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A Case Study on Reducing Traffic Congestion–Proposals to Improve Current Conditions

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Abstract

Traffic congestion has been considered one of the most serious global issues confronting all nations in recent years. Basrah City's highways in general, and particularly the highways surrounding and leading to the University of Basrah, the campus of Bab Azzubair, and the college complex, have experienced traffic congestion and higher delays. The focus of this study is to propose some solutions to mitigate traffic congestion and higher delays on these highways. Field traffic data and questionnaires where SPSS was used to analyse the collected data, and Highway Capacity Software (HCS 2010) was used to assess the level of service (LOS) on the highways. The results showed that the LOS reaches level F on Baghdad Street, while other streets range from level B to level C. Two proposals have been suggested to improve the LOS on Baghdad Street: (1) applying a park-and-ride system; and (2) widening Baghdad Street by adding two lanes in each direction. The LOS for both proposals has been evaluated, and the results showed that the first proposal performed better. The analysis of the collected data also showed that public transportation services are very limited on the highways surrounding and leading to the Bab Azzubair campus. Therefore, public transportation services should be promoted and enhanced in Basrah City.

Keywords: Traffic Congestion; Delay; Level of Service (LOS); Park-And-Ride; University of Basrah (UOB).

1. Introduction

In recent years, traffic congestion has been considered one of the most serious global issues confronting all nations [1–3]. Several factors influence traffic congestion, including bad road surfaces, a lack of road capacity, poor driving behaviour, poor parking practices, poor road markings, a high number of vehicles, insufficient traffic management, insufficient drainage systems, the presence of heavy goods vehicles (HGVs), excessive speeding, poorly designed intersections and roundabouts, and a lack of public transportation [4–6]. Many of these factors exist on Basrah City highways. The highways have also seen an increase in the number of vehicles, with increased numbers of HGVs in recent years [7]. Additionally, prior planning to accommodate this large number of vehicles is lacking. Subsequently, the city's highways continue to suffer from narrowness and suffocation traffic, particularly during peak hours [8]. Traffic delays due to the congestion will have other impacts on work, meetings, and studies, potentially leading to serious social and economic consequences [9, 10]. In addition to traffic delays, traffic congestion can also lead to increased air pollution, fuel consumption, noise, and accidents [11].

The highways of Basrah City in general and the highways surrounding and leading to the University of Basrah (UOB), the Bab Azzubair campus in particular, have experienced traffic congestion and higher delays, especially during morning and evening peak hours. Therefore, students and staff waste their time in the streets and are late for work and lectures due to the accumulation of vehicles on the highways. The present study will try to investigate the causes of traffic congestion and delays on the highways surrounding and leading to the campus of Bab Azzubair. Also, this study will try to propose some traffic solutions to mitigate the traffic congestion and delays on these highways.

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The methodology of this study includes (1) studying causes of traffic congestion on the highways surrounding and leading to the Bab Azzubair campus (as described by the previous studies), (2) collecting and analysing traffic data, and (3) proposing traffic solutions to mitigate traffic congestion. Figure 1 illustrates the study methodology.

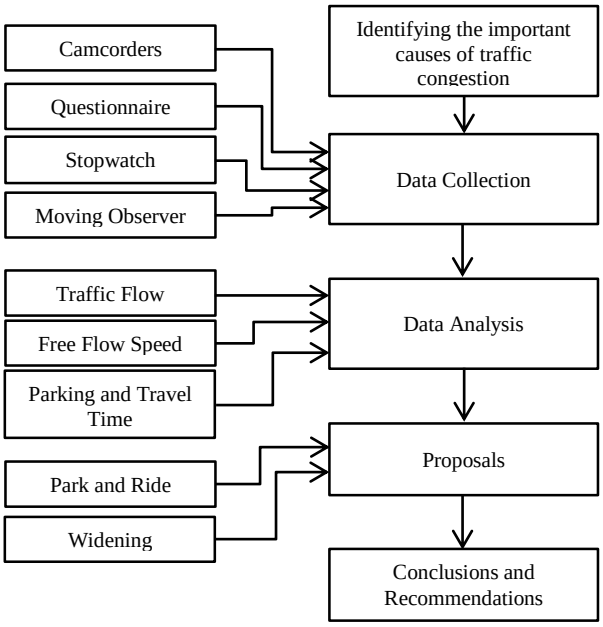

Figure 1. Research Methodology Flowchart

2. Previous Studies

Traffic congestion and delays on highways surrounding and nearby university campuses have been extensively studied by previous research studies. Hamo [12] conducted a study on traffic congestion in Dohuk City, focusing on the university area. The researchers reported that the majority of students and staff of the University of Dohuk (UOD) have been found driving their own vehicles or taking private taxis due to a lack of public transportation. Additionally, they reported that the lack of parking spaces near the UOD campus, especially for students, led students to park their vehicles on the streets, further leading to traffic congestion and delays for both staff and students. The researchers suggested the following remedies: (1) improving and supporting public transportation in Dohuk City; (2) providing more parking spaces and constructing more sidewalks on the UOD campus; (3) encouraging students and staff to ride bicycles on the UOD campus; and (4) constructing a new ring road for the UOD campus. Aoun et al. [13] conducted a study on traffic congestion and parking issues for the American University of Beirut (AUB). The researchers found that the population of the AUB campus has a higher rate of vehicle ownership than the rest of Lebanon. In addition, they found a lack of organised public transportation and effective law enforcement in Beirut. The researchers proposed a dynamic taxi-sharing mode to reduce own-vehicle trips at the AUB. Al-Mosaind [14] studied traffic conditions on the King Saud University (KSU) campus. The researcher reported that the higher rate of vehicle ownership and lack of public transportation are the main reasons for traffic congestion and parking shortages. He suggested that public transportation and the pedestrian environment should be enhanced and promoted by the KSU. Additionally, several previous studies reported that traffic congestion can be reduced by prompting public transportation (see, for example, [11, 15–18]).

Taha & Ali [19] conducted a parking study at the University of Mosul main campus. The researchers reported that the campus experienced higher delays at the campus gates and increased traffic volumes on its streets. Likewise, they found that higher percentages of staff use their own vehicles for commuting from and to the university campus. The researchers suggested developing an effective transit system to connect several locations within the campus. Additionally, they suggested promoting the walking environment by connecting all campus gates, the most important buildings and transit stations, and other popular pedestrian destinations. Kaplan & Clapper [20] reported that most of the traffic congestion problems on university campuses occurred around campus gates or near parking facilities. Additionally, several previous studies reported that on-street parking [21] and inappropriate parking manoeuvres [22] can cause traffic congestion and higher delays.

In general, the previous studies indicate that the most important factors that lead to traffic congestion near university campuses are: (1) a lack of public transportation services; (2) a higher rate of vehicle ownership; and (3) a lack of parking spaces. However, no study has been found in the literature to address traffic congestion on the highways surrounding and leading to Bab Azzubair campus, UOB.

This study aims to investigate the causes of traffic congestion and delay on the highways surrounding and leading to the campus of Bab Azzubair, as suggested by the previous studies. The study will also assess the level of service (LOS) by using the Highway Capacity Software (HCS 2010) based on the Highway Capacity Manual (HCM 2010) [23]. To propose some traffic solutions to mitigate the traffic congestion and delay on those roads.

3. Data Collection

Several data collection techniques were used, such as camcorders, the moving observer method (MOM), stopwatches, and questionnaires. The data collected by camcorders has been used to compute traffic volumes and vehicle classifications. The data collected by the MOM were used to compute the average travel time and free flow speed (FFS). The stopwatch method was used to calculate the spot speed for direct field measurement of FFS. The questionnaire was used to gain a better understanding of the UOB population's characteristics and commuting habits, vehicle ownership, and traffic volumes. Four multi-lane divided highways surrounding and leading to the UOB Bab Azzubair campus have been chosen to collect the field traffic data. These four multi-laned divided highways are (1) Baghdad Street, (2) Zubair Street, (3) the street off Zubair Street, and (4) Qibla Street. Figure 2 shows the site location map of the Bab Azzubair campus along with the four highways. The following sections will describe the data collection techniques.

Figure 2. Site location map (source of map: ArcMap, 10.7.1)

3.1. Camcorders

Field traffic data collected by camcorders has been used to compute traffic volumes and vehicle classifications. Four highway sites surrounding and leading to the UOB Bab Azzubair campus were chosen to collect the data. Table 1 summarises the details of the four selected highway sites. Several sets of traffic data were collected during autumn 2020, between September 22nd and November 3rd. The traffic data were collected during the weekdays and during morning and evening peak hours from 7:00 until 15:00. All field data were collected during the COVID-19 pandemic.

Table 1. Details of the selected highways

Site No.	Site location	Traffic direction	Number of lanes	Date	Duration
1	Baghdad Street	Both directions	4 in each direction	Tuesday (22/09/2020) & Wednesday (23/09/2020)	3h morning and 3h afternoon (6h total)
2	Zubair Street	Both directions	4 in each direction	Wednesday (30/09/2020) & Monday (19/10/2020)	3h morning and 3h afternoon (6h total)
3	Street off Zubair street	One direction	3	Tuesday (03/11/2020) & Tuesday (20/10/2020)	3h morning and 3h afternoon (6h total)
4	Qibla Street	Both directions	3 in each direction	Monday (26/10/2020) & Tuesday (27/10/2020)	3h morning and 3h afternoon (6h total)

Baghdad Street (site no. 1) is a dual carriageway with four lanes in each direction. The data collection was conducted over two days on Tuesday (22/09/2020, from 7:00 until 10:00) and on Wednesday (23/09/2020, from 12:00 to 15:00). Two camcorders were used for data collection, and they were installed on a footbridge. Zubair Street (site no. 2) is also a dual carriageway with four lanes in each direction. The data collection was conducted over two days on Wednesday

(30/09/2020, from 7:00 until 10:00) and on Monday (19/10/2020, from 12:00 to 15:00). Two camcorders were also used and installed on a footbridge. The street off Zubair Street (site no. 3) is a three-lane single carriageway with one movement direction. The data collection was conducted over two days: on Tuesday (03/11/2020, from 7:00 until 10:00) and on Tuesday (20/10/2020, from 12:00 to 15:00). One camcorder was used and installed by using a tripod on the selected segment. Qibla Street (site no. 4) is a dual carriageway with three lanes in each direction. The data collection was conducted over two days: on Monday (26/10/2020, from 7:00 until 10:00) and on Tuesday (27/10/2020, from 12:00 to 15:00). Two camcorders were used for data collection, and they were installed on tripods.

3.2. Questionnaires

The purpose of using questionnaires is to collect data about a population's characteristics, commuting habits, and vehicle ownership. Additionally, the COVID-19 pandemic forced the UOB to explore innovative methods of learning and teaching, such as e-learning and distance education. Therefore, part of the questionnaire was dedicated to studying the traffic volume generated from the Bab Azzubair campus and its impact on the roads leading to the campus. The questionnaire was divided into two main groups: private vehicle users and public transportation users. Demographic information such as sex, marital status, occupation, and educational level of staff and students were also included. Arrival and departure time, parking location, which highway was used to drive to the Bab Azzubair campus, and which gate was used to enter the campus are all included in the questionnaire. Further details of the questionnaire information can be found elsewhere [24]. The population of the Bab Azzubair campus is 16,342, which comprises the number of students and staff for the 2020–2021 academic year. Table 2 summarises the campus population. A large number of participants participated and answered the questionnaire. The number of participants was 4021, and 91% of the participants were students.

Table 2. Summary of the Bab Azzubair campus population (for 2020 – 2021)

No.	Institution	Number of Students	Number of Staff
1	College of Administration and Economics	4426	281
2	College of Literature	6603	212
3	College of Arts	1334	180
4	College of Law	1249	133
5	Girls' Education College	657	135
6	Al-Zahraa College of Medicine	880	70

3.3. Stopwatch

Spot speed studies were conducted in this study by using the stopwatch technique to measure the FFS. Several techniques can be used for spot speed, such as stopwatches, radar metres, and pneumatic road tubes. The stopwatch technique was used in this study because it is efficient, straightforward, and economical [25]. The spot speed data were collected over two days, March 11 (from 7:00 to 10:30) and October 20 (from 12:00 to 15:00), 2020. The data were collected only from site no. 3 (the street off Zubair Street).

3.4. Moving Observer Method

The MOM has been used to measure the FFS factor for two segments on Baghdad Street, one segment on Zubair Street, and one segment on Qibla Street. To obtain unbiased FFS data, the data were collected during weekdays, during morning off-peak hours, and during good weather conditions, as suggested by Che Puan et al. [26]. The data were collected in January 2021 from 9:00 to 11:00. Che Puan et al. [26] and Mortimer [27] reported that six runs in each traffic direction can be considered sufficient to obtain accurate and fair estimates of measuring variables. However, for this study, 10 runs were implemented for each segment. Additionally, the MOM was used to measure travel time for Baghdad Street, Zubair Street, and Qibla Street. Table 3 summarises the details of the selected highway segments.

Table 3. Details of the selected segments

Site location	Traffic direction	Segment length (m)	Date	Duration
Baghdad Street (Segment 1)	Northbound	4600	Sunday (17/01/2021)	2h, (09:00-11:00) a.m.
	Southbound	4600	Sunday (17/01/2021)	2h, (09:00-11:00) a.m.
Baghdad Street (Segment 2)	Northbound	4300	Monday (18/01/2021)	2h, (09:00-11:00) a.m.
	Southbound	4300	Monday (18/01/2021)	2h, (09:00-11:00) a.m.
Zubair street	Westbound	1000	Wednesday (20/01/2021)	1h, (10:00-11:00) a.m.
	Eastbound	1000	Wednesday (20/01/2021)	1h, (10:00-11:00) a.m.
Qibla Street	Northbound	1500	Wednesday (27/01/2021)	2h, (09:30-10:30) a.m.
	Southbound	1500	Wednesday (27/01/2021)	2h, (09:30-10:30) a.m.

4. Data Analysis

4.1. Traffic Flow and Vehicle Classification

As discussed in Section 3, traffic flow and vehicle classification data have been collected by two means: camcorders and questionnaires. To extract and analyse the data that was collected by the camcorders, the recorded films were replayed on a laptop screen, and a manual count of vehicles was made as soon as the front of a vehicle passed on a reference line on the laptop screen. The number of vehicles travelling in both directions on the selected highway during the morning and evening periods was counted separately. The morning period was from 7:00 to 10:00, whereas the evening period was from 12:00 to 15:00. Fifteen-minute intervals were used to group the collected data as suggested by Garber & Hoel [28] and then converted to hourly traffic flows for each interval. Vehicles were then classified into three classes: passenger cars, HGVs, and buses.

SPSS Statistics 26 was used to analyse the data that was gathered by the questionnaire. To present the results of the questionnaire in the form of tables and charts, cross tables were used to calculate frequencies and percentages. To compute traffic volume and vehicle classification, an analysis was carried out using descriptive statistics. In the questionnaire, participants were requested to answer some questions regarding their arrival and departure times, the type of vehicle used, and which roads were used to enter the campus.

The total traffic volume of the selected highways leading to the university campus was calculated by summing the traffic volume resulting from the camcorders with the traffic volume resulting from the questionnaire. Table 4 shows the traffic flow data for morning peak hours for sites nos. 1, 2, 3, and 4 for each direction of movement, whereas Table 5 shows traffic flow data for evening peak hours. Table 6 shows the composition of the traffic for sites nos. 1, 2, 3, and 4.

Table 4. Traffic flow data for morning peak hours

Time interval	Traffic Flow (veh/hr)						
	Site No.1 Northbound	Site No.1 Southbound	Site No.2 Westbound	Site No.2 Eastbound	Site No. 3	Site No.4 Northbound	Site No.4 Southbound
07:00 – 07:15	2180	2972	2424	2460	824	660	372
07:15 – 07:30	2132	3132	3012	2952	904	840	436
07:30 – 07:45	2424	3772	3552	3336	1140	848	560
07:45 – 08:00	2656	3728	3640	3296	968	1376	784
08:00 – 08:15	4232	5872	5164	5340	2088	1804	1488
08:15 – 08:30	4456	4360	4668	4920	1508	2060	2020
08:30 – 08:45	7528	8020	6936	7484	2748	2780	2628
08:45 – 09:00	5828	6604	6576	7056	1900	2092	2116
09:00 – 09:15	5424	5416	4692	5408	1656	1592	1684
09:15 – 09:30	4592	5432	4356	5100	1260	1108	1048
09:30 – 09:45	2932	4052	2552	3612	1044	772	796
09:45 – 10:00	2632	3580	2672	3388	1068	700	896

Table 5. Traffic flow data for evening peak hours

Time interval	Traffic Flow (veh/hr)						
	Site No.1 Northbound	Site No.1 Southbound	Site No.2 Westbound	Site No.2 Eastbound	Site No. 3	Site No.4 Northbound	Site No.4 Southbound
12:00 – 12:15	2680	3176	2712	4620	848	772	864
12:15 – 12:30	2692	3332	2748	4500	712	580	900
12:30 – 12:45	2684	3360	2880	4712	800	780	1008
12:45 – 13:00	2864	3312	2808	4600	728	748	844
13:00 – 13:15	2888	3536	3244	5064	1100	1136	1200
13:15 – 13:30	3328	3620	3256	4628	852	996	1016
13:30 – 13:45	3884	4036	4092	6112	1648	1776	1932
13:45 – 14:00	4876	5188	4568	5612	1196	1148	1412
14:00 – 14:15	6348	6512	5780	7288	2020	2168	2080
14:15 – 14:30	4232	4400	5972	6752	1428	1232	1416
14:30 – 14:45	3616	3924	4172	4808	1268	1056	960
14:45 – 15:00	3124	3652	4628	4852	1076	824	1060

Table 6. Summary of vehicle composition for the selected highways

Site No.	Vehicles Composition (%)		
	Passenger Cars	HGVs	Buses
Site No. 1	89.8	7.4	2.8
Site No. 2	89.6	6.6	3.8
Site No. 3	88.9	4.6	6.5
Site No. 4	94.6	2.8	2.6

Tables 4 and 5 show that the traffic flow conditions for Baghdad Street and Zubair Street range from moderate to heavy traffic flow conditions. For both sites (i.e., sites nos. 1 and 2), the traffic flow started from around 2500 veh/hr at 07:00 and slightly increased to around 3500 veh/hr at 08:00, then increased dramatically up to around 7500 veh/hr during the period from 08:30 to 08:45. After it reached its peak flow, the traffic flow then decreased to around 3000 veh/hr at 10:00. Both sites were kept running with a traffic flow of around 3000 veh/hr until 13:30, then increased dramatically up to around 6500 veh/hr during the period from 14:00 to 14:15. After 14:30, traffic flow started decreasing until it reached 3000 veh/hr at 15:00. The lectures for the morning sessions of the UOB start at 08:30 and finish at 14:30, whereas the lectures for the evening sessions of the UOB start at 14:30 and finish at 20:30. This indicates that during these periods (i.e., starting and finishing), the traffic flow reached its peak for both Baghdad Street and Zubair Street, as shown in Tables 4 and 5.

The traffic flow for sites nos. 3 and 4 ranges from free to moderate traffic flow conditions, as shown in Tables 4 and 5. Likewise, traffic flow for sites nos. 3 and 4 increased slightly from around 750 veh/hr at 07:00 up to around 1000 veh/hr at 08:00. Then, it increased dramatically during the interval of 08:30–08:45, up to around 2750 veh/hr. Likewise, the evening peak (for sites nos. 3 and 4) occurred during the interval of 14:00 to 14:15 with a traffic flow of around 2000 veh/hr. Likewise, it can be concluded that the streets off Zubair Street and Qibla Street reached their peaks during the starting and finishing periods of the UOB.

Table 6 shows that the percentage of buses that are travelling to the selected sites has a very low value. It was around 3% for sites nos. 1, 2, and 4, except 6.5% for site no. 3. This indicates that public transportation services are very limited in Basra. This conclusion is in good agreement with the findings of previous studies, as discussed in Section 2 [12–14].

4.2. Free Flow Speed

As mentioned in Section 3, FFS data have been collected by two means: the stopwatch method and MOM. The stopwatch technique was used only for site no. 3 (i.e., the street off Zubair Street). Two reference points were chosen and labeled 'start-point' and ‘end-point’, 150 metres apart. Two brightly coloured traffic cones were placed at the points to enhance the precision by providing a suitable line of sight to the observers. The observers start the stopwatch when a vehicle’s front wheels cross the start point, and then, when the vehicle’s front wheels cross the end point, the stopwatch stops. Simple calculations of distance over time were used to calculate the speeds.

The MOM was used to measure the FFS for Baghdad Street, Zubair Street, and Qibla Street (as shown in Table 3). The Manual of Transportation Engineering Studies [29] reported that the observer should travel at the average speed of the traffic stream along the selected segment. A test car supplied with a camcorder was used to travel along the selected segments. Real-time traffic events throughout the period of the test runs were captured on video. Then, the observer reviewed the recorded traffic events by playing them back on a computer and analysing them. Table 7 shows the FFS data for the selected segments.

Table 7. Free flow speed (FFS) data

Site location	Traffic direction	Method	FFS (km/hr)
Baghdad Street (Segment 1)	Northbound	MOM	80.5
	Southbound	MOM	81.1
Baghdad Street (Segment 2)	Northbound	MOM	81.8
	Southbound	MOM	79.8
Zubair street	Westbound	MOM	82.3
	Eastbound	MOM	81.1
Street off Zubair street		Stopwatch	70.9
Qibla Street	Northbound	MOM	75.1
	Southbound	MOM	76.2

Table 7 shows that the FFS for Baghdad Street (both segments) and Zubair Street was around 80 km/hr. Baghdad Street and Zubair Street have different posted speed limits for each lane: 40 km/hr for lane 1 (i.e., nearside lane), 40 km/h for lane 2, 60 km/hr for lane 3, and 80 km/hr for lane 4 (i.e., offside lane). This indicates that the motorists drive at an average speed close to the posted speed limits.

Additionally, Table 7 shows that the FFS for Qibla Street was 75 km/hr and 70 km/hr for the street off Zubair Street. The posted speed limit for both Qibla Street and the street off Zubair Street is 40 km/hr. This indicates that the motorists drive at an average speed higher than the posted speed limit. This could be due to the free to moderate traffic conditions for both Qibla Street and the street off Zubair Street, as discussed in the previous section.

4.3. Parking Location and Travel Time

The location of the parking area is one of the factors that could affect the traffic flow and lead to traffic congestion, especially during peak hours. For this study, some questions in the questionnaire were dedicated to parking. Figure 3 shows the percentages of vehicles for students and staff and where they parked their vehicles on the Bab Azzubair campus.

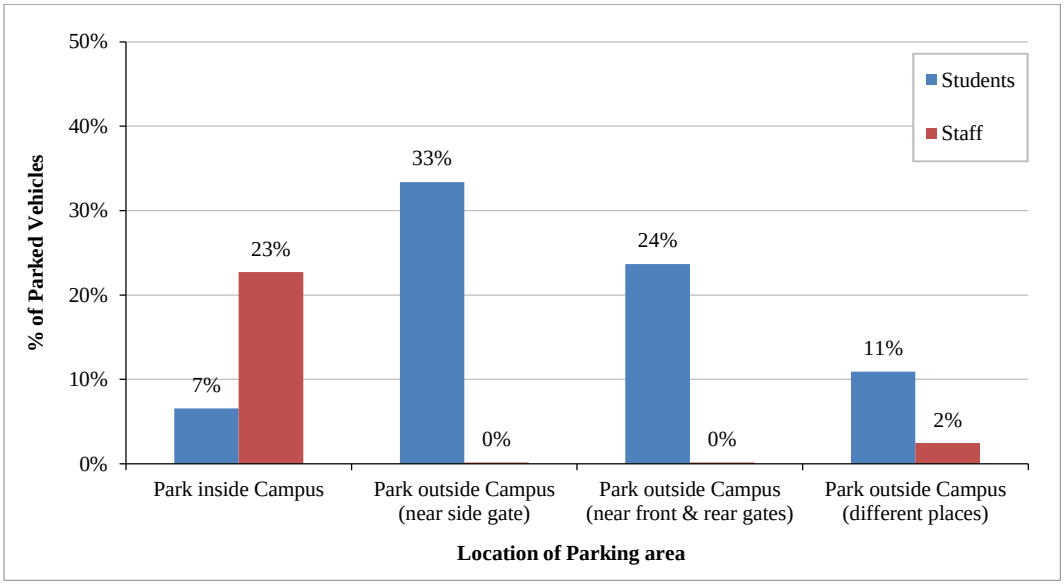

Figure 3. Parking locations for students and staff of the Bab Azzubair campus

Figure 3 shows that (1) 33% of vehicles park outside the Bab Azzubair campus near the side gate of the campus; (2) 24% of vehicles park outside the campus near the front and rear gates of the campus; (3) 30% of vehicles park inside the campus; and (4) 13% of vehicles park outside the campus in different places. The majority of vehicles (i.e., 33%) were observed parking near the side gate of the campus. This will affect the traffic flow conditions on the street off Zubair Street. Additionally, the analysis of the questionnaire showed that 24% of vehicles are parked outside the campus near front and rear gates, potentially affecting the traffic flow conditions on Baghdad Street and Qibla Street.

The travel time parameter was also investigated in this study. It was measured via the MOM and the questionnaire. Table 8 shows the travel time and delay measured by the MOM for Baghdad Street, Zubair Street, and Qibla Street, whereas Figure 4 shows the travel time measured by the questionnaire for all the selected highways.

Table 8. Summary of travel time and delay measured by the MOM

Site location	Segment length (m)	Posted Speed Limit (km/h)	Travel Time (seconds)	Delay (seconds)
Baghdad Street	4600	60	398	122
Zubair street	1000	60	116	56
Qibla Street	1500	40	100	0

Table 8 shows that Baghdad Street and Zubair Street experienced longer travel times and delays than Qibla Street. Figure 4 shows good agreement with Table 8, and Figure 4 further shows that Baghdad Street and Zubair Street experienced longer travel times than other streets. This could be due to the heavy traffic conditions on Baghdad Street and Zubair Street during the start and finish of the UOB school hours, as discussed in Section 4.1.

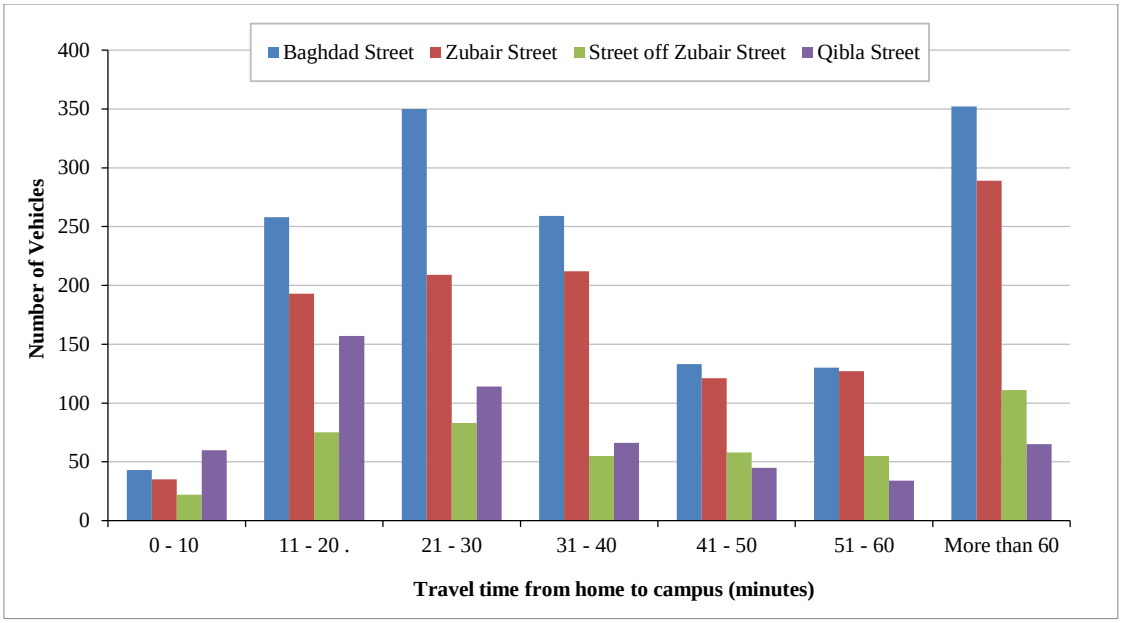

Figure 4. Summary of travel time measured by the questionnaire students and staff of Bab Azzubair campus

5. Level of Service

The level of service (LOS) for all the selected highways was calculated using Highway Capacity Software (HCS 2010). All required inputs from the HCS, such as traffic volume, peak hour factor, and FFS, have been calculated and input into the software. Table 9 shows the LOS results for all selected highways for both morning and evening periods.

Table 9. LOS calculated by HCS 2010 for all multi-lane selected highways

Site No.	Site location	Traffic direction	Number of lanes	LOS during Morning period	LOS during Evening period
1	Baghdad Street	Northbound	4 in each direction	F	F
		Southbound		F	F
2	Zubair Street	Westbound	4 in each direction	C	C
		Eastbound		C	C
3	Street off Zubair street	One direction Southeast	3	C	B
4	Qibla Street	Northbound	3 in each direction	C	B
		Southbound		C	B

Table 9 shows that Baghdad Street has the worst possible LOS at level F. The LOS for Zubair Street is C. The LOS for the street off Zubair Street and Qibla Street is level C for the morning period and LOS B for the evening period. To improve the LOS for Baghdad Street, two proposals have been suggested, as discussed in the following sections.

5.1. First Proposal: Park and Ride

The first proposal is represented by applying a park-and-ride system to improving the LOS for Baghdad Street. A new garage parking area is suggested to be constructed on Zubair Street towards the west. Figure 5 shows the new garage, which is titled “Garage Parking No. 1”, two “P” letters highlighted in pink were used to mention the new garage in the figure. The students and staff driving on Baghdad Street should be advised to park their vehicles in the new garage parking area and use the free shuttle buses that will be provided to transport the students and staff from the new garage parking to the Bab Azzubair campus and vice versa. Figure 5 also shows the routes that should be used by the shuttle buses; these routes, “path 2," are highlighted in yellow. Additionally, the students and staff driving on Baghdad Street should also be advised to change their route from Baghdad Street to other adjacent highways (as shown in Figure 5, these adjacent highways are “pathway new,” highlighted in turquoise colour). Furthermore, the students and staff who are driving on Zubair Street should also be advised to park their vehicles in the new garage parking and ride the free shuttle buses to the Bab Azzubair campus.

Figure 5. Aerial view of the proposed garage parking toward the west of Zubair Street

To validate the first proposal, the LOS for both Baghdad Street and Zubair Street was evaluated using HCS (2010) during the morning and evening periods. Table 10 shows the LOS for Baghdad Street and Zubair Street after applying the first proposal (i.e., park-and-ride).

Table 10. LOS for Baghdad Street and Zubair Street after applying the first proposal (park-and-ride)

Site location	Traffic direction	LOS during Morning period	LOS during Evening period
Baghdad Street	Northbound	C	B
	Southbound	B	B
Zubair Street	Westbound	B	B
	Eastbound	B	B

Table 10 shows that the LOS for both Baghdad Street and Zubair Street has been improved. Particularly for Baghdad Street, the LOS has been significantly improved.

5.2. Second Proposal: Widening Baghdad Street

The second proposal is represented by widening Baghdad Street by adding two lanes in each direction. Baghdad Street will have six lanes in each direction. To validate the second proposal, the LOS was evaluated by using the HCS (2010) for Baghdad Street during the morning and evening periods. Table 11 shows the LOS for Baghdad Street after adding two lanes in each direction.

Table 11. LOS for Baghdad Street after adding two lanes in each direction

Site location	Traffic direction	LOS during Morning period	LOS during Evening period
Baghdad Street	Northbound	C	C
	Southbound	C	D

Table 11 shows that the LOS for Baghdad Street has been improved after adding two lanes in each direction. The LOS has been improved from level F (as shown in Table 9) to level C. This is in good agreement with the study by Abbas et al. [30], who suggested adding a new road to reduce the negative impacts of freight trips on traffic flow conditions. The result of the study showed that LOS improved from level D to level C at peak hours.

However, the first proposal (i.e., park-and-ride) shows better performance than the second proposal (i.e., widening). The LOS for the first proposal was improved from level F (as shown in Table 9) to level B (as shown in Table 10).

6. Conclusion

The aim of this paper is to obtain a good understanding of the causes of traffic congestion and higher delays on the highways surrounding and leading to the Bab Azzubair campus. Additionally, this paper tries to propose some solutions to mitigate traffic congestion and delays on these highways. Field traffic data and questionnaires were collected. The analysis of the collected data showed that the percentage of buses that are travelling on the selected highways has a very low value of around 5%. This indicates that public transportation services are very limited in Basra City. Therefore, public transportation services should be promoted and enhanced in Basrah City. In addition, analysis of the collected data showed that both Baghdad Street and Zubair Street experienced heavy traffic conditions and longer travel times compared with the other two selected highways. Morning and evening peak periods for all selected highways occurred during the starting and finishing of the UOB school hours. Most of the students use the main gate to enter the Bab Azzubair campus, whereas the back gate has the lowest rate of being passed through by the students. The LOS for all the selected highways was calculated using the HCS (2010). The results showed that Baghdad Street has the worst LOS among the four highways leading to the Bab Azzubair campus, with level F. To improve the LOS on Baghdad Street, two proposals have been suggested: (1) applying a park-and-ride system; and (2) widening Baghdad Street by adding two lanes in each direction. The LOS for both proposals has been evaluated, and the results showed that the first proposal performed better. It is suggested to implement a park-and-ride system by constructing a new garage parking lot on Zubair Street. Additionally, the students and staff of the Bab Azzubair campus should be encouraged to use public transportation. Students should also be divided into groups based on where their colleges are, rather than entering the campus through the same gate.

7. Declarations

7.1. Author Contributions

Conceptualization, I.T., Z.N., and L.A.; methodology, I.T., Z.N., and L.A.; formal analysis, I.T., Z.N., and L.A.; investigation, I.T., Z.N., and L.A.; data collection, I.T.; writing—original draft preparation, I.T., Z.N., and L.A.; writing—review and editing, I.T., Z.N., and L.A. All authors have read and agreed to the published version of the manuscript.

7.2. Data Availability Statement

The data presented in this study are available on request from the corresponding author.

7.3. Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

7.4. Conflicts of Interest

The authors declare no conflict of interest.

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