

Location	Adults (18-50 yrs)		Older People (>50 yrs)		Children (<18 yrs)	
	Waiting Time (Sec)	Crossing Time (Sec)	Waiting Time (Sec)	Crossing Time (Sec)	Waiting Time (Sec)	Crossing Time (Sec)
India Gate Intersection	17.03	18.67	19	20.91	14.05	16.75
Sanganer Thana Intersection	15.23	24.01	17.56	26.75	13.78	23.47

Variation in waiting time and crossing time with Respect to Age group classified as Adults, Older People and Children are mention in table no6. Waiting time and crossing time of adults, olds, and children are estimated.
Direct observation survey was conducted at the selected signalized intersection location during the
Working day in normal conditions from the direct
Observation pedestrian demographic data have been collected which includes pedestrian gender, age, crossing pattern, crossing time and waiting time on kerb etc. The average observed vehicular traffic volume (at mix traffic condition) during the survey at study location was 2546 vehicles per hour.

3.3. Analysis of pedestrian characteristics and pedestrian behavioral aspects:

The pedestrian characteristics comprises of gender, age groups (i.e., < 18 years-children, 18-35 years-young, 35-50 years-middle aged and > 50 years-elders) by visual appearance. Also the data collected from visual observation contains waiting time and gap acceptance condition. Pedestrians' and drivers' behavioural data were extracted from the visual appearance [3]. In this study, the pedestrian rolling gap is the one of the important parameter influencing pedestrian behaviour. From the field, it has been observed that drivers are more unlikely to yield to pedestrians waiting at curbs. So, in this study driver yielding behaviour is considered as whether they stop or reduce speed or change the vehicular path while a pedestrian is in the middle of the crossing. After arriving at the curb, most of the pedestrians may look at the traffic to check the suitable gap for crossing the road. The duration and number of times they are checking available gaps in traffic affect the pedestrian gap acceptance behaviour. So, the following pedestrian behavioural aspects have been observed from the visual appearance: observation duration at curb or median (duration of time spent by a pedestrian at curb or median during traffic flow for suitable gap acceptance), number of observations at curb or median (number of observations made by a pedestrian at curb or median during traffic flow for suitable gap acceptance), observation duration while

crossing (duration of time spent by a pedestrian while crossing during traffic flow for accepting gap), number of observations while crossing (number of observations made by a pedestrian while crossing on traffic flow for accepting gap).
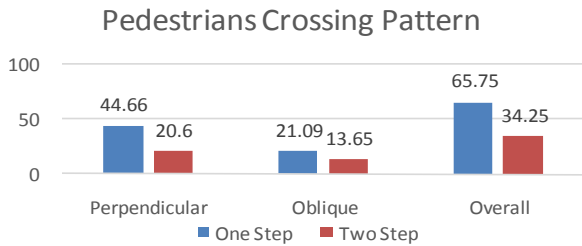

Fig 2. Pedestrians Crossing Pattern

3.4. Factors affecting

Pedestrian crossing behaviour is usually get influenced by various factors related to pedestrian characteristics, pedestrian movements, traffic conditions, road conditions and environmental surroundings. Rosenbloom et al. (2008) observed unsafe crossing behaviour of children, like not stopping at the curb, not looking before crossing, seeking to cross when a vehicle is nearing and running across the road. Female pedestrians are observed accepting more gaps and less risk compared to male pedestrians. Oxley et al. (2005) have done experimental studies on the effect of age of a pedestrian in gap selection. They reported that, for all age groups, gap selection is primarily based on vehicle distance and speed [2].

Situational factors like presence of other pedestrians and their behaviour towards 'Walk' and 'Don't Walk' signs affect the behaviour of female pedestrians and traffic volume affect the behaviour of male pedestrians at signalized intersections.

IV. RESULT AND DISCUSSIONS

The major findings of this study are Two types of pedestrian crossings movements namely perpendicular movements and oblique movements are observed at the selected study locations in Jaipur, Pedestrian's females and older people have higher accepted time gaps and crossing time, The average pedestrian crossing speed is calculated to be 1.204 m/sec for perpendicular movement conditions and as 1.08 m/sec for oblique movement conditions, The crossing speed for males is found to be 1.287 m/sec and that of females was 1.219 m/sec.

Figure-2 shows the percentage data for different crossing patterns of pedestrians such as one step/two step.

Figure-3 shows the variation in crossing speed with age group of pedestrians and gender of pedestrians.

Figure-3: Variation in speed

V. CONCLUSION

The pedestrian crossing behaviour with convenience, reliability and speed, using visual appearance data.
- The three age groups resulted in a balanced sample:
  - 18% (<18 years old)
  - 56% (18-35 years old)
  - 26% (>35 years old)
- More men walk during the morning peak hours:
  - 72% (men)
  - 38% (women)
- Pedestrians mainly cross the road illegally where the vehicle traffic flow and speed are lower.
  - 55% (green traffic light)
  - 45% (red traffic light)
- Older pedestrians cross the road with lower speed:
  - V=1.323m/sec (adults)
  - V=1.254m/sec (children)
  - V=1.004m/sec (older)
  -
  -

Male cross the streets faster than female:
- V=1.377m/sec (male)
- V=1.3m/sec (female)
- Pedestrians cross the street faster during the red traffic light:
- V=1.35m/sec (red)
- V=1.26m/sec (green)

Pedestrians usually respect the traffic light indications crossing the road only when they judge that there is a safe traffic gap. Pedestrians crossing behaviour is influenced on their physical skills and road safety education. Better understanding of pedestrian crossing behaviour in urban crosswalks. Implementation of focused remedial actions according to a pedestrian road safety audit procedure

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