ISSN: 0974-5823 Vol. 7 No. 1 January, 2022

International Journal of Mechanical Engineering

Evaluation and Improvements of Congestion in Chosen Multilane Segments in Al-Hillah City

Dina Khaled Khelfa[1] Abdul Kareem Naji Abbood[1]

[1] Civil Engineering Department, College of Engineering, University of Babylon, Iraq.

Abstract. The efficiency of roads network of any city is one of the essential elements in the prosperity and development of that city, as roads have an important and effective role in urban development and social advancement of society. Nowadays, roads represent the backbone of countries, around which the unity, growth and development of the country are centered.

This study aims to analyze and improve the traffic performance of two locations inside the multilane highways in urban in Al-Hillah city. As those locations suffers from traffic congestion and conflict points between traffic movements. Data collection was done using digital cameras video recordings of study segments during peak hours at typical workdays. The congestion was evaluated by calculating the level of service (LOS) using Highway Capacity Software **(HCS 2010)** to and congestion cost for study segments

The results of study showed that the chosen highway segments is not enough to carry the huge traffic demand projected on them as these segments had low levels of service and high congestion cost. Therefore, many improvements must be done in order to upgrade the LOS and reduce the fuel and time waste on those traffic facilities.

The study concluded that the best improvement that can be done under the current circumstances is to construct parallel/frontage roads in each direction for both streets and prevent on-street parking.

Keywords: Traffic Engineering, Congestion, Level of Service, Urban Roadway, multilane

1. Introduction:

Traffic congestion is and was always a substantial problem that faces urban road networks. The main characteristics of traffic congestion are slower velocities, travel time increase, and vehicles queuing. It usually accompanies urban areas where the value of land is relatively high due to it being highly populated.

The increasing number of automobiles and the lack of highway development in Al-hillah City contributed to the significance of the congestion problem. The spike of private vehicle ownership in the recent decades has led to more congestion, as the lack of public transportation Systems made the general public turn to private vehicles. **[Wackrill & Wright, 1992]** has stated that congestion has several sources; like traffic growth and Bottlenecks within the road network. Capacity and Level of service are connected terms that work as a measure for congestion. **[NPTEL, 2007]**. Capacity is characterized by the highest amount of vehicles passing through a certain point per hour under predominant circumstances; it is regularly evaluated based on expected values for saturation flow. The undeveloped infrastructures of Al-Hillah city is simply not enough to keep up with the huge number of vehicles traveling on city roads. The lack of good city planning also contributed to the problem as new residential districts were built without organized design, which generated more traffic in certain areas than other areas did.

2.Previous Congestion Studies in Iraq:

Ameerah Al- Hameed et al. [2020] studied traffic congestions on urban transport system in Al-Hillah City. The study demonstrated that many causes have participated in increasing congestion in study locations, involving straight causes embodied by the enlarged urban growth of population and the increased standard. While the secondary causes were the small region of urban transportation system use in the original city plan as well as some technical and social aspects for the managerial establishments and population. The study located three sites where traffic congestions intensify in the north, northeastern and southern entrance of Al-Hillah city. It also presented the recurrent times when traffic congestions intensify in the times of religious occasions due to their geographic location. The study has come up with a set of conclusions and alternatives.

P. J. Muhammad et al. [2013] studied traffic congestion on the highway linking Sawaz district and Shaheedan district in Koya city in Erbil governorate. Congestion was measured by calculating the highway level of service. LOS of the studied road was found to be D. The study presented the actual sources of traffic congestion on this particular highway in Koya city and suggested a number of solutions and alternatives to eliminate the problem.

Farah S. Attab et al. [2020] studied the traffic network at AL-Karkh area in Baghdad City. This area located amid numerous streets; 14th July Street, Dimaishq Street, Mansour Street and 14th Ramadan Street. And their border intersections that included; Shaljia Intersection, Dimaishq Intersection, Deilal Intersection, Gailani intersection, and Topaji Intersection. The key outcome of this study is creating a new roadway to decrease the congestion impacts on the environment and on the transport system at the chosen streets.

The proportions of traffic after constructing the suggested road was only 23% and 52 % from the original peak hour volume in study locations.

Mohammed Zuhair et al. [2021] worked to create a maintainable transport network in Baghdad City to operate large traffic volumes with the least possible environmental impact. A railway transport system was proposed as it was found to be the best maintainable scheme, with recommended path and station locations planned to guarantee effective connections with the present road system. To evaluate the suggested system, the city was segmented into 15 sectors. The outcomes shown that the construction of such system would cause a significant decrease in travel time among most sectors. Moreover, the suggested system would alter the land-use next to stations, enhancing investment in housing and motivating the public to move from the congested city center.

3. Definition of Study Area:

Al-Hillah city is the center of Babil governorate. It embodies the principal connection point among the northern and southern governorates. Urban road networks in Iraq has several problems due to mishandling, no government maintenance and puzzling political conditions. Thus, there is an actual necessity to study the existing condition of Al-hillah road network system to deliver precise data, which is essential for its improvement. Figure (1) show the study segments location on study area:

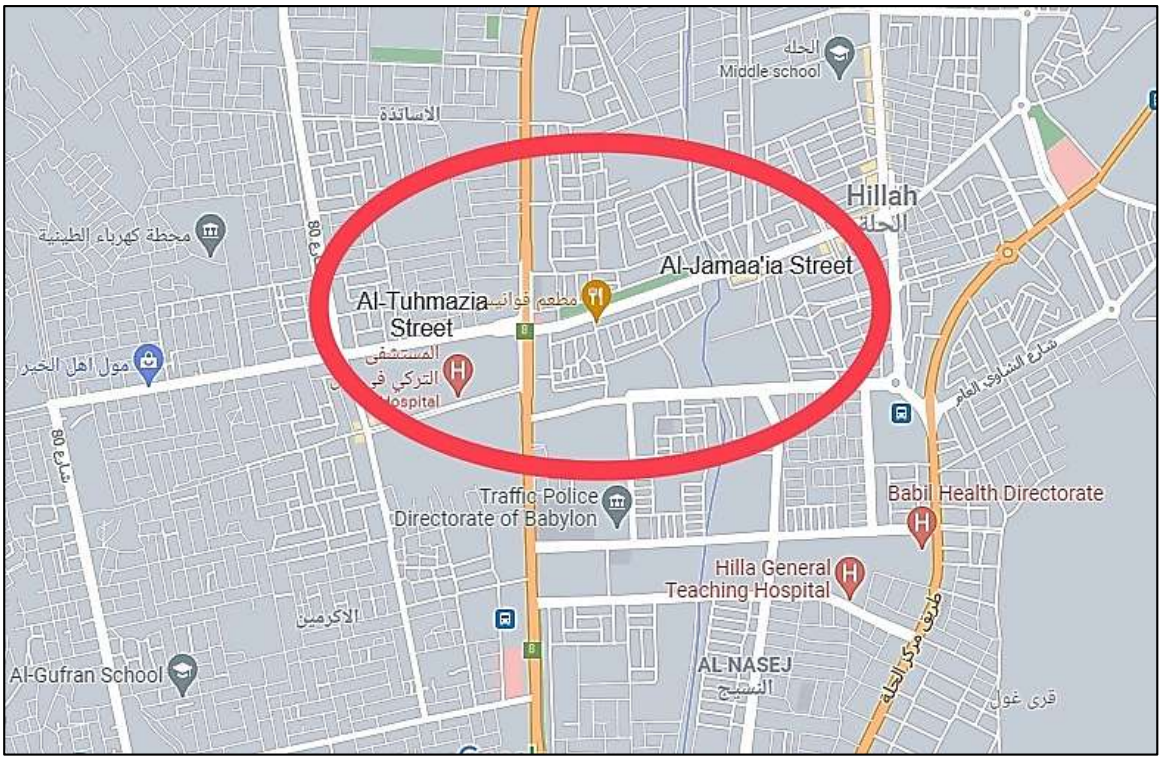

Figure 1. Study area on Map. [Google Maps,2021]

4. Selection of Study Area:

These locations were selected for this study for many reasons:

1. Insufficient infrastructures, such as the lack of interchanges, railways, expressways, subways, parking lots, exits, etc.
2. Placing a lot of government and private offices in the same region had increased the number of vehicles using the roads leading to those regions which led to major congestions
3. The lack of public transportation systems like metros, trains and rapid transit, as public buses are the only means of public transportation in the city.
4. Breaking traffic rules is normalized in our society, as city drivers do not respect rules and regulations, which makes handling traffic flow more difficult
5. Shopkeepers taking over sidewalks by placing goods outside shop borders, forcing citizens to leave the sidewalks and walk on street lanes.

5. Problem Statement:

The problem of traffic congestion has many negative effects road networks and its intersections in urban areas, such as increasing travel time delay, vehicle operation cost, levels of air pollution and traffic noise not to mention traffic accident. This makes the roads work with full capacity and critical density; these factors contribute in decreasing the road level of service (LOS) and decrease the efficiency of carrying traffic volume increase in traffic accidents, all this leads to a decrease in safety, comfort and efficiency factors of the road.

6. Objective of the Study :

1. Estimation of level of service and congestion cost in two congested segments in Al-hillah City

2. Presenting a number of improvements and alternatives designs to solve the traffic problems discovered at the study sections, based on the results obtained after the data analysis.

7. Study Segments:

7.1: Al-Tuhmazia Street:

This road is classified as an urban multilane, with 3 lanes in each direction, and a length of 1.850 Km, it is a divided with sidewalk. This street is located in the center of the city and is one of the streets that connects Street 60 with Street 80. It overlooks Imam Al-Sadeq Hospital, and is surrounded by many commercial shops and workplaces. This street attracts great traffic demand due to its important location.

► **Main operational and design problems in Al-Tuhmazia Street:**

1- The parking area next to the Imam Al-Sadeq Hospital (Turkish Hospital) usually occupies a big portion of the street and reduces the actual usable width of the street. A parking lot is ideal to help relieving this problem.

2- The presence of pavements depressions and other distresses along the street makes drivers compelled to reduce vehicle speed in order to cross it, this problem led to an increase in the average travel time on this street and reduced the levels of travel safety.

7.2: Al-Jamaa'ia Street:

This road is classified as urban multilane, with 2 lanes in each direction, and a length of 0.740 Km, it is a divided two-lane with sidewalk. It is one of the most important streets in city center, as it connects Street 60 with Street 40. This street passes through Al-Jamaa'ia district, which is one of the central commercial areas that is usually crowded with shoppers, as it surrounded by many commercial shops, restaurants and supermarkets, not to mention that this street overlooks Al-Jamaa'ia Park.

► **Main operational and design problems in Al-Jamaa'ia Street:**

1- Al-Jamaa'ia Street is a relatively narrow street, as the width of the street is not adequate for traffic volumes traveling on it, which are usually large, considering this street includes a large number of shopping centers and restaurants, in addition to the presence of a public park. Congestion occurs frequently at many times of the day, at morning, evening and even at night peak periods, which led to frequent queues of vehicles.

2- The presence of a large number of shopping centers, restaurants, pharmacies, etc., and the lack of parking lots, vehicles usually park in the street, even double-parking. which reduces the usable width of the road and decreases road capacity, which in turn worsens the current congestion problem.

3- The median is relatively wide on this street, with width that is nearly 60% of street lanes width in one direction, so the median width should be reduced to provide more space for street lanes.

4- Shops and sellers occupying a large area of the sidewalk, has led pedestrians to walk on street lanes instead of the sidewalk, which affected flow of traffic and created conflicts between pedestrians and vehicles, all that increased the possibility of traffic accidents and reduced safety levels for pedestrians.

8. Data Collection:

In this study, data was collected after a detailed investigation of the selected study segments. First, geometric data was obtained by measuring Lane widths, Sidewalk with median island widths. Then, traffic Data was collected using video recordings of flow peak hours of normal workdays of the

week.

8.1: Geometric Data:

Tables (1) shows the collected geometric data from study segments

Tables (1): collected geometric data from study segments

Multilane Name	From	To	Segment Length (km)	No. of lanes	Approach Width (m)	Lane Width (m)	Median Width (m)
Al-Tuhmazia Street	Tuhmazia Intersection	Street.80/ Tuhmazia Intersection.	1.850	3	10.5	3.60	5
Al-Jamaa'ia Street	Jamaa'ia Intersection	Tuhmazia Intersection.	0.780	2	8.5	3.60	5.5

8.2: Traffic Volume Data:

Collecting data of traffic volumes is one of the fundamental necessities for the analysis and management of roads. Volume Count is calculating the number of vehicles traveling over a roadway during a specified time interval. It's utilized to compute the roadway capacity, Level of Service (LOS) and other essential measures of effectiveness. Traffic volume count was obtained from video recordings of study segments, and categorized into three groups, passenger cars (PC), buses and trucks (HV) with the aid of (Smart Traffic Analyzer) (STA) computer program. Figure (2) show the process of vehicle count from video recordings.

Figure (2): Screenshot from the (STA) Program.

It is essential to convert heavy vehicles to their passenger car equivalent units (PCU), in order to carry on the required analysis accurately. Traffic volume videos used for analysis were divided into 15-minutes periods throughout the peak hour. The percentage of heavy vehicles fluctuated between (6% – 12%) percent, whereas the recreational vehicles (RV) were neglected. Tables (2) and (3) shows the collected volume data:

Table (2): Al-Tuhmazia Street Traffic Volume Data and Heavy Vehicles Percentage.

Time (15 min)	PC	Bus	Trucks	Average HV%
Up stream				
Sum 7:45 - 8:45 AM	2478	2183	201	12%
Sum 12:45-1:45 PM	1855	168	49	10%
Down Stream				
Sum 7:45 - 8:45 AM	2338	2471	197	10%
Sum 12:45-1:45 PM	1936	164	43	10%

Table (3): Al-Jamaa'ia Street Traffic Volume Data and Heavy Vehicles Percentage.

Time (15 min)	PC	Bus	Trucks	Average HV%
Left Direction				
Sum 7:45 - 8:45 AM	2478	135	51	7%
Sum 12:45-1:45 PM	1855	107	34	7%
Down Stream				
Sum 7:45 - 8:45 AM	2338	101	48	6%
Sum 12:45-1:45 PM	1936	98	40	6%

8.3: Speed and Delay Data Collection:

Spot speed is the immediate velocity of an automobile at a certain position. It can be used for congestion and incidents analysis. The average spot travel speed of a roadway segment is the (Time Mean Speed) as the spot travel speed collection requires collecting travel time over a specified section length. Travel speed data was collected manually using a stopwatch and a measuring tape, this method was used as the study sections were surveyed over a relatively short time period. The stopwatch technique is a fast and low-cost way to gather fairly accurate travel time data.

To measure travel time with stopwatch method, the length of road section (AB) must be measured using measuring tape, assuming the section length is (X) in (mile), a vehicle passes the road section from point A to point B in a (T) period of time, where (T) is the travel time in (hr). The watch should be started as soon as the front wheels of the specified vehicle passes on point A, and stopped immediately when the front wheels of same vehicle passes on point B. Figure (3) shows the methodology of speed data collection. On the other hand delay was computed from the difference in travel time from vehicles traveling below posted speed (45 mph), Table (4) and (5) shows the collected speed and delay data for both streets.

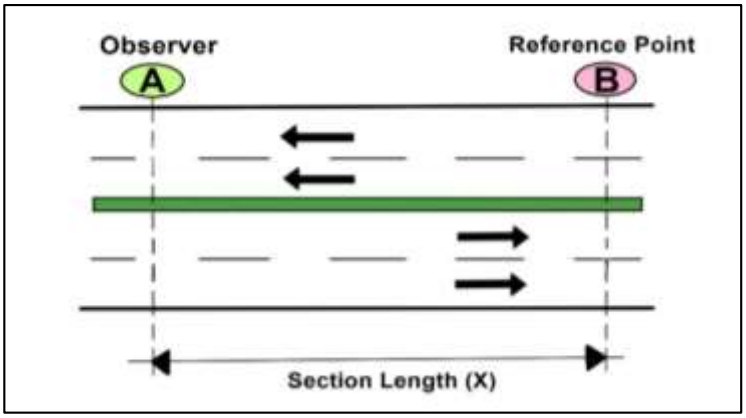

Figure (3): Spot Speed Data Collection by Stopwatch Method.

Table (5): Average speed and delay for Al-Tuhmazia Street.

Time	Average Travel Speed (mph)			Average Delay Under Posted Speed (hr/veh)		
	Passenger Cars	Buses	Trucks	Passenger Cars	Buses	Trucks
7:45 – 8:45	43.7	37.8	29.8	0.138	0.235	0.392
12:45 - 1:45	44.6	38.1	32.2	0.112	0.174	0.313

Table (6): Average speed and delay for Jamaa'ia Street.

Time	Average Travel Speed (mph)			Average Delay Under Posted Speed (hr/veh)		
	Passenger Cars	Buses	Trucks	Passenger Cars	Buses	Trucks
7:45 – 8:45	42.3	36.2	27.4	0.159	0.257	0.422
12:45 - 1:45	43.8	38.6	30.5	0.132	0.236	0.352

9. Measuring Congestion:

9.1: Level of Service Evaluation:

(Highway Capacity Software (HCS 2010) software was used to analyze multilane segments at the study locations. Highway Capacity Manual (HCM 2010) analysis methodology was adopted by Highway Capacity Software (HCS 2010) to evaluate the traffic operations at multilane and calculate the level of service of these segments. Table (4) shows (HCS 2010) program analysis output for Al-Tuhmazia Street and Al-Jamaa'ia Street segments.

Table (4): (HCS 2010) program output for Each Street Segments at Study Area.

Street Name	Dir.	Length (mi)	Flow Rate Vp (pc/ln/hr)	FFS (mi/hr)	Average Passenger Car Travel Speed (mph)	Density D (pc/mi/ln)	LOS
Tuhmazia Street	left	1.15	1143	44.2	39.6	16.3	D
	right	1.15	938	44.3	40.3	16.2	D
Jamaa'ia Street	left	0.49	1543	43.3	38.3	22.2	E
	right	0.49	1621	42.9	38.9	23.4	E

9.2: Congestion Cost Evaluation:

From multilane segments in study area the congestion cost can be calculated from the summation of opportunity cost (OC) per (Iraqi Dinar ID), fuel cost (FC) (ID), vehicle operation cost (VOC) (ID), wear and tear cost (ID) give

n in Equation (1) to (4),

$$OC = (VOT_m \times D_m \times V_m \times Vocc_m) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

$$FC = \sum_{Ft=1}^{3} (Fcq_m^{Ft} \times Fp^{Ft} \times \mu^{Ft}) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (2)$$

$$VOC = L \times \sum_{m=1}^{m} (FC_m \times D_m \times V_m) \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (3)$$

$$Wear \,\&\, Tear\ Cost = 10\%\, VOC \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (4)$$

where VOT is the value of time in (ID/hr), Vm is the average daily traffic (veh/day), Vocc is the vehicle occupancy factor, Fcp is fuel consumption quantity, (liter/km), Fp is fuel price, Ft is Fuel types (1 for CNG, 2 for Gasoline and 3 for Diesel). μ is proportion of particular mode (m) using that road segment, and L is the length of congested segment per (km).

Table (5): Average Occupancy Factors, ADT volumes and Average Delay for Study segments.

Vehicle Type	Average Occupancy Factor	Average Daily Traffic (ADT) (veh/day)	Average Delay (hr/veh)	OC (ID/day)	FC (ID/day)	VOC (ID/day)	Wear & Tear Cost (ID/day)	Total Congestion Cost
Al-Tuhmazia Street								
PC	1.5	18578	0.128	5,853,749	4300	5,331,137	533,113	11,717,999
Bus	3.5	2080	0.201	1,983,190	4300	978,962	97,896	3,060,048
Truck	1.2	853	0.356	485,865	4300	652,542	65,254	1,203,661
Al-Jamaa'ia Street								
PC	1.5	20633	0.134	6,639,751	4300	6,232,467	623,246	13,495,464
Bus	3.5	2124	0.216	2,747,500	4300	1,052,272	105,227	3,904,999
Truck	1.2	794	0.383	598,643	4300	702,402	70,240	1,371,285

9. Suggested Improvements:

9.1: Al-Tuhmazia Street:

- Constructing parallel/frontage roads to Al-Tuhmazia Street, by other means, separating through movement from access points merging and turning maneuvers by medians, hence, dedicating 2 exclusive lanes for through movement and 2 exclusive lanes for merging and turning movements from access points for each direction along the street, to give some decrease congestion, diminish conflicts and increase accessibility without affecting the main through stream.
- Preventing on-street parking and providing free parking area, to relief the parking/ double-parking issue and enhance road capacity, travel speed and safety levels, and adding suitable traffic signs to warn and guide drivers traveling on the roadway.
- Constructing a pedestrian bridge with proper design, using Energy efficient Escalators to save electrical energy, which would encourage pedestrians to use it instead of conflicting with vehicular traffic movements.
- Adding traffic signs and markings to road, and imposing traffic penalties for drivers violating traffic rules to get a smoother traffic flow.
- Paving and maintaining the street on constant basis for smoother and safer traveling experience.

9.2: Al-Jamaa'ia Street:

- Reducing Al-Jamaa'ia Street median width from 4.5m to 1.5m, which creates more space for street widening.
- Adding two new lanes, one in each direction, in order to increase street capacity and give more space to complete all kinds of vehicle maneuvers.
- Preventing on-street parking and providing free parking area, in order to solve the street parking/ double-parking issue and increase road capacity, operating speed, safety and establishing proper traffic signs to warn and assist drivers making trips on the roadway.
- Installing pedestrian crossways with pre-timed signal lights to regulate pedestrian crossing movement.
- Establishing strict instructions regarding storefronts borders, where a significant width of sidewalks is occupied by the adjacent storefronts, in order to give pedestrians their own space to walk in and not interfere with vehicular movements.

10. Conclusion:

1. The study displayed that Al-Tuhmazia Street is working with a rather low level of service, with LOS D at Southbound direction and LOS C at Northbound direction during peak hour.
2. Al-Jamaa'ia Street is working with a very low level of service, with LOS E at both directions during peak hour.
3. Constructing parallel/frontage roads in each direction for both streets, preventing on-street parking to increase road capacity and operating speed, and establishing proper traffic signs to warn and assist drivers making trips on these roadways can actively increase the Level of Service LOS at both street segments from D &C for south and northbound directions to C & B for Al-Tuhmazia Street, and E at both directions to C at both directions for Al-Jamaa'ia Street.

References

1. Adolf Darlington May, *Traffic Flow Fundamentals* (Prentice Hall), 1990.
2. Caves, R. W. *Encyclopedia of the City*. Routledge. p. 141. 2004.
3. Fred L. Mannering & Scott S. Washburn. *Principles of Highway Engineering and Traffic Analysis: 5th Edition*. John Wiley & Sons, Inc. 2013.
4. Howard Preston, Nicole Farrington and Michael Elder. *Design of Turn Lane Guidelines. Minnesota Department of Transportation.* 2010.
5. *Managing Urban Traffic Congestion*, European Conference of Ministers Of Transport (ECMT), Transport Research Centre. OECD. 2007.
6. Martin Rogers. *Highway Engineering*, Department of Civil and Structural Engineering. Dublin Institute of Technology. Blackwell Science Ireland. 2003
7. Martin Treiber, Arne Kesting. *Traffic Flow Dynamics: Data, Models and Simulation*.
8. Michael R. Morris, Neil J. Pedersen , Robert E. Skinner, Jr & others, *Highway Capacity Manual*, Transportation Research Board of The National Academies. Washington, Dc, United States. 2010.
9. Myer Kutz, *Handbook of Transportation Engineering*. McGraw-Hill Handbooks, the McGraw-Hill Digital Engineering Library. 2004
10. E.A. Hussein, I.M. Shaheed, R.S. Hatam, M.M. Kadhim, D.T. Al-Kadhum, E.A. AL-Kareem (2020), Adsorption, thermodynamic and DFT studies of removal RS dye on the Iraqi's clay from aqueous solutions, Syst. Rev. Pharm. 11
11. Warne T R, Carlson D, King L and Horsley J, *A Policy on Geometric Design of Highways and Streets", American Association of State Highway and Transportation Officials* (Dan Flowers & others. Washington, D.C.), 2001