A Case Study of Pedestrian Facility at Rangpo Traffic Intersection (Sikkim)

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Abstract

The risk to pedestrians increases as vehicular traffic increases, especially in developing countries where pedestrian movement is not given much consideration in design considerations. In hilly areas, pedestrian facilities such as foot paths and foot over bridges are available, but pedestrian crossings are not available at most of the busy intersections. The lack of dedicated pedestrian crossings causes pedestrians to cross at random, disrupting traffic flow and increasing pedestrian danger. In this analysis, a busy unsignalized intersection is investigated. This is a three-arm intersection leading to Majhitar, Rorathang and Teesta. A detailed traffic study (traffic volume and vehicle types) and pedestrian volume data is collected for each arm. The information gathered is evaluated, and recommendations for engineering design and planning elements of pedestrian facilities along roadways and at road crossings are made.

Keywords: Unsignalized intersection; Pedestrian, Level of Service, Traffic flow.

1. Introduction

Walking is an integral part of any journey, regardless of the mode of transportation used. As a result, every person is a pedestrian at some point during their journey. Historically, urban road planners have preferred mobility and economic efficiency over safety, particularly for non-motorized road users. As globalization rises, walking has become more dangerous in many countries, and pedestrians are now a major component of urban traffic accidents. E Rune et al. [1] stated that mixed traffic forces pedestrians to share the road with motor vehicles in many countries, forcing them to negotiate dangerous situations in fast-moving traffic. In India, 1,51,417 people were killed in road accidents in 2018, with 4,69,418 people being injured as per report by Ministry of Road Transport and Highways [2]. Many traffic injuries are caused by pedestrians crossing out of crosswalks (on an unmarked roadway), but most pedestrian studies concentrate on crosswalk crossing in developed countries. Pedestrians tended to cross in a cautious manner rather than waiting passively. The time spent waiting at the curb, in the median, and on the road, all followed exponential curves. Pedestrians preferred safe to short paths and they crossed second half of the road with significantly higher speed as stated by Zhuang et al. [3]. According to report by Manuel et al. [4], pedestrian crossing behaviour varies depending on age, gender, and whether the individual is a driver. Brigitte et al. [5] highlighted the road infrastructure (i.e., number and width of lanes, the presence of pedestrian signals, marked areas, overpass, and medians) and trip purpose are two important factors affecting pedestrian crossing behaviour. Generally, most of the pedestrian accidents occurs while crossing the road hence proper raised crosswalks should be provided. Crosswalks are the most important and widely used pedestrian facility for reducing pedestrian-vehicle collisions and, as a result, helping to minimize the number of pedestrian deaths in urban areas. Kadali et al. [6] stated that the pedestrian crossing mechanism is influenced by various types of crosswalks, which are also dependent on accessible vehicle headways and pedestrian and driver behaviour. Crossings during the pedestrian red process in signalized sites appeared to happen more when traffic demand was high, according to the study of Torres et al. [7]. In addition, in unsignalized areas with medium to high traffic flow demand, drivers yielded more to pedestrians. In terms of driver yielding, it should be noted that the inclusion of the elevated facility increased the number of drivers yielding to pedestrians by around 20 times as compared to the marked-only crosswalk. In the case of aggressive/risky crossings, it was shown that the presence
of mechanisms that aid pedestrian crossing, such as elevated crosswalks or traffic signals, significantly decreased the number of such crossings. The objective of this study is to check the current pedestrian facilities provided at an intersection in Rangpo, East Sikkim. This is a three-arm intersection leading to Majhitar, Rorathang and Teesta. A detailed traffic study (traffic volume and vehicle types) and pedestrian volume data will be collected for each arm. The data collected will be analysed and will recommendations for engineering design and planning elements of pedestrian facilities on roadsides and at road crossings will be given.

2. Study area

Rangpo is a town in the Indian state of Sikkim's East Sikkim district. The town is located along the Teesta River and borders West Bengal. It has a sub-tropical climate and is about 200 metres above sea level. It is the Sikkim Gateway, and all vehicles entering the state must stop here. Rangpo is located at 27° 11’ N 88° 32’ E / 27.18° N 88.53° E / 27.18° N 88.53° E / 27.18° N 88.53° E / It is 333 meters above sea level on average (1093 feet). The three-arm unsignalized intersection in the heart of Rangpo town will be the subject of the investigation. The three arm branches off to Majhitar, Rorathang and Teesta. The traffic in this circle is normally regulated by traffic police stationed in the intersection's centre on a 2.9-diameter traffic circle.

![Fig. 1. (a) Top view of the Rangpo Intersection; (b) Front view of Rangpo Intersection](image)

3. Methodology and data collection

3.1. Accident Data

The accident data assisted us in determining the number of injuries that occurred in our research area over the previous eight years (2012-2019). Just one fatal accident occurred in our research area in 2013, according to the accident data record. It has also come to our attention that certain minor injuries are not always reported, and this must be taken into account when proposing suggestions for pedestrian safety.

3.2. Geometric Data

The geometric data of the Rangpo Intersection is presented in Table 1.

| Direction       | Entry Width(m) | Exit Width(m) | Traffic Island Dia.(m) | Inscribed Circle Dia.(m) |
|-----------------|----------------|---------------|------------------------|--------------------------|
| Majhitar Arm    | 6.9            | 6             | 2.9                    | 17.95                    |
| Teesta Arm      | 7.4            | 7.3           | 2.9                    | 17.95                    |
| Rorathang Arm   | 3.5            | 3.5           | 2.9                    | 17.95                    |
Since this intersection is not a proper traffic rotary, the geometric parameters and flaring of entry and exit widths do not meet traffic rotary requirements. There are no road markings at the intersection to direct drivers in the right direction. The 1.5 m footpath along the side of the road serves as a pedestrian facility in this location. Since there is no pedestrian crossing facility, the smooth flow of traffic in this area is greatly hampered.

3.3. Traffic Volume

On weekday and weekend, a detailed categorised volume count for the intersection was performed for 12 hours (6am-6pm). The traffic volume count for various routes at Rangpo Intersection are presented in Table 2.

Table 2. Traffic volume count in weekdays

| Time   | From Majoritar Teesta Rorathang | To Majoritar Teesta Rorathang |
|--------|---------------------------------|-------------------------------|
| 6:00-7:00 | 61 24 1                          | 164 0 33                     |
| 7:00-8:00 | 125 51 0                          | 268.5 1 29                  |
| 8:00-9:00 | 77 75 5                            | 407.5 15 38.5               |
| 9:00-10:00 | 85 61 18                           | 378.5 1 44.5                |
| 10:00-11:00 | 69 96 3                            | 310.5 15 77                 |
| 11:00-12:00 | 80 93 3                           | 328 2 83.5                  |
| 12:00-13:00 | 73 65 7                            | 236.5 1 56.5                |
| 13:00-14:00 | 44 82 6                            | 247 2 40.5                  |
| 14:00-15:00 | 46 82 2                            | 212.5 4 55.5                |
| 15:00-16:00 | 88 83 7                            | 249.5 9 58                  |
| 16:00-17:00 | 73 94 4                            | 283 2 51                     |
| 17:00-18:00 | 68 63 2                           | 242 1 74.5                  |

The traffic volume count for the Rangpo Intersection for various routes for weekends is presented in Table 3.

Table 3. Traffic volume count in weekends

| Time   | From Majoritar Teesta Rorathang | To Majoritar Teesta Rorathang |
|--------|---------------------------------|-------------------------------|
| 6:00-7:00 | 23 37 6                           | 139.5 0 21.5                 |
| 7:00-8:00 | 63 57 3                           | 146.5 1 34                   |
| 8:00-9:00 | 66 36.5 2                          | 130.5 1 34                   |
| 9:00-10:00 | 70.5 46.5 10                        | 263 4 59.5                   |
| 10:00-11:00 | 73 27.5 6                         | 282.5 2 21.5                 |
| 11:00-12:00 | 68 82 13                          | 203 6 33                     |
| 12:00-13:00 | 50.5 64.5 12                        | 230 3 44                     |
| 13:00-14:00 | 60.5 53.5 11                        | 235.5 4 38                   |
| 14:00-15:00 | 58.5 35 12                         | 238 1 39.5                   |
| 15:00-16:00 | 58.5 43 7                          | 253.5 3 34                   |
| 16:00-17:00 | 48.5 30 4                         | 247.5 2 48.5                 |
| 17:00-18:00 | 45 37 6                            | 126 1 34                     |
The modal vehicle distribution coming from Rorathang Arm of the Rangpo Intersection is shown in Fig. 2 for both weekdays and weekends.

The modal vehicle distribution coming from Teesta Arm of the Rangpo Intersection is shown in Fig. 3 for both weekdays and weekends.

Fig. 2. Modal Distribution from Rorathang Arm at weekdays and weekends

Fig. 3. (a) Modal Distribution from Teesta Arm at weekdays and weekends
The modal vehicle distribution coming from Majhitar Arm of the Rangpo Intersection is shown in Fig.4 for both weekdays and weekends.

Fig. 4. (b) Modal Distribution from Teesta Arm at weekdays and weekends

Fig. 5. (a) Modal Traffic Distribution from Majhitar Arm at weekdays and weekends
3.4. Pedestrian Volume

The data was collected by conducting video-graphic survey in Teesta direction and Majhitar direction for the peak hours 8:00AM-10AM, 12:00PM-2:00PM & 4:00PM-6:00PM for both the days. For the Teesta arm of the intersection, the pedestrian volume is presented in Fig. 5 a. and 5 b.

For the Majhitar arm of the intersection, the pedestrian volume is presented in Fig. 6 a. and Fig. 6 b.

For the Majhitar arm of the intersection, the pedestrian volume is presented in Fig. 6 a. and Fig. 6 b.
3.5. Speed Data

The speed data for different types of vehicles on weekday in Majhitar, Teesta and Rorathang arm of the Rangpo intersection is presented in the Fig. 7, Fig. 8 and Fig. 9 respectively.

Fig. 9. Speed data for Majhitar Arm

Fig. 10. Speed data of Teesta Arm
4. Results and Discussions

4.1. Traffic Flow Level of Service

The capacity of section is found out by Wardrops model and the geometric features considered are weaving width, entry road width ($e_1$), length of weaving section, width of weaving and non-weaving section. The capacity for existing dimensions of the road is found recommendations and present traffic volume is found out from CVC survey. From the analysis it is observed that, the present entry volume of all approaches is significantly more than its capacity and need to improve geometrically to increase entry capacity. The present volume on study stretch is significantly more than capacity of road on weekdays.

Table 4. Level of safety for various arms

| Arm        | Weekday  | Weekend |
|------------|----------|---------|
|            | V/C      | LOS     | V/C      | LOS     |
| Rorathang Arm | 0.58     | C       | 0.49     | B       |
| Teesta Arm  | 0.97     | E       | 0.94     | E       |
| Majhitar Arm | 0.96     | E       | 0.89     | D       |

4.2. Pedestrian Level of Service

Pedestrian LOS for walkways and sidewalks is calculated using the pedestrian unit flow rate. Determination of the peak 15-min count and effective walkway width is required to compute pedestrian unit flow rate. This analysis is according to given equation and corresponds to obtained result of all legs analysis in Table 5.

\[ v_p = \frac{v_{15}}{15 \times W_E} \]

Where, $v_p$ = pedestrian unit flow rate in person/min/m; $v_{15}$ = peak pedestrian 15-minute flow rate (person/15min.); $W_E$ = width of the walkway in m.
For a 1.5 m sidewalk, the pedestrian unit flow rate in the study is 5 p/min/m for Majhitar arm and 3 p/min/m for Teesta arm. Since there is no walkway or sidewalk in the Rorathang arm, the pedestrian unit flow rate is zero. As a result, the level of service for three arms as of HCM 2000 [9] and 2010 [10] (Exhibit 18.3) is as follows:

Table 5. Pedestrian LOS for Walkways and Sidewalk

| Arm          | Flow rate (p/min/m) | LOS |
|--------------|---------------------|-----|
| Majhitar     | 5 p/min/m           | A   |
| Teesta       | 3 p/min/m           | A   |
| Rorathang    | 0 (No sidewalk provided) | F   |

The pedestrian LOS for sidewalks after analysis is very good for Majhitar and Teesta arm. The Rorathang arm is not facilitated with any sidewalks for pedestrian movement. The real problem as per visual survey is the unavailability of crossing in the intersection. Since, no designated crossings are provided in this intersection the pedestrians tend to cross in a randomly manner. This causes a lot of disturbance to the traffic flow as there is no designated crossing where the driver has to yield, so, because of random crossing behaviour of the pedestrian the traffic flow get interrupted before the intersection, at the intersection as well as after the intersection is crossed. This absence of designated crossing also increases the risk for passengers while crossing.

5. Conclusion

Traffic Volume Count: Through traffic volume counting, we were able to determine the volume of various vehicle groups travelling in nine directions. Taxi had the highest volume (5477), followed by private cars (4319), two wheelers (1575), HCV (1364), LCV (656), and bus had the lowest volume (656) according to the study (612). We also discovered that the Teesta to Majhitar direction has the most traffic, while the Teesta-to-Teesta direction has the least.

Collection of speed data: Speed data was collected in three directions: Majhitar arm, Teesta arm, and Rorathang arm. The average speed of 25 kmph was recorded in this intersection. Pedestrian Volume: The data was collected using a video graphic survey in the Teesta and Majhitar directions during peak hours of 8:00 a.m. to 10:00 a.m., 12:00 p.m. to 2:00 p.m., and 4:00 p.m. to 6:00 p.m. With the help of the video graphic study, we found out that majority of pedestrians were between the ages of 20 and 50, while the minority were over 50. Due to this lack of proper crossing points, various pedestrians were crossing the road from different points in the intersection, creating traffic congestion and raising the area's vulnerability. Following the study, we suggested installing a raised crossing in each of the intersection's entry arms. As per IRC 103:2012, we also recommend providing a minimum of 1.8 m wide footpath for all the arms of intersection [8].

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