Evaluation and Analysis of Al-Matar Road (Ring Road) In Al- Najaf City

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Abstract. Assessing and comprehending the degree of service rendered by diverse transportation infrastructures is of utmost significance for individuals responsible for designing and managing traffic networks. The current study was carried out on the principal urban road named Al-Matar, situated in Al-Najaf City. The methodology involves collecting data regarding the geographic location and implementing traffic surveys, which can include various metrics, including traffic volume, travel time, and free flow speed. The Highway Capacity Manual (HCM) has been designated for evaluating the functional effectiveness of various urban streets. The research findings indicate that the time of travel could be mainly used as an indicator for measuring performance during peak hours or off-peak hours. Additionally, the study observed that U-turns have a significant influence on both travel time and speed. The results indicated the crucial effect of U-turn on the city's operational performance on the ring road.

Keywords: Free flow speed; level of service (LOS); travel time; U-Turn

1. INTRODUCTION

Iraq's roads and highways are vital to the country's economy and communal growth. Maintaining a high standard of service at these facilities is crucial for the every day, efficient, and cost-effective running of traffic. The fast expansion in Iraq's population has resulted in higher demand levels. Hence, vehicle utilization and highway capacity increase demand [1-4]. Al-Najaf City in Iraq has a street network that suffers from traffic congestion in various segments of its highways [5]. The issue of traffic congestion significantly impacts the speed of vehicular movement, thus impacting the overall travel time. As traffic volume approaches the network's maximum capacity, the flow becomes unstable and susceptible to disruptions such as road works, adverse weather conditions, or accidents. The increase in travel time variability is known to impact user sensitivity towards it significantly.

In addition, categorizing streets according to the quality of service they provide is a helpful way to prioritize traffic management programs, which is especially important when there is a finite amount of cost available [6]. U-turn operations are poorly studied. The HCM [7], which offers techniques and models for assessing capacity and delay for different movements at non-signalized crossings, does not include instructions for U-turns at median openings. U-turn median opening traffic operations are unresolved. Field experiments by Al-Masaeid [8] estimated U-turn delay and capacity using regression equations. Empirical calculations show high connections between delay, capacity, and conflicting traffic flow. According to the findings of Hummer and Reid [9], the significance of arterial geometry in relation to total system time, average stops per vehicle, and average speed was determined. Compared to the conventional two-way left turn lane, the findings demonstrated that the median U-turn and super street median can reduce the time spent traveling while simultaneously increasing average speed. The study aims to evaluate the selected street as a case study, additionally computing the time of travel and the influence of U-turns on it.

2. STUDY AREA AND METHODOLOGY

The subject of this research pertains to the ring road, a segment of the roadway systems in Al-Najaf City (see Figure 1). The urban principal arterial route originates from the Al-Radhawia bridges and extends towards the northern direction of the city. It ultimately intersects with the Najaf-Karbala highway at the Al-Shuhada Bridge due to the large number of vehicular movements between Al-Diwania and Karbala. The roadway comprises six lanes, with three lanes in each direction and a median of three meters in width.

This research focuses on evaluating Al-Matar Street, emphasizing the data gathered, including travel time, traffic flow, and speed. A camera was employed on the pedestrian bridge adjacent to the Al-Ghadeer residential complex to capture peak traffic hours and calculate vehicle speed. The camera recorded videos between 6:00 am and 9:00 am, as depicted in Figure 2a. The speed gun (Bushnell radar) has been used to measure the free flow speed, as illustrated in Figure 2b. The speed measurements were obtained at 6:00 am using a speed gun to target and track moving vehicles. Regarding the travel time, it was computed using the floating vehicle technique. The time was recorded along the road and within the U-turn areas.

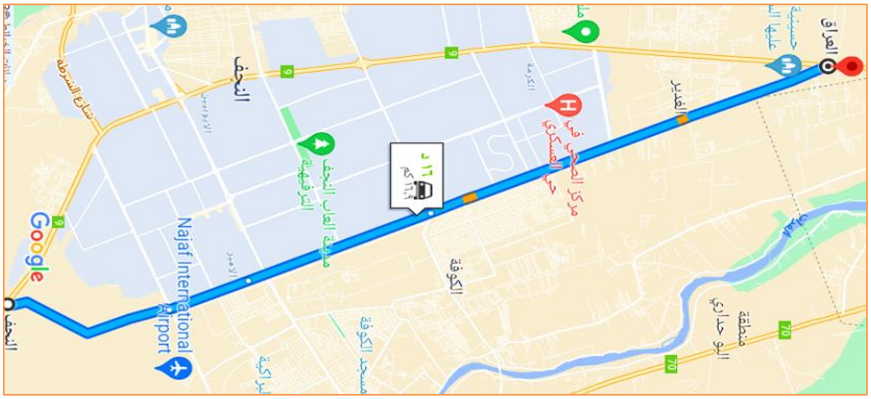

Figure 1: Al-Matar highway by Google map.

a. Video camera **b. Bushnell radar**

Figure 2: Devices used for the research.

3. RESULTS AND DISCUSSION

3.1 Free Flow Speed

Free Flow Speed (FFS) is the driver's anticipated average speed in low-flow and diverse road conditions [10-12]. According to the HCM [10], FFS refers to the mean speed of traffic flow under conditions where drivers are not influenced by other vehicles and where intersection control traffic is either absent or sufficiently distant so as not to impact the selected speed. Speeds were collected at 6:00 am for the street case study by utilizing the gun-speed instrument and directing it toward moving cars. The collected data is presented in Figure 3.

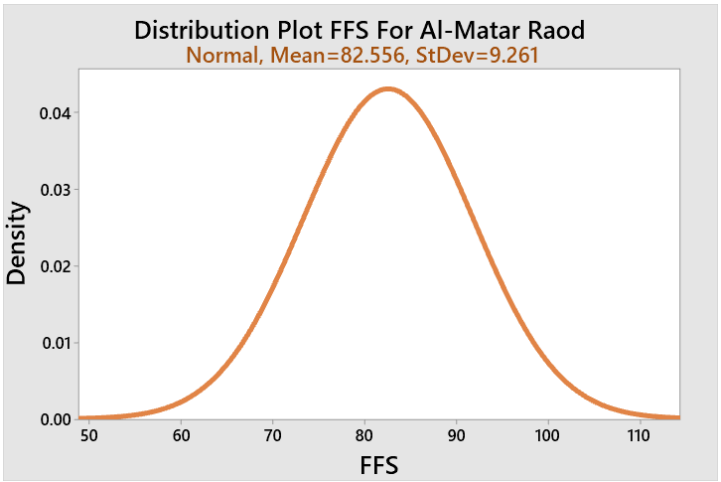

Figure 3: FFS for Al-Matar highway.

3.2 Traffic Flow Rates

Using video cameras in the early morning hours (6:00–9:00 am), traffic flow rates were determined at the study points every five minutes. These measurements were taken to cover peak hours on a variety of days. Table 1 indicates the flow rates at Al-Matar highway in peak hours (7:30–8:30 am) toward Al- Shuhada Bridge; Table 2 shows the other direction toward Al-Radhawia bridges (Wednesday-12/10/2022).

Table 1: The direction of the ring road toward Al-Shuhada bridge.

Time	Passenger car(veh/hr)		Minibus (veh/hr)	Bus (veh/hr)	Truck (veh/hr)	MTR (veh/hr)	Motor (veh/hr)	Flow (veh/hr)
	Private	Taxi						
7:30-7:35	2340	288	60	12	168	48	60	2976
7:35-7:40	2400	240	12	12	252	24	36	2976
7:40-7:45	2100	180	84	0	156	60	48	2628
7:45-7:50	1860	216	192	0	72	48	60	2448
7:50-7:55	3540	420	180	0	240	60	96	4536
7:55-8:00	3600	384	276	12	156	108	168	4704
8:00-8:05	3060	564	132	0	228	108	108	4200
8:05-8:10	2916	480	36	0	300	216	144	4092
8:10-8:15	2340	372	84	12	180	96	132	3216
8:15-8:20	1476	228	24	12	144	108	180	2172
8:20-8:25	1860	216	36	36	228	108	108	2592
8:25-8:30	1608	288	96	0	192	72	60	2316

Table 2: The direction toward Al-Radhawia bridges.

Time	Passenger car (veh/hr)		Minibus (veh/hr)	Bus (veh/hr)	Truck (veh/hr)	MTR (veh/hr)	Motor (veh/hr)	Flow (veh/hr)
	Private	Taxi						
7:30-7:35	1320	264	84	0	180	36	108	1992
7:35-7:40	1380	228	108	12	180	48	48	2004
7:40-7:45	1644	228	96	0	264	72	72	2376
7:45-7:50	1680	192	132	0	180	72	60	2316
7:50-7:55	1320	252	96	12	144	36	96	1956
7:55-8:00	1272	252	120	0	216	60	120	2040
8:00-8:05	1164	132	24	0	120	60	96	1596
8:05-8:10	1092	240	60	0	144	84	96	1716
8:10-8:15	1296	216	36	0	48	36	36	1668
8:15-8:20	1044	192	36	0	180	36	60	1548
8:20-8:25	1140	168	48	0	180	96	36	1668
8:25-8:30	960	216	60	0	264	36	72	1608

3.3 Time Mean Speed and Space Mean Speed

TMS is a measurement used to determine the average spot speed on a road. It is calculated by taking the arithmetic mean of the speeds at which vehicles pass a specific location. Table 3 shows the TMS data.

Table 3: Time mean speed (TMS) for Al-Matar highway.

Time	Avg. travel speed (km/h)	
6:30-6:35	86.2	
6:40-6:45	84.2	
6:50-6:55	75.3	
7:00-7:05	79.7	
7:05-7:10	76.7	
7:15-7:20	72.7	
7:25-7:30	68.2	
7:38-7:48	22.0	
7:50-8:00	22.5	
8:00-8:05	29.4	**TMS (66.2 km/h)**
8:05-8:10	29.4	
8:10-8:15	70.7	
8:15-8:20	76.6	
8:20-8:25	74.8	
8:25-8:30	79.8	
8:35-8:40	75.1	
8:45-8:50	74.3	
8:50-8:55	77.4	
8:55-9:00	71.0	

The diagram shown in Figure 4 represents the relationship between speed and flow during the study period.

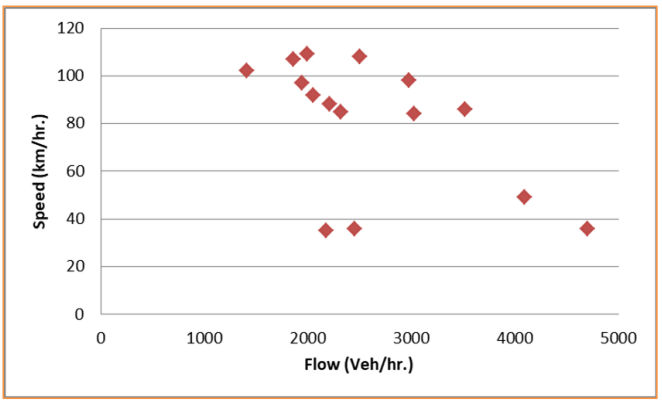

Figure 4: Speed-flow relationship.

The statistical term "space mean speed" is commonly utilized to denote an average speed determined by the mean time vehicles take to traverse a specific segment of road. Table 4 shows the SMS data.

Table 4: Space mean speed (TMS) for Al-Matar highway.

Section	d (km)	Average Travel time (hour)	
SEC. 1	1.3	0.02	
SEC. 2	2.2	0.05	
SEC. 3	0.85	0.01	
SEC. 4	1.3	0.03	
SEC. 5	2.7	0.06	
SEC. 6	1.2	0.03	**SMS (50.9 km/h)**
SEC. 7	3.2	0.06	
SEC. 8	1.8	0.03	
SEC. 9	2.2	0.03	
SUM	16.8	0.33	

3.4 Travel Time

Traffic control measures on a particular section of road are often associated with a reduction in vehicle speeds below the average operating speed. Average travel speed is a measure used to determine transportation speed and its relationship to traffic management. Speed is determined by dividing the length of the segment by the average travel time. Travel time duration includes the entire time requirement to traverse a street segment, considering any stops or obstacles encountered. Field measurements of travel times and traffic delays at crossings can be used to calculate the total travel time, and thus travel speed, along a segment of an urban street. While driving the car and using the "floating car" method, it could calculate how long each part of the trip takes. For this method, the driver controls the test vehicle and drives it along the specified route while maintaining a constant distance from other vehicles. The amount of time it takes to drive the road under study is recorded. Several iterations of the trajectory are carried out to determine the average flight time. There are a variety of statistical factors that must be taken into account when determining the necessary minimum number of experimental runs [5]. The study area was subjected to data collection to ascertain the travel time on different main streets at varying times. This encompassed the periods of highest activity during both weekdays and weekends. The impact of a U-Turn on travel time and speed has been studied. The travel time for Al-Matar road is presented in Tables 5 and 6.

Table 5: Travel time from Al-Radhawia bridges to Al-Shuhada bridges.

From Al-Radhawia bridges To Al- Shuhada bridges				
16.8 km	Wednesday 21/12/2022	7:46 am	one Try	20.4 minute
	Monday 26/12/2022	1:27 pm	Try two	24.22 minute
	Saturday 28/1/2023	8:01 am	Try three Holiday	13.6 minute

Table 6: Travel time from Al-Shuhada Bridge to Al-Radhawia Bridge.

From Al- Shuhada bridges To Al-Radhawia bridges				
16.8 km	Wednesday 21/12/2022	8:08 am	one Try	38.9 minute
	Monday 26/12/2022	1:52 pm	Try two	23.1 minute
	Thursday 21/12/2022	7:46 am	Try three	32.8 minute
	Saturday 28/1/2023	7:45 am	Try four Holiday	15.6 minute

3.5 Influence Of U-Turns on Road Speed

A 16-km multilane route with a median has more than 13 U-turn locations on this site. One of AL-Najaf City's main business districts is the Al-Matar roadway. There are various median openings and U-turn or right-turn points. Several vehicles can't do the U-turn properly, causing delays. Long lineups form along the street because U-turn places at the median opening are close. Thus, it is vital to determine the influence of U-turn movement by estimating the traffic delay at the median opening on the urban street and suitable problem-solving to improve traffic performance.

In addition to the airport and the Al-Zahraa roundabout (formerly the Al-Zahraa Square), the Hawalli-Al-Matar Road features a total of fourteen U-turns along the length of the roadway from the beginning of Al-Radhawia Bridge to the beginning of Al-Shuhada Bridge. Figure 5 is a diagram that illustrates the relationship between speed and these U-turns, as well as the severity of the impact that these U-turns have on speed, which in turn affects the effectiveness of the road, which in U-turns causes traffic jams and delays in travel times.

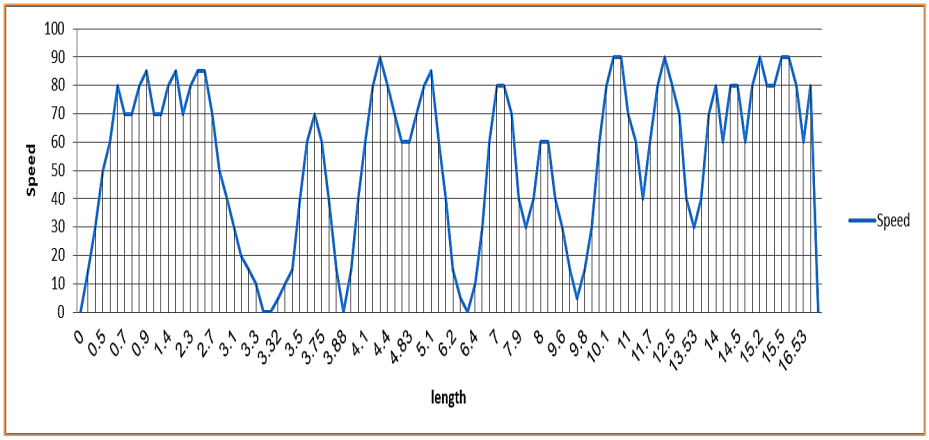

Figure 5: Relationship between speed (km/h) and length (km).

These drops represent the effect of the reduction in speed due to existing of turning vehicles. This effect may extend to 200 m before and after the U-turn location. It was noticed that the speed of the testing vehicle reached zero within the U-turn location because of turning vehicles. These turning vehicles may turn even from the far lane from the U-turn. This behavior leads to closing the whole road, even preventing the through vehicles from proceeding.

3.6 Los of Al-Matar Road

The road has been classified as Class I based on the data computed for the FFS, following the principles of the HCM [7]. According to Table 7, the level of service (LOS) in both street directions has been determined based on (v/c).

Table 7: LOS for Al-Matar road based on v/c.

Direction	FFS	Class	v max.	c	v/c	LOS
From Al-Radhawia bridges	83 km/h	I	1874 vph	3430 vph	0.55	B
From Al- Shuhada bridges	83 km/h	I	3238 vph	3430 vph	0.94	E

4. CONCLUSIONS

- It was observed that there exists a discernible discrepancy in travel time, which amounts to approximately half the duration of travel time during non-peak periods.
- The frequency of U-turns on roadways has a significant impact on travel times, causing a reduction in the average speed of vehicles and leading to heightened levels of congestion and traffic.

- The findings indicate that the Ring Road segment in Najaf City operates at service levels B and E in both directions. This investigation is related to the evaluation of the level of service (B) in the western direction, specifically towards Al-Shuhada Bridge, as well as the level of service (E) in the eastern direction, specifically towards Al-Radhawia Bridges.
- It is recommended that further research on the capacity of U-turns be carried out in order to ascertain the bare minimum length of the U-turn storage lane.

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