UDC: 656.1.056.4:625.746.1(540) DOI: http://dx.doi.org/10.7708/ijtte2022.12(3).02

AMBER PHASE EFFECT ON EVALUATING THE PERFORMANCE OF SIGNALIZED INTERSECTIONS UNDER MIXED TRAFFIC CONDITIONS

Jatoth Jithender[1], Arpan Mehar[2]

[1,2] Transportation Division, Civil Engineering Department, NIT, Warangal, Telangana, India

Received 26 May 2022; accepted 7 July 2022

Abstract: Analysis of amber phase effect on evaluating the performance of signalized intersections under mixed traffic conditions is a primary component of traffic signal analysis and design. From previous studies, assessing the performance of signalized intersections is mainly conducted in homogeneous traffic conditions. The amber phase effect is high during the inter transmission of signal phases for the first few vehicles, predominantly due to driver behaviour, and it also confirmations the impact on not only fourth or fifth vehicle but also vehicles at end of the queue. However, this may be the case mostly under heterogeneous traffic conditions, such as those in India, which also the additional problem of lacking lane discipline. The present study evaluates the performance of signalized intersection with effect of amber phase on queue length and delay at approaches of selected confluences. The analysis was carried out using field data collected from approaches of two signalized intersections through video graphic technic in Hyderabad City. The queue-up behaviour analyzed with effect of amber phase for the duration of each cycle obtained from the field was compared with active and inactive conditions of amber phase. Average control delay and queue length at selected intersections were reduced as soon as the amber phase was lively condition. Hence, the present study determined that the amber phase helps to improve the safety and efficiency of a signalized intersection.

Keywords: queue length, mixed traffic, amber phase, signalized intersection, traffic safety, Indian highway capacity manual.

1. Introduction

The furthermost essential measure of road network is signalized intersections which directly affect the performance of the entire system. Stream of traffic size is quickly mounting day by day under a different situation in emerging nations resembling India. The enactment of nodes and road systems under diverse situations is essential to progress charming the queue length and delay as crucial components at signalized intersections. Drivers approaching a signalized intersection at the beginning of the amber phase necessary to choose towards entering or else clear intersection, otherwise halt out of harm's way before the stop line. The crashes among the vehicles come about as soon as their judgments are situated contradictory at the end of the green

[1] Corresponding author: jithuvenka5@student.nitw.ac.in

phase. To avoid driver's misperception amber phase must be displayed at the approaches of a signalized intersection. The amber phase is predictable to assist various drives such as anxiety while queuing, drop crash rate, advances intersection capability, and level of service.

Signalized intersections are hypothetical to upturn efficiency and reduce traffic mishaps. Numerous actions (Sharma *et al*., 2012; Devalla *et al.,* 2017) exist to enhance the safety and effectiveness of signalized intersections. Consequently, countdown devices are introduced through the amber phase, these are technical measures becoming prevalent in several nations, counting India. However, scientific studies executed gaging the performance of signalized intersections in Indian conditions that exist few and are inadequate to locations. Furthermore, driver behavior varies significantly from geographical location, therefore necessary to carry out a comprehensive study to observe the effect of the amber phase on the operational performance of signalized intersections under the different stream of traffic and roadway characteristics. Hence, the present study analyzed using collected field data with active and inactive conditions of the amber phase at approaches of a signalized intersection.

2. Literature Review

A review of studies has been presented on evaluation of signalized intersection performance varies with various factors in previous studies. Koll *et al.* (2004) carried out an investigation through and lacking countdown timers at selected signalized intersections in Malaysia. They observed that the countdown timer remained persuaded on the saturation flow rate moreover certainly not substantial influence on the capacity of a signalized intersection. Lum *et al.* (2006) deliberated the traffic signal countdown timer abridged red-light violation at the selected intersections in Singapore, where a 65% decrease in red light violation accomplished after one and a half months installation of the traffic signal countdown timer. Limanond *et al.* (2010) reconnoitered the bearing of countdown signals on the startup lost time at signalized intersections of Bangkok, Thailand. They found countdown signals not influenced on the saturation headway of the vehicles, nevertheless remained effective on startup lost time. Long *et al.* (2011) investigated the influence of green signal countdown timer and cycle length on the queue discharge pattern at signalized intersections in China. They observed the green signal countdown timer associated with longer cycle time cause in increased startup lost time and unstable saturation rate. Sharma *et al.* (2012) examined the effect of the signal countdown timer on headway pattern in Chennai, India, in addition, they established traffic signal countdown timer technology that effectually abridged startup lost time and clearance time. Chuanyun *et al.* (2013) explored two intersections in China, study found red signal countdown timer reduced the initial headways of discharged vehicles and fluctuations of queued vehicle headways. Devalla *et al.* (2017) conducted a before-and-after study with SCT at three reported signalized intersections in New Delhi. The countdown timer of the green signal remained influenced on the saturation rate and red signal significantly abridged the startup lost time.

3. Field Data Collection and Extraction

The data was collected from two signalized intersections in Hyderabad City. The carefully chosen intersections are four-legged and three-legged which comprises major and minor stream approaches. The outline and geometry of selected intersections are entirely dissimilar. The selected signalized intersections specifically, Crown Cafe junction and Amber pet junction. The traffic flow data was collected at selected junctions covering the peak hours with active and inactive maneuver conditions of amber phase. The snapshot and Google map view of selected junctions is given in Figure 1 and Figure 2.

(a) (b)

Fig. 1.
Google Map View of selected Intersections (a) Crown Cafe Junction (b) Amber pet Junction

(a) (b)

Fig. 2.
Snapshot of selected Intersections (a) Crown Café Junction (b) Amber pet Junction

Field data was collected at a signalized intersection by videography method covering peak and non-peak hours during before noon starting from 7:00 A.M to 10:00 A.M and evening from 3:00 P.M to 6:00 P.M. Data was extracted by playing video on a widescreen monitor at every 15 minutes intervals. The queue length was observed for the duration of each cycle by counting several vehicles joining in the queue at major and minor stream approaches of selected intersections. The proportion of vehicle compositions observed at selected intersections is shown in Figure 3. Dissimilarities of green time, red time, and approach width of intersection are shown in Table 1.

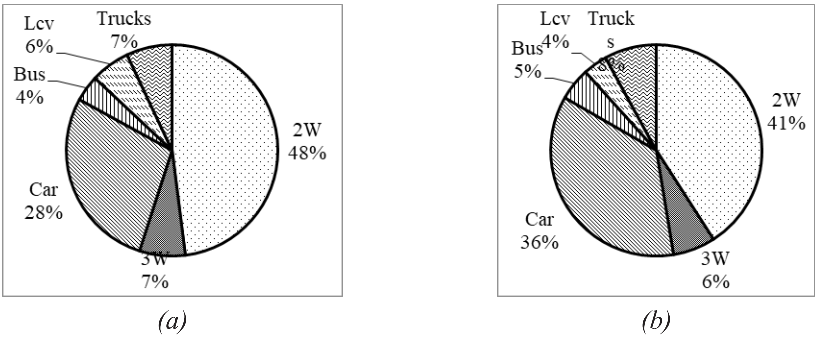


Fig. 3.
Percentage of Vehicle Composition at (a) Amber pet Junction and (b) Crown Cafe Junction

Table 1
Geometric and Control Conditions of selected Intersections

Location	Intersection Name	Approach Name	Approach Width (m)	Cycle Time (in Sec.)	Green Time (in Sec)	Amber Time (in Sec.)
Uppal	Amberpet Junction	Uppal Road	8.08	155	60	5
Old Alwal	Crowncafe Junction	Komaplly Road	8.92	165	82	4

4. Approaching Speed Analysis

The consequence of amber phase was analyzed using the approaching speed of vehicles at selected intersections. The situation brings that the period of working amber phase the average approaching speed of vehicles is greater than the period once the amber phase was inactive. The approaching speed of individual vehicle types with active and inactive amber phase conditions is shown in Figure 4. After statistical Z-test the situation observed there exists a significant increase in approaching speed of vehicles with active state of amber phase at 5% significant level.

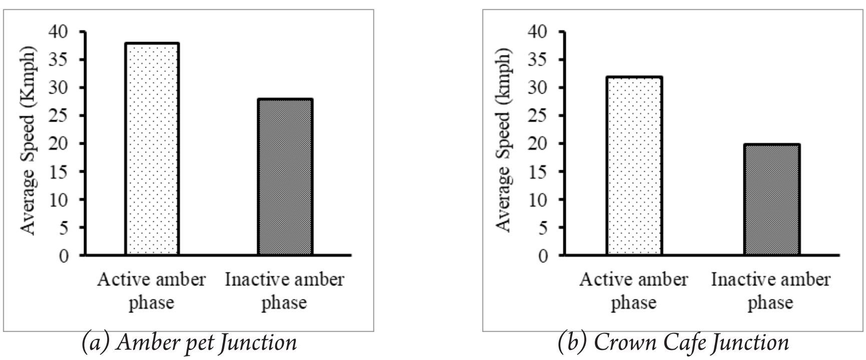
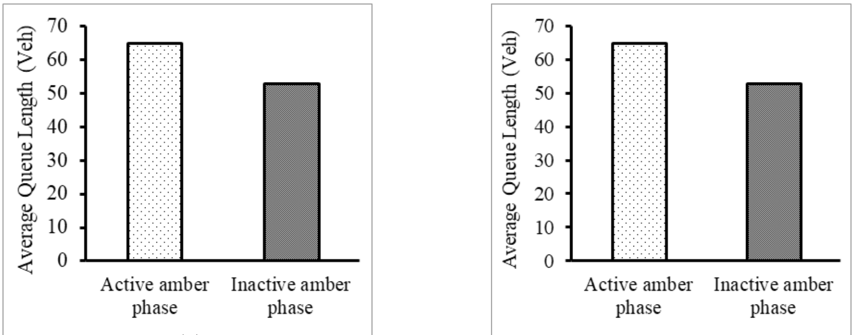


Fig. 4.
Average Approaching Speeds of Vehicles at selected Intersections

5. Queueing Analysis

The present study mainly analyzed the effect of amber phase on queue length at approaches of signalized intersections. The queue length during each cycle observed from the field covering the peak hours with active and inactive conditions of the amber phase. The queue length was estimated by HCM (2010) with active and inactive amber phase conditions compared with the observed queue length obtained from the field. HCM (2010) methodology overestimating the queue length values with observed queue length. Therefore, analysis was carried out for observed queue length obtained from the field compared at both intersections with the active and inactive condition of the amber phase. The observed queue length with active amber phase condition is found to be less in comparison to inactive amber phase condition. Hence, observed queue lengths were reduced with active amber phase conditions at both intersections shown in Figure 5.



(a) *(b)*

Fig. 5.
Average Queue Length at (a) Amber pet Junction, and (b) Crown Cafe Junction

The control delay estimated at the approaches of selected intersection by using Indian Highway Capacity Manual (INDO-HCM, 2017) methodology. The control delay estimated at both the intersections compared with active and inactive condition of amber phase. The analysis period considered for estimating control delay 15 minutes interval, the following equations applied to estimate control delay:

$$d = 0.9 * d_1 + d_2 \qquad (1)$$

Where,
d = average control delay in sec/PCU, d1 = average uniform delay sec/PCU, d2 = average incremental delay sec/PCU

$$d_1 = 0.5 * C * \frac{(1-\frac{g}{C})}{(1-\frac{g}{C} * \min(x,1))} \qquad (2)$$

$$d_2 = 900 * T * [(x-1) + \sqrt{\{(x-1)^2 + \frac{4*x}{c*T}\}}] \qquad (3)$$

Where,
T = analysis period in hours, g = effective green time in seconds, C = cycle time in

seconds, X = degree of saturation in PCU/hour, C = capacity in PCU/hour. The average control delay observed with inactive amber phase condition was found to be higher at both intersections, hence the control delay was reduced with the active amber phase which affects the level of service at approaches of a signalized intersection. The average control delay estimated at selected intersections is shown in Figure 6.

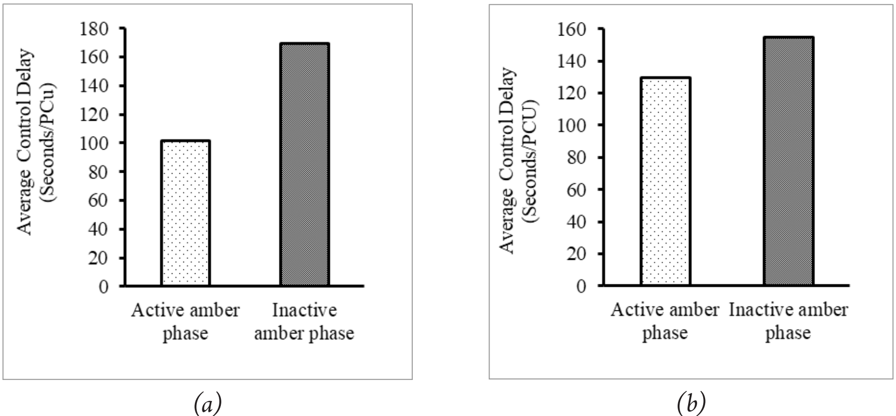


Fig. 6.
Average Control Delay at (a) Amber pet Junction, and (b) Crown Cafe Junction

6. Conclusions

Junctions in the urban arterials play a vital role in the operation and performance of the traffic stream. The overall performance and capacity of the traffic stream are decided by the capacity of a signalized intersection which is influenced by the signal amber phase. The average approaching speed of vehicles measured at selected signal intersections showed a significant difference with active and inactive amber phase conditions. A significant increase in approaching speed was found during the active amber phase. In addition to that, the observed queue length obtained from the field with active amber phase reduced compared to inactive amber phase condition. Furthermore, average control delay at signalized intersections was found to be reduced in the presence of amber period which may result in an enhancement in the level of service (LOS). Because the drivers do not want to wait for a longer red interval, hence they find gaps and cross the intersection during the red phase. And, at the end of the red phase, drivers are not aware that at what time the green phase going to start then they want to travel from the queue as a result, queue length and control delay are reduced, and the approaching speed of vehicles increased at both intersections. Based on analysis of the present study with active amber phase condition, may help to increases the efficiency and safety of signalized intersections.

References

Chuanyun, Fu.; Zhang, Y.; Qi, W; Cheng, S. 2013. Effect of digital countdown timer on intersection safety and efficiency: A systematic review, *Traffic Injury Prevention* 17(1): 98-103. DOI: 10.1080/15389588.2015.1043128.

Devalla, J.; Biswas, S.; Ghosh, I. 2017. The effect of countdown timer on the approach speed at signalized intersection, *Procedia Computer Science* 52: 920-925. DOI: 10.1016/j.procs.2015.05.166.

HCM. 2010. Highway Capacity Manual. 5th ed. National Research Council (U.S.). Transportation Research Board. Washington, D.C. USA.

INDO-HCM. 2017. Indian Highway Capacity Manual. Council of Scientific and Industrial Research (CSIR), New Delhi, India.

Koll, H.; Bader, M.; Axhausen, K. 2004. Driver behavior during flashing green before amber: a comparative study, *Accident Analysis & Prevention* 36: 273-280. DOI: org/10.1016/S0001-4575(03)00005-8.

Limanond, T.; Prabjabok, P.; Tippayawong, K. 2010. Exploring impacts of countdown timers on traffic operations and driver behavior at a signalized intersection in Bangkok, *Transport Policy* 217: 420–427. DOI: 10.1016/j.tranpol.2010.04.009.

Long, K.; Han, L.D.; Yang, Q. 2011. Effects of Countdown Timers on Driver Behavior after the Yellow Onset at Chinese Intersections, *Traffic Injury Prevention* 12(5): 538–44. DOI: org/10.3141%2F2286-05.

Lum, K.M.; Halim, H. 2006. A before-and-after study on green signal countdown device installation, *Transportation Research F* 9: 29–41. DOI: 10.1016/j.trf.2005.08.007.

Sharma, A.; Vanajakshi, L.; Girish, V.; Harshitha, M.S. 2012. Impact of Signal Timing Information on Safety and Efficiency of Signalized Intersections, *Journal of Transportation Engineering* 138(4): 467–478.