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ESTIMATING CAPACITY FOR WORK ZONE CONDITION- A CASE STUDY OF AHMEDABAD

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Abstract- Work zone significantly influence traffic flow operation in urban roadway. Long term work zone leads to many issues like delay, reduction in capacity, reduction in space mean speed, increase in density, decrease in LOS etc. due to closure of available lane width. The objective of present study is to investigate capacity of urban road having work zone condition. It is aimed to investigate independent factors that contribute to capacity reduction in work zone. Traffic data have been collected at 6 locations of Ahmedabad city with variable lane closure by video graphic technique in one direction from stadium to Thaltej. The observed capacity of work zone for the six-lane road vary from 1580 PCU/hr to 3490 PCU/hr. The observed capacity of four lane is 1120 PCU/hr. Indo-HCM suggests capacity for six lane 4380 PCU/hr and capacity for two lane 2710 PCU/hr. It is observed that the average reduction of capacity is 16.5% due to closure of road width on the selected corridor.

Index Terms- *work zone, heterogenous traffic*

1. INTRODUCTION

Population of India is increasing at a faster rate. Due to increase in the income of people and lack of public transport facilities, people are buying more and more personal vehicles. This has led to increase in demand of new transportation facilities which in turn leads to construction of new bridges, flyover and highways. Construction of new facilities such as new roads, bridges, fly over, new transportation system are aimed at decongesting the road but during construction period it caused more and more problem to user such as reduction in capacity, increase in travel time delay, queue length, increase in fuel consumption, no of forced merges, and roadway accident. These problems lead to unaccounted economic losses. Many of these problems occur due to inefficient traffic control system. sometimes lane closure is also required for various types of work activities such as flyover construction, pavement maintenance, overlaying of pavement, asphalt removal, installation of pavement markers etc. Estimation of capacity is necessary as by knowing it, other traffic impacts delay and queue length can be estimated. Most of the computer model uses capacity as a basic parameter to find out delay and queue length.

2. LITERATURE REVIEW

(**Rajesh gajjar**) Observed capacity has been compared with maximum road capacity value specified as per IRC106-1990 for urban road to critically analyses the existing capacity potential of major road in Mumbai. It was observed that volume per lane for several major road in Mumbai was way beyond the capacity but interestingly there was no congestion problem because of better technology better roads familiarity with road and urban traffic characteristics.(**Alexander novikov**)described the potential for capacity increase of highway with use of intelligent transport system. It results in reduction in congestion and accident rate. Highway Munich-nurenberg of 45 km in Germany was tested. It was loaded with vehicle more than other highway, with daily intensity of 1,45,000 vehicles. The use of linear control near the city reduce congestion level and environmental impacts. (**Nanbanita Roy**) focused on effect of mixed traffic on capacity of two-lane roads. Data were collected in western part of India where speed of vehicle is relatively high then in eastern part of India where speed is low and in north eastern part of india where speed is medium. On the basis of data collected they told that capacity reduces if proportion of slower vehicle increase in traffic stream because these slow-moving vehicles leads to formation of platoons and their increasing proportion would accordingly increase equivalency factor of vehicles thereby resulting in variation in capacity. They further added that dynamic passenger car unit would alleviate the current implication on capacity standards of such roads under mixed traffic.(**Bo Du**) calculated total cost of road user including agency, user delay and accident cost in three different scenarios without shoulder and with shoulder in new jersey. To increase the capacity and mitigate congestion impact for short term work zone, temporary shoulder use may be applied. (Linfeng Gong) applied bi-level genetic algorithm-based optimization model to the Sioux fall network, which has 76 links and 24 origin destination pair. In this study, the impacts of scheduling long term work zone are analyzed from the perspective of traffic agencies and jurisdiction. The upper subprogram minimizes total travel time over the entire horizon, while lower level subprogram is user equilibrium problem where all user tries to find the routes that minimize their own travel time. The result of numerical example indicate that proposed model can effectively identify the near optimal solution of the long-term work zone scheduling problem. The research work focused on influence of work zone area from the perspective of traffic agencies jurisdiction. However, from the standpoint of contractor, they may be more concerned with the work zone schedule on

the maintenance cost. (**Taehyung Kim**) studied the effect of work zones on a freeway capacity. They found that the long-term work zone capacity can be affected by various independent factors such as traffic and roadway conditions, and therefore these factors should be included in capacity estimation models to obtain accurate capacity values. Author develop new capacity estimation model to estimate capacity for work zones using multiple linear regression analysis. They compared the developed model with the existing capacity models and the HCM and it performed better than the others that excluded various key independent factors that might affect long-term work zone capacity. (**Perco paolo**) studied accidents and deaths in work zone area and considered it as a critical point for the safety of both vehicle occupant and worker. This study analyses the speed of vehicle approaching the work zone. Study has shown that driver do not follow the temporary speed limit and they reduce speed only when speed is reduced, resulting in high deceleration rate. It should be considered while designing work zone sites.

3. STUDY AREA

Ahmedabad is located in one of the highly industrialized and urbanized parts of Gujarat State. It is the seventh largest metropolitan area of India. The city has become a localized center of attraction for people searching for job opportunities and living standards. The study area is a Long-term construction work zones corridor consisting of intersections and a mid-block section between them. Construction work zone is permanently demarcated from traffic throughout the construction time which leads to reduction in capacity of road. Total length of construction work zone is 5.5 km. The vehicular flow consists of mixed type of traffic including motorized two-wheelers, motorized three wheelers, motorized four-wheelers (cars & jeeps), buses, trucks, light commercial vehicles and bicycles. Selected area represents the real traffic scenario that is a composition of vehicular flow. Data have been collected at 6 work zone corridors. selected areas comprise of high heavy vehicle traffic and traffic flow is continuous. Due to this construction activity at Ahmedabad increasing day by day so that for carried out efficient traffic management a long-term work zone capacity model will be developed.

3.1. *Corridor no 1*

The first corridor that has been selected is Stadium cross road to Commerce cross road.

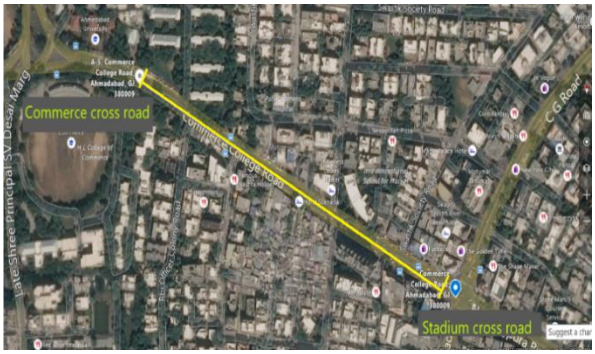


Figure 1: Google image of corridor Stadium cross road to Commerce cross road

3.2. *Corridor no 2*

The second corridor that has been selected is Commerce cross road to Vijay cross road.

3.3. *Corridor no 3*

The third corridor that has been selected is Vijay cross road to Saurabh cross road

3.4. *Corridor no 4*

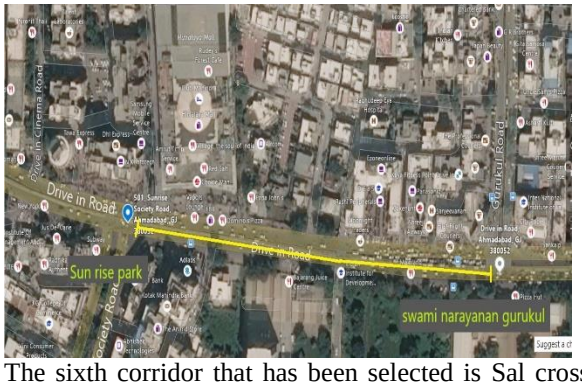
The fourth corridor that has been selected is Saurabh cross road to Helmet cross road.

Figure 4: Google image of corridor Saurabh cross road Helmet cross road

3.5. *Corridor no 5*

Figure 5: Google image of corridor Swami narayanan gurukul to Sunrise park

3.6. *Corridor no 6*



The sixth corridor that has been selected is Sal cross road to thaltej cross road.

Figure 6: Google image of corridor Sal cross road to thaltej cross road

4. DATA COLLECTION

In the present study, speed and other variable are found by Videography method. Two-points are marked on the urban traffic stream on selected location. The length of the road is taken 30 m as mid-block section of the road. The video is played and the time taken by different vehicles to cross that distance is measured in seconds. Speed is found by dividing distance with time. Space mean speed (SMS) is found from Time mean speed (TMS) by using formula

SMS = TMS - (Variance/TMS)

4.1. *Traffic data*

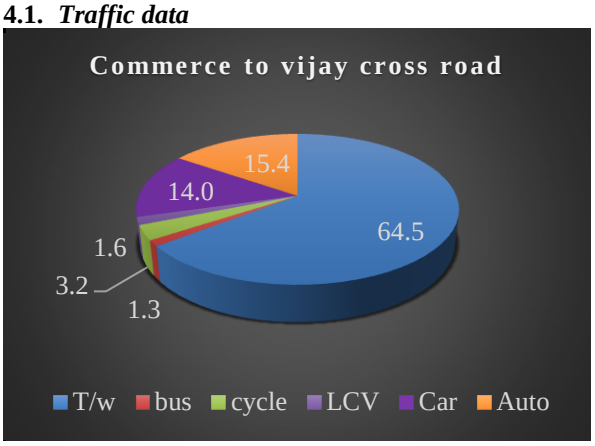


Figure 7: Traffic composition from Commerce cross road to Vijay cross road

It is observed that two wheelers are about 65%, cars 14% and auto rickshaw are about 15%. The major traffic is two wheelers and auto rickshaw. The effect of two wheelers, cars and auto are more on the capacity.

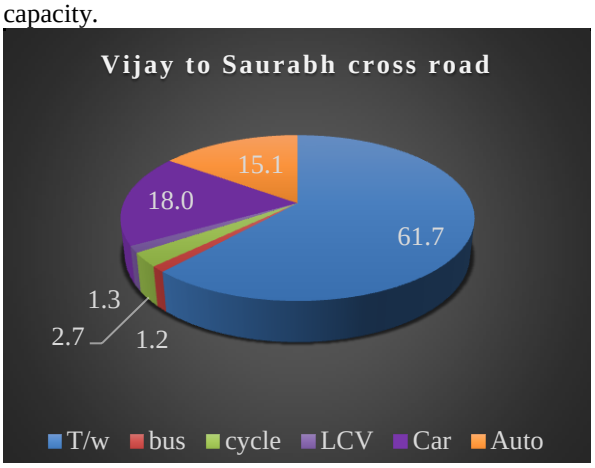


Figure 8: Traffic composition from Vijay cross road to Saurabh cross road

It is observed that two wheelers are about 62%, cars are 18% and auto rickshaw are about 15%. The major traffic is two wheelers and cars. The effect of two wheelers, cars and auto are more on the capacity.

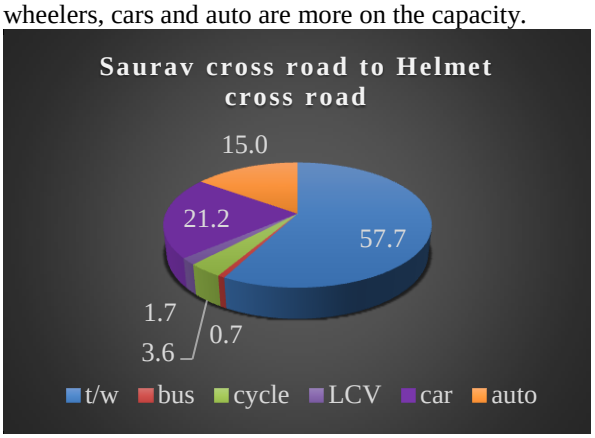


Figure 9: Traffic composition from Saurabh cross road to Helmet cross road

It is observed that two wheelers are about 58%, cars are 23% and auto rickshaw are about 13%. The major

traffic is two wheelers and cars. The effect of two wheelers and cars are more on the capacity.

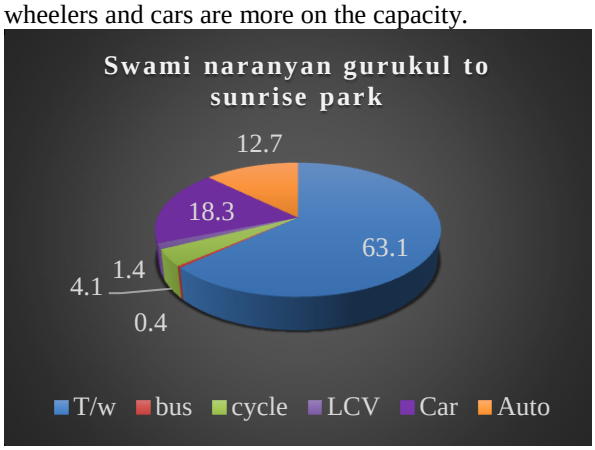


Figure 10: Traffic composition from Swami narayanan gurukul to Sunrise park

it is observed that two wheelers are about 63%, cars are 18% and auto rickshaw are about 13%. The major traffic is two wheelers and cars. The effect of two wheelers and cars are more on the capacity.

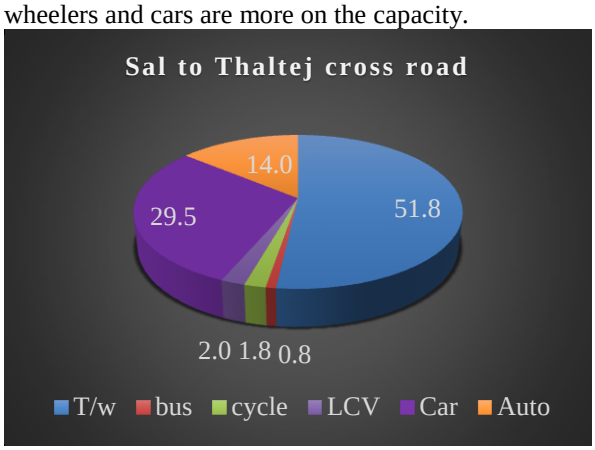


Figure 11: Traffic composition from Sal cross road to Thaltej cross road

it is observed that two wheelers are about 52%, cars are 30% and auto rickshaw are about 1%. The major traffic is two wheelers and cars. The effect of two wheelers and cars are more on the capacity.

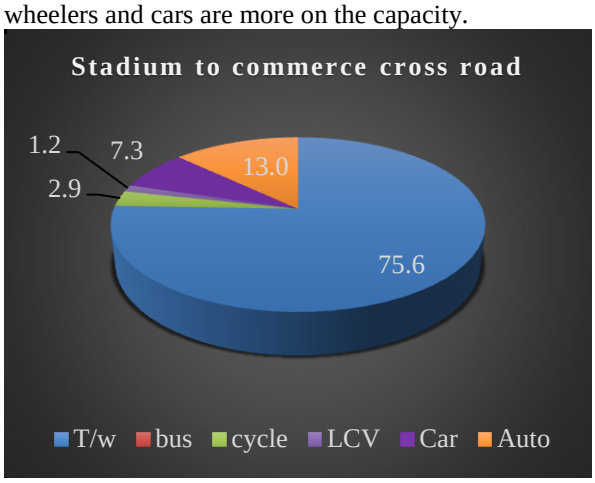


Figure 12: Traffic composition from Stadium cross road to Commerce cross road

it is observed that two wheelers are about 76%, cars are 7.5% and auto rickshaw are about 13%. The major traffic is two wheelers and cars. The effect of two wheelers, car and auto are more on the capacity

4.2. *Inventory Data*

Odometer is used for measurement of lane width. Width has been measured manually using odometer. Total lane width including work zone, work zone width and available lane width has been measured. Inventory data has been collected at respective corridor in one direction only. Available lane width has been used for analysis. Determination of capacity is important for available lane width. Determined capacity is divided by available lane width to get capacity per meter lane width.

Table 1: One-way lane width in m

Sr. no	Corridor name	Total width	Work zone width	Available lane width
1	Stadium to commerce cross road	6.1	2.6	3.5
2	Commerce to Vijay cross road	9.8	4.6	5.2
3	Vijay to Saurav cross road	11.3	4.3	7
4	Saurav to helmet cross road	10.5	4	6.5
5	Swami narayanan gurukul to sun rise park	11.5	2.5	9
6	Sal to thaltej cross road	11.4	3.9	7.5

5. RELATIONSHIP BETWEEN SPACE MEAN SPEED AND TRAFFIC FLOW

Space mean speed vs flow graph is prepared at each corridor. Maximum flow obtained at each corridor is its capacity.

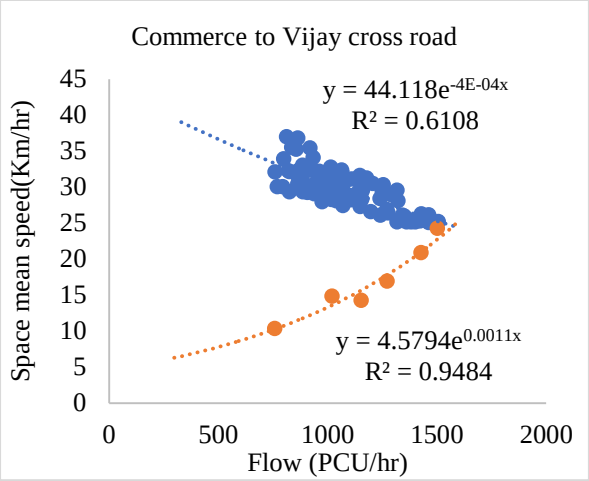


Figure 13: Speed flow relationship for Commerce to Vijay cross road

The Figure 13 shows the relation between flow and speed. The capacity of an approach is 1580 PCU/hr and average speed is 25 km/hr. Upper curve and lower curve both follow exponential relationship between speed and flows for Commerce to Vijay cross road. The relationship between space mean speed and flow are established in free speed flow condition.

Flow = $44.118e^{-4E-04x}$

R square value of upper curve is 0.6108 which shows the good relationship betwSeen speed and flow. It is observed that if space mean speed is more than 38 then it is free flow condition.

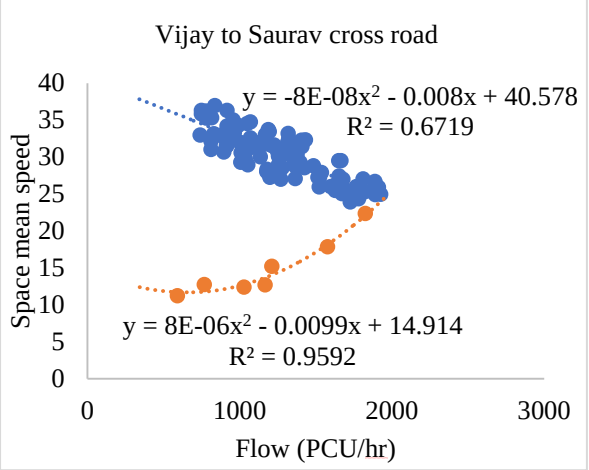


Figure 14: Speed flow relationship for Vijay cross road to Saurav cross road

The Figure 14 shows the relation between flow and speed. The capacity of an approach is 1960 PCU/hr and average speed is 24.5 km/hr. Upper curve and lower curve both follow 2nd degree polynomial relationship between speed and flows for Vijay to Saurav cross road. The relationship between space mean speed and flow are in free flow condition are shown below-

Flow = $-8E-08speed^2-0.008speed+40.578$

R square value of upper curve is 0.5983 which shows the good relationship between speed and flow. It is observed that if space mean speed is more than 26.5 then it is free flow condition.

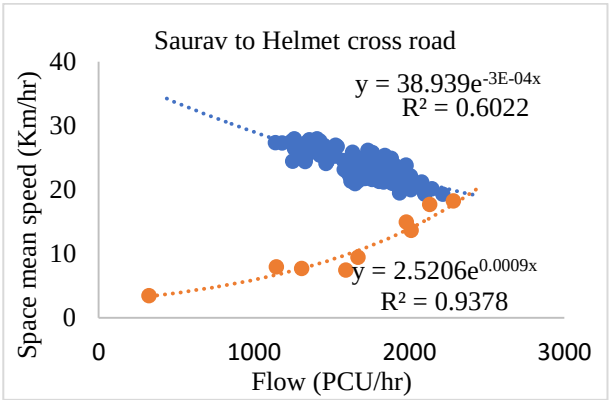


Figure 15: Speed-flow relationship for Saurav to Helmet cross road

The Figure 15 shows the relation between flow and speed. The capacity of an approach is 2400 PCU/hr and average speed is 19.5 km/hr. Upper curve and lower curve both follow exponential relationship between speed and flows for Saurav to helmet cross road. The relationship between space mean speed and flow are established in free speed flow condition.

Flow = $38.939e^{-3E-04speed}$

R square value of upper curve is 0.6022 which shows the good relationship between speed and flow. It is observed that if space mean speed is more than 28.5 then it is free flow condition.

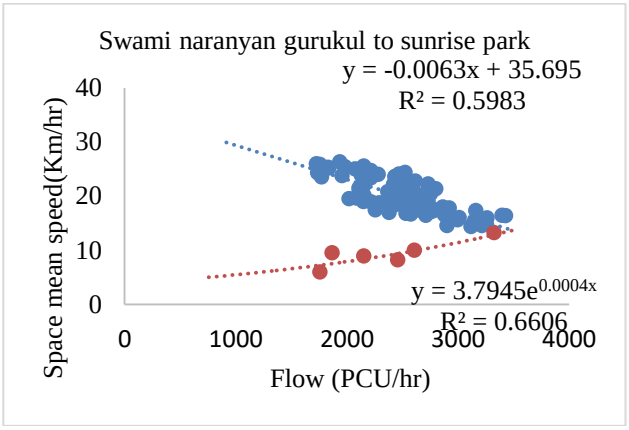


Figure 16: Speed flow relationship for Swami narayanan gurukul to Sunrise park

The Figure 16 shows the relation between flow and speed. The capacity of an approach is 3490 PCU/hr and average speed is 14 km/hr. Upper curve follows linear relationship and lower curve follow exponential relationship between speed and flows for Swami narayanan gurukul to Sunrise park. The relationship between space mean speed and flow are established in free speed flow condition.

Flow = 0.0063Speed+35.695

R square value of upper curve is 0.5983 which shows the good relationship between speed and flow. It is observed that if space mean speed is more than 26.5 then it is free flow condition.

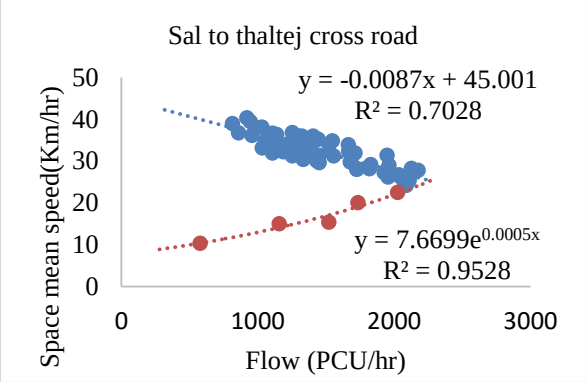


Figure 17: Speed flow relationship for Sal cross road to Thaltej cross road

The Figure 17 shows the relation between flow and speed. The capacity of an approach is 2260 PCU/hr and average speed is 25 km/hr. Upper curve follows linear relationship and lower curve follow exponential relationship between speed and flows for Sal to thaltej cross road. The relationship between space mean speed and flow are -

Flow = -0.0087speed+45.001

R square value of upper curve is 0.7028 which shows the good relationship between speed and flow. It is observed that if space mean speed is more than 41km/hr then it is free flow condition.

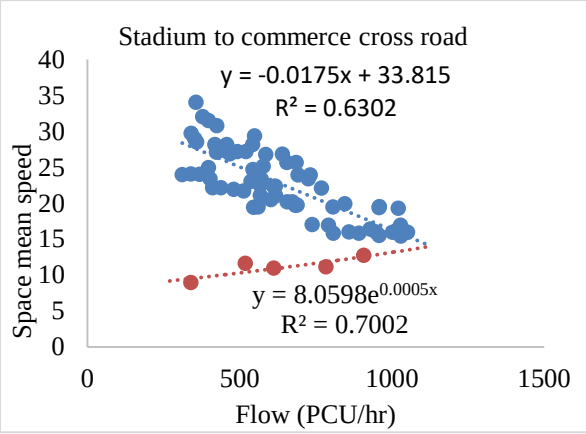


Figure 18: Speed-flow relationship for Stadium cross road to Commerce cross road

The Figure 18 shows the relation between flow and speed. The capacity of an approach is 1120 PCU/hr and average speed is 14 km/hr. Upper curve follows linear relationship and lower curve follow exponential relationship between speed and flows for Stadium to commerce cross road. The relationship between space mean speed and flow are -

Flow = -0.0175speed+33.815

R square value of upper curve is 0.6302 which shows the good relationship between speed and flow. It is observed that if space mean speed is more than 34.5 km/hr then it is free flow condition.

Table 2: Reduction in capacity due to work zone

Corridor name	Width (m)	Observed capacity due to work zone (PCU/hr)
Commerce to Vijay cross road	5.2	1580
Vijay to saurabh cross road	7	1960
Saurabh to helmet cross road	6.5	2400
Swami narayanan gurukul to Sunrise park	9	3490
Sal to Thaltej cross road	7.5	2260
Stadium to Commerce cross road	3.5	1120

Recommended Capacity per meter width (Indo HCM) in PCU/hr	Observed capacity per meter lane width in PCU/hr	% Reduction
398	304	24
398	280	30
398	369	7
398	388	3
398	301	24
361	320	11

It is observed from analysis that the capacity of road is reduced in the range from 3% to 24% due to work zone condition compare to capacity recommended by Indo-HCM

6. CONCLUSION

Following are the conclusion of research work:

1. The study stretch is a long-term work zone. According to MUTCD, long term work zone occupies the lane for more than 3 days.

2. It is major sub-arterial road and it is very important for proper management of traffic by local authority
3. The capacity is determined at mid-block section at all selected corridor.
4. The observed work-zone capacity of six lane vary between 1580 PCU/hr to 3490 PCU/hr and observed work-zone capacity of four lane is 1120 PCU/hr.
5. The average reduction of capacity due to work zone condition is 16.5%, which has a huge impact on traffic management.
6. The capacity determined can be used by policy maker for improvement of traffic management.

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