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Traffic operations at the approaches to the highway checkpoint sites

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Traffic operations at the approaches to the highway checkpoint sites

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Abstract. In recent years, more use of security and traffic safety checkpoints on Iraqi highways were made. Add to this, the huge increase in the numbers of vehicles using these highways (with increased numbers of heavy goods vehicles). This situation could lead to traffic congestion, higher delays and higher operational costs to motorists and also could lead to an increase in the rate of traffic accidents. This study tries to investigate the traffic operations at the approaches to the highway checkpoint sites in the Southern of Iraq (in Basrah Governorate) and focuses on some of the parameters that affecting both safety and capacity. For the purpose of this study, field data have been collected by using camcorders from two highway sites, each site has three lanes with a checkpoint. Both sites were at highway 31 near the interchange between highway 6 and highway 31. Several traffic parameters were observed such as traffic flow, average speed, lane utilization, speed differential, traffic congestion and queuing. The observations revealed that for both sites the traffic flow condition was free to moderate, ranging from 750 to 1750 (pcu/hr), with an average speed ranging from 70 to 120 (km/hr). Lane utilization behavior has also been observed for both sites and the results suggest that there is similarity between both sites with lower traffic flow in the nearside lane in comparison with the other lanes (i.e. middle lane and offside lane). For both sites, the lane utilization for the nearside lanes was around 10% – 20%, whereas, the lane utilization for the middle lane and offside lane were around 40% – 50%. Traffic congestion and queuing have been observed as well and the results suggest that there are some differences in queuing length between two sites. In addition, an increased number of speed differentials amongst motorists and late merging with accepting smaller gaps behavior have been observed for both sites. Other site observation is represented by a very lack implementation of traffic management measures (such as traffic schemes and signage) at the checkpoint sites.

Keywords. Traffic operations, checkpoints, highways, traffic flow, average speed, lane utilization and traffic management schemes.

1. Introduction

According to the Central Statistical Organization (CSO) Iraq [1], the number of cars of private sector in Iraq is increased nearly threefold over the period of just three years (2009-2012). Add to this the increased number of using security and traffic safety checkpoints on highways. This situation could lead to cause disturbance to traffic stream. In order to manage the traffic operational turbulence at highway checkpoint sections, which could affect the capacity and safety levels, a good understanding of the traffic operations at such sections is needed. This study tries to investigate the traffic operations at the approaches to the highway checkpoint sites in the Southern of Iraq (in Basrah Governorate) and focuses on some of the parameters that affecting both safety and capacity.

According to Salter and Hounsell (1996) [2] traffic flow could be used to represent the quantity measure of the traffic stream, whereas, traffic speed can be used to represent the quality measure of the traffic stream. Therefore, the traffic flow and speed will be observed and determined in order to evaluate the operations and performance of traffic at the approaches of highways checkpoints. For the purpose of this study, lane utilization, traffic congestion, queening length and speeds differential will also be observed. Geistefeldt (2011) and Yousif (1993) [3,4] reported that the higher differential in speeds amongst motorists could lead to increase the traffic accidents rate. The higher variation in speeds amongst drivers could lead to an increase in the lane changing frequency amongst motorists and also can cause disturbance for some drivers with others who are traveling at unsafe speeds or following too close behind them. Therefore, this parameter (i.e. speed differential) will be observed in order to evaluate the traffic safety at the approaches to the highway checkpoint sites.

2. Data collection

For the purpose of this study, field data taken from two highways with checkpoint sites. Camcorders used for collecting the field data from each site. Both sites were at highway 31 near the interchange between highway 6 and highway 31 (around 750 meters from the interchange towards the west). Figure 1 shows the locations of these sites. The first site was at the highway 31 eastbound; around two hours of video footage were recorded from 11:30 a.m. to 13:30 p.m. on Wednesday, the 28th of November 2018. The second site was at the highway 31 westbound; around four hours of video footage were recorded from 07:30 a.m. to 11:30 a.m. on Monday, the 3rd of December 2018. Table 1 summarizes details of the selected sites.

Figure 1. Sites locations map (Source of map: Google Maps, 2021)

Table 1. Summary of the selected sites details

Site No.	Site location	Highway Classification	Traffic direction	Number of lanes	Width of each lane	Date	Duration
1	Highway 31	Arterial	Eastbound	3	3.65 m	Wednesday 28/11/2018	2 hours
2	Highway 31	Arterial	Westbound	3	3.65 m	Monday 03/12/2018	4 hours

Site No. 1 (i.e. Highway 31 – Eastbound) consists of three lanes with an additional lane constructed at the checkpoint site. The nearside lane was restricted for traffic movements and is kept for emergency situations only. The other lanes (i.e. middle lane, offside lane and the additional lane) were kept running for traffic movements but with very low speed around 5 (km/hr) or less, with some of the vehicles have been instructed by the officers for total stopping. It is worth mentioning here that, the very low speed (i.e. 5 km/hr or less) at the checkpoint was measured by driving through the checkpoint several times. Figure 2 shows a schematic layout for site No. 1.

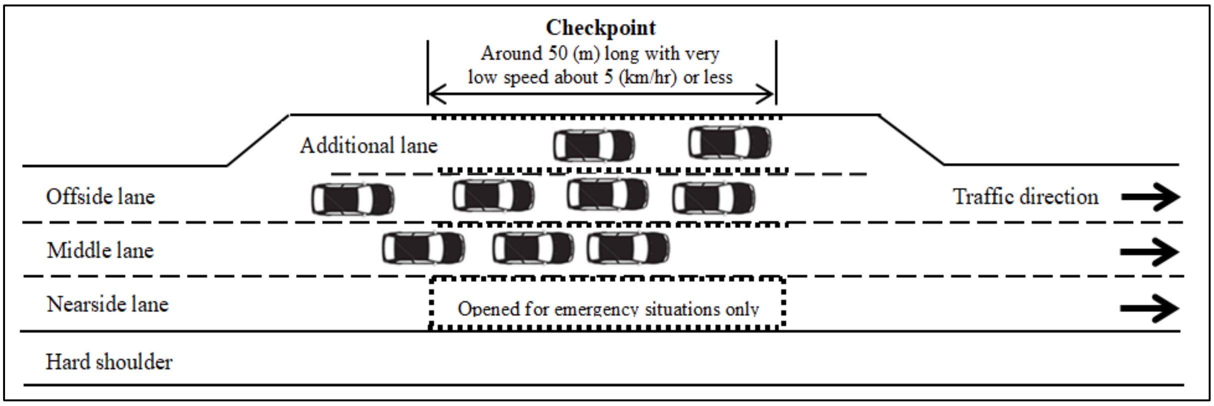

Figure 2. Schematic layout for site No. 1 (Highway 31 – Eastbound)

Site No. 2 (i.e. Highway 31 – Westbound) consists of three lanes. The offside lane was restricted for traffic movements and is kept for emergency situations only. The other lanes (i.e. middle lane and nearside lane) were kept running for traffic movements but with very low speed around 5 (km/hr) or less, with some of the vehicles have been instructed by the officers for total stopping. Figure 3 shows a schematic layout for site No. 2.

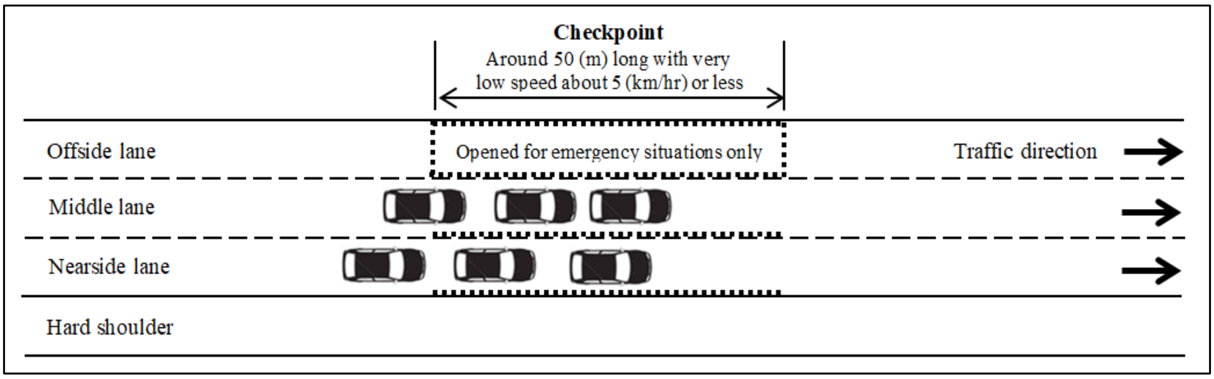

Figure 3. Schematic layout for site No. 2 (Highway 31 – Westbound)

3. Data analysis

Traffic flow and average speed for each lane of the observed highways have been extracted by playing back the two footages. It should be noted here that the accuracy of the extracted traffic data provided by using camcorders technique is influenced by the observer decision. To overcome this issue, a sample of half an hour from each footage have been extracted twice by two trained observers. Both observers have been instructed to extract the traffic flow and speed data for the same sample separately then compare their results. The comparison of the results showed a very close fit between both observers. For both sites (i.e. site No. 1 and site No. 2) the camcorder was installed around 750 meters upstream of the checkpoint site facing traffic from behind.

3.1. Traffic flow data

Deferent type of vehicles have been observed on the selected highway sites such as cars, vans, minibuses, buses, trucks and heavy goods vehicles (HGVs). Therefore, the traffic flow data have been converted into passenger car units per hour (pcu/hr). Each light vehicle is regarded as equivalent to 1 passenger car unit (pcu) and each heavy vehicle is equivalent to 2 passenger car unit (pcu) (Smith, 2010) [5]. Table 2 shows the observed vehicles' types and their correspondent value of pcu.

Table 2. Summary of the observed vehicles' types and their pcu values

Light Vehicles		Heavy Vehicles	
Vehicle Type	pcu	Vehicle Type	pcu
Motorcycle	1	Bus	2
Car	1	Truck	2
Van	1	Heavy goods vehicle	2
Pickup	1	Construction vehicle	2
Minibus	1		

Traffic flow data was extracted by displaying the video playback on a computer screen. Using a marker pen, a thin line across the computer screen was sketched to help in counting vehicles manually. An event recorder program (computer programming codes which was designed for this purpose and works as a stop watch) was used to help the extraction of events which were registered on a spread sheet whenever a button was pressed on the keyboard (i.e. 1 for light vehicles and 2 for heavy vehicles). Traffic flow data were grouped into five minute intervals and then converted to hourly flows for each five minute interval, as recommended by many previous researchers such as Al-Jameel (2012) [6] and Yousif et al. (1993) [7].

Table 3 shows the observed traffic flow data for nearside lane, middle lane, offside lane and all lanes for site No. 1, whereas, Figure 4 shows the lane utilization for site No. 1. Likewise, Table 4 and Figure 5 show the traffic flow data and lane utilization, respectively, for site No. 2.

It can be seen from Table 3 and Figure 4 that the traffic flow condition for site No. 1 is ranging from free flow to moderate flow, this could be attributed to the time when footage was recorded (i.e. 11:30 a.m. to 13:30 p.m.) which represents off peak period. Also, the data analysis revealed that the heavy good vehicles percentages was 32% for site No. 1. In addition, it can be seen from Figure 4 that the lane utilization for nearside lane is lower than that for middle lane and offside lane. The lane utilization for the nearside lane was around 20% whereas the lane utilization for the middle lane and offside lane was nearly similar and it was around 40%. This is different from the finding of Al-Jameel (2012), Yousif et al. (2013) and Duret et al. (2012) [6-8]. Al-Jameel (2012) and Yousif et al. (2013) [5,6] collected their data from the UK and reported that under free flow condition the majority of vehicles are utilizing the nearside lane, whereas, Duret et al. (2012) [8] who collected their data from France reported that when traffic flow lower than 1800 (veh/hr) no distinct trend of lane utilization could be observed. The lower amount of vehicles on the nearside lane that were observed on site No. 1 (which is around 20% of the total traffic flow) could be attributed to the higher percentage of HGVs (i.e. 32%) and most drivers of passenger cars tried to avoid moving behind slower HGVs. Also, this could be due to, the motorists trying to change their nearside lane to the adjacent lanes when they are getting closer to the checkpoint site. According to the Highway Capacity Manual (HCM, 2010) [9] different parameters could affect the lane utilization behavior such as traffic composition, speed, traffic flow and local driver habits.

Table 3: Observed traffic flow data for site No. 1 (Highway 31 – Eastbound)

Data type	Time slice (minutes)	Nearside lane flow (pcu/hr)	middle lane flow (pcu/hr)	offside lane flow (pcu/hr)	Total flow (pcu/hr)
Flow	0-5	108	324	408	840
	5-10	216	468	456	1140
	10-15	216	396	360	972
	15-20	144	444	324	912
	20-25	168	564	528	1260
	25-30	204	348	324	876
	30-35	132	384	492	1008
	35-40	228	444	600	1272
	40-45	180	552	612	1344
	45-50	204	636	624	1464
	50-55	312	444	660	1416
	55-60	252	348	312	912
	60-65	120	264	288	672
	65-70	144	396	384	924
	70-75	204	348	336	888
	75-80	216	600	516	1332
	80-85	384	576	648	1608
	85-90	132	396	360	888
	90-95	240	444	384	1068
	95-100	168	360	420	948
	100-105	168	396	360	924
	105-110	180	468	396	1044
	110-115	204	336	432	972
	115-120	170	390	362	922

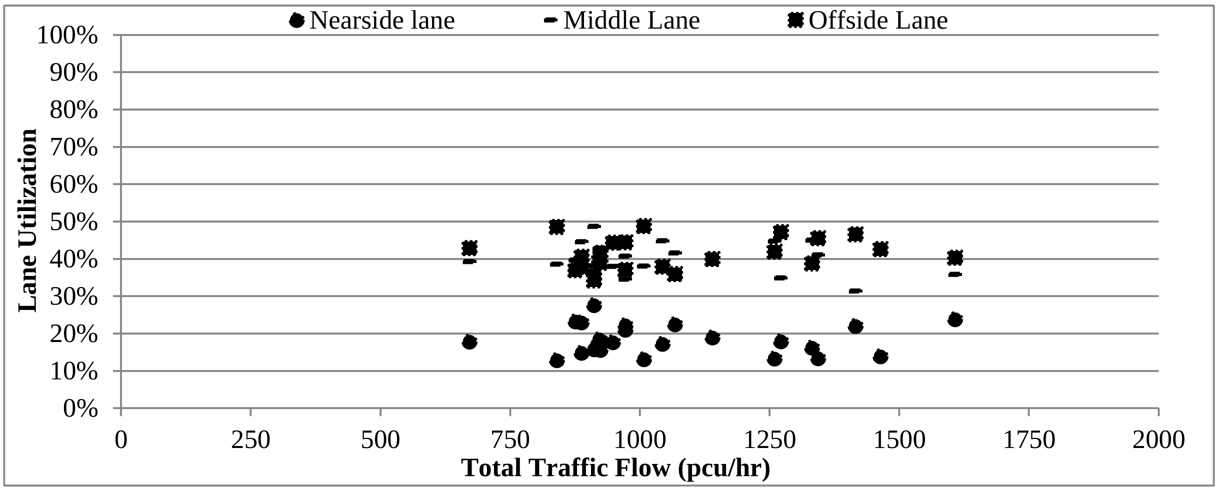

Figure 4. Lane utilization for site No. 1 (Highway 31 – Eastbound)

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Table 4. Observed traffic flow data for site No. 2 (Highway 31 – Westbound)

Data type	Time slice (minutes)	Nearside lane flow (pcu/hr)	middle lane flow (pcu/hr)	offside lane flow (pcu/hr)	Total flow (pcu/hr)
Flow	0-5	132	600	720	1452
	5-10	252	588	816	1656
	10-15	108	648	624	1380
	15-20	132	588	672	1392
	20-25	108	744	780	1632
	25-30	120	696	564	1380
	30-35	180	600	684	1464
	35-40	120	804	660	1584
	40-45	108	732	480	1320
	45-50	60	564	432	1056
	50-55	108	768	636	1512
	55-60	72	612	516	1200
	60-65	144	444	552	1140
	65-70	180	636	456	1272
	70-75	12	636	492	1140
	75-80	72	504	444	1020
	80-85	120	516	456	1092
	85-90	24	516	444	984
	90-95	12	564	480	1056
	95-100	132	492	648	1272
	100-105	72	480	540	1092
	105-110	108	456	492	1056
	110-115	108	432	468	1008
	115-120	96	540	528	1164
	120-125	132	552	384	1068
	125-130	84	540	528	1152
	130-135	144	612	552	1308
	135-140	108	648	564	1320
	140-145	84	564	384	1032
	145-150	84	564	312	960
	150-155	60	636	384	1080
	155-160	84	768	492	1344
	160-165	48	636	336	1020
	165-170	24	576	336	936
	170-175	156	480	420	1056
	175-180	96	528	240	864
	180-185	48	564	444	1056
	185-190	72	516	456	1044
	190-195	24	444	288	756
	195-200	144	336	456	936
	200-205	36	480	432	948
	205-210	60	540	360	960
	210-215	84	600	324	1008
	215-220	60	432	384	876
	220-225	60	384	312	756
	225-230	96	516	396	1008
	230-235	24	312	408	744
	235-240	36	480	360	876

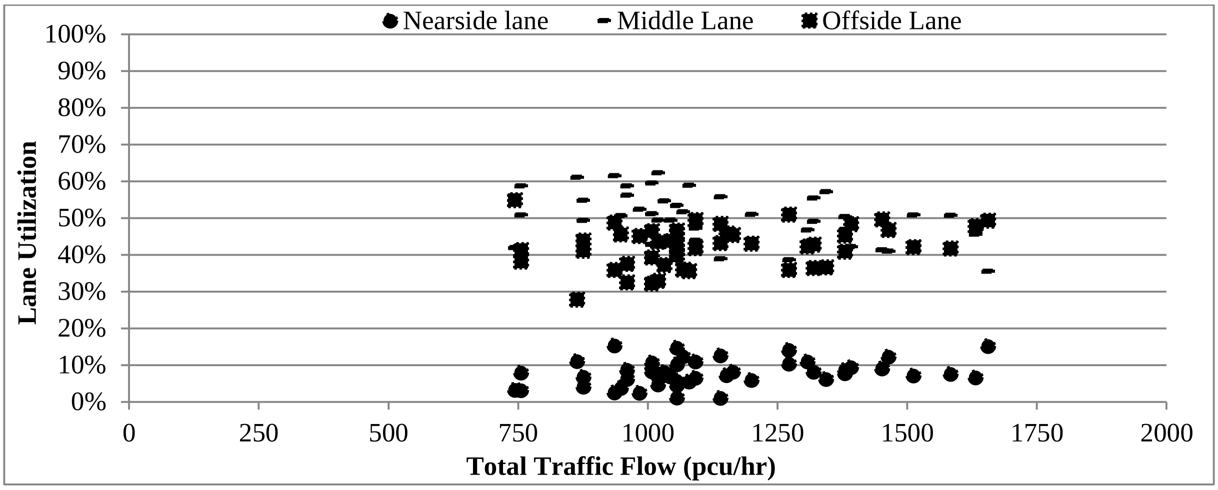

Figure 5. Lane Utilization for site No. 2 (Highway 31 – Westbound)

It can be seen from Table 4 and Figure 5 that the traffic flow condition for site No. 2 is also ranging from free flow to moderate flow. Although, peak period (i.e. 07:30 a.m. to 11:30 a.m.) has been selected to record the footage for this site (i.e. site No. 2). Also, data analysis revealed that the HGVs percentages was 12% for site No. 2. In addition, it can be seen from Figure 5 that the lane utilization for nearside lane was around 10% whereas the lane utilization for middle lane and offside lane were around 50% and 40%, respectively. This shows good agreement with the lane utilization results that obtained from site No. 1. This agreement in the lane utilization behavior between both sites is associated with similarity in traffic flow condition for the both sites which was ranging from around 750 – 1750 (pcu/hr). However, site No. 1 has HGVs% and layout differs from those for site No. 2. This similarity in lane utilization behavior for these two sites could be attributed to the local driver habits, most local drivers seem not preferring to travel on the nearside lane (slower moving lane).

3.2. Average speed data

The vehicles' speeds data were calculated by drawing two screen lines (datum lines) on the computer monitor to cover a distance of about 100 meters. The time required for a vehicle to cross this distance is then measured using the event recorder. Then, simple calculations of distance over time were used to convert the readings into speeds. Then, speeds data have been grouped and averaged into five minute intervals for each lane. The manual speed estimation method was adopted in this study due to unavailability of radar speed gun device and also following many previous researchers such as Naidu (2018) [13] and Nassrullah & Yousif (2020) [14]. Figure 6 shows the observed average speed data for nearside lane, middle lane and offside lane for site No. 1, whereas, Figure 7 shows the observed average speed data for site No. 2.

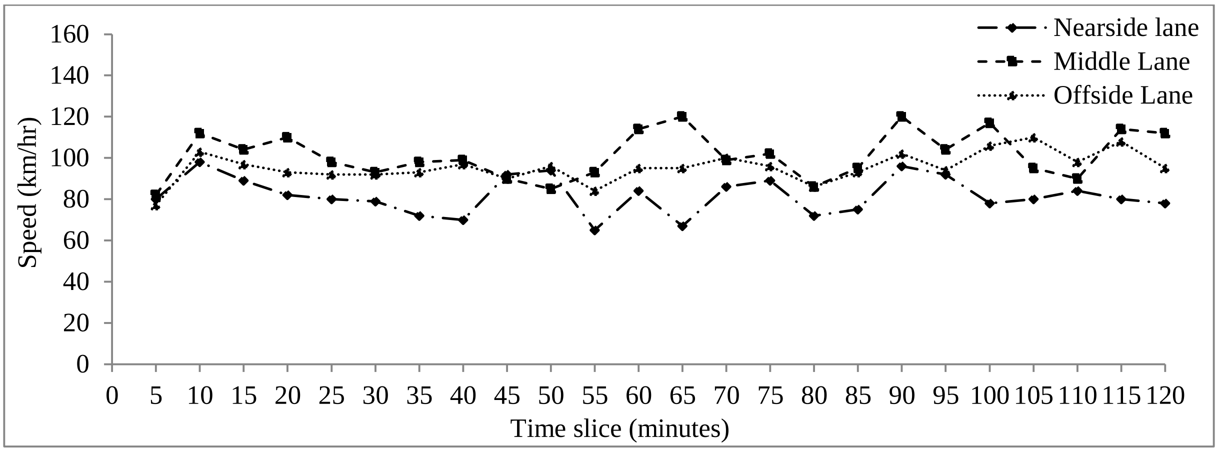

Figure 6. Observed average speed data for site No. 1 (Highway 31 – Eastbound)

It can be seen from Figure 6 and Figure 7 that there were similarities in speeds between drivers in the nearside lane, middle lane, and offside lane. Also, it can be seen from Figures 6 and 7 that there were similarities in speeds between both sites (i.e. site No. 1 and site No. 2) which was ranging from around 70 (km/hr) to 120 (km/hr). This is because both sites have similar traffic flow conditions which were ranging from around 750 (pcu/hr) to 1750 (pcu/hr). In addition, it can be concluded that the traffic demand for both sites was much lower than the traffic capacity, according to the HCM (2010) [9] the base capacity of freeway facilities with a speed of 60 miles per hour (i.e. 96 km/hr) is 2300 (pcu/hr/lane).

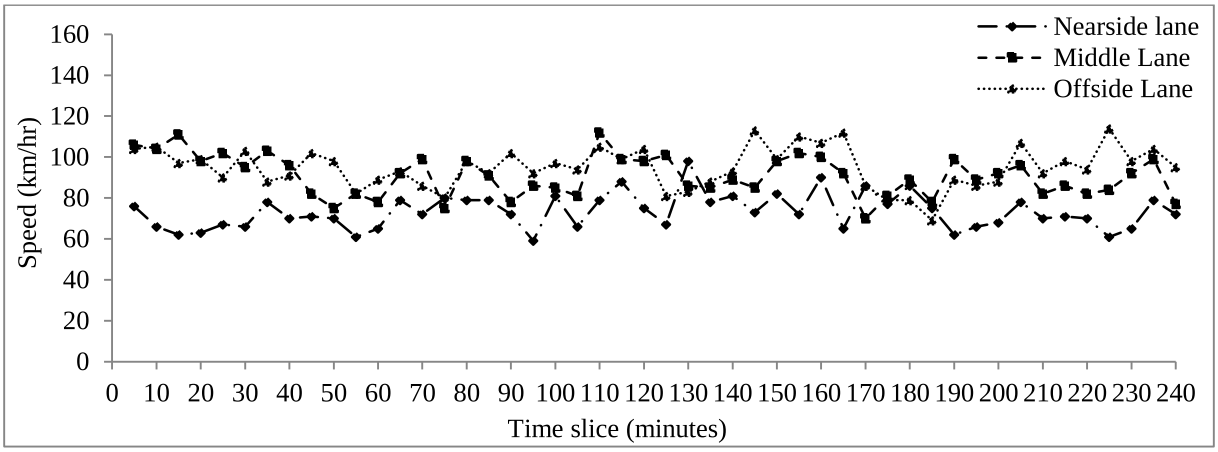

Figure 7. Observed average speed data for site No. 2 (Highway 31 – Westbound)

3.3. Other site observations

3.3.1. Speed differential. The speed differential amongst motorists has been taken into consideration due to the effect of this parameter on the safety of highway. The Speed differential parameter was observed on site. For both sites the variation in speeds amongst motorists were observed relatively high. Also, as discussed in section 3.2, the average speed of vehicles was ranging from around 70 to 120 (km/hr) at a distance of around 650 – 750 meters far from the checkpoint and these vehicles need to reduce their speed to less than 5 (km/hr) or zero at the checkpoint. However, site observations showed that most motorists are not starting reducing their speed until they are getting very closer to the checkpoint (which was around 100 – 200 meters from the checkpoint). Assuming that a vehicle with an initial speed of 100 (km/hr) and a final speed of zero (km/hr) and starting to decelerate at 150 meters from the checkpoint. The deceleration rate for this vehicle equals to 2.6 (m/sec^2) and this value could be worst for other vehicles especially for those with higher speeds. The ITE (2010) [10] recommended that the normal deceleration rates are 3.0 m/sec^2 for passenger cars and 1.8 m/sec^2 for HGVs. Also, some drivers have been observed forcing themselves into the path of others on adjacent lanes by accepting smaller gaps to merge into especially when they are getting closer to the checkpoints.

3.3.2. Traffic congestion and queuing. Although, the traffic conditions were ranging from free flow to moderate flow for both sites, as presented in section 3.1, some traffic congestion and queuing have been observed for both sites. However, traffic congestion and queuing for site No. 2 is much lower than that for site No. 1, even though site No. 1 has an additional lane. The number of vehicles in queue for site No. 2 was ranging from 3 to 7 vehicles for each lane, whereas, the number of vehicles in queue for site No. 1 was ranging from 10 to 15 vehicles for each lane. This difference in queuing length between the two sites could be attributed to the officers and their measures. It seems that the measures that are followed on site No. 2 is more lenient than those followed on site No. 1. It is worth mentioning here that, the checkpoint at site No. 1 can be considered as an entrance for Basrah city from the west, whereas, the checkpoint at site No. 2 can be considered as an exit from Basrah city.

3.3.3. Traffic management scheme and signage. Another site observation is that there is a very lack implementation of traffic management measures (such as traffic schemes and signage) at the checkpoints. For both sites, no signs have been observed which tells upstream traffic about the checkpoint ahead. An advance warning zone or section should be provided for drivers before approaches the checkpoint. Also, no speed limit signs have been observed. The purpose of implementing traffic management at checkpoints or at any sections of roadway is to maintain the safety of motorists with the least possible amount of traffic delay. To overcome such issue, several traffic management schemes and signage have been proposed by many design manuals such as Manual on Uniform Traffic Control Devices (MUTCD, 2009) [11] and Traffic Signs Manual (Chapter 8, 2009) [12] should be adopted at the highway checkpoint sections.

4. Conclusions

This study tries to investigate the traffic operations at the approaches to the highway checkpoint sites in the Southern of Iraq (in Basrah Governorate) and focuses on some of the parameters that affecting both safety and capacity. The sites observations reveal that the traffic flow condition was free to moderate, ranging from 750 to 1750 (pcu/hr), with an average speed ranging from 70 to 120 (km/hr) for both sites. At such sections (i.e. checkpoints) of highway the speed of vehicles should be lower than the observed ones (70 – 120, km/hr). Traffic congestion and queuing have been observed with some differences in queuing length between the two sites. A similarity in lane utilization behavior have been observed between the two sites. Both sites have a lower traffic flow in the nearside lane in comparison with the other lanes (i.e. middle lane and offside lane). For both sites, the lane utilization for the nearside lanes was around 10% – 20%, whereas, the lane utilization for the middle lane and offside lane were around 40% – 50%. An increased number of speed differentials amongst motorists and late merging with accepting smaller gaps behavior have been observed for both sites. Other site observation is represented by a very lack implementation of any traffic management measures (such as traffic schemes and signage) at the checkpoint sites.

5. Recommendations

As speed differential increases the road safety decreases. Also, high speeds of vehicles could lead to reduction in roadway safety. Therefore, to maintain safety levels, a reduction in speed differentials between motorists and a reduction in vehicle speed along the highways network and particularly at checkpoint sections should be taken place. At highway checkpoint sections, the vehicle speeds need to be reduced to be compatible with safety requirements at such sections, and also, the variation in speeds amongst motorists should be kept low. To achieve such objective, an implementation of traffic management schemes and signage as suggested by [11,12] should be taken placed. The implementation of the traffic management schemes and signage at the highway checkpoint sites is helping to providing drivers with clear information about the upcoming obstructions in the highway in order to guide them safely and efficiently through the unusual maneuvers sections of checkpoints. The traffic congestion and queuing that were observed at both sites of highway checkpoints could be alleviated by adding an extra lanes at the checkpoints sections.

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