# CAPACITY ESTIMATION OF URBAN ROAD IN BAGHDAD CITY: A CASE STUDY OF PALESTINE ARTERIAL ROAD 

Zainab Ahmed Alkaissi<br>Department of Highway and Transportation Engineering, College of Engineering, Al-Mustansiriyah University, Baghdad, Iraq<br>E-Mail: dr.zainabalkaissi77@uomustansiriyah.edu.iq


#### Abstract

Palestine urban street one of the most important urban arterials rods in Baghdad city. Severe congestion conditions at PM peak time periods (4:00-9:00) which become very concern problems regarding its location which considered as one of the most attractive region in Baghdad city due to the mixed land use surrounding this urban arterials road. In this research two links are selected namely as Link (1) from Al-Mawall Intersection to to Al-Nakhla Intersection and Link (2) from Al-Nakhla Intersection to Al-Skharah Intersection. The results of hourly traffic flow rate showed scattering of observed data and there is no fitting relation between flow and speed for both Link (1) and link (2). The absence of both commitment and responsibility for traffic rules, poor pavement surface conditions, illegal on street parking conditions that reduced number of lanes; driver behaviour of sharing carriageway and disturbance manoeuvres ..etc., due to all these factors the direct empirical method for capacity estimation are adopted based on observed volume and fundamental diagram method. The heavy congestion conditions for south direction of link (1) and north direction for Link (2) with V/C ratio of 1.2 and 1.4 respectively. Also the saturation conditions occurs at Link (1) and (2) at jam density of approximately ( $100 \mathrm{veh} / \mathrm{km}, 58 \mathrm{veh} / \mathrm{hr}, 60 \mathrm{veh} / \mathrm{hr}, 70 \mathrm{veh} / \mathrm{hr}$ ) for south and north directions respectively.


Keywords: capacity, direct empirical method, arterial, hourly traffic flow, saturation conditions, jam density.

## 1. RESEARCH OBJECTIVES

The aim of this research is to estimate the capacity of a major arterial road in Baghdad city and a case study is selected for Palestine arterial street which considered as one of the most urban roads that pass through mix of land uses characteristics: residential, commercial and educational. Based on limited studies for capacity assessment for arterial roads and due to diverse and complications of high traffic volume and various vehicle maneuvering with lane changing of driver behavior that all give rise to heterogeneous of traffic behavior for urban arterial Iraqi roads ; and due to all previous facts a capacity analysis should be concerned . An empirical direct method of observed volume and speed are studied and used for capacity estimation of mid block section of two links; Link (1) from Al- Mawall Intersection to Al-Nakhla Intersection and Link (2) from Al-Nakhla Intersection to Al-Skharah Intersection.

## 2. INTRODUCTION

One of the problems that all metropolitans cities are the high level of traffic congestions of arterial major roads due to the rises of using vehicular mode of transportation. Oversaturation conditions appeared due to the demand volume exceed the capacity of roads and this intern produced unstable conditions that affect on the capacity of major arterials; therefore the capacity is a major factor that should be considered for traffic engineer and for transportation planning. The capacity of a road can be defined as maximum number of vehicles per unit time as hour or day. Several factors affect on capacity such as; geometric design element (lane width, median, access points, pavement and shoulder conditions, etc.); traffic conditions and environmental conditions.

Gajjar and Mohandas (2016) analyzed the existing critical potential capacity of major roads in

Mumbai and the obtained results for volume per lane were beyond the capacity and not withstanding excessive volume. Joseph and Nagakumar (2014) studied different parameters such as capacity, level of service and volume to capacity ratio, average journey travel time and average delay time to get the measures of improvement for midblock section. The obtained results for level of service was found to be F during the survey period and a 17 min . travel time is obtained that required to travel 3.8 km stretch during the peak hour with travel speed of $13 \mathrm{~km} / \mathrm{hr}$. Sony signal should be done as improvement measures in junctions where maximum delay is occurring.

Pratik Mankar and B.V Khode (2016) found the capacity of urban roads by using Greenshield model and compared the results with microscopic simulation model. and concluded that increased lane width maximize the capacity as well. Al-Ghamdi, A. (2001),(1999) studied the distribution of time headway which follow Gamma distribution which considered as empirical direct methods for capacity estimation. The Erlang headway time distribution found to fit the field observed data at high traffic flow. Chang and Kim, (2000) used the quantitative methods to define capacity by estimating the distribution of headway and volume from the obtained field traffic flow data. They concluded that to take $95 \%$ cumulative distributions of observed traffic flow and eliminating 5\% of long headways. Sara, M. (2014) found that an appropriate models for headway distribution for heavy vehicles and passenger cars at different flow rates using Chi-Square test. The time headway distribution variation for heavy vehicles and passenger cars is refer to the different behavior of drivers under congestion in the vicinity of heavy vehicles and passenger cars.

Alkaissi, Z. (2017) developed model for Palestine arterial street in Baghdad for travel time and delay based on the obtained field traffic data. And a best fit is
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presented as compared the prediction models with observed field travel time data. Higher delay is observed on $\operatorname{link}(1),(2)$ and (3) in terms of $95 \%$ percentile travel time of about (301.9, 219.4, and 193.8)sec. for Link (1, 2 and 3 ) respectively.

## 3. STUDY AREA

Palestine Arterial Street is one of the major arterial roads in Baghdad city as shown in Figure-1 which is located in the east of Baghdad and its run parallel to the west of Army Canal between AlMustainsiriyah Square through Beirut square to the Maysalone Square. It is six lane divided carriageway 3 lane each direction. In this research two links are selected namely as Link (1) from Al-Mawall Intersection to Al-Nakhla Intersection and Link (2) from Al-Nakhla Intersection to Al-Skharah Intersection. These selected two links are most loaded and congested due to dramatically changing in residential, commercial and educational surrounded land use area that created a potential pressure of additional attraction and production daily trips that produce the oversaturation conditions in traffic flow where the demand exceed the design capacity of roads.


Figure-1. Study area of urban arterial palestine street with selected region of two links.

## 4. DATA COLLECTION

Two days take up for the collection of field data on Monday 22/5/2017 and Tuesday 23/5/2017 for traffic volume and speed with good weather conditions (sunny) and good visibility with adequate and appropriate distance from the mid block of selected two links in this research. Time survey periods from 4 p.m. to 9 p.m. are adequate duration to involve the peak and non peak traffic demand volume which utilised to find the critical demand volume and identify the trend of traffic volume.

Also A stop watch is used for speed data collection to record the pass time between two successive vehicles. The data for traffic speed estimation are analysed for the obtained field sample data of 30 set recorded
during the time periods from (4:00 p.m. - 9:00 p.m.). The conduction of spot speed study at mid block of selected links enhanced the distribution of traffic speed.

## 5. RESULTS AND DISCUSSIONS

### 5.1 Analysis of traffic volume demand

Depending on the established field data for traffic volume for two studied links; link (1) from Al-Mawall Intersection to to Al-Nakhla Intersection and Link (2) from Al-Nakhla Intersection to Al-Skharah Intersection during the time periods from 4:00 p.m. to 9:00 p.m., the hourly variations of volume are shown in Figures (1) and (2) for the selected links in both north and south directions. The trend of traffic volume for Link (1) increased gradually with time periods from 4 p.m. and reach maximum flow at 9 p.m. and the traffic volume in south direction are greater than in the north direction. Link (2) demonstrated oscillate variation of traffic volume and achieved maximum hourly number of vehicle at 9 p.m. and the north direction displayed higher traffic volume of demand.


Figure-2. Hourly traffic volume variations for link (1).


Figure-3. Hourly traffic volume variations for link (2).
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### 5.2 Analysis of traffic speed distribution

Based on the field data for traffic speed, and through the application of (SPSS ver. 21statistical software) the enhanced distribution of traffic speed for Link (1) and Link (2) are shown in Figure-3 to Figure-4 for south and north direction respectively. A statistical analysis of average traffic speed is applied for more confidence in the obtained results and to describe their variations. The estimation of speed distribution, coefficient of variation, standard deviations and the squared skewness and their kurtosis for normality testing of traffic speed for the link (1) and link (2) in both direction as presented in Table-1 to Table-4. Also the variation of traffic speed for link (1) and link (2) in both directions are displayed in Figures (5) to (8) respectively; its observed a higher reduction in speed after 7 a.m due to the oversaturation flow that induced a negative impact on the travelled speed of vehicles.


Figure-4. Traffic speed distribution for link (1), South direction.


Figure-5. Traffic speed distribution for link (1), North direction.


Figure-3. Traffic speed distribution for link (2), South direction.


Figure-6. Traffic speed distribution for link (2), North direction.

Table-1. Descriptive statistics for traffic speed for link (1), South direction.

|  | Statistic | Std. Error |
| :---: | :---: | :---: |
| Mean | 35.7683 | 2.23563 |
| 95\% Confidence Interval <br> for Lower Bound | 31.1960 |  |
| Mean Upper Bound | 40.3407 |  |
| $5 \%$ Trimmed Mean | 35.3898 |  |
| Median | 34.2300 |  |
| Variance | 149.941 |  |
| Traffic Speed Std. <br> Deviation | 12.24502 |  |
| Minimum | 16.67 |  |
| Maximum | 64.29 |  |
| Range | 47.62 |  |
| Interquartile Range | 19.04 |  |
| Skewness | .343 | .427 |
| Kurtosis | $-.423-$ | .833 |

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Table-2. Descriptive statistics for traffic speed for link (1), North direction.

|  | Statistic | Std. error |
| :---: | :---: | :---: |
| Mean | 39.4603 | 1.95349 |
| 95\% Confidence Interval <br> for Lower Bound | 35.4650 |  |
| Mean Upper Bound | 43.4557 |  |
| $5 \%$ Trimmed Mean | 38.9698 |  |
| Median | 38.6050 |  |
| variance | 114.484 |  |
| Traffic Speed Std. <br> Deviation | 10.69973 |  |
| Minimum | 22.50 |  |
| Maximum | 67.50 |  |
| Range | 45.00 |  |
| Interquartile Range | 13.78 |  |
| Skewness | .611 | .427 |
| Kurtosis | .259 | .833 |

Table-3. Descriptive statistics for traffic speed for link (2), South direction.

|  | Statistic | Std. Error |
| :---: | :---: | :---: |
| Mean | 34.8817 | 1.64014 |
| 95\% Confidence Interval <br> for Lower Bound | 31.5272 |  |
| Mean Upper Bound | 38.2361 |  |
| 5\% Trimmed Mean | 34.2754 |  |
| Median | 33.7500 |  |
| variance | 80.702 |  |
| Traffic Speed Std. <br> Deviation | 8.98343 |  |
| Minimum | 21.77 |  |
| Maximum | 61.36 |  |
| Range | 39.59 |  |
| Interquartile Range | 7.33 |  |


| Skewness | 1.241 | .427 |
| :---: | :--- | :--- |
| Kurtosis | 1.923 | .833 |

Table-4. Descriptive statistics for traffic speed for link (2), North direction.

|  | Statistic | Std. Error |
| :---: | :---: | :---: |
| Mean | 37.2053 | 1.87969 |
| 95\% Confidence Interval <br> for Lower Bound | 33.3609 |  |
| Mean Upper Bound | 41.0497 |  |
| $5 \%$ Trimmed Mean | 36.7567 |  |
| Median | 37.5000 |  |
| variance | 105.997 |  |
| Traffic Speed Std. <br> Deviation | 10.29547 |  |
| Minimum | 21.77 |  |
| Maximum | 61.36 |  |
| Range | 39.59 |  |
| Interquartile Range | 15.96 |  |
| Skewness | .563 | .427 |
| Kurtosis | $-.159-$ | .833 |



Figure-7. Traffic speed variation for link (1), South direction.
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Figure-8. Traffic speed variation for link (1), North direction.


Figure-9. Traffic speed variation for link (2), South direction.


Figure-10. Traffic speed variation for link (2), North direction.

### 5.3 Capacity estimation

Palestine urban street which considered as one of the major urban arterial roads in metropolis Baghdad city showed severe congestion conditions at PM peak time periods (4:00-9:00) pm.

The absence of both commitment and responsibility for traffic rules, poor pavement surface conditions, illegal on street parking conditions that reduced number of lanes; driver behaviour of sharing carriageway and disturbance manoeuvres ..etc., due to all these factors the direct empirical method for capacity estimation are adopted based on observed volume and fundamental diagram method.

The hourly traffic flow rate is observed based on 10 min . block and the corresponding average speed are depicted in Figures (9) to (11) for Link (1) and (2) north and south directions respectively. The results showed scattering of observed data and there is no fitting relation between flow and speed. The capacity is obtained from these figures as the maximum flow rate for each link and in both directions respectively:

Link (1) South Direction: 1950 vph
Link (1) North Direction: 1740 vph
Link (2) South Direction: 1540 vph
Link (2) North Direction 1560 vph
For three -lane Palestine road; the macroscopic variables: flow rate (vehicle/ hour), mean speed (km/hour) were measured and depicted from empirical field data. For each observation the value of density (flow / speed) and plotted in Figures (12) to (20) for both Links (1) and (2) in each directions respectively. The saturation conditions occurs at Link (1) and (2) at jam density of approximately ( $100 \mathrm{veh} / \mathrm{km}$, $58 \mathrm{veh} / \mathrm{hr}, 60 \mathrm{veh} / \mathrm{hr}$, $70 \mathrm{veh} / \mathrm{hr}$ ) for south and north directions respectively.
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Figure-11. Traffic flow -speed for link (1), North direction.


Figure-12. Traffic flow -speed for link (1), South direction.


Figure-13. Traffic flow -speed for link (2), South direction.


Figure-14. Traffic flow -speed for link (2), North direction.


Figure-15. Traffic flow -density for link (1), South direction.
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Figure-16. Traffic flow -density for link (1),
North direction.


Figure-17. Traffic speed -density for link (1), South direction.


Figure-18. Traffic speed -density for link (1), North direction.


Figure-19. Traffic flow -density for link (2), South direction.


Figure-20. Traffic flow -density for link (2), North direction.


Figure-21. Traffic speed -density for link (2), South direction.

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Figure-22. Traffic speed -density for link (2), North direction.

After estimating the capacity for both Link (1) and (2) of Palestine arterial road; the volume to capacity ration in each midblock of links are estimated and presented in Figures (20) and (21) respectively. It's obvious from the presented results, the severe congestion conditions for south direction of link (1) and north direction for Link (2) with V/C ratio of 1.2 and 1.4 respectively.


Figure-23. Volume to capacity ratio link (1).


Figure-24. Volume to capacity ratio link (2).

## 6. CONCLUSIONS

Palestine urban street showed severe congestion conditions at PM peak time periods (4:00-9:00) which become very concern problems regarding its location which considered as one of the most attractive region in Baghdad city due to the mixed land use surrounding this urban arterials road. From Previous results; the following concluding remarks can be obtained:
a) The trend of traffic volume for Link (1) increased gradually with time periods from 4 p.m. and reach maximum flow at 9 p.m. and the traffic volume in south direction are greater than in the north direction. Link (2) demonstrated oscillate variation of traffic volume and achieved maximum hourly number of vehicle at $9 \mathrm{p} . \mathrm{m}$. and the north direction displayed higher traffic volume of demand.
b) Its observed a higher reduction in speed after 7 a.m due to the oversaturation flow that induced a negative impact on the travelled speed of vehicles.
c) The absence of both commitment and responsibility for traffic rules, poor pavement surface conditions, illegal on street parking conditions that reduced number of lanes; driver behaviour of sharing carriageway and disturbance manoeuvres ..etc., due to all these factors the direct empirical method for capacity estimation are adopted based on observed volume and fundamental diagram method.
d) The results of hourly traffic flow rate showed scattering of observed data and there is no fitting relation between flow and speed for both Link (1) and link (2).
e) The capacity is obtained from these figures as the maximum flow rate for each link and in both directions respectively:

Link (1) South Direction: 1950 vph
Link (1) North Direction: 1740 vph
Link (2) South Direction: 1540 vph
Link (2) North Direction 1560 vph
f) The severe congestion conditions for south direction of link (1) and north direction for Link (2) with V/C ratio of 1.2 and 1.4 respectively.
g) The saturation conditions occurs at Link (1) and (2) at jam density of approximately ( $100 \mathrm{veh} / \mathrm{km}, 58$ $\mathrm{veh} / \mathrm{hr}, 60 \mathrm{veh} / \mathrm{hr}, 70 \mathrm{veh} / \mathrm{hr}$ ) for south and north directions respectively.

Zainab Alkaissi: Literature Search and Review, Manuscript, Research concept, Writing and editing conclusions.
No Co- authors

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