Reduction the traffic congestion-induced vehicle emission by construction new road: Case Study in Baghdad City

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Abstract: Numerous regions in the city of Baghdad experience the congestion and traffic problems. The study area is located at Karkh side in Baghdad City. The geographical area situated among several streets; 14th July Street (section in Ring road No. 1), Demishq Street, Mansure Street and 14th Ramadan Street. The main intersections in these streets are; Shaljya Intersection, Demishq Intersection, Dilal Intersection, Gailani intersection, and Topji Intersection. The proposed road starts from the Gailani intersection and jointed with 14th July Street (Ring road No. 1) with length (1.9 Km). The study area is facing a low level of service during traffic congestion resulting from an inefficient and poor road network. The main purpose is to study constructing a new road to reduce the environmental and congestion impacts on the transportation system at selected roads. The percentages of expected generated traffic that will be serviced in the suggested rout are 23% and 52% from the peak hourly volume counting in location 1 (Shaljya Intersection). On the other hand, at location 2 (Demishq Intersection), the percentages of generated traffic transported to the suggested rout are 22% and 23%. By using Highway Capacity Manual (HCM), the required lanes for the suggested road are 3 lanes for each direction. According to findings, construction of the suggested road is important to improve the road network in term the traffic and reduction the vehicle emissions at present routs.

1. Introduction
The city of Baghdad is the largest city in Iraq and the most important industrial and commercial center in the country. Therefore, Traffic congestion is a serious problem in it due to the rapid increase in the use of the private vehicles which have adverse effects on travel time, vehicle operation costs, air quality, etc.

There are many possible measures for improving transportation systems by which can be properly controlled. Changing the land uses to a multi-center city structure, where residential areas and workplaces are close together, thus reducing the average length of trips [1]. Moreover, increase the capacity of the transportation facilities is another method. The overall objective of this measure is to increase the capacity by effective use and improvement of existing transportation facilities. Several methods are found to achieve the increase of the capacity of the transportation facilities such as the improvement of the existing network [2] or the establishment of a new road network [3,4] or exposing the streets by adding a number of lanes [5]. The other way to increase transportation system capacity is through enhance the traffic control. It is usually in several forms such as improve signal phasing to demand responsive [6], improve traffic control systems by modification of the signal timing [7], introduce and control one way street system, restrict turning movement, introduce reversible lane, grade separation [8,9], introduce on street parking control.
2. Purpose of the Study
Traffic congestion is a serious problem in Baghdad city due to the rapid increase in the use of the private vehicles which have adverse effects on travel time, vehicle operation costs, air quality, etc. For this reason, construct and improve the road network are considered an important way to increase or improve the capacity of the existing transportation facilities. The main purpose is to study constructing a new road to reduce the environmental and congestion impacts on the transportation system at selected roads.

3. Study Area Description
The study area is located at Karkh side in Baghdad City. The geographical area situated among several streets; 14th July Street (section in Ring road No. 1), Demishq Street, Mansure Street and 14th Ramadan Street. The main intersections in these streets are; Shaljya Intersection, Demishq Intersection, Dilal Intersection, Gailani intersection, and Topji Intersection. The proposed road starts from the Gailani intersection and jointed with 14th July Street (Ring road No. 1) with length (1.9 Km). The study area and the proposed route are shown in Figure 1.

3.1 Determination of Peak Hour Periods
Several personal observations and pilot survey have been made in the study area, also personal interviews were made with interested people like traffic policemen at the study area and different road users in order to predict the most congested period for traffic data collection. These observations showed that the study area is characterized by (A.M.) peak period of (7:00-9:00) and P.M. peak period of (2:00-4:00) for typical weekdays (Monday, Tuesday, and Wednesday).

3.2 Data Collection
Collecting data is a critical step in the method of evaluation. Before beginning the collection, knowing what to gather, when to collect, how long to collect and how to handle the information must be addressed. In this study, two methods were applied to collect the required data:
A- The traffic flow data are recorded by using a video camera to show the traffic flow of the street at each direction. Data are recorded on digital camera.
The traffic volume was recorded for every 15 minutes to compute the peak hour factor (PHF) at the locations (1, 2, 3, and 4) (see Figure 2). The traffic volume contains two types of vehicle:
1. Passenger car: Any vehicle contains four tires only.
2. Heavy Vehicle: Any vehicle contains more than four tires. This type of vehicle is converted to passenger car by using (PCU) factor equal to (1.5).
B-Questionnaire: The questionnaire was designed to include the determination of the origin-destination (O-D) trips of the drivers. The purpose of the questionnaire is to estimate the percentage of
trips that will be attracted to the proposed road by which can design the number of lanes required. The questionnaires were achieved at two locations (1 and 2) synchronous with traffic recording at these locations. For each location, two persons commissioned to take the questionnaire (i.e. one at each direction of the street).

Figure 2. locations of the traffic recording and questionnaire

It should be noted herein, that there is no questionnaire done in locations (3 and 4) and the purpose of traffic recording at these locations is to determine peak hour volume and environmental impact due to changing in traffic (i.e. Demishq Street and 14th Ramadan Street) for existing condition and after construction the proposed road.

3.3 Forecasting Traffic Volume Data

Traffic forecast or prediction volume is defined as "the current (existing) traffic volume multiplied by the ratio of future traffic volume to current traffic volume" [10]. This ratio is called "Traffic Forecast Factor (TFF)" and can be calculated from Equation (1).

\[
TFF = (1+r)^n
\]

Where:
TFF : Traffic forecast factor (composed growth factor)
r : Annual rate of traffic increase (%).
n : Traffic analysis period (year).

In fact, the annual rate of increase in car-ownership in the year 2003 increases dramatically growth rate due to the policy of importing the vehicles. This reflects the inadequacy of auto vehicles in the city. Several studies adopted different value of growth rate, for example, Ismael and Mohammed, 2016 [7] have used 3%. This value may increase due to the generated traffic according to the type of improvement. The extra traffic from a transportation network change can be divided into generated and induced traffic demand [11], both of which should be included in transportation assessments. For this reason, annual rate of traffic (r) will be assumed to be 5% and use for forecasting the future traffic volume.

In the present study, 2040 (i.e. 2019 is study year +1 year for construction+ 20 years for service) is taken as a target year. By substituting the aforementioned values in Equation (1) the value of traffic forecast factor (TFF) will result as (2.785). This value is used to find the future traffic volume.

4. Results
4.1 Traffic Volume

The volume for peak hour represents the design hour volume, which will be used in the analysis of this study.
4.1.1 Shaljya Intersection (Location #1)
At the direction of traffic going to 14th Ramadan Street, Figure (3 a) shows the traffic account for 15 min. period from 7:00-9:00 A.M and 2:00-4:00 P.M, while Figure (3 b) illustrates the total volume for each accounted hours. By using Excel program, the traffic account shown in Figures (3a and 3b) were analyzed to specify the peak hour. The results clear that, the total traffic volume during the peak hour is found to be between 2:00 and 3:00 P.M. The total volume during this hour is 2110 (Veh./h.).

![](image1.png)

**Figure 3.** Distribution of traffic volume at direction going to 14th Ramadan Street at (Shaljya Intersection)

Same procedure was adopted at the direction of the traffic coming from 14th Ramadan Street. Every 15 min. traffic account was achieved as shown in Figure (4a). The total volume for the adopted period was calculated (see Figure 4b). It is found that, the peak hour is located at 8:00-9:00 A.M., where it reach to be 892 Veh./h.

![](image2.png)

**Figure 4.** Distribution of traffic volume at direction coming from 14th Ramadan Street (Shaljya Intersection)

4.1.2 Demishq Intersection (Location #2)
At the direction of traffic going to 14th Ramadan Street, the traffic flow every 15 min. and total volume for each accounting hours are stated in Figures( 5a and 5b), respectively. The peak hour is found to be between 2:00-3:00 P.M. with maximum traffic volume of 2699 Veh./h.
Figure 5. Distribution of traffic volume at direction going to 14th Ramadan Street (Demishq Intersection)

At the direction of traffic coming from 14th Ramadan Street, the 15 min. traffic flow of the four counting hour (7:00-9:00 A.M and 2:00-4:00 P.M) (Figure 6a) and there hourly volume were found. It is concluded that, the peak hour volume was found between 8:00-9:00 A.M. to be 4640 Veh./h as shown in Figure 6b.

Figure 6. Distribution of traffic volume at direction coming from 14th Ramadan Street (Demishq Intersection)

4.1.3 Heavy vehicle percentage and PHF

From the traffic account for the above locations (1 and 2) the peak hour factor (PHF) for each location and direction were found. The peak hour factor is defined as the ratio of total hourly volume to the maximum 15-min rate of flow within the hour. The PHF is calculated using following Equation:

\[
PHF = \frac{\text{Hourly Volume}}{4 \times V_{15\text{min.}}} 
\]  

Where:
PHF= Peak-hour factor
V15 = Volume during the peak 15 min of the peak hour.

In addition, at the peak hourly volume, the percentages of the passenger car and heavy vehicle (medium trucks, long trucks) were counted. Table 1 summarizes the values of the PHF, passenger car, and heavy vehicle percentages.
Table 1. PHF and heavy vehicle percentage

| PHF | Passenger Car% | Mini Bus% | Total | Medium Truck% | Long Truck% |
|-----|----------------|----------|-------|---------------|------------|
|     | Car%           |          |       |               |            |
| Shaljya Intersection (Location #1) | 0.88 | 87 | 9 | 96 | 3 | 1 |
| To 14 Ramadan Street | 0.85 | 91 | 6 | 97 | 2 | 1 |
| From 14 Ramadan Street |     |     |   |     |   |    |

Demishq Intersection (Location #2)

|       | To 14 Ramadan Street | From 14 Ramadan Street |
|-------|----------------------|-------------------------|
| PHF   | 0.86 | 0.87 |
|       | 60 | 63 |
|       | 37 | 35 |
|       | 97 | 98 |
|       | 2 | 1 |
|       | 52 | 1 |

4.2 Number of Lanes required for Suggested Road

4.2.1 Traffic attracted to Suggested Road

The purpose of the questionnaire is to estimate the percentage of trips that will be attracted to the proposed road. After counting of the peak hour volume at locations 1 and 2, the percentages of the traffic at these locations that have possibility to make trips to/from 14th Ramadan Street were estimated. Table 2 illustrates the total number of questionnaire and their trips to/from 14th Ramadan Street.

Table 2. Percentage of the trips to or from 14th Ramadan Street at locations 1 and 2

| Questionnaire | Shaljya Intersection (Location #1) | Demishq Intersection (Location #2) |
|---------------|-----------------------------------|-----------------------------------|
|               | Total | No  | Yea | % |
| To 14 Ramadan Street | 132 | 101 | 31 | 23 |
| From 14 Ramadan Street | 178 | 86 | 92 | 52 |
| To 14 Ramadan Street | 189 | 148 | 41 | 22 |
| From 14 Ramadan Street | 127 | 108 | 19 | 15 |

In the present study, assumption that the traffic counted at locations 1 and 2, to make trips to/from 14th Ramadan Street, will be attracted to the suggested road. Thus, according to the trips percentages shown in Table 2, the estimated traffic that will be serviced in the suggested road can be found as percentage from the maximum hourly volume recoded. The matrix of Origin-Destination trips that will be attracted to the suggested road between (1) Shaljyyam, (2) Demishq, and (3) Dilal Intersections has been drawn (Table 3). Finally, the total traffic volume that will be serviced at the suggested road, in addition to the average values of PHF, percentages of passenger care, and the heavy vehicle percentages are calculated as shown in Table 4.

Table 3. Generated traffic volume to suggested road (Veh./h).

| u | O | 1 | 2 | 3 |
|---|---|---|---|---|
| 1 | 485 |
| 2 | 594 |
| 3 | 464 | 696 |
Table 4. The total generated traffic volume to the suggested road

| Direction               | Traffic volume (Veh./h) | Average PHF | Average Passenger Care% | Heavy Trucks % |
|-------------------------|-------------------------|-------------|-------------------------|----------------|
| To 14th Ramadan Street  | 1079                    | 0.87        | 96.5                    | 2.5            |
| From 14th Ramadan Street| 1160                    | 0.86        | 97.5                    | 1.5            |

4.2.2 Forecasting the traffic volume

For target year 2040 (1 year for construction+20 years for service with 5% annual growth rate), and by using Eq1, the expected future traffic volume (FT) is:

FT (To 14th Ramadan Street) = traffic volume*TFF* ET
  =1079*2.785=3005 (Veh./h)
FT (From 14th Ramadan Street) = traffic volume*TFF* ET
  =1160*2.785=3231 (Veh./h)

By using the above traffic volumes, Highway Capacity Software (HCS) [12] has been used to calculate the required lanes. The results show that the required numbers of lanes is 3 in each direction. According to the specification of the State Corporation for Road and Bridges [10], Road with Class A6/33 will be designed.

4.3 Environmental evaluations

Regarding the impact of construction the suggested road on the reducing vehicle emissions, especially, resulting from the traffic congestion was studied.

4.3.1 Traffic volume in locations 3 and 4.

The existing traffic and its properties in locations 3 and 4 (Demishq Street and 14th Ramadan Street) were counted, and then the peak hourly volumes were found for each direction. The summary results of the existing traffic are shown in Table (5).

Table 5. Existing peak hourly volumes in Locations 3 and 4.

| Location #3 (Demishq Street) | Peak hourly volume (Veh./h) | PHF | Hv % |
|-----------------------------|-----------------------------|-----|------|
| Direction 1 O-D (3 to 2)    | 3480                        | 0.88| 7.0  |
| Direction 2 O-D (2 to 3)    | 3400                        | 0.90| 8.0  |
| 14th Ramadan Street (Location #4) | 3164                        | 0.91| 10   |
| Direction 1 O-D (3 to 1)    | 3285                        | 0.90| 9.0  |

It is assumed that the traffics in the above table will be reduced when the suggested road is achieve and being in service. This reduction is resulted from transforming some of the traffic to new-attracted rout. Table 6 shows the final peak hour volume after reduction the generated traffic.

Table 6. Final peak hourly volumes in Locations 3 and 4.

| Location #3 (Demishq Street) | Peak hourly volume (Veh./h) | PHF* | Hv* % |
|-----------------------------|-----------------------------|------|-------|
| Direction 1 O-D (3 to 2)    | 2784                        |      |       |
| Direction 2 O-D (2 to 3)    | 2804                        |      |       |
| 14th Ramadan Street (Location #4) | 2700                        |      |       |
| Direction 1 O-D (3 to 1)    | 2800                        |      |       |
| Direction 2 O-D (1 to 3)    | 2800                        |      |       |

* Same in Table 5
4.3.2 Vehicle emission using SIDRA program

After finding the traffic volumes in locations 3 and 4, before and after construction the suggested road, SIDRA Software [13] has been used to estimate the vehicle emissions such as Carbon monoxide (CO), Carbon dioxide (CO2), nitrogen oxides (NOx), and Hydrocarbon (HC). The results of the emission before and after achieving the suggested road are shown Table (7). The results indicated that (CO) has a significant reduction in comparing with other emissions gases as illustrated in Figure 7.

| Demishq Street (Location #3) | CO2 (kg/h) | CO (kg/h) | HC (kg/h) | NOx (kg/h) |
|-----------------------------|------------|-----------|-----------|------------|
| **Direction 1 O-D (3 to 2)** | Before     | 1663.6    | 34.40     | 1.930      | 2.990      |
|                             | After      | 1424.0    | 22.98     | 1.589      | 2.874      |
| **Direction 2 O-D (2 to 3)** | Before     | 1618.3    | 32.86     | 1.845      | 2.855      |
|                             | After      | 1429.0    | 22.61     | 1.565      | 2.828      |

| 14th Ramadan Street (Location #4) | CO2 (kg/h) | CO (kg/h) | HC (kg/h) | NOx (kg/h) |
|----------------------------------|------------|-----------|-----------|------------|
| **Direction 1 O-D (3 to 1)**     | Before     | 1543.0    | 30.24     | 1.700      | 2.624      |
|                                  | After      | 1411.7    | 21.48     | 1.491      | 2.560      |
| **Direction 2 O-D (1 to 3)**     | Before     | 1591.6    | 31.75     | 1.783      | 2.757      |
|                                  | After      | 1357.2    | 27.02     | 1.520      | 2.353      |

Figure 7. Reduction in vehicle emissions in locations 3 and 4.

5. Conclusions

Within the limits of the traffic and geometric features of the study area, the main conclusions that can be drawn from this research are summarized as follows:

1- The peak hourly volume in location 1 (Shaljya Intersection) are 2110 and 892 Veh./h for each direction.
2- At location 2 (Demishq Intersection), the peak hourly volume are 2699 and 4640 Veh./h.
3- The percentages of expected generated traffic to the suggested rout at location 1 are 23% and 52% from the peak hourly volume.
4- At location 2, the percentages of generated traffic transported to the suggested rout are 22% and 23%.
5- The required lanes for the suggested road are 3 lanes for each direction.
6- The results show that, the vehicle emissions such as Carbon monoxide (CO), Carbon dioxide (CO2), nitrogen oxides (NOx), and Hydrocarbon (HC) have been lowered at locations 3 and 4 in case the suggested road is constructed.

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