

Safety Assessment of Junctions - A Case Study of Koottanad Junction

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ABSTRACT

Road safety is the practice of preventing congestion, accidents and minimizing the risk of injury or death to road users. There is a huge increase in vehicles and the number of accidents. Ensuring the safety of junctions has great importance, to reduce the number of accidents. Here the evaluation of the traffic is assessed by mainly focusing on mobility aspect, which is to reduce congestion. The existing conditions of Koottanad junction was assessed by conducting a questionnaire survey. It was found that the existing safety conditions were insufficient. So, based on the current scenario of Koottanad junction, a base model is developed and simulated using VISSIM software. Then a signal was designed in the existing condition. But the delay was greater than the requirements. So as a further solution, the signalized design was modified by widening the road at the junction and thus providing space for free left.

Keywords-- Road Safety, Congestion, VISSIM, Delay

I. INTRODUCTION

Road safety entails preventing traffic accidents and minimizing harm to road users such as pedestrians, cyclists, and motorists. It encompasses various strategies aimed at enhancing road safety, reducing accidents, and safeguarding lives. Junctions, where different traffic streams intersect, are particularly prone to accidents due to increased vehicle volumes. Ensuring safety at junctions is crucial for smooth traffic flow and protecting all road users.[1]

Koottanad junction, located in Palakkad district, Kerala, India, is a pivotal intersection connecting four major roads, including the Nilambur-Perumbilavu state highway. Recent coverage in a Malayalam newspaper highlighted the concerning lack of road safety infrastructure at Koottanad junction. The article titled "KOOTTANADINU VENAM MATTAM" vividly described the junction's dire condition, citing prolonged neglect and narrow roads as significant issues. Currently,

the junction lacks effective traffic control measures, leading to frequent accidents involving pedestrians and drivers.

The existing safety measures, limited to a small underutilized roundabout at the start of Edappal road, are insufficient in addressing recurring traffic jams and accidents. It is imperative to identify and rectify these road safety deficiencies at Koottanad junction. Implementing comprehensive safety measures will not only mitigate accidents but also improve overall traffic efficiency, ensuring a safer environment for all road users.

II. METHODOLOGY

Accident data obtained from the local police station were found to be inadequate due to underreporting of incidents. To supplement this data, a questionnaire survey was conducted among various road users at the junction. The survey aimed to gauge their perceptions of the current safety measures and facilities. A total of 100 road users participated in the questionnaire. Additionally, traffic volume data for each road segment at the intersection was collected.

Using these data, traffic simulation was conducted using Vissim software. The simulation assessed the feasibility of installing traffic signals and implementing provisions for free left turns at the junction. Based on the simulation results, additional safety measures were recommended to enhance overall junction safety.

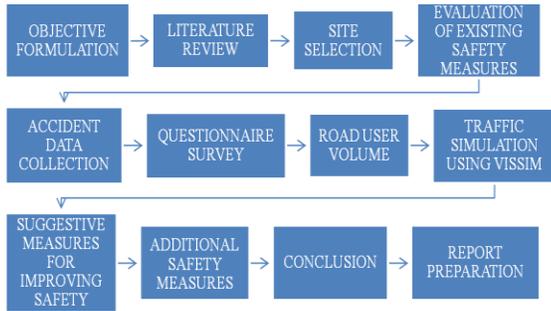


Figure 1: Flow chart of methodology

III. DATA COLLECTION

Based on the studies conducted at Koottanad junction, the current road safety measures are insufficient to address the existing safety issues. The ineffectiveness of the current roundabout is evident from the data collected, with less than 3% of vehicles using it correctly out of 100%. Moreover, there are potholes located at the center of the junction, posing a significant hazard, especially for two-wheelers.[2]

Pedestrian safety is also a critical concern due to the high pedestrian volume at this junction. Preliminary data indicates that during peak hours (4 to 6 pm), pedestrians, four-wheelers, and two-wheelers constitute the majority of road users. The table below presents the breakdown of road users during a peak hour:

Table1: Traffic volume of peak hour

SL NO	ROAD USERS	NO. OF ROAD USERS
1	Pedestrians	265
2	2 Wheelers	495
3	3 Wheelers	185
4	4 Wheelers	390
5	Bus	85
6	Lorry	70
7	Bicycle	53

The volume of road users for 24 hour is also estimated from the cctv footage collected from the junction. Volume of road users varies according to peak and non-peak hours. From this, pedestrians and two wheelers are the majority of the road users. They are also

mostly affected by accidents and congestion. The data of road users in 24 hours is given below in table .

Table 2: Traffic volume of 24 hours

SL NO	ROAD USESRS	NO. OF ROAD USERS
1	Pedestrians	2974
2	2 Wheelers	3694
3	3 Wheelers	1458
4	4 Wheelers	2528
5	Bus	186
6	Lorry	301
7	Bicycle	27

The traffic volume obtained from CCTV footage is utilized to determine the road user volume for both one hour and a full 24-hour period. This includes gathering data on the volume of various types of vehicles and their turning movements from each road within the junction. This data serves as input for simulations conducted using VISSIM software.

IV. ACCIDENT DATA

The analyzed road user volume is represented in the following pie charts. These charts clearly illustrate the inadequacy of the current safety measures at the junction. They indicate the distribution of road users between those passing through the main roads and those utilizing the roundabout.

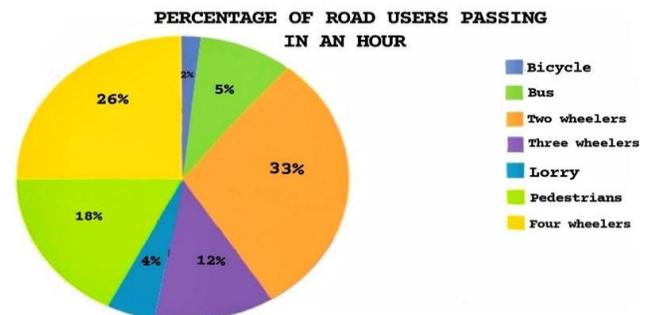


Figure 2: % of road users passing in an hour.

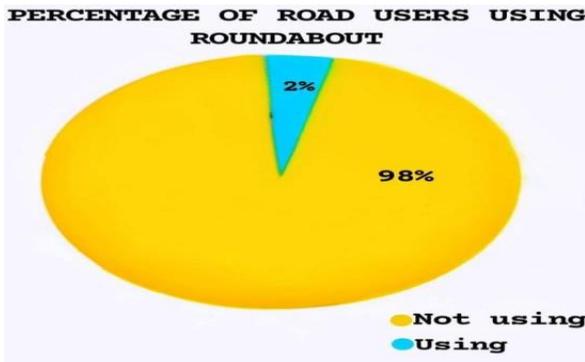


Figure 3: % of road users using the roundabout



Figure 4: CCTV footage of Koottanad junction

The inefficiency of existing roundabout was identified from the previous data collected. Accident data was also collected. It is given below,

Table 3: Traffic volume of 24 hours

LOCATION	NO. OF ACCIDENTS
KOOTTANAD JUCTION	4
KOOTTANAD	32

Due to the inefficiency of the accident data a questionnaire was prepared. The survey was conducted in the junction from various road users. The road users include pedestrians, drivers, nearby shop workers, etc. The questionnaire was conducted among 100 road users. A sample of the questionnaire is given below.

Name	<input type="text"/>	DATE	<input type="text"/>
Age	<input type="text"/>		
Occupation	<input type="text"/>		

SL NO	PARAMETERS	RATING				
		EXCELLENT	VERY GOOD	GOOD	POOR	VERY POOR
1	Road Condition					
2	Traffic Signals					
3	Quality of curve					
4	Vehicle parking					
5	Intersecting quality					
6	Street light					
7	Side-walk passenger side					
8	Pedestrian crossing facilities					
9	Speed limit					
10	Speed management and traffic calming					

Figure 5: Questionnaire sample

According to the questionnaire survey conducted, most of the road users responded that the existing safety measures in Koottanad junction is insufficient. The pie chart shown below shows the road users perception on the safety measures in Koottanad junction.

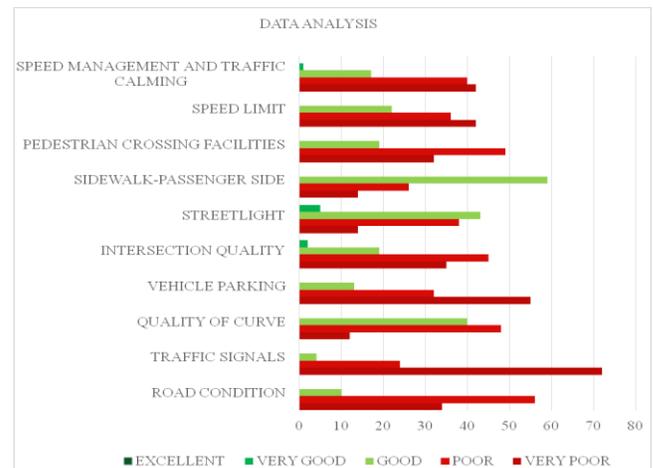


Figure 6: Data Analysis

Koottanad junction also lack in other safety measures such as pedestrian crossing, street light, signals, sign boards etc. These are clearly visible in the images given below.

V. CONFLICT POINTS

The study stretch is Koottanad junction which is a scissor shaped junction. For scissor type junctions oval shaped roundabouts are normally opted. For an elliptical roundabout, the width of the road should be sufficient to accommodate the widest turning path of the largest vehicles expected to use the roundabout. This typically includes larger vehicles like buses, trucks, and emergency vehicles. In many cases, a minimum width of about 28-30 meters is recommended for an elliptical roundabout. But due to the lack of space in the junction roundabout design

in Koottanad junction is not possible in the current situation of the junction. So instead of roundabouts traffic signals are proposed.

To design a roundabout, it is important to collect necessary data required in the design. Weaving length is such a data. Weaving length determines the ease with which the traffic can merge and diverge. Weaving length is decided on the basis of factors such as the width of the weaving section, the average width of entry, total traffic and the proportion of weaving traffic in it. Width of carriage way and design speed is found to an approximate value. The shape of intersection is scissor and each intersection leg has non uniform traffic flow

Table 3: Traffic flow in each leg

Approach	Left turning			Stright ahead			Right turning		
	Cars	Commercial	Scoters	Cars	Commercial	Scoters	Cars	Commercial	Scoters
N	329	116	315	86	22	92	86	22	92
E	69	29	82	296	116	308	458	366	596
S	1102	670	1278	366	76	398	1139	1139	1253
W	60	28	92	505	379	536	60	34	94

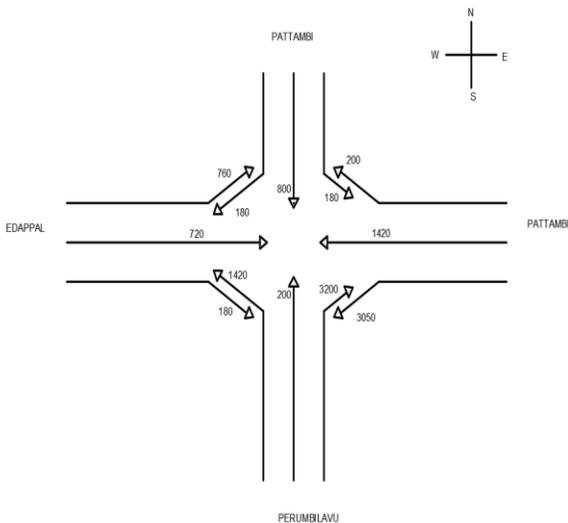


Figure 7: Traffic volume in each leg

VI. TRAFFIC SIMULATION USING VISSIM

PTV Vissim is a traffic simulation software developed by PTV group. Vissim stands for “Visual Simulation and Modeling”. Vissim software is used here to do traffic simulation and find the potential possibilities of formation of conflict points. For simulating traffic using Vissim it is necessary to create a base model like the real

situation in the junction. Base model preparation includes the following procedures. After adjusting the map, the units and right-hand driving must be set.

Then 2D/3D model of vehicles are imported. Data regarding the types of vehicles mostly using the junction during a peak hour is already collected. According to this necessary 3D models of different vehicles (Car, Motorbike, Scooter, Cycle, Bus, Lorry, Autorickshaw) are imported to the software (fig17). The volume of each type of vehicle and their corresponding design speed can also set in this process.

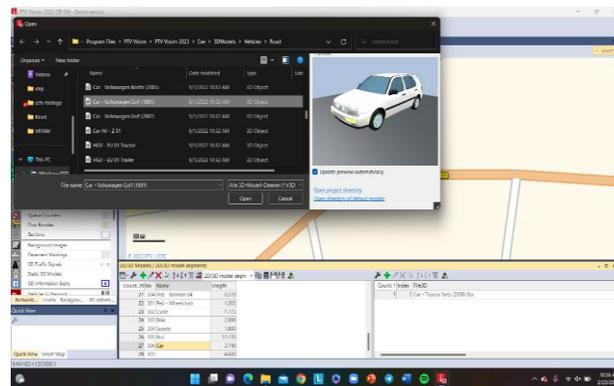


Figure 8: Importing 2D/3D models of vehicles

To draw lanes on the road in the map LINK tool is used. Using this, lane is drawn on all the roads in the intersection using correct scale. The links are then connected to all the directions of the roads. Vehicle composition is defined by selecting the tool vehicle composition from traffic from the tool bar. Here required vehicle types are selected for each leg separately and their corresponding design speed is also assigned. Relative flow of each type of vehicle in each leg is also assigned here in the table.

Static vehicle route is assigned in the next step. For this the tool static vehicle route is selected and click on the input road of Perumbilavu, and then click on the other roads (straight ahead, Left turning, right turning). This indicates the paths which vehicles coming from perumbilavu will go. Just like this vehicle routes are assigned for the other three roads.

Traffic safety in the road network mainly depends on the driver’s behavior. So, some parameters such as lateral arm line following, average standstill distance, etc. are adjusted accordingly.

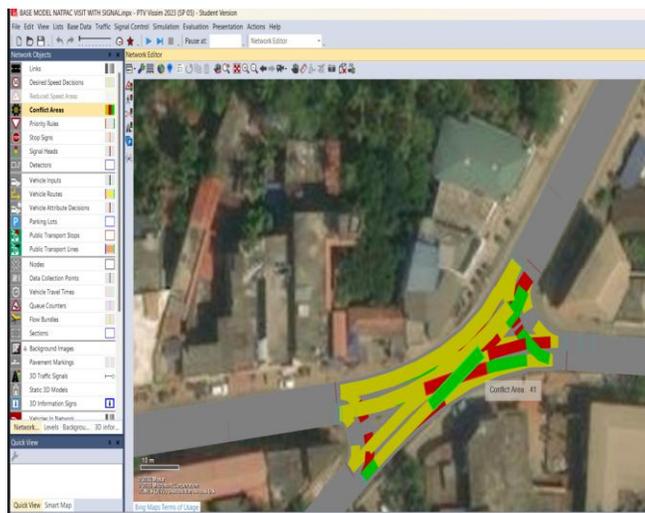


Figure 9: Conflict areas

To get the result of number of vehicles passing through each road data collection points are assigned. Data collection points are assigned on all the exit roads

There will be many conflict points in a junction. It is important to find those conflict points. For that the tool conflict areas is selected. Here the area which have conflict points will be highlighted. Here each conflict points are selected one by one and the traffic flow which is more important is marked as green, and the other one as red. Here the traffic marked as red will wait for the traffic marked as green to pass. Similarly Important traffic flows in the conflict area are marked accordingly

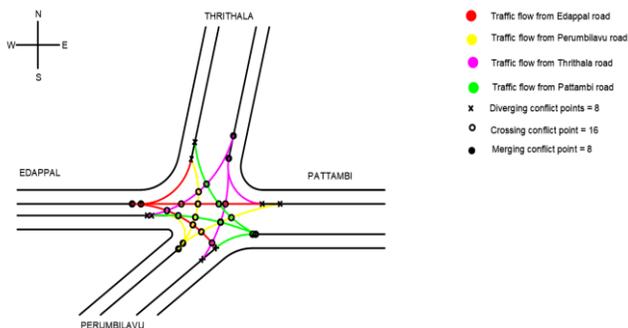


Figure 10: Conflict points in the junction

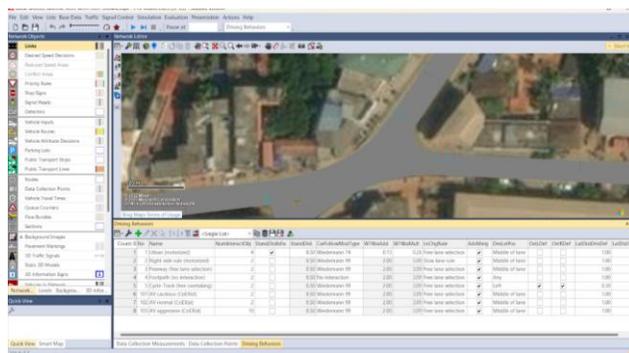


Figure 11: Conflict points in the junction

Traffic safety in the road network mainly depends on the driver's behavior. So, some parameters such as lateral arm line following, average standstill distance, etc. are adjusted accordingly.[3]

To get the result of number of vehicles passing through each road data collection points are assigned. Data collection points are assigned on all the exit roads

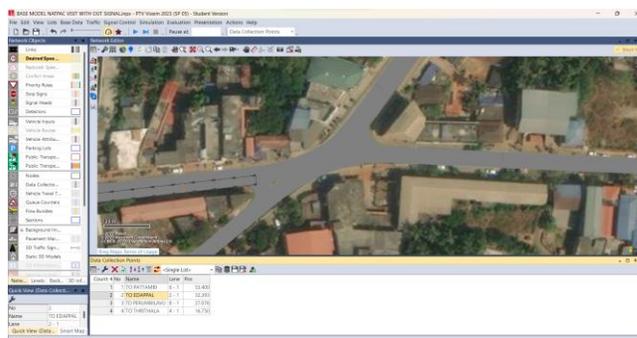


Figure 12: Data collection points

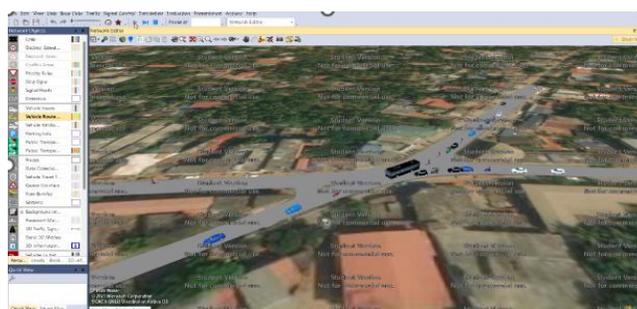


Figure 13: Simulation of base model

VII. COMPARISON OF FIELD DATA AND SIMULATED DATA

To validate if the base model is calibrated properly, traffic volume from each arm is taken as the validation parameter. For that data collection results were

collected after the simulation and corresponding data from field condition was also collected. From these the % error value can be found out and it should be within the limits

Table 4: % Error

NO	ARM VOLUME	FIELD DATA	SIMULATED DATA	% ERROR
1	From Pattambi	1034	865	16
2	From Edappal	539	486	9.83
3	From Thrithala	600	522	13
4	From Perumbilavu	827	949	14.75

VIII. SIGNAL DESIGN

The Webster equation, also known as the Webster’s delay formula or Webster’s traffic flow equation, is an empirical equation used in traffic engineering to estimate the average delay experienced by vehicles at signalized intersections. It was developed by Arthur E. Webster in the 1950s. It’s important to note that the Webster equation assumes a fixed-cycle signal control and homogeneous traffic conditions. It provides an approximation of delay but may not capture all complexities and variations of real-world traffic situation. Therefore, it is commonly used as a starting point for estimating delay and is often supplemented by more advanced traffic analysis methods and simulation tools.

Table 5: signal design

Approach	NB	SB	WB	EB
Width	9	7	7	8
S = 525W	4725	3675	3675	4200
Q	563	764	715	1038
Y = Q/S	0.119	0.2	0.19	0.24

Here Webster equation is being used find the optimum cycle length and corresponding green time for all legs. Here data required are traffic volume of each leg during a peak hour & width of the roads.

$$\Sigma y_i = y_1 + y_2 + y_3 + y_4$$

$$L = n * l + r$$

$$= 4 * 2 + 4 = 12 \text{ seconds}$$

$$C_0 = \left(\frac{1.5 * L + 5}{1 - \Sigma y_i} \right) = 91.63$$

$$G = 91.63 - 12 = 80$$

C0= Optimum cycle length (sec)

L= Lost time per cycle

N= number of phases

l= average lost time / cycle

R= Total red time

G=Effective green time

$$g = \frac{y_n}{\Sigma y} \times [C_0 - L]$$

Thrithala=13 seconds

Perumbilavu=21 seconds

Edappal=20 Seconds

Pattambi=26 seconds

The values of green time of each road calculated is then assigned in Vissim. For that signal controller option is selected. Here number of phases are selected. The combination of Red-Green -Amber is selected. Then the green time values are assigned.

IX. SIGNALIZED MODEL USING VISSIM

The values of green time in each leg were found manually by using webster equation. The value is given in the allocated space for green time of first signal group and the red time is set to be zero. And amber time is set to be three seconds. In the next signal group, the red time is given as the sum of the values(green time +amber time+ red time) previous signal group. Then green time is given, and this is repeated in all the signal groups. After assigning the necessary data for the signal, signal heads are selected, and these are assigned on all input roads where signal should be given.

Queue counters are also allocated to get the queue length in the simulation.

After assigning the signals, the traffic simulation of signalized model is played. The duration of simulation is set as 3600 seconds prior to the simulation.

After the simulation queue results are used to compare with the queue length collected from field condition. This is to check whether the proposed design of signal is sufficient to make the junction safer.

Queue delay from each arm was taken for the validation of the data. The data of 1 hour was collected on 14th June, Wednesday at 4:30 to 5: 30. The largest queue between every 10 minutes was noted and the average value is taken as the queue delay during the hour.

Table 6: Queue delay in field condition

Sl NO	ARM	QUEUE DELAY
1	From Pattambi	21.23
2	From Edappal	34.821
3	From Thrithala	38.845
4	From Perumbilavu	60.916

Table 7: Queue delay of signalized model

No	Queue delay	Field data	Simulated data	Difference
1	From Pattambi	21.23	90.51	-69.28
2	From Edappal	34.821	92.85	-58.03
3	From Thrithala	38.845	114.71	-75.865
4	From Perumbilavu	60.916	65.17	-4.254

When a signal was proposed in the current situation of road in the junction, the result was not satisfactory. So, another model was created by extending the road width through the mud and tar shoulder without interfering with any of the buildings. A provision for free left was also allocated in the new model by utilizing the extended width, so that vehicles that must go left do not have to wait for the signal. Thus, a smooth flow traffic will be there.

After the simulation difference in queue delay is again checked. Queue delay is greatly reduced in the arms compared to the previous simulation. By providing a proper signal system and free left vehicles can move more freely. The delay was found reduced in the simulation after providing free left along with the signal.

Table 8: Queue delay of model with free left

Sl. No	Queue delay	Field data	Simulation data	Difference
1	From Pattambi	21.23	4.44	16.79
2	From Edappal	34.821	26.63	8.191
3	From Thrithala	38.845	17.00	21.845
4	From Perumbilavu	60.916	33.64	27.276

X. ALTERNATE SOLUTIONS

Traffic calming is a system that utilizes design strategy and physical adjustments to reduce traffic speeds for the sake of safety and accessibility. Environmental adjustments, such as physical barriers and speed humps, force motorists to pay attention to their surroundings and alter their driving behaviors, resulting in lower speeds and safer driving. Traffic calming aims to prevent high-speed, rushed driving by ‘calming’ motorists through increased sensory awareness. This is particularly important in areas, such as residential neighborhoods, with increased pedestrian and bicycle traffic, where high-speed, unfocused driving can be fatal.

Traffic calming has a range of proven benefits, including speed reduction, lower fatality rates, decrease in injury severity, reduced traffic noise, better conditions for non-motorists, and improved street aesthetics. The primary benefit of traffic calming is increased safety and better-quality travel conditions for pedestrians and bicyclists. A study by The American Journal of Public Health found that children who lived within a block of a speed hump, a popular traffic calming method, had significantly reduced odds of being hit by a vehicle.[4]

XI. CONCLUSION

Road safety is the practice of preventing traffic accidents and minimizing the risk of injuries to road users. Traffic has mobility aspect and safety aspect. Mobility aspect is about congestion and safety is about crash



Figure 14: Simulation of signalized model

reduction. The existing condition is evaluated based on congestion. The existing road safety measures are not sufficient in the Kootanad junction. Road user volume was collected from CCTV footage collected from the junction. Accident data was collected from the nearby police station, and it was found to be insufficient for the study. Analyzed the existing safety measures using a questionnaire survey. A base model was developed using Vissim software based on the current condition of the junction. The maximum error between the field data and simulated data should be below 15% and the error was found out to be within the limits. Traffic signal was designed for the junction in the existing condition. Free left was provided in the junction to improve the efficiency. The queue delay was found to be greatly reduced compared to the previous signalized model. Alternate safety measures can be implemented in the junction to improve the overall safety of the junction.

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