Evaluations of traffic flow on Al-Yarmouk Overpass Bridge

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Abstract Traffic volume has been increasing rapidly throughout the country, people have a hard time because of the traffic problems especially on the peak hours causing traffic congestion which is the biggest problem in Baghdad city, one of the solutions for congestion is to build an overpasses bridge at intersections in order to minimize these kinds of problems, the research maintains to evaluate the overpass bridge with the help of GIS, the various advantage of GIS makes it an attractive option to be used to face the emerging traffic problems. The main objective of this research is analyzing the existing traffic situation on Al-Yarmouk Overpass Bridge and estimating the level of service via v/c ratios were level of service is one of the constant functions of traffic to either maintain a stable traffic flow or to identify and cure for traffic congestion by gathering information concerning the transportation system in the study area by using field information count, camera for estimating traffic volume, speed Gun device for measuring vehicle speed. The result showed that the overpass bridge operates with the level of service (LOS F), at which the vehicle relative to the road capacity (v/c) is (1.48) as illustrated in analysis map on the basis of analyses of the existing traffics situation of the bridge. Some improvements are suggested to improve the level of service, and optimization suggestion, in addition to geometric improvement, is suggested in this study.

1. Introduction

Traffic congestion has been one of the significant issues that most metropolises in Iraq are facing specially in Baghdad [1]. It profoundly impacts the movement of people and freight, it wastes time and energy, causes pollution and stress, decreases productivity and imposes costs on society [2]. The high risks of accidents, the efficiency of the urban traffic performance are influenced by congestion of the traffic. It is a crucial issue for the whole community with transportation planners and road users [3]. It happens when the number of vehicles on the road overrun the capacity that the road can accommodate vehicles. This congestion is specified by the delay in the time of travel, slower speeds, and very long queues [2]. The concepts of traffic volume, capacity, and level of service must be taken into consideration for the analysis of the traffic flow on the overpass bridges as it is the first step of procedure analysis [4]. Analyzing with the help of GIS is growing fast in so many fields of transportation for its ideal management of information, analyzing ability which displays the simulation of the new proposition and planning scheme with results [5]. The utility of using the GIS can be imputed to its tendency to deal with data with a large volume within geographical spatial property, it has a capacity storage of a large database, and it can integrate data from different sources, integration of the spatial and non-spatial data from different origins furthermore it is a primary visualization tool because it outputs relevant maps that supports in the decision-making operation [6].
2. Literature review

Many types of research have been done to determine the level of service to evaluate traffic performance. Al–Azawee [7] evaluated the performance of traffic of Ahmed Urabi square by estimating the existent level of service using HCS software. Where the hourly traffic volumes were counted for all movement of the intersection, the counting of traffic had been executed three times of the days (Sunday, Monday and Wednesday) to take into consideration the variance of the traffic volume, the time of conduct was from (7 am to 5 pm) by using video recording technique to find the peak hour. She indicated that Ahmed Urabi roundabout was operated with level of service F and with an average control delay of 300 seconds per vehicle during the peak hours [7]. Gozde and Asli [8] investigated the concept of safety level of service (LOS) at a section existing on the Trans European Motorway (TEM) which passes through Istanbul via the Fatih Sultan Mehmet Bridge which has huge traffic congestions especially in peak hours, LOS is determined with the help of using Geographic Information Systems (GIS) [8]. Level of service at the urban street network and intersections are investigated in Kut city, using geomatics techniques like (GPS, GIS) for detecting the traffic flow patterns and evaluating the operational capacity. Khalaf et al., [4] evaluation of AL-Kafa’at intersection in AL-Kut city and better proposals had been shown to improve the performance in terms of capacity. The information of the Traffic was collected by using a digital camera to various directions, and the HCS program was used for the traffic analysis process. The existing conditions analysis of this intersection indicates that the LOS is (F) with a delay value of 105.1 sec./vehicle [4]. Miller et al., [9] described a method of evolving the information of transportation by using a global position system (GPS) receiver with the integration of geographic information system (GIS) technology; the performance measurements evaluation relies on the reliability and accuracy of the collected data of the traffic, with the rapid growth volume of the vehicle on roads [9]. The measurement of traffic speed by using the GPS technique was investigated for parts of Al-Karada roads by identifying the congested segments. The GPS points were collected and mapped to the highway by using (Arc Map 10) program in a GIS environment. Speed, travel time, and the congestion index values have been measured for all the selected highway segments in order to evaluate the traffic conditions of the highways [5].

3. Problem statement and Objectives

The traffic volume has been growing fast over the current years in the capital Baghdad for many reasons like increase in the number of vehicles. As a result, the related problems of transportation are getting worse. Al-Yarmouk Overpass Bridge suffers from increase in the traffic volume resulting in growing of congestion where travelers lose more time, money and effort to reach their destination, particularly during peak periods also resulting in an increase in vehicle fuel consumption. The essential objectives of this study are:

1. Assess accurately the traffic flow and road performance of Al-Yarmouk Overpass Bridge to resolve the traffic congestion and reduce the delay time.
2. Gathering information in the study area by observers, using Camera for estimating hourly traffic volume and 15 min flow rate, speed Gun device for speed measurement (FFS), and coordinates with GPS device.
3. Analyzing the existing traffic situation and finding the level of service using the HCS program.
4. Geographic spatial analysis using GIS capabilities and cartography, which is one of the practical tools in the transportation branch.

4. Major parameters for evaluating highway operations

Traffic flow is counted as a one-dimensional way of movable vehicles. So to clarify traffic flow, there is a requirement for a shortened explanation of traffic variables.
• **Speed**

It is known as a ratio which is expressed as distance per unit of time, usually in kilometers per hour km/hr, when speed is aforesaid in traffic flow notion, it is, in general, points to space-mean speed or accurately weighted mean of speeds of the vehicles to pass a distance, because speed indicates the length of road that a vehicle travels in a specific time interval. This is mentioned in [10] but referred to in [11].

• **Free flow speed (FFS)**

Free-flow speed (FFS) is the traffic speed at low density and low volume, at which drivers can feel at ease to travel under the environmental, physical, and traffic-control situation on the not full part of a highway. It will be lower on parts of highway with finite vertical or horizontal alignments. When speed limits are posted lower, the FFS will tend to be lower. It is vital to measure the FFS because it is the beginning point of the capacity analysis and level of service (LOS) for the condition of uninterrupted-flow.

• **Volume to Capacity Ratio (V/C)**

Volume is the entire number of vehicles that pass over a specific section or point of a roadway or a lane during a given period; volumes can be expressed in many terms: annual, daily, hourly, or sub-hourly periods. Capacity is the maximum number of vehicles that can pass on a particular point during specific period under the prevailing roadway, traffic and control condition. The V/C ratio is the most prevalent parameter that is used to evaluate traffic conditions in the cities.

• **Flow rate**

It is the equivalent hourly rate when vehicles pass on a given section or point of a lane or roadway during a given time interval, which is less than 1 hour, generally 15 minutes. Volume and flow are variables which are quantified demand, which is, the number of vehicle riders or drivers (commonly expressed as the number of vehicles) who want to use a specific facility during a particular time.

• **Level of service (LOS)**

Level of service (LOS) is a quality measure that describes the conditions of operational traffic stream, usually, an expression of service measures like travel time, speed, traffic interruptions, freedom to maneuver, and comfort. Six LOSs are defined for each sort of facility that has analysis method obtainable; letters specify every level, which is from A to F, with LOS A performing in the best conditions of operating and LOS F the worst [12, 13].

| Table 1. Level of Service with (V/C) ratio |
|------------------------------------------|
| **Level of service** | **Degree of saturation (V/C)** |
| A | x ≤ 0.60 |
| B | 0.60 < x ≤ 0.70 |
| C | 0.70 < x ≤ 0.80 |
| D | 0.80 < x ≤ 0.90 |
| E | 0.90 < x ≤ 1.00 |
| F | 1.00 < x |

• **Peak Hour Factor PHF:**

PHF represents the variation in traffic flow within an hour. It is based on demand volumes for a peak 15-min period within the hour of attending—usually the peak hour. For analysis of operational, the demand volumes of a full-hour must be turned into flow rates for the 15 min peak, as it is shown in Equation below.
Heavy vehicle

The existence of heavy vehicles in the traffic stream lowering the free flow speed (FFS) because at base conditions the traffic stream is presumed to consist only of passenger cars—an unusual appearance. So, traffic volumes have to be adjusted to an equivalent flow rate expressed in passenger cars per hour. This adjustment is achieved by using the factor $f_{HV}$. Heavy-vehicle adjustment considers trucks and recreational vehicles (RVs). Buses are included with trucks. The adjustment factor of a heavy-vehicle requires two steps. First, the passenger-car equivalency factors for trucks (ET) and recreational vehicles (ER).

5. Study Area

Al-Yarmouk district in Al-karkh side of Baghdad City on the west side of Dejla River; it is one of the most crucial and congested areas in Baghdad. Al-Yarmouk overpass is located at Qahtan roundabout. Figure 1 shows a satellite image of the area. It is a two way with 0.45 Km length and 16.5 km width which starts at metric coordinates 439548 x, 3684035y and ends at 439352x, 3683666y, as shown in Figure 2. Figure 3 shows a geometric design of the overpass bridge, and it is one of the essential routes in Baghdad city. It is placed in a location that is very pivotal as there is the medical college of Al-Mustansiriya University, Al-Yarmouk educational hospital, and many restaurants, shopping centers, cafes and many commercial shops and other activities which is a route for many commuter road users like employees, students, patients, tradesmen and others, which leads to a high traffic volume and leads to create a high traffic congestion especially in the morning and evening peak hours. It is crucial to assess its accessibility by defining the level of service (LOS), which is the best representation of traffic road capability.

\[ PHF = \frac{\text{hourly volume}}{\text{peak flow rate (within the hour)}} \] (1)
6. Survey of Traffic

It is necessary to investigate the current traffic situation of the selected area to accomplish the objective of the research.

6.1 Traffic data collection

Traffic data was collected at field using video recording techniques, using a digital camera to make it easy for recording all the information that the researcher needs to identify the traffic state like the count of the hourly traffic volume, a 15 min flow rate, and vehicles classification (passenger car, heavy vehicle, and others). Data were collected from 7:00 am to 4:00 pm for all weekdays from Sunday to Saturday to take into consideration the difference in the traffic volume within all weekdays (as represented in the bar chart below) to define the morning and evening peak hours, table shows the variation in volume in the day which is the hour in the day that has the highest traffic volume. The standard conditions, excellent weather (dry), and good visibility were taken into consideration when video recording is made. A free flow speed (FFS) was measured in the steady area using a Speed Gun.
Device. GPS device to know the exact location of the overpass and the area around it by knowing the coordinate of it.

6.2 Geometric Data

The geometric data of the road are essential to find because it influences the traffic flow. Some of these data were defined by using satellite image of Baghdad city with an accuracy of 0.5m, updated to 2015. Other geometric feature like lane width, segment length, number of lanes, have been taken from Baghdad Municipality and also some of these data were measured at the field using a tape measure for more insurance. The critical flow time can be shown with the help of these data to show the traffic flow conditions, determine the impact of pedestrians or large vehicles on vehicular traffic flow, or record traffic volume tendency, and to use as an input data for the selected program.

7. HCS 2010 Software

The geometric, traffic and signal input data were entered into HCS 2010 software in order to precede all the operational analyses of the present and future (after improvement application) of the Al-Yarmouk overpass bridge for estimating the level of service of traffic flow. The input data for the HCS software are as follow:

a- Traffic Data
   1. hourly traffic volume
   2. free flow speed (FFS)
   3. the rate of the heavy vehicle (truck and buses and recreational vehicles)

b- Geometric data:
   1. lane width
   2. segment length
   3. shoulder width

8. Data processing with Arc Map software

This research presents traffic volume analysis. In this study we dealt with a map and all the processes using Arc GIS V10.4.1 software to get the final results by using the capabilities of a Geographic Information System (GIS). Transportation applications of GIS have become increasingly popular in recent years because of its interest, easiness, movement of traffic flow, and minimum time outlay on a
roadway, improved traveling mobility, increased safety for personal and roadway, efficiency for transportation planning. (GIS) is an information system which is specialized in the input, management, and analysis and reporting of geographical information. It can help assessment of the traffic congestion, width of road, land use and many others. GIS has various applications in traffic; it is the robust implement used for analyzing the spatial, attribute data for effective traffic management. GPS data were collected to identify the spatial location of traffic congestion and other location-based spatial information. Data representation is a core research topic of GIS, using GIS for the analysis and evaluation of different transport data analysis is a method to convert data into a visual representation. Cartographic is mainly concerned with the visual representation of spatial data. The Level of Service can differ from one day to another, and from hour to hour thus the analysis of Level of Service using spatial distribution will give an actual representation of road and traffic condition in the real world as different level of service happened in the road. The spatial distribution of LOS could also be easily characterized by using a different colour so we could recognize whether the level of service A or F or any other would be more comfortable.

9. Results
The result of the field work conducted on the level of service of Al-Yarmouk overpass bridge was LOS F as analyzed by the HCS program using Arc GIS V 10.4.1 software which is represented in Figures 7 and 8 with the colour code visualization and a peak hour factor (PHF) of 0.96 and a capacity to volume ratio 1.48 (v/c). It suffers from traffic jam. The morning peak hours are (from 7:00 to 9:00) am and evening peak hours (from 2:00 to 3:00) pm as shown in Figures 9 and 10, (Table 2 explains the difference in 15min flow rate over days) and Figure 6 summarizes the hourly traffic volume over the weekdays.

![Figure 6. The Hourly Traffic Volume](image)

| Table 2. The 15 min Flow Rate for All Weekday |
|-----------------------------------------------|
| time                      | Sunday | Monday | Tuesday | Wednesday | Thursday | Friday | Saturday |
| 7:00-7:15                 | 922    | 621    | 787     | 778       | 905      | 189    | 188      |
| 7:15-7:30                 | 935    | 665    | 814     | 781       | 911      | 196    | 189      |
| 7:30-7:45                 | 961    | 654    | 824     | 811       | 913      | 211    | 217      |
| 7:45-8:00                 | 949    | 655    | 841     | 813       | 907      | 223    | 221      |
| 8:00-8:15                 | 904    | 651    | 815     | 811       | 912      | 214    | 228      |
| 8:15-8:30                 | 897    | 633    | 822     | 817       | 904      | 234    | 227      |
| 8:30-8:45                 | 898    | 614    | 824     | 815       | 900      | 229    | 237      |
| Time       | BCEE4 | IOP Conf. Series: Materials Science and Engineering 737 (2020) 012130 doi:10.1088/1757-899X/737/1/012130 |
|------------|-------|--------------------------------------------------------------------------------------------------|
| 8:45-9:00  | 888   | 591 821 812 901 227 235                                                                          |
| 9:00-9:15  | 864   | 593 812 788 887 219 244                                                                          |
| 9:15-9:30  | 876   | 580 776 765 876 231 239                                                                          |
| 9:30-9:45  | 855   | 581 779 743 877 233 246                                                                          |
| 9:45-10:00 | 832   | 574 765 714 865 243 240                                                                          |
| 10:00-10:15| 765   | 554 733 721 862 235 346                                                                          |
| 10:15-10:30| 667   | 504 723 709 845 233 253                                                                          |
| 10:30-10:45| 611   | 477 698 621 812 253 255                                                                          |
| 10:45-11:00| 612   | 465 667 604 758 251 254                                                                          |
| 11:00-11:15| 621   | 466 665 591 744 256 255                                                                          |
| 11:15-11:30| 622   | 468 632 587 723 252 259                                                                          |
| 11:30-11:45| 621   | 478 621 588 743 256 271                                                                          |
| 11:45-12:00| 615   | 488 643 644 734 266 277                                                                          |
| 12:00-12:15| 654   | 489 644 661 739 267 266                                                                          |
| 12:15-12:30| 634   | 491 665 713 754 264 268                                                                          |
| 12:30-12:45| 665   | 583 676 724 787 271 264                                                                          |
| 12:45-1:00 | 732   | 599 666 765 822 268 259                                                                          |
| 1:00-1:15  | 775   | 645 734 774 834 252 262                                                                          |
| 1:15-1:30  | 834   | 664 754 787 888 249 267                                                                          |
| 1:30-1:45  | 876   | 676 777 789 923 262 271                                                                          |
| 1:45-2:00  | 986   | 732 822 880 1005 266 274                                                                         |
| 2:00-2:15  | 1042  | 743 821 867 1011 278 277                                                                         |
| 2:15-2:30  | 1008  | 746 845 889 1001 273 281                                                                         |
| 2:30-2:45  | 991   | 712 844 897 989 286 288                                                                         |
| 2:45-3:00  | 992   | 711 834 903 987 288 287                                                                         |
| 3:00-3:15  | 953   | 688 833 908 966 291 288                                                                         |
| 3:15-3:30  | 922   | 665 811 899 965 293 291                                                                         |
| 3:30-3:45  | 887   | 664 809 885 958 294 298                                                                         |
| 3:45-4:00  | 854   | 644 788 882 943 287 291                                                                         |
Figure 7. The Representation of the level of service on ArcMap (LOS F)

Figure 8. The Representation of the level of service on ArcMap (LOS D)

Figure 9. The Morning Hourly Peak Volume
10. Conclusion
The existence of the medical college park on the right side of the Al-Yarmouk overpass bridge was one of the leading causes of the congestion problem at the overpass, so is an Al-Yarmouk hospital on the same side. The driver behavior, especially buses drivers, was one of the most significant causes of the traffic congestion in the study area, road condition also affected badly on the traffic, the presence of the railway became like a distress when road users need to slow down when reaching it so causing traffic jam, the pedestrians not cross from the area designated for transit moreover, there is a pedestrian bridge near the overpass roadway filled with so many vehicles, all these reasons causes traffic congestion. The overpass operates with LOS F and it did not yet get to the target year of the design were the overpass was constructed on 2009 (design year) with a design life of 20 years by which the target year would be 2029, with annual growth factor of 3 percent, which has inverted the socioeconomic situation of Baghdad city, there would be a considerable increase in traffic volume so there should be an earnest solution for the traffic condition.

Traffic Projection Factor = (1 + R)^n

(2)

r = Annual Rate of Traffic Growth, %

n = Design Life (year)

Future traffic volume = current year traffic volume × traffic projection factor

Tpf = (1 + 0.03)^20

(3)

Tpf = 1.8, and should be taking into consideration and to improve this situation the suggestions are as follows:

- Make a new design of the overpass which should start from a distance before the existence of the college and the hospital and make the railway pass under the overpass and with an access point to whoever wants to go to the airport highway.
- Transfer the Al-Yarmouk hospital consultancy and the park of the medical college inside Al-Yarmouk district, or remove the medical college of Al-Mustansiriyyah University to another place.
- Erection of a regular bus stop on distance from the overpass bridge.
- Activation of public transport instead of personal vehicles.
- Regular maintenance for the roadway.
- Remove the checkpoint that is near to the overpass bridge and monitor and charge the roadway user by the officials.

Figure 11 below summarizes the degree of saturation before and after the applying of the improvement.

![Figure 11. Degree of Saturation before and after the improvement](image)

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